ECONOMIC EVALUATION OF THE PHILIPPINE ALCOGAS AND COCODIESEL PROGRAMS

Economic Evaluation of the Philippine Alcogas and Cocodiesel Programs
by Armando Armas, Jr.
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ABSTRACT

The research evaluates the economics of the Philippine alcogas and cocodiesel fuel programs. It examines the social cost-benefit as well as cost effectiveness of the different projects of the programs, and determines the conditions and policies that would significantly affect their economic desirability. In particular, the comparative advantage of the alternative fuel sources vis-à-vis imported petroleum is highlighted. The implication of prices particularly fuel and raw material feedstocks on the competitiveness of alternative energy sources is assessed under various simulated settings. The main conclusion of the study indicates that alcogas and cocodiesel fuels are prominently non-competitive against the conventional energy fuels. In all, the alcogas and cocodiesel programs look economically unattractive under the prevailing economic conditions.

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CONTENTS

LIST OF TABLES

FOREWORD

The energy crises of 1973-74 and 1979-80 brought home to many oil-importing nations the importance of gradually diversifying their energy sources and developing indigenous supplies of energy.

In the Philippines, one of the responses was to draw up an energy development program in order to harness local energy sources and tap alternative energy forms. The latter includes the development of non-conventional sources of energy, among which are alcogas and cocodiesel. The ultimate objective, of course, is to become relatively self-reliant in the use of energy.

This study is an attempt to look into the economic viability of the alcogas and cocodiesel programs of the government which were officially launched in 1982 with very optimistic prospects but which were, in the immediate year after, shelved due to exogenous factors. It is also an attempt to see how these programs fit into the overall energy development plan.

How socially profitable and cost competitive are these programs? Under what assumptions are these programs anchored? Authors Armando Armas, Jr. and Denise Joyce Cryde try to answer these and other questions. It is hoped that their analysis and conclusions will be useful inputs in the fine-tuning of the country's energy development program.

FILOLOGO PANTE, JR.
President

ABBREVIATIONS AND ACRONYMS

ADB	–	Asian Development Bank
B	–	Billion
bbl	–	barrel
BOI	–	Board of Investments
CB	–	Central Bank of the Philippines
CIF	–	Cost Insurance and Freight
CPI	–	Consumer Price Index
DBP	–	Development Bank of the Philippines
DRC	–	Domestic Resource Cost
EROR	–	Economic Rate of Return
FOB	–	Free on Board
Ha	–	Hectare
Kl	–	Thousand liters
LIBOR	–	London Interest Bank Offered Rate
ltrs	–	Liters
M	–	Million
MMBOE	–	Million Barrels of Oil Equivalent
MOE	–	Ministry of Energy
NEDA	–	National Economic and Development Authority
NPCC	–	National Pollution Control Commission
NPV	–	Net Present Value
OER	–	Official Exchange Rate
p.a.	–	Per Annum
PCA	–	Philippine Coconut Authority
PD	–	Presidential Decree
PHILSUCOM	–	Philippine Sugar Commission
PNAC	–	Philippine National Alcohol Commission
PNB	–	Philippine National Bank
PNOC	–	Philippine National Oil Company
PSA	–	Philippine Sugar Association
SER	–	Shadow Exchange Rate
TOE	–	Tons Oil Equivalent
UCAP	–	United Coconut Association of the Philippines

Chapter 1

INTRODUCTION

The 1973-74 energy crisis heralded the dangers of overdependence on foreign energy sources. Like many oil importing nations, the Philippines reacted by gradually diversifying its energy sources and developing indigenous supplies. The second round of OPEC price escalations in 1979-80 forced the government to hasten the development of alternative energy forms and raised targets for energy self-reliance. Yet the Philippines at the turn of the decade witnessed a much slower pace of energy program implementation and lower achievement of stated targets. In response to the unprecedented decline of oil prices in 1982 and the persistent sluggish growth of the Philippine economy, the government has revised its energy programs to reflect the changing energy outlook.

Background of the Study

The Philippine Energy Development Program 1982-1987 updates the previous energy plan to incorporate important changes in the energy sector and the national economy. Despite dramatic changes in the world energy balance, the Energy Program maintains the former strategy of supply diversification and indigenous energy development. The government, however, has reportedly become more confident in expanding the share of indigenous energy sources to 49 percent of total energy forms by 1987, from less than 5 percent in 1973. There seems to have been important modifications in the energy source mix, as the implementation of well publicized alternatives is being delayed and their production targets reduced. While major conventional energy alternatives such as coal and geothermal energy are being re-evaluated due to environmental problems, non-conventional sources are being reviewed because of changing economic prospects.

Dynamic flexibility in the development of non-conventional energy is profoundly expressed by changing thrusts in the implementation of the alcogas and cocodiesel programs. To begin with, the energy program of 1982-1987 published in April 1982 reiterated that among the renewable energy sources, cocodiesel and alcogas offer the *highest* potential contribution to the transport sector. Accordingly, that same year, the alcogas and cocodiesel programs were officially launched, the latter with a Presidential Directive as well as a resolution on rules and regulations implementing this Directive issued by the Philippine Coconut Authority. Yet shortly after, a cabinet decision called for the freezing of the alcogas program at prevailing negligible production levels. Similarly in early 1983, the cocodiesel project was shelved as world prices of petroleum started to fall while those of coconut exports took an upward trend.

Scope of the Study

This paper attempts to shed some insights on the economic viability of the alcogas and cocodiesel programs. In particular, the research aims to identify scenarios that would make the programs cost competitive and socially profitable. Moreover, it hopes to determine the threshold prices of petroleum, foreign exchange, and domestic indigenous resources required for the programs' social effectiveness. For several reasons, this study focuses on the economic analysis of six different models of alcogas distilleries utilizing sugarcane or molasses as feedstock. This alone would generate a number of indicators and comparative estimates notwithstanding possible simulated cases. If data and time permit, this study will cover the six proposed alcogas projects in a number of alternative sugar districts. On the other hand, due to data constraints, the cocodiesel program will be undertaken on opportunity costs of using coconut oil for diesel fuel against exporting to earn foreign exchange. The gains or losses of the cocodiesel program will be estimated under given assumptions. On the whole, the scope of the study is expected to be larger than those of previous studies including those of a World Bank study, *Philippine Energy Sector Survey* (1982).

This paper consists of six chapters and a substantial number of statistical appendices. Chapter 2 reviews the literature on non-conventional energy, discusses the research methods used and data sources. Chapter 3 discusses energy prospects including non-conventional substitutes in the transportation sector.

Chapter 4 begins with a brief alcogas program overview, and reports estimates of selected indicators for "base case" analyses. The chapter concludes with an evaluation of alternative scenarios using a simulation approach to assess the economics of different alcogas projects under different conditions. Chapter 5 deals with the cocodiesel program. It gives an overview of the program and discusses some issues and problems particularly those concerning technical feasibility. The paper ends with a chapter presenting the study's major conclusions and policy implications.

Chapter 2

REVIEW OF LITERATURE AND EVALUATION METHODS

Review of Literature

Philippine economic literature has several energy studies since the 1973-74 energy crisis. While the literature is undeniably rich, there seems to be a dearth of materials on the economics of non-conventional energy. There are very few published economic studies on alcogas or cocodiesel as alternative energy forms in the Philippines. This chapter, therefore, mainly reviews published economic studies on non-conventional energy conducted elsewhere. Such studies may be useful in identifying important economic variables and suggesting some acceptable evaluation methods that can be used.

In the first section, recent studies done in highly developed countries are reviewed. Next, studies on non-conventional energy in developing countries are discussed. The third section focuses on alcogas in developing countries, particularly Brazil. The chapter ends with a review of the only published paper that touches on Philippine non-conventional energy issues.

Non-Conventional Energy Studies

After the 1973-74 petroleum crisis, prospects for alternative energy resource development spurred great interest not only among governments but more so among business organizations. Several studies on alternative energy problems and project feasibilities have been undertaken but many remain unpublished for various reasons. The studies reviewed in this section are only those that are published, have detailed presentations, and are written by reputably objective authors.

The MIT *Energy Self-Sufficiency Study* (1974), conducted in response to the US Energy Independence Program, was, the first in-depth study to pose the question thus: "whatever the goal of energy independence (for US by 1980) could be achieved and, if so, what price its achievement might entail for the nation." Similarly, the *Project Independence Evaluation System* (PIES-74) was launched by the US Federal Energy Administration in 1974 to assess the US energy outlook. While both MIT and PIES dealt with vast research topics and areas, each substantially evaluated the prospects of different energy sources, e.g., oil, natural gas, coal, and nuclear and non-conventional forms, e.g., synthetic fuel, shale oil, geothermal, and solar energies in the different regions of the United States. With regard to the latter, the studies speculated that production of new energy forms would be negligible in the near future (up to 1980) even though their commercialization production costs turn out to be low.

After the MIT and PIES, several studies done by individual researchers were published. Palz (1978), for instance, looks into the economics of solar electricity in the United Kingdom while Merril and Gage (1978) deals with non-conventional energy alternatives such as water, solar, wind, and biofuels in the US. Another important study, Merrow (1978) discusses constraints in the commercialization of shale oil especially in California. In more recent years, Ben et al. (1981) analyzes the economics of producing synthetic liquid and gaseous fuels from coal, oil shale, tar, sands, and industrial wastes in UK while Walton et al. (1982) presents an overview of economic issues relating to solar energy and evaluates its economic possibility in the US.

Not surprisingly, most of the studies evaluate non-conventional energy alternatives mainly on the basis of engineering costs or prior cost data. Such an approach is perhaps acceptable since most of the studies deal with non-conventional energy in the US and UK. No serious market distortions are assumed to prevail in these highly developed market economies and the energy sector remains largely in private hands. A more serious drawback of these studies, however, is their use of aggregated cost estimates that do not explicitly distinguish among different extraction sources. Offshore production costs, for example, are assumed to equal those of onshore, or future production costs are largely determined by prior cost experience. As a result, many studies are optimistic about the future share of non-conventional vis-à-vis hydrocarbon-based energy. Their highly imprecise forecasts suggest that most of their results especially those on the feasibility of non-conventional energy are dubious. For one, their evaluations are based on simplifying assumptions that were outrun by events. The dearth of experience with *new* technologies and processes contributes to the uncertainty and imprecision of the evaluations and results.

Non-Conventional Energy in Developing Countries

On the whole, economic studies on non-conventional energy in developing countries are scarcely available and the ones readily obtainable are those reported by government agencies and interested project proponents. Moreover, most reports are either merely descriptive or deceptively biased. Few studies are undertaken by independent researchers and scholars. Furthermore, the published research done by respectable institutions usually analyzes energy alternatives by geographical or socio-economic groups of countries.

Among the studies on Asian energy prospects, the Asian Development Bank-sponsored *Regional Energy Survey 1981* covers not only the energy problems and prospects of ADB developing member countries but also of sub-groups and even selected individual countries. It presents potential energy resource and supply estimates for major traditional energy forms such as petroleum, hydroelectricity, coal, and non-conventional forms including biomass, wind, and solar energy. The report discusses the consumption trends of major energy products and forecasts energy demand and domestic prices for each ADB developing member country from 1980 to 1990. It devotes a chapter on energy self-reliance and attempts to evaluate prospects for renewable indigenous energy in selected countries. As it seems, however, the ADB report is largely based on opinions and judgmental observations and its research methods are weak and poor in theoretical framework.

Like the ADB, the World Bank as a development institution would be expected to have substantial research on non-conventional energy alternatives of oil importing developing countries. The long list of Staff Working Papers, however, reveals only one paper (No. 346, July 1979) dealing with the traditional and non-conventional energy prospects in developing countries. The study reports on the widespread shortages of traditional fuels, which about half of the world's population uses for household needs. The authors furthermore estimate the supply and demand of traditional fuels and describe existing technologies for non-conventional energy sources such as biomass (including alcohol), solar, wind, and mini hydro. Some short case studies in Bangladesh, Nepal, and Sudan are also presented although they are largely descriptive and have only few important implications for other oil importing countries. In its conclusion, the World Bank paper echoes the innocuous advice that "many developing countries could usefully consider programs to increase fuelwood production and improve charcoal production techniques."

Alcogas Prospects in Developing Countries

A more relevant World Bank publication is the paper, *Alcohol Production from Biomass in the Developing Countries* (1980). The first half of the report discusses non-economic aspects such as the chemical properties and technological options of ethanol, while the second half conducts an economic analysis of ethanol production. In the latter context, countries are distinguished in terms of the estimated capital costs of installing distilleries as against Brazilian costs. Although the World Bank study reportedly received its data base from a number of engineering firms, contractors, suppliers, and consultants of interested proponents in the US, Africa, Asia and Latin America, it nevertheless relies heavily on data collected by the Bank mission to Brazil.

In the study, the cost analysis of ethanol production from different biomass materials such as molasses, sugarcane, cassava, and corn is extended through simulation under different key assumptions. Moreover, economic rates of return on ethanol production are estimated using different wholesale gasoline prices and ex-distillery feedstock costs. Despite its elaborate presentation, however, the Bank's study is unclear as to its use of social costs and values or actual costs, and it presents results without publishing basic data even in an annex or appendix.

As for specific country studies, a confidential World Bank publication on Brazil (Report No. 3001 BR [1980]) reviews the country's alcohol and biomass sector. This is quite significant since almost all published studies on non-conventional energy sources reiterate that the economic viability of a particular energy project would greatly depend on the project's specific conditions. Brazil is the only country in the world that has so far launched a large scale alcogas program. As such, it is the only one with extensive experience in alcogas production and distribution. Although Hammond (1977) and Yand et al. (1979) provide an overview of the Brazilian experience, the World Bank report is the only available publication that analyzes the economics of the Brazilian alcogas program.

Using standard evaluation methods, the study starts by estimating benefits of the alcogas program in terms of the economic value of the alcogas program using the economic value of imported petroleum products. The economic costs of producing biomass alcohol (of about two thirds of total production costs), in turn, are determined on the basis of the production costs of raw materials such as sugarcane juice or molasses. Accordingly, the amount and productivity of agricultural land strongly influences the economic costs of raw materials. In sum, the relevant aspect of the Brazilian study in economically evaluating alcogas projects is its dominant use of shadow prices for outputs and inputs.

The Philippine Alcogas Program

While numerous studies on the Philippine alcogas program and its projects have been conducted by interested proponents and government institutes, only one restricted World Bank publication, the *Philippine Energy Sector Survey* (Report No. 3199 PH [1982]) is available which provides insight into the economics of the Philippine alcogas program. The study devotes about 46 pages (excluding statistical annex) to alcogas while the rest of the paper deals with the development of conventional energy forms such as coal, petroleum, and hydroelectricity. The chapter on alcogas gives an insider's knowledge of the program and contains confidential data usually not available to local scholars or researchers. It is so far the best available document on the whole Philippine non-conventional energy program. Unfortunately, however, it fails to consider the newly launched coco-diesel program.

For purposes of this study, one important aspect of the Bank's report is an evaluation of the economic feasibility and viability of the Philippine government's targets. Essentially, the evaluation crucially depends on the estimates of major agricultural and industrial costs. The Bank mission, for instance, based sugarcane molasses, and cassava costs on either the higher of (1) their domestic marginal economic costs of production or (2) their respective prices in world or export markets. For the former, the Bank mission was unable to get nationwide cost data on sugar, cassava, and molasses despite its strong influence on Philippine authorities. The analysis of sugarcane production costs, therefore, had to almost entirely be based on sugar cost data obtained from a "large, well-managed sugar mill in Negros Occidental" (presumably that of Victorias Sugar Mill). In effect, the Bank mission merely uses one mill location's specific data to evaluate the country's national alcogas program. With respect to world sugar prices, in turn, it assumes projected world prices for 1980-94 derived from the Bank's world sugar model which was adjusted for the effects of sugar supply being diverted to the alcogas program.

On the industrial aspect, the analysis centers on installed capacity capital costs, which incidentally constitute the biggest industrial cost component. Again, in spite of the World Bank's global connections, the mission could hardly obtain accurate price quotations for distillery equipment and machineries. As stated, most of the reported cost figures were roughly derived from foreign suppliers and Brazilian quotations. With such cost estimates, the study derives its "base case" production costs for the three distillery models being envisioned for alcogas projects.

Economic rates of return and net present values for the three distillery models are estimated in the study using, among others, the following key assumptions: (a) $2-21/ton sugarcane millgate prices in 1980-84 and $16/ton in 1985-95; (2) $32/bbl. crude oil price in 1980 rising at 3 percent per annum thereafter; and (3) 165 days/year of distillery operation. Alternative scenarios are then simulated and resulting rates of return compared. Assumed changes include (1) a 25 percent change in sugarcane prices; (2) a 5 percent per annum increase in the real price of crude oil from 1980-85; (3) a 10 percent change in distillery operating costs; (4) an increase to 180 days/year of distillery operation; and (5) a delay of distillery investments until later years (1981-1984). Results of the Bank's study show that anhydrous alcohol production under "base case" assumptions is not economically viable and the rates of return approach only 10 percent per annum under favorable scenarios. No scenarios, moreover, resulted in an economic rate of return greater than 12 percent.

Perhaps because of these unsatisfactory findings, the Bank mission proceeded to employ the domestic resource cost (DRC) coefficient which is a more elaborate comparative indicator commonly used to evaluate tradable projects. Use of the DRC, nevertheless, supports the initial findings that alcogas production under the "base case" and alternative scenarios is not economically viable. Without giving much attention to the shadow price adjustment and other assumptions, the World Bank paper estimates that the DRC of anhydrous ethanol production may be 15-20 percent higher than the cost of importing oil and refining an equivalent volume of gasoline.

On the whole, it seems that the World Bank paper has been influentially important as indicated by succeeding government decisions on the alcogas program. More specifically, the report may have supported the cabinet decision to freeze alcogas projects. Yet a closer review of the Bank's mission report would reveal that their conclusions are derived mainly on the basis of a highly restricted and questionable data base and analysis. Clearly, further study would have to be undertaken to more accurately assess the program in view of the country's technological and resource alternatives and price prospects.

Evaluation Methods and Data Sources

This section presents the methods used and data sources in the economic evaluation of the Philippine alcogas and cocodiesel programs. The first section briefly deals with standard methods of estimating economic rates of return and domestic resource cost coefficients. It also presents alternative assumptions adopted in the "base" and simulation cases. The next section elaborates on the data sources at the project-specific and industrial levels. The chapter ends with a note on the shadow prices of important production factors.

Economic Rate of Return and Domestic Resource Costs

The non-conventional transport fuel programs are evaluated in terms of rate of return and domestic resource costs instead of in terms of multi-objective socioeconomic variables. This approach presumes that the end goal of any economic activity is to increase output or reduce costs. Thus, while such aspects as employment generation, rural development, and energy self-sufficiency are undeniably important, it is argued that, other things being equal, greater rates of return or lesser social costs would imply higher gross national products and hence, improved economic welfare. Among the various techniques presented in the literature on project appraisals, this study adopts the concept and measure of economic rate of return (EROR) and the domestic resource cost (DRC) coefficient, respectively, to determine the social attractiveness and cost effectiveness of the alcogas and cocodiesel programs. These techniques are standardized in such manuals as the OECD (1969), UNIDO (1972), NEDA (1978), and evaluation studies such as Pearson et al. (1976).

The EROR is simply the rate of return to investment viewed from the social standpoint. It measures the social economic profit and is also referred to as the national rate of return in several project evaluation manuals. The DRC coefficient, in turn, measures the comparative advantage or cost competitiveness of tradable activities especially in an economy with a distorted foreign exchange market.

In equation form, the two indicators, stated for activity j, are as follows:

$$EROR_j = \frac{(\Sigma a_{ij}\, p_i - \Sigma f_{si} v_s - M_j\, V_{fx} + E_j) - \Sigma k_{ij}}{\Sigma k_{ij}}$$

$$DRC_j = \frac{\Sigma f_{si} v_s + E_j}{(U_{ij} - M_j - R_j)\, V_{fx}}$$

where: a_{ij} is the quantity of output i produced by activity j; p_i is the shadow price of output i; f_{si} is the quantity of primary inputs used in i production; v_s is the shadow price of input s; M_j is the total value of tradable inputs in j (in foreign currency); V_{fx} is the shadow exchange rate: E_j is the external costs or benefits (negative), imparted to the rest of the economy due to i; k_{ij} is the investment to produce i in activity j; U_i is the total value in world prices of all outputs i in j (expressed in foreign currency); and R_j is the total value of repatriated earnings of foreign owned production factors employed in activity j.[1]

In both equations, shadow prices of outputs and inputs are needed to estimate the respective indicators, not to mention the components of taxes, external costs, and repatriated earnings. Since the alcogas and cocodiesel projects are to be registered with the Board of Investments to avail of the package of fiscal and other incentives, the estimated private costs would already exclude certain taxes and other transfers. Moreover, while the above equations include externalities, this study makes no adjustments for linkage and other external effects because first, such effects are presumably embodied in the selected shadow prices; second, the alcogas and cocodiesel projects have very little expected side effects to non-users or third parties; and third, most of their expected outputs and inputs are marketable items.

In estimating the shadow prices of project outputs, this study, like the World Bank reports, uses the projected prices of conventional transport fuels (gasoline and diesel) at ex-refinery. Similarly, as in the World Bank study, the shadow prices of the feedstock, raw material depend on whichever is higher of (1) their domestic marginal economic cost of production, or (2) their world or export prices, adjusted for quality and price changes due to the project effects on supply and demand for the respective raw materials. Unlike the World Bank studies, however, this paper estimates the social costs of the other major inputs namely capital, labor, intermediate inputs, and foreign exchange. Moreover, as much as possible, production costs are separated into their agricultural and industrial components. Finally, given certain estimated parameters, this study develops alternative scenarios for simulation and compares respective rates of return and domestic cost coefficients. The effects of different assumptions concerning selected key variables such as projected prices of crude oil vis-à-vis sugarcane juice, molasses, or coconut oil export prices are compared.

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1. These formulas, though basically static in appearance, are sufficiently general to incorporate the case of a multi-period dynamic framework. For this, it would have to be assumed that streams of benefits and costs are discounted at an appropriate social discount rate to allow for comparability at a specified point in time. For expositional clarity, time was not introduced into the formula although in actual estimation net profit and investment cost streams are discounted at an assumed social discount rate of 10 percent.

Data Sources

This study relies on primary and secondary, published or unpublished, data sources. Private "base case" variables and parameters will depend mostly on primary unpublished data while assumed key social parameters will be drawn from secondary published sources. Some better known studies would also be looked into for data or indicators not usually presented in statistical publications. In particular, these include shadow price indices and price projections. As much as possible, all information sources used in this study will be acknowledged except those that have requested confidentiality.

Specific feedstock prices for sugar, molasses, and alcohol can be obtained from the Philippine Sugar Commission (Philsucom). Similarly, the Philippine Coconut Authority (PCA) could provide copra price data as it has been monitoring coconut prices in the local and export markets. For alternative sources, the annual *Philippine Sugar Handbook* and the Philippine Sugar Association (PSA) can be referred to for updated statistics and projections on the price behavior of sugar and its by-products. Likewise, coconut product prices can be obtained from the *Philippine Coconut Yearbook* and the United Coconut Association of the Philippines (UCAP). Petroleum prices, on the other hand, can be procured from the Ministry of Energy (MOE) as it has a regular statistical series not only on time-series domestic but also world prices. In addition, commodity price statistics are also reported in the publications of international organizations such as the World Bank, United Nations, Dow Jones Corporation, and Merryl Lynch and Company.

Private industrial production cost data are restrictively available from local sources such as project feasibility studies. On the alcogas projects, there are 9 private proponents that have submitted their proposals to the Philippine government agencies directly involved in alcogas projects. The evaluation of alcogas heavily consults several feasibility studies submitted by private proponents. Among the important studies consulted are the following:

1) Japan International Cooperation Agency. *Feasibility Study Report on Alcogas Project in Maragondon, Cavite, The Republic of the Philippines* (Tokyo: JICA, 1982).

2) Ifagraria, S.p. a. *Feasibility Study for a Fuel Alcohol Farm and Distillery in the Province of Bohol* (Rome: Ifagraria S.p.a., 1981).

3) Technical Research Centre of Finland. *A Techno-Economic Study on Production of Ethanol From Cellulosic Materials in the Philippines* (Vienna: UNIDO, 1983).

4) Vöest-Alpine AG. *Feasibility Study of Philippine Power Alcohol Program* (Austria: Vöest-Alpine AG, 1978).

On the cocodiesel project, however, it is unfortunate to say that there are no coconut oil mills seriously interested in the program under the present set-up. Since the Philippines is the first coconut producing country to envision such a program, data are not available elsewhere. Nevertheless, industry data will be used to evaluate the cocodiesel program unless the MOE or PCA provides some project specific figures.

The analysis of alcogas on a national or regional level will make extensive use of industry statistics. Unlike in the World Bank alcogas study, sugarcane production costs in selected sugar districts will be extrapolated from the Philsucom field survey conducted for crop-year 1976-77.

Given the production cost structures, social valuations would be made on the basis of shadow price estimates derived for highly distorted production factors. Several in-depth studies related to the issue of factor market distortions exist. This study, like aforementioned ones limit social cost adjustments to the distorted prices of major inputs such as capital, labor, and foreign exchange. Agro-based production costs, moreover, would be socially valued vis-à-vis the estimated social values of land and other intermediate inputs such as fertilizer, insecticide, and machinery, as is done in some agricultural sector studies. For the projected time-series components, however, the same shadow prices or some allowable ranges for such inputs will be used unless it is highly probable that different indices will be necessary to reflect future conditions.

With regard to the all-important social discount rate, the literature's estimates range from 10 to 12 percent (see Manalaysay in Bautista and Power, 1979). To guide policymakers, the NEDA 1978 manual for project appraisal set it at 17 percent equivalent to the marginal productivity of capital in Manalaysay. The social discount rate used is 10 percent and 17 percent as marginal productivity of capital. It must be recognized, however, that the use of a national social discount rate assumes that capital is mobile within the country such that the capital market, whether distorted or not, is not regionally fragmented. So, unless evidence indicates significant regional fragmentation, this study would adopt the national social discount rate of 10 percent for each project.

With respect to wages, the literature on labor markets suggests not only lower industrial shadow wages (ILO 1974, Medalla in Bautista, Power and Associates 1979) but with regional differentials (Alonzo 1974). Based on the estimates of these studies, the shadow wage rates would be updated to reflect project scenarios and also the realities of the regional labor markets. Finally, the estimates of shadow exchange rates from earlier studies (Baldwin 1975, Bautista, Power, and Associates 1979) would also be revised to incorporate recent trends in trade and international payments.

Chapter 3

ENERGY CONSUMPTION IN THE TRANSPORT SECTOR

The transport sector has always been one of the major consumers of petroleum-based commercial fuels. As such, large savings in petroleum supplies are envisioned through the substitution of conventional fuels with such biomass fuels as alcogas and cocodiesel. Thus, a discussion of the transport sector is in order since this sector is envisioned to become the largest market for alcogas and cocodiesel.

The first section presents an overview of energy consumption among the major fuel consuming sectors in the Philippines, the more significant discussion being centered on energy consumption in the transport sector. The other section describes the profile of road motor vehicles in the country because alcogas and cocodiesel fuels are initially intended almost entirely for land motor vehicles. Lastly, alcohol and coconut oil are discussed as transport fuel source alternatives.

Transport Energy Consumption

Table 3.1 summarizes commercial energy consumption by major sector during selected years before and after the 1973-74 crisis. Before the 1973-74 petroleum price hikes, the transport sector consumed over half of total commercial energy. After the 1973 oil price increase, the transport sector experienced a sharp decline in its energy consumption share, reaching 29 percent in 1978. In contrast, the industry sector's share rose steadily from about 34 to 49 percent during the 1970s. Likewise, household consumption's share doubled to 14 percent and that of other sectors remarkably expanded from nearly 1 to 9 percent during the last decade. In absolute terms, total commercial energy consumption rose from 3.9 million to 14.9 million toe while transport sector consumption slowly increased from 2.3 million to 4.3 million toe in 1965 to 1978.

The 8.4 percent growth rate of consumption in the transport sector registered before the energy crisis sharply declined to 1.3 percent per annum (p.a.) in 1973-78. The total commercial energy consumption growth of 9.6 percent p.a. in 1965-73 declined to 4.8 percent p.a. in 1973-78 whereas the gross domestic product growth of 5.5 percent p.a. in 1965-73 mildly increased to 6.1 percent from 1973-78. It is clear from these figures that the transport sector had become more energy efficient during the 1973-78 period compared

Table 3.1
SECTORAL COMMERCIAL ENERGY CONSUMPTION, 1965-78
(In thousand tons of oil equivalent, numbers in parenthesis are percentage shares)

Major Sectors	1965	1970	1972	1973	1978
Industry	1,242	2,056	2,409	5,100	7,258
	(32.0)	(33.7)	(35.2)	(44.1)	(48.8)
Transport	2,329	3,556	3,890	4,036	4,297
	(60.0)	(58.3)	(56.8)	(34.9)	(28.9)
Household	267	413	463	1,549	2,042
	(6.9)	(6.8)	(6.8)	(13.4)	(13.7)
Others	45	75	86	873	1,278
	(1.2)	(1.2)	(1.2)	(7.6)	(8.6)
Total Commercial	3,883	6,100	6,848	11,558	14,875
Energy Consumption	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Source: Asian Development Bank, *Regional Energy Survey*, September, 1980.

to the rest of the economy. At any rate, the transport sector has been the most fuel-intensive sector of the economy and thus higher fuel prices can be speculated to have had a greater adverse impact on this sector relative to other sectors. It is estimated that in 1978, the transport sector used 4.07 toe to produce $1,000 value-added compared to the .6 toe of energy used on the average in all sectors to produce the same amount of value-added.

Aside from the reduction in its consumption growth, the transport sector has noticeably changed its fuel consumption mix. Table 3.2 summarizes transport fuel consumption by major fuel type for selected years during the 1965-79 period. In 1965, gasoline comprised about 55 percent of the total transport fuel consumed while diesel made up a mere 38 percent. These shares were then recorded at 52 percent and 41 percent, respectively, in 1973. Finally, in 1979, diesel consumption's share of almost 50 percent had already surpassed gasoline's share of 43 percent.

These remarkable changes in the composition of transport fuel can be explained by the significantly higher increases in the retail prices of gasoline products vis-à-vis diesel, especially during the period following the 1973-74 price hikes. Moreover, energy effi-

Table 3.2
TRANSPORT FUELS BY SOURCES,
1965-79
(In thousand barrels, numbers in parenthesis are percentage shares to total fuels)

	1965	1970	1972	1973	1979
Motor Gasoline	10,168 (55.4)	15,047 (54.2)	15,849 (52.8)	16,462 (52.4)	14,454 (42.3)
Aviation Gasoline	319 (1.7)	104 (0.03)	118 (0.4)	158 (0.5)	111 (0.3)
Jet Fuel	900 (4.9)	1,867 (6.7)	2,050 (6.4)	2,035 (6.4)	2,664 (7.8)
Gas/Diesel Oil	6,976 (38.0)	10,749 (38.7)	11,984 (37.4)	12,753 (40.6)	16,972 (49.8)
Total Fuel	18,363 (100.0)	27,767 (100.0)	30,001 (100.0)	31,407 (100.0)	34,201 (100.0)

Source: Asian Development Bank, *Regional Energy Survey*, September, 1980.

ciency in terms of ton-kilometers per liter for diesel engine vehicles has been established to be 30 percent higher than gasoline-driven ones. Then, more diesel-than gasoline-engine vehicles were registered in the 1970s and the diesel-powered vehicles were reportedly used more frequently for longer distances.

Road Motor Vehicles

While railways, water vessels, and air carriers consume a share of the total transport fuels, this share is small compared to the fuels used in road transport. Accordingly, alcogas and cocodiesel are primarily envisioned as road motor vehicle fuel substitutes. Table 3.3 presents the number of motor vehicles registered for selected years from 1965-80. The total number of registered motor vehicles steadily rose from 273 thousand in 1965 to over one million in 1980. While almost all types of vehicles increased in number, shifts in the composition of vehicles occurred over the years. In 1972, private passenger vehicles accounted for about 48 percent of the total vehicles in the country. By 1980, they accounted for a much smaller share of 38

Table 3.3

MOTOR VEHICLES REGISTERED ACCORDING TO USE, 1965-80

(Numbers in parenthesis are percentage shares)

Type of Vehicles	1965	1970	1972	1973	1979	1980
Private Passenger	127,586	243,795	316,498	296,480	447,232	424,358
			(48.1)	(40.3)	(41.8)	(38.2)
Public Utility	49,861	65,982	45,536	87,308	56,830	116,161
			(6.9)	(11.9)	(5.8)	(10.4)
Service Vehicles	89,120	132,039	136,557	176,155	280,897	282,957
			(20.8)	(24.0)	(25.7)	(25.4)
Government Vehicles	6,165	14,498	17,676	9,242	24,664	17,162
			(2.7)	(1.26)	(2.31)	(1.54)
Trailers	N.A.	N.A.	14,070	13,789	19,570	15,688
			(2.14)	(1.87)	(1.83)	(1.41)
Motorcycles	N.A.	N.A.	127,460	150,155	224,853	236,472
			(19.4)	(20.4)	(21.0)	(21.3)
Others	471	1,973	274	2,162	15,093	18,655
			(0.04)	(0.29)	(1.41)	(1.68)
Total Vehicles	273,203	458,287	658,071	735,241	1,069,139	1,111,433
			(100.00)	(100.00)	(100.00)	(100.00)

Source: NEDA *1982 Philippine Statistical Yearbook.*

percent. Similarly, the share of government vehicles have declined from 2.7 percent in 1972 to 1.5 percent in 1980. Public utility and service vehicles, in turn, increased their shares during the same period from 6.9 percent to 10.4 percent and from 21 percent to 25 percent, respectively. Motorcycles, the third largest group in unit terms, likewise recorded an increase in its share from 19 to 21 percent during 1972-80.

To assess cross sectional trends in the motor vehicle transport sector, Table 3.4 presents a regional breakdown of motor vehicles in 1981 according to type of fuel used. As expected, Metro Manila, though occupying less than 1 percent of the country's land area, had the greatest number of motor vehicles, accounting for around 44 percent of the total reported 991 thousand units.[2] The remaining motor vehicles are unevenly scattered throughout the country, with Central Luzon registering 12.4 percent of the country's total while Southern Tagalog registering the third, 8.6 percent. Western and Central Visayas registered 5.6 percent and 5.5 percent, respectively, while the Ilocos region accounts for 5.2 percent. The rest of the regions record shares ranging from 4.9 percent (Southern Mindanao) to 1.6 percent (Eastern Visayas). In all, around 75 percent of the country's motor vehicles are in Luzon while the 12 percent are in Mindanao, and the remaining 13 percent are in the Visayas.

By type of fuel use, Table 3.4 displays regional breakdown for gasoline-driven and diesel-driven vehicles. In 1981, about 78 percent of the nation's motor vehicles were run on gasoline while only 22 percent used diesel as fuel. Regionally, relatively high percentages of diesel motor vehicles were observed in Southern Tagalog (39 percent), Cagayan (35 percent) and Eastern Visayas (32 percent) while lower shares were reported for Central Visayas (11 percent), Western Mindanao (12 percent), and Southern Mindanao (15 percent). In Metro Manila, diesel powered vehicles represented 19 percent.

Unfortunately, data on the regional distribution of motor vehicles cannot be used to directly derive regional transport fuel consumption levels. This is because several factors in addition to the stock of vehicles determine the consumption flow. These include, among others, the general vehicular energy efficiency and usage by region, as well as regional road quality, per capita income, income distribution, and population density. Significantly, in many cases, motor vehicles, particularly the provincial public utilities, travel across

2. Actually the total number of registered motor vehicles in 1981 was 1,006,030, some thousand vehicles are not classified in terms of gasoline or diesel-driven units.

Table 3.4
REGIONAL DISTRIBUTION OF REGISTERED MOTOR VEHICLES ACCORDING TO FUEL TYPES, 1981

Region	Total	Regional Distribution	Gasoline Driven	%	Diesel Driven	%
Ilocos	52,089	5.2	39,856	76	12,233	24
Cagayan Valley	22,202	2.2	14,511	65	7,691	35
Central Luzon	123,303	12.4	93,339	76	29,964	24
Southern Tagalog	85,398	8.6	52,484	61	33,114	39
Bicol	21,039	2.1	15,461	74	5,578	26
Western Visayas	55,131	5.6	42,228	77	12,903	23
Central Visayas	54,653	5.5	48,805	89	5,848	11
Eastern Visayas	15,670	1.6	10,697	69	4,973	32
Western Mindanao	19,647	2.0	17,204	88	2,443	12
Northern Mindanao	34,715	3.5	27,820	80	6,895	20
Southern Mindanao	48,889	4.9	41,364	85	7,525	15
Central Mindanao	17,470	1.8	13,921	80	3,549	20
Metro Manila Area	439,386	44.3	354,409	81	84,977	19
Philippines	990,742	100.0	773,049	78	217,693	22

Source: NEDA *1982 Philippine Statistical Yearbook.*

regional boundaries so that their fuel consumptions can not be easily assigned to their respective places of registration.

Nevertheless, the regional distribution data on motor vehicles may become useful in considering locations for the alcogas and cocodiesel projects. While the fuel production projects are considered raw materials rather than market oriented, their respective feasibility in some regions may greatly depend on the size and composition of the regional road transport sector. Hence, such detailed regional breakdowns of the sector may become useful in discovering viable project locations. Moreover, they can be used to determine the number of vehicles that may need engine/component modifications for the different fuel mixes. In sum, the regional transport profile may serve as an important information supplement to the planning and implementation of the alcogas and cocodiesel programs.

Alcohol and Coconut Oil as Transport Fuel Source Alternatives

Alcohol and coconut oil are the two major non-conventional energy sources in the Philippines viewed as immediate motor vehicle fuel substitutes or supplements to gasoline and diesel. As far back as the mid-1920s, hydrous alcohol had already been used to power tractors in the sugar industry. It had, moreover, been used as an important liquid fuel during World War II. While recent experience regarding the actual use of hydrous and anhydrous alcohols in the transport sector is limited, experiments and road tests indicate that the use of such materials in internal combustion gasoline engines is technically feasible and in fact promising.

Table 3.5 compares the proposed alcohol and coconut oil straight fuel and fuel blend alternatives under the non-conventional energy program with regular gasoline and diesel fuels. As is evident, the principal properties affecting combustion efficiency (such as maximum allowable engine compression ratio, calorific value, auto-ignition temperature, and octane rating) among the gasoline alternatives are different from that of regular gasoline.

Normally, a spark ignition "otto cycle" gasoline (SIG) engine utilizing gasoline of research octane numbers (RON) ranging from 87 to 90 would have an average compression ratio (CR) of around 7-8 to 1. Overall engine performance and fuel efficiency for this same engine can be substantially improved by increasing the compression ratio to 12-15 to 1. This design change, however, would require a much higher octane fuel (about 96 to 98 RON) to avoid uneven combustion or "pinging" in the engine's cylinder. Gasoline's octane rating, for one, can only be boosted up to 3 to 5 points and

Table 3.5
COMPARISON OF ALTERNATIVE TRANSPORT FUELS

	Gasoline	Hydrous Ethanol (94% Pure) as Gasoline Substitute	Alcogas (Anhydrous Ethanol-Gasoline blend up to 20%)	Diesel	Ethanol as Diesel Dual Fuel or Blend (up to 20%)	Crude Coconut Oil	Cocodiesel (30% Blend)
Required Engine type and Modification	Internal combustion spark ignition "otto cycle" gasoline (SIG) engines with average compression ratios (CR) of 6.5-8.5	"Normal" SIG engines with following modifications: a) modified cylinder heads and carburetor to raise CR to 12-14 b) additional small gasoline tank to reduce delays due to cold start c) anti-corrosive paint in carburetor, exhaust, and intake manifold	"Normal" SIG engines; modifications not necessary except perhaps modified cylinder heads and carburetor to raise CR to 12-15 to 1 for greater fuel efficiency.	Internal combustion compression ignition "diesel cycle" diesel (CID) engines with CR of around 15-20.	"Normal" CID engines	"Normal" CID engines with greater injection advance for optimum thermal efficiency	"Normal" CID engines
Combustion Efficiency Properties:							
– Calorific value (BTU/1)	30,569	20,041	28,463	36,313	20,041	32,323	35,116
– Auto-ignition temperature (°C)	257	423	300-350	–	423	–	–

Table 3.5 (continued)

	Gasoline	Hydrous Ethanol (94% Pure) as Gasoline Substitute	Alcogas (Anhydrous Ethanol-Gasoline blend up to 20%)	Diesel	Ethanol as Diesel Dual Fuel or Blend (up to 20%)	Crude Coconut Oil	Cocodiesel (30% Blend)
– Octane Rating							
Research Octane No.	79-98	106-111	94 for 87 RON gasoline	–	106-111	–	–
Motor Octane No	71-90	89-100	81 for 73 NON gasoline	–	89-100	–	–
– Cetane Number	5-10	0-5	5-10	45-58	0-5; min of 45 in blend	50	38
Relative Fuel Economy (Specific Consumption):		1.18-1.20 x that of gasoline used in 7.8 to 1 CR engines	Same as that of gasoline when used in 7-8 to 1 CR engines; fuel efficiency improved in 12-15 CR engines.		1.6-1.8 x that of diesel when blended up to 5%.	1.20 x that of diesel	1.07 x that of diesel
Other Fuel Characteristics:	– Insoluble in water – Completely miscible with anhydrous alcohol	– Infinitely insoluble in water – Corrosive on zinc and aluminum automobile paves – Fuel is adversely affected by low ambient temperature water	– Fuel is highly sensitive to moisture combination – Blend of anhydrous alcohol with gasoline boosts fuel octane number eliminating the necessary environmentally harmful lead additives.	– Insoluble in water – Completely miscible with anhydrous alcohol and coconut oil	– Poor combustibility; requires ignition additive when used as dual fuel – Low miscibility with diesel oils in the presence of moisture	– Oil solidifies in cold temperatures	– Oil components solidify in cold temperatures

only through the use of harmful lead additives such as tetra-ethyl lead in concentrations of .60 to .85 grams/liter of premium gasoline. Because of its higher octane number, ethanol, when used in alcogas up to a 20 percent blend would automatically increase the octane number of the blend without the need for such additives. A 20 percent blend of 110 RON ethanol with 87 RON gasoline, for instance, would increase the gasoline's RON to 94. This ability to increase octane number adds value to the ethanol because it permits a less costly base stock to be used for blending into alcogas of an octane number equivalent to leaded premium gasoline.

In general, existing SIG engines with CRs of 7-8 to 1 do not require any modifications when run on alcogas of up to 20 percent ethanol in blend. Road tests, moreover, reveal that mileage performance and fuel economy for such engines are equal for both alcogas and gasoline. Fuel economy with alcogas in 12-15 to 1 CR engines, in turn, is improved over that of gasoline in 7-8 to 1 CR engines. Moreover, the blending of alcohol with fuel displays a positive volume change on mixing at alcohol levels below 16 percent (maximum expand of .55 percent for 12.5 percent ethanol blend).

In contrast, the combustion efficiency properties of straight hydrous ethanol are so significantly different from that of gasoline that use of hydrous ethanol as gasoline substitute would require modifications in the engine's design. These include: (a) modified cylinder heads and carburetor to raise CRs to 12-14 to 1 to take advantage of the fuel's higher octane rating; (b) anti-corrosive paint in the carburetor, exhaust and intake manifold; and (c) an additional small gasoline tank, to start the engine in cold temperatures in view of the fuel's poor volability and high required auto-ignition temperature. Based on road tests in Brazil, fuel economy of straight ethanol used in 11-12 CR engines is estimated to be 83-85 percent that of gasoline used in 7-7.5 CR engines. Expressed alternatively, the relative specific consumption of straight ethanol is 1.8-1.20 times that of gasoline.

Unlike its use as a gasoline substitute, ethanol as a straight substitute to diesel is unsuitable for existing diesel engines. This is so because of its very poor ability to auto-ignite and combust uniformly under conditions of pressures and temperatures developed in these engines. This poor ignition characteristic is reflected in ethanol's low cetane number of 0-5 compared to diesel's 45-55. Blending with diesel up to 5 percent, however, is possible at the expense of fuel economy (specific consumption of 1.6-1.8 x that of regular diesel). Results of experimental work on hydrous alcohol as dual fuel with diesel in the Philippines, in turn, reveal that when used in dual fuel operation of the engine, alcohol diluted with 30-40 percent water to suppress engine knock can successfully displace around 30-50 percent of the diesel depending on traffic conditions.

With regard to coconut oil, its miscibility, or ability to be mixed in any proportion to form an even, homogenous substance, with diesel fuel was evaluated at various blending ratios from which physio-chemical properties were obtained to predict fuel performance when used in diesel engines. Although any proportion of coconut oil and diesel fuel was found possible, laboratory experiments indicate that a 10-90 percent coconut oil blend in diesel fuel hardly affects the blend's critical fuel properties, low temperature characteristics, volatility, corrosivity, and heating value.

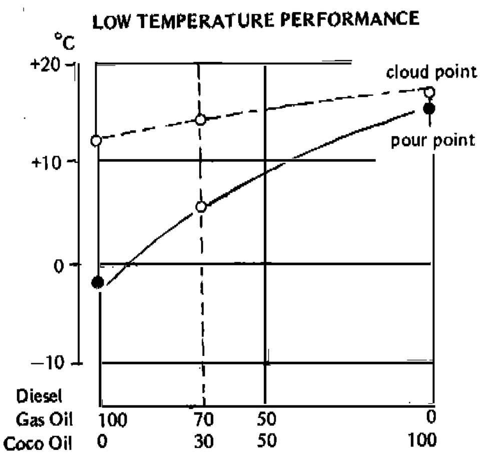
Figure 3.1 compares the tested fuel properties of cocodiesel (at the recommended 30-70 percent blend) to that of crude coconut oil, diesel oil, and JIS (Japan Standard) gas oil. The kinematic viscosity at 30°C of crude coconut oil is very high at 40.5 cSt vis-à-vis 4.5 cSt for diesel and 3.4 cSt for JIS gas oil. At the 30 percent coconut oil blend, on the other hand, the kinematic viscosity approaches the maximum tolerable limit of 8.0 cSt. Moreover, the cloud and pour point[3] temperatures of the cocodiesel mix approach the maximum limits of 13°C and 5°C, respectively. While its high cetane index (50) and calorific value (10,400 Kcal/kg) is close to that of diesel oil. Unfortunately, however, the 30-70 percent coconut oil-diesel fuel mix, was found to yield some quality dislocations, especially in terms of low temperature properties. The coco-oil components such as paraffin, for instance, partly solidified in cold weather, resulting in fuel filter plugging problems and other engine operating difficulties like power loss, poor startability and occasional stalling.

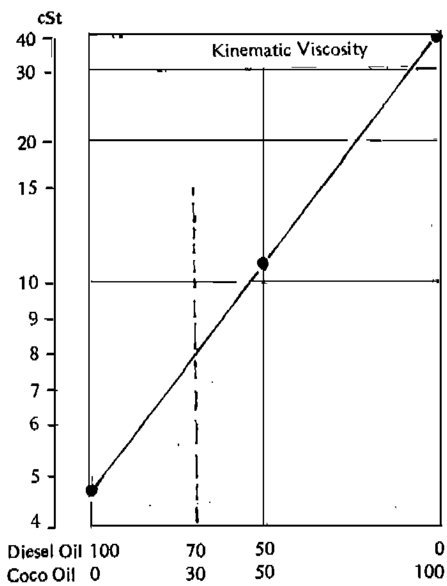
Given these experimental properties, a series of road tests from 1977 to 1978 to determine the performance of crude coconut oil as alternative fuel in jeepney diesel engines found that the average fuel efficiency of coconut oil was 83 percent that of regular diesel (i.e. specific consumption was 1.20 x diesel). Moreover, use of crude oil as fuel without engine modifications was found to be technically feasible although difficulties with cold start persisted during cold weather due to the clogging of solidified coconut oil in the fuel filter. Fleet tests on the suggested coco-diesel fuel blend of 30 percent revealed a fuel efficiency close to that of diesel at a specific consumption rate of 1.07 x that of regular diesel.

3. Cloud point indicates the service temperature at which precipitation may occur and pour point is a guide to the lowest temperature at which the fuel can be pumped through the system.

Figure 3.1
FUEL PROPERTIES – (1) DENSITY, K. VISCOSITY, ETC.

	30% Coco Diesel	100% Coco Oil	Philippine Diesel Oil	JIS Gas Oil Grade 2
Density 15/4 °C	0.866	0.923	0.841	0.831
Kinematic Viscosity at 30°C cSt	8.0	40.5	4.5	3.4
Cloud Point °C	+13	+17	+12.5	–8
Pour Point °C	+ 5	+15	– 2.5	–12.5
Sulfur Content wt %	0.64	0	0.92	0.45
Cetane Index	50	38	58	60
Heating Value $\frac{kcal}{kg}$	10,400	9,200	10,900	11,000
Water Content Max. Vol. %	0.07	0.3	0.006	0.006





Chapter 4

EVALUATION OF THE PHILIPPINE ALCOGAS PROGRAM

Program Overview

The Philippine Fuel Alcohol Program was formally launched in late 1979 by an inter-agency Presidential Alcohol Committee headed by the Minister of Energy. Initially, the program intended to primarily promote consumer acceptance of a maximum 20-80 percent anhydrous ethanol (99.5 percent pure) – gasoline blend for automobile engines, then to expand ethanol use as an industrial "ethylene" feedstock and in pure alcohol engines as the program progresses. Substantial changes in thrusts and targets, however, have taken place since program inception. Despite this, the Philippine Alcogas Program's guiding objective remains primarily to sizably displace imported petroleum fuels with an indigenous renewable energy alternative that is rural-based in order to generate job opportunities and other beneficial effects for the rural sector.

Implementation of the alcogas program has been organized under the Philippine National Alcohol Commission (PNAC). The Commission, established in early 1980, is tasked to provide the overall management and supervision of the program. It is chaired by the Minister of Energy, with the Chairman of Philsucom, the Ministers of Agriculture, Industry, Finance, and Natural Resources, and private-sector representatives as members. While the private sector is expected to provide the bulk of the investment and managerial resources, PNAC is in charge of outlining the program's targets and policy directions.

Targets and Resource Requirements

Originally, the alcogas program was targetted to yield 22M liters of ethanol during its first year of implementation, escalating to around 925M liters by 1988 (Table 4.1). A 20 percent ratio of alcohol production to gasoline demand was to be attained by 1986, after which use of increases in ethanol output would be diversified into chemical feedstock, probable diesel additive, and pure automotive fuel in specially designed alcohol engines. For this, 47 distillery complexes (12 with capacities of 120 thousand liters (Kl) per day or more) were expected to be fully operational by 1988, requiring a total of around ₱6.5B of investment and some 260,000 hectares of

Table 4.1
THE PHILIPPINE ALCOGAS PROGRAM – ORIGINAL
TARGETS AND RESOURCE REQUIREMENT PROJECTIONS
1980 – 1988

Year	Total Anhydrous Alcohol Product (Mltrs)	Total Gasoline[1] Demand (Mltrs)	Ratio of Alcohol Product to Total Gasoline Demand (%)	Required Model I (Units)	Required Model I (Mltrs)
1980	22	2,505	0.9	2	22
1981	55	2,571	2.1	4	44
1982	144	2,640	5.5	6	66
1983	244	2,718	9.0	8	88
1984	400	2,802	14.3	10	110
1985	545	2,886	18.9	10	110
1986	680	2,973	23.2	10	110
1987	835	3,068	27.2	10	110
1988	925	3,170	29.2	10	110

Table 4.1 (Continued)

Year	Distillery Capacities[2]				Required[3] Investment	Land Resource Requirement[4]		
	Model II		Model III			Sugarcane	Cassava	Total
	(Units)	(Mltrs)	(Units)	(Mltrs)	(₱ M)	(Has)	(Has)	(Has)
1980	–	–	–	–	150	5,030	1,222	6,252
1981	–	–	1	11	347	12,574	3,055	15,629
1982	1	45	3	33	467	32,918	7,999	40,917
1983	2	90	6	66	585	55,776	13,554	69,330
1984	4	180	10	110	1,015	91,434	22,220	113,654
1985	6	270	15	165	1,074	124,576	30,275	154,851
1986	8	360	20	220	1,181	157,718	38,330	196,048
1987	10	450	25	275	1,115	190,860	46,385	237,245
1988	12	540	25	275	605	211,430	51,385	262,815

Notes: [1] Includes both regular and premium gasoline

[2] Model I – Small annexed distilleries with capacities of 30-60 Kl/day
Model II – Large annexed or autonomous with capacities of 120-240 Kl/day
Model III – Autonomous municipal distilleries with capacities of 30-60 Kl/day.

[3] Prices escalated at 10% per annum

[4] Estimates assume 3,500 and 3,600 liters/ha/year for sugarcane and cassava, respectively.

Source: Philippine National Alcohol Commission land resources. Gasoline displacement, moreover, was projected to be at an average of around 2.2M barrels annually until 1988, equivalent to ₱372M at an oil price of $20/barrel.

Revised targets (Table 4.2) barely three years after the program was launched, however, showed the over-optimism of original program plans. Based on estimates arrived at from private sector intentions submitted to PNAC,[4] projected alcohol output was drastically reduced to 10M liters in 1982 and 73.8M liters by 1990, with a 20 percent ratio of alcohol production capacity to regular gasoline demand foreseen by 1987. Seven distilleries, five of which were to be converted for anhydrous ethanol production from existing hydrous ethanol plants annexed to sugar mills (Vicmico, La Carlota, Canlubang, BUSO, Bais), and each with less than 100Kl/day capacity were expected to be installed by 1990, with total program investment estimated at ₱536.1M (at 1982 prices). These substantially reduced estimates imply that private-sector interest in alcogas had not grown as initially expected. This is not surprising since trends in sugar and oil prices dramatically reversed in early 1982. Moreover, private investors have not yet been sufficiently convinced with the terms of the program to have firm judgements on its financial attractiveness.

Although sugarcane was selected as the principal crop for power alcohol production in the original program, a strategy of raw material source diversification has been proposed mainly to ensure a broader base for farmer participation. Molasses, cassava, sweet potato, sorghum, and some fruits with high sucrose content are considered as source of feedstock alternatives when deemed favorable by relative costs and prices. Because sugarcane was the initial priority crop, however, steps had been provided to avoid disruptions in the local and export markets of molasses and sugar. Accordingly, Philsucom, through PNAC, was authorized to closely monitor program developments and regulate the use of new and existing cane areas for fuel

4. In September 1980, the Victorias Milling Corporation (Vicmico) began to produce power alcohol at a rate of 41.5 kl/day upon complete rehabilitation of its distillery from an existing hydrous alcohol plant of 47.2 kl/day into an anhydrous plant based on molasses feedstock. In early 1980, moreover, negotiations by Philsucom and PNAC for the purchase and installation of annex distilleries from foreign suppliers through supplier credits were at various stages. To supply these distilleries' raw material requirements, three distressed mill districts (Casudeco, Bisudeco, and Tolong), the management of which was assumed by Philsucom were pre-designed. Similar initial discussions were under way between Philsucom and PNAC and two interested local companies (CDCP, Atlantic Gulf, and Pacific Co., Inc.).

Table 4.2
REVISED ALCOGAS PROGRAM TARGETS AND RESOURCE REQUIREMENT PROJECTIONS
1982-1990

Year	Anhydrous Alcohol Production						Regular Gasoline Demand (Mltrs)	Share of Alcohol Produced to total Regular Gasoline Demand (%)	Required Investment[3]			
	Annexed[1]		Autonomous[2]		Total				Farm (₱ M)	Distillery (₱ M)	Logical Facility (₱ M)	Total (₱ M)
	Units	Mltrs	Units	Mltrs	Units	Mltrs						
1982	2	10.0	–	–	2	10.0	537	1.9	–	–	–	–
1983	2	13.5	–	–	2	13.5	473	2.8	5.1	–	–	5.1
1984	3	18.6	–	–	3	18.6	426	4.4	18.4	182.3	7.9	208.6
1985	5	38.9	–	–	5	38.9	387	10.0	42.8	151.1	7.2	201.1
1986	5	42.9	1	9.0	6	51.9	356	14.6	24.3	83.3	13.7	121.3
1987	5	45.6	2	23.0	7	68.6	331	20.7	–	–	–	–
1988	5	45.6	2	26.6	7	72.2	314	23.0	–	–	–	–
1989	5	45.6	2	28.2	7	73.8	303	24.3	–	–	–	–
1990	5	45.6	2	28.2	7	73.8	298	24.8	–	–	–	–

Notes: [1] Includes Vicmico, La Carlota, Canlubang, Busco, and Bais distilleries.

[2] Includes distilleries set up by Southeast Aquatic and the Philippine Alcogas Corporation.

[3] Investment requirements in 1982 prices.

Source: Philippine National Alcohol Commission.

alcohol production.

At the industrial level, while the design, location, and size of the distilleries are expected to vary by project, three basic types had been suggested in the original plan.

a) Models I are existing or new distilleries with capacities ranging from 30-60 Kl per day annexed to existing sugar centrals and utilizing sugar mill excess capacities and/by-products (e.g. molasses) as raw materials. These may readily be located in areas where an excess crushing capacity in the sugar mill exists and where the productivity of sugarcane land can be readily enhanced or where excess sugarcane land is available.

b) Models II are large autonomous or annexed distilleries with capacities of 120-240 Kl/day. These require that new production areas be developed with at least two years lead time before distillery construction (grass roots land development takes from 4 to 4½ years to fully cultivate and meet capacity requirements of a 120 Kl/day distillery). Such plants are expected to experience economies of scale with output to supply major demand areas such as Metro Manila.

c) Models III are autonomous distilleries with capacities ranging from 30 to 60 Kl/day, sized to meet local area alcogas requirements. Such distilleries may obtain their raw material supplies from small farmers through supply contracts from farmers associations or may develop their own farm estates. They, moreover, may be set up by the government, after which small farmers shall be encouraged to buy equity by way of deductions from their receipts each time they deliver raw materials to the plant. At the same time, extension services to small farmers will be provided and PNAC shall gradually prepare the planter's association to take over management of the distillery to minimize transport costs and facilities control movements. Models III distilleries are planned to be located near gasoline depots, with a network of roads leading from farms to the distillery site.

To ensure continuous operation of distilleries, it is required that at least 50 percent of the raw material supply be secured either from the distilleries' own farms or through supply contracts. PNAC, in consultation with Philsucom, will determine in advance annual production quotas as well as guaranteed producer prices.

Presently, PNAC is revising the entire production strategy of the alcogas program. On the basis of more private sector participation and interest, the new program devises a distillery construction schedule to produce the alcohol requirement of the program and attain a 10 percent blend on gasoline demand by 1990. Thirteen distilleries, five of which are upgraded or converted existing distilleries, shall be constructed over a period of seven years beginning 1984. Five upgraded distilleries (Vicmico, Asian Alcohol, La Carlota, Canlubang, Tarlac), capable of producing around 50 million liters/year of anhydrous ethanol, are expected to require ₱28 million during 1984-85. In the next program phase, six new distilleries (Bais, Tolong, Casuco, Davao, Bisudeco, and Batangas) with almost 90 million liters capacity on the aggregate and annexed to sugar mills will be constructed at an expected investment of ₱346 million. Finally, two new sugarcane based distilleries with an annual capacity of about 10 million liters will be built at a total investment cost of ₱60 million for farm estate development and ₱200 million for distillery and cane processing facilities. At full implementation, total annual distillery capacity would be 147.5 million liters at a total investment of ₱691.5 million broken down into ₱575.7 million for distillery upgrading and construction, ₱60.4 million for agricultural development and ₱55.4 million for logistical facilities.

Unlike the original program, the new program under consideration favors molasses as the main feedstock raw material to be supplemented by sugarcane for extended distillery operations. Given an estimated 514 Kl/day capacity of full implementation, the annual molasses and sugarcane requirement was placed at 500,000 MT and 158,000 MT, respectively. Such a high molasses requirement is striking considering that it is roughly equivalent to the Philippine average annual molasses export for the past ten years of 542,000 MT. What PNAC suggests is a technology that directly processes sugarcane into molasses at high yields rather than extracting molasses as a sugar processing by-product at a fixed extraction rate (around .038 tons molasses/ton cane). However, the huge molasses requirement may be a problem in the attainment of program targets.

Apart from the emphasis on molasses, the newly proposed program reclassifies distillery types. Type I (upgraded distilleries) consists of two distilleries with existing anhydrous ethanol production facilities and three distilleries with existing hydrous alcohol production facilities which could be upgraded to produce anhydrous ethanol. Type II (new annexed distilleries) consists of six new molasses-based distilleries annexed with existing sugar centrals. Type III (autonomous distilleries) consists of two autonomous distilleries which shall process sugarcane and molasses into alcohol. None of the distillery types have capacities over 100 Kl/day and average capacity is around 40 Kl/day. With regard to program implementation, incentives, and pricing strategies, the new and original programs are alike.

Program Implementation Guidelines and
Proposed Investment Incentives

In a Letter of Instruction 933 issued September 1979, the Fuel Alcohol Program was given pioneer "preferred" status under the Energy Priorities Program. With this, alcohol projects approved by and registered with the Board of Investments (BOI) are entitled to the host of investment incentives stipulated for pioneer industries in the Omnibus Investments Code (PD 1789). Moreover, the CB, DBP, and PNB have been directed to relax collateral requirements and rediscounting policies for fuel alcohol projects registered under the program. Before acceptance by the BOI, however, proposed projects should conform to certain project criteria as laid down by PNAC.

For one, at least 10 percent equity of the registered corporation should be initially open to the public, preferably to farmers supplying raw materials to the plant, with such share eventually rising to a minimum 25 percent. Then, alcohol plants are specified a maximum investment cost per installed capacity to prevent unnecessary investments in the program and to protect government interest when the project is financed by government loans or loans that are government-guaranteed.[5] Moreover, a minimum portion of the plant equipment (initially 50 percent of total installed equipment cost) shall be locally fabricated or manufactured, and distilleries must meet the minimum production performance standards regarding juice extraction efficiency, alcohol recovery, strain consumption, and alcohol purity identified by PNAC.[6] Distilleries must also have 50 percent of their raw materials guaranteed, must not use petroleum-based fuels in processing, and must conform with NPCC environmental standards, particularly in the disposal of stillage. In decisions to ac-

5. Based on proposals received applying the batch fermentation process, the maximum investment cost levels per liter per day computed in the original plan were as follows: ₱525 and ₱338 for annexed distilleries of capacities ranging from 30-60 and 120 or more K liters/day, respectively, ₱938 for a 30-60 K liters/day autonomous plant, and ₱750 for an autonomous 120 or more K liters/day distillery.

6. These minimum production performance standards are as follows:

– Crushing and Milling	– 94% (sugarcane juice) extraction efficiency
– Fermentation and Distillate	– 265 liters/ton (molasses) 67 liters/ton (sugarcane) 160 liters/ton (cassava/sweet potato)
– Steam Requirements	– Maximum utilization of 5 kgs. of steam/liters of alcohol produced
– Alcohol	– 99.5% purity

cept proposed projects, the BOI would coordinate with Philsucom and the various Ministries. For instance, proposals to annex distilleries to existing sugar mills must first be approved by Philsucom. When the project is finally accepted and registered with the BOI, the project is eligible for investment, credit, price and other incentives. The Philippine National Oil Company (PNOC), moreover, shall immediately enter into an alcohol purchase agreement through the PNOC Alcohol Corporation to procure all alcohol produced at the established price for resale and alteration to local distributors of petroleum products.[7]

Among the incentives offered by the government are tax incentives available to project proponents. These include deductions from taxable income, tax exemptions, and tax credits and are explained in detail in Table 4.3. Non-tax incentives include post-operative tariff protection (up to 50 percent), protection from government competition, guaranteed financing for land development and farm machinery, and preference in government arranged loans. For loans from local financial institutions, the government will arrange financing of up to 75 percent of project cost at 16-18 percent "effective interest" with a 2-year grace and 10-year repayment period. Other loans arranged by the government include untied loans channeled through the DBP (14-16 percent effective interest with 2-3 years grace and 10-15 years repayment periods) and through foreign commercial credit resources (LIBOR + 1½-1¾ percent effective interest with 1 percent management fee and with 3 years grace and 8-10 years repayment periods) as well as tied loans for importing equipment (8.5-9.5 percent effective interest with 3 years grace and 7-10 years repayment periods). Privately arranged loans will be provided government guarantees upon CB approval of financing terms.

Pricing Policy

Another function of PNAC is to set feedstock and alcohol prices as well as determine appropriate tax and subsidy levels for the program. At the very least, alcohol raw material prices will be set in parity with the farmgate crop prices. In the case of sugar, floor and ceiling levels will be established so as to ensure availability of raw materials when prices are low and not to overprice the alcohol out of the fuel market when they are high. The expressed policy is that

7. PD 927, amending the Charter of PNOC, converted PNOC into a total energy company covering subsidiaries harnessing indigenous energy sources. For alcohol, the subsidiary is the PNOC Alcohol Corporation which engages in the manufacture, production, and purchase of alcogas and other similar fuels.

Table 4.3
TAX INCENTIVES FOR BOI REGISTERED ENTERPRISES
ENGAGING IN ALCOGAS PRODUCTION

Incentive	Specification
Tax Deductions from Taxable Income:	
a. Deduction of Organization and Preoperating Expenses	– expenses are deductible over a period not more than ten yers from start of operations; expenses include cost of pre-investment studies, start-up, manpower recruitment and training, etc.
b. Deduction of Accelerated Depreciation Expense	– depreciation of fixed assets may be accelerated to the extent of not more than twice as fast as the normal rate if its expected life is ten years or less; depreciation may be computed over any number of years between 5 years and expected life if the latter is more than 10 years.
c. Deduction of Net Operating Losses Incurred in any of the First Ten Years Operations	– loss may be carried over as deduction for the six taxable years immediately following the year of loss.
d. Deduction of Expansion Reinvestment	– extent of deduction (50%, 75%, 100%) shall be decided by the BOI
e. Deduction of Labor Training Expense	– deduction allowed to the extent of ½ the value of the labor training expense provided that the deduction does not exceed 10% of direct labor wages.
Tax Exemptions:	
a. Tax Exemption on Imported Capital Equipment	– imported capital equipment are fully exempt from tariff duties and the minimum 10% compensating tax within the 7 years from date of registration.
b. Exemption from all Taxes (except Income Tax) under National Internal Revenue Code (NIRC)	– extent of tax exemption is as follows: i) 100% for first 5 years ii) 75% for the 6th through 8th year iii) 50% for the 9th and 10th year iv) 20% for the 11th and 12th year v) 10% for the 13th through 15th year (NIRC stipulates corporation tax of 25% for taxable income that does not exceed ₱100,000 or 35% otherwise; specific tax to producers is stipulated at 1 centavo/liter.)

Table 4.3 (continued)

Incentive	Specification
Tax Credits:	
a. Tax Credit on Domestic Capital Equipment	– tax credit is equivalent to 100% of the value of the compensating tax and custom duties that would have been paid on the machinery, equipment, and spare parts had these items been imported.
b. Tax Credit for Withholding Tax on Interest on Foreign Loans	– tax credit is granted provided: – a. no such credit is available to lender remittance b. the enterprise has assumed liability for payment of tax due from the lender remittance

farmers will be guaranteed annual price increases for their products regardless of world market trends.

Anhydrous alcohol, in turn, will be procured by the government at a guaranteed price. Distributors are to pay PNAC the same price for alcohol as for gasoline, ex-refinery. Under these conditions, government financial assistance will decrease as the production cost difference between alcohol and gasoline decreases. Retail prices for alcogas will be identical to that of gasoline.

For computing guaranteed prices, the Presidential Alcohol Committee originally recommended the following formula:

$$A_T = A_o \left[1 + (K_v I_I + K_r dR_c)(1 + K_m)\right]$$

where A_T is the alcohol price at time T; A_o, the alcohol base price in 1979; K_v, the share of variable cost (other than raw material cost) in total alcohol processing cost; I_I, the wholesale price index used to proxy for inflationary increases in variable costs other than raw material cost; K_r, the share of raw material cost in the total cost of alcohol production; dR_c, the rate of change in raw material cost set 5-25 percent per annum depending on market trends; and K_m, the percentage markup for alcohol producers stated over and above alcohol processing cost.

Using this formula, the alcohol price for 1979 was computed at ₱2.60/liter. This consisted of ₱1.60/liter raw material cost, (61.5 percent), ₱0.50 (19.5 percent) and ₱0.30 (11.58 percent) per liter fixed and variable cost, respectively; and ₱0.20/liter (7.5 percent) markup. By 1980, the guaranteed price had risen to ₱4.25/liter broken down into ₱2.827/liter raw material cost, ₱0.714/liter fixed cost, ₱0.30/liter variable cost, and ₱0.384/liter markup. Thereafter, increases in guaranteed alcohol prices were recommended to be equivalent to 50 percent of the price adjustment for gasoline net of adjustments in taxes, duties and other government imposts unless PNAC deems such adjustment insufficient.

Compared to the ex-refinery gasoline price of around ₱1.98/liter in August 1980 and with oil companies paying the same price for alcohol and gasoline, this guaranteed price of ₱4.225/liter implies a producer subsidy transfer of ₱2.245/liter shouldered by PNOC. This amount is covered by the tax and other import duties normally charged for gasoline at service station pumps (₱2.519/liter in 1980). The ₱4.225/liter price represented a 60 percent premium over the gross returns available to sugarcane growers if the cane had instead been processed into sugar and molasses.[8] In 1981, the alcohol base price was reset at ₱4.37/liter. Under the newly proposed program, however, the price remunerative in 1983 for the predominantly molasses-based plants was estimated at ₱2.6148/liter broken down into ₱0.8590/liter raw material cost, ₱1.1704/liter fixed operating and interest cost, ₱.3477/liter variable cost, and ₱.2377/liter (10 percent) markup.

Ethanol Production Technology

Two distinct types of alcohol are often promoted as renewable alternatives to petroleum fuels. Methyl alcohol (methanol) or "wood alcohol" can be produced by distillation of wood or synthesized from carbon monoxide and hydrogen which is in turn obtained from natural gas or coal. Ethyl alcohol (ethanol) or "grain alcohol", on the other hand, is either produced by fermentation of carbohydrates materials or synthesized from petro-chemical feedstocks. Either type may be used to power vehicles either straight (for which it can be hydrous, i.e. of 94 percent purity) or blended (for which it must be anhydrous, i.e. of 99.8 percent purity) with gasoline. Methanol, however, is limited in its application as an automobile fuel as it presents some technical and environmental problems because it is toxic. Hence, this study concentrates only on ethanol and its production technology.

Fermentation ethanol can be produced from three main types of

8. Assuming that one ton cane yields about 98 kg of raw sugar and 38 kg of molasses or 68 liters of alcohol, the sugar-molasses option would have grossed planters (with 65% share of produce) ₱120/ton (= .65 x (98 kg x ₱1.66/kg + .038s ton x ₱600/ton) in 1980. This is in contrast to the alcohol alternative which would have grossed ₱192 (= 2.827 x 68).

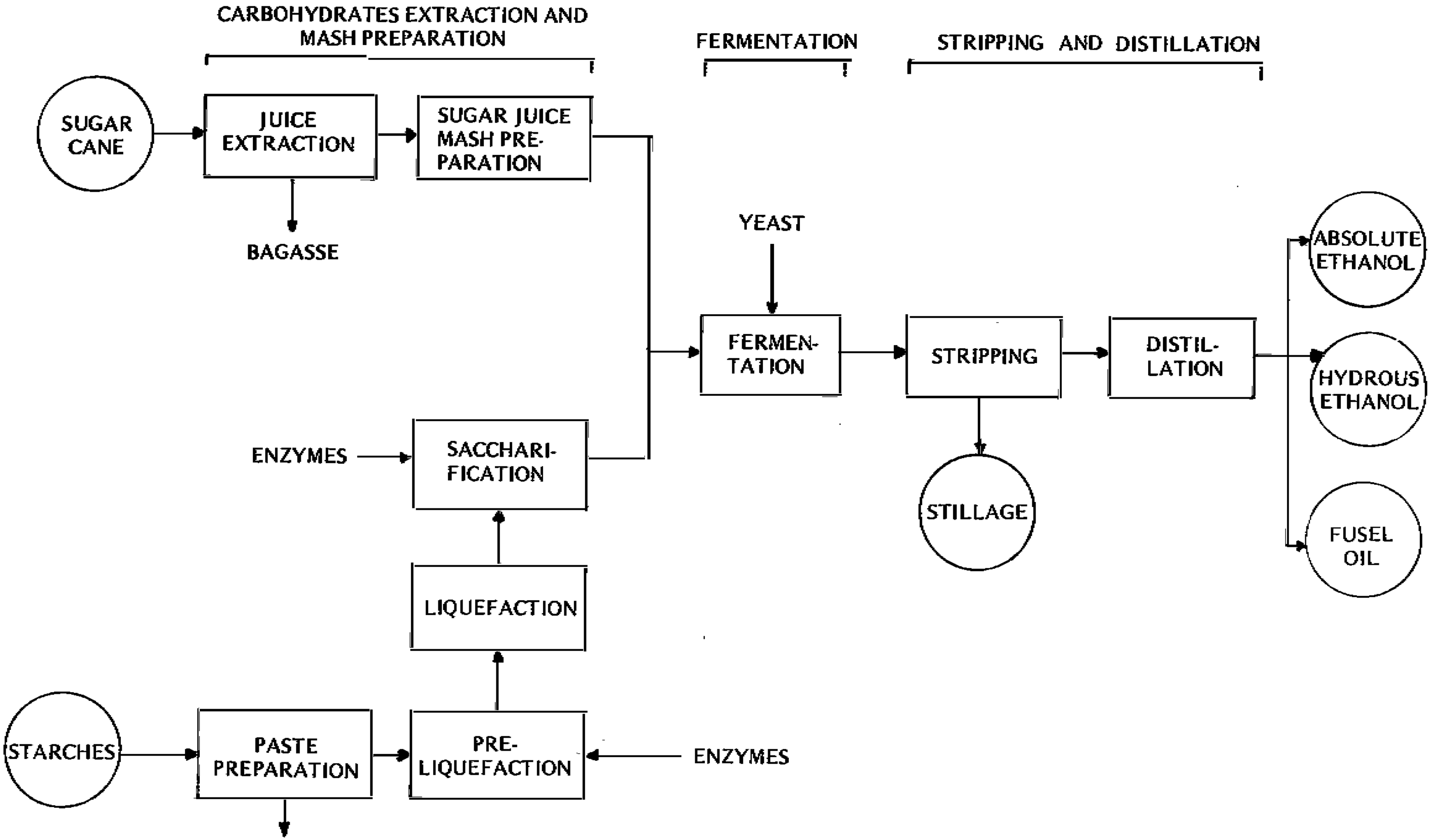
biomass raw materials: (a) sugar bearing materials (e.g. sugarcane, molasses, sweet sorghum, etc.) containing carbohydrates in sugar form; b) starches (e.g. cassava, corn, and sweet potato) containing carbohydrates in starch form; and c) celluloses (e.g. wood) containing carbohydrates in complex molecular form. Among these, sugar bearing materials are technically the most attractive feedstock alternatives since their carbohydrate content is already in the fermentable simple sugar form and fermentation can be immediately undertaken after the carbohydrate extraction stage. Starchy carbohydrates, in turn, would first have to be broken down to simple sugar through a saccharification process, while the complex carbohydrates in cellulosic materials would have to be converted into fermentable sugars by acid hydrolysis. Both saccharification and acid hydrolysis add steps to the alcohol production process that substantially increase capital and operating costs. Moreover, some of the simple sugar derived may not be as readily fermentable by yeast or alcohol thereby reducing the overall carbohydrate to alcohol conversion efficiencies of the starch and cellulose feedstocks.

Essentially, current biomass production technology involves three main processes: (a) extraction of carbohydrates and conversion into water soluble (6 to 12 carbon) sugars; (b) fermentation of these sugars into ethanol; and (c) stripping and separation of ethanol from water and other products by distillation. A simplified process flow diagram for sugarcane and starch based alcohol production technologies are presented for comparison in Figure 4.1. Ethanol production from cellulose has so far not been proven commercially feasible and thus will not be presented here.

As is evident, the basic process flow for both sugarcane and starch derived ethanol differ only in the extraction and mash preparation stage. Alcohol production from sugarcane entails a juice extraction stage usually carried out mechanically through sugar mills to remove bagasse, the cellulose fiber in the sugar stalk. In this stage, the cane is mashed, sheared, and shredded, then crushed and filtered to separate bagasse from the sugar juice. The bagasse is then dried and burned to generate steam and power for energy. The sugar juice mash, in turn, enters a preparation stage where it is clarified and sterilized to prevent microbial contamination when fermented. Along with clarification and sterilization may be juice concentration to raise the initial sugar content of the fermentation medium and keep it uniform throughout.

Alcohol produced from starches, on the other hand, entails a more complex preparation procedure to convert starches into fer-

Figure 4.1
SIMPLIFIED PROCESS FLOW DIAGRAM OF ALCOHOL PRODUCTION FROM SUGARCANE AND STARCHES



mentable sugars. After the initial washing, peeling, and size reduction, the starches are crushed and mixed with water as paste. The starchy mash is then preliquified (converted to dextrines) through a combination of thermal (steam cooking) and enzymatic actions. Enzymes such as amylase are added prior to the cooking step. The mash is then liquified and hydrolized to fermentable sugars in the saccharification step through the action of other enzymes, such as glucoamylase.

After preparation, both sugar juice and processed liquified mash are ready for fermentation. Three types of fermentation methods exist: (a) batch fermentation; (b) the yeast recycle method; and (c) the continuous fermentation process. In the first type, sugar mash is fermented using large amounts of common yeasts to produce a maximum 8-10 percent alcohol solution, after 14-16 hours of fermentation. During fermentation the yeast is gradually rendered ineffective due to increased alcohol concentration and would have to be disposed of. In the second type, the yeast is separated from the fermented mash by centrifuge, acid treated to grow additional yeast, and recycled to the fermentation step. This method reduces fermentation time over the batch method to 8 – 14 hours after which the ethanol concentration of fermented mash is round 8-10 percent. Extra care, however, would have to be taken in sterilizing the mash when this method is used because of the high probability of contamination when using the recycled yeast. In the continuous fermentation process, the yeast is immobilized and packed into the fermentation tank to which sugarcane is contacted for continuous fermentation. Fermentation using this method takes around 4-8 hours, after which ethanol concentrations of 8-12 percent are produced. On the whole, the productivity of ethanol through continuous fermentation is greatest, as this type requires fermenter capacities of around 7-18 grams of ethanol/liter of mash per hour (g ethanol/l/h) in contrast to the 5-7 g ethanol/l/h for the yeast recycle and 4 g ethanol/l/h for the batch systems.

After fermentation, the fermented mash is sent to a stripping column to separate ethanol from the fermentation solids and water. The waste stream, or stillage, must be well disposed of as it contains large amount of water soluble organic and inorganic substances with high pollution potential when discharged into rivers. Since they do not usually contain pathogenic bacteria or viruses, recovery of minerals and organics and their conversion into such marketable products as fertilizer and feed additives may be attractive. The stream containing ethanol, on the other hand, is distilled in multi-stage distillation columns to concentrations of up to 94 percent (hydrous ethanols). At 95 percent concentrations water and ethanol form a constant boiling mixture or azeotrope. Hence, to produce higher ethanol concentrations, a dehydrating agent less likely to dissolve in water such as benzene or cyclohexane must be added to remove the azeotropic characteristic of the 95 percent ethanol – 5 percent water mix. Further distillation subsequently permits production of anhydrous alcohol up to 99.8 percent purity, with fuel oil as by-product. The dehydration agent is then separated from the alcohol and recycled, while the anhydrous alcohol is ready for storage or immediate blending with gasoline or diesel. In doing so, water contamination in blending, storage and transport should be prevented.

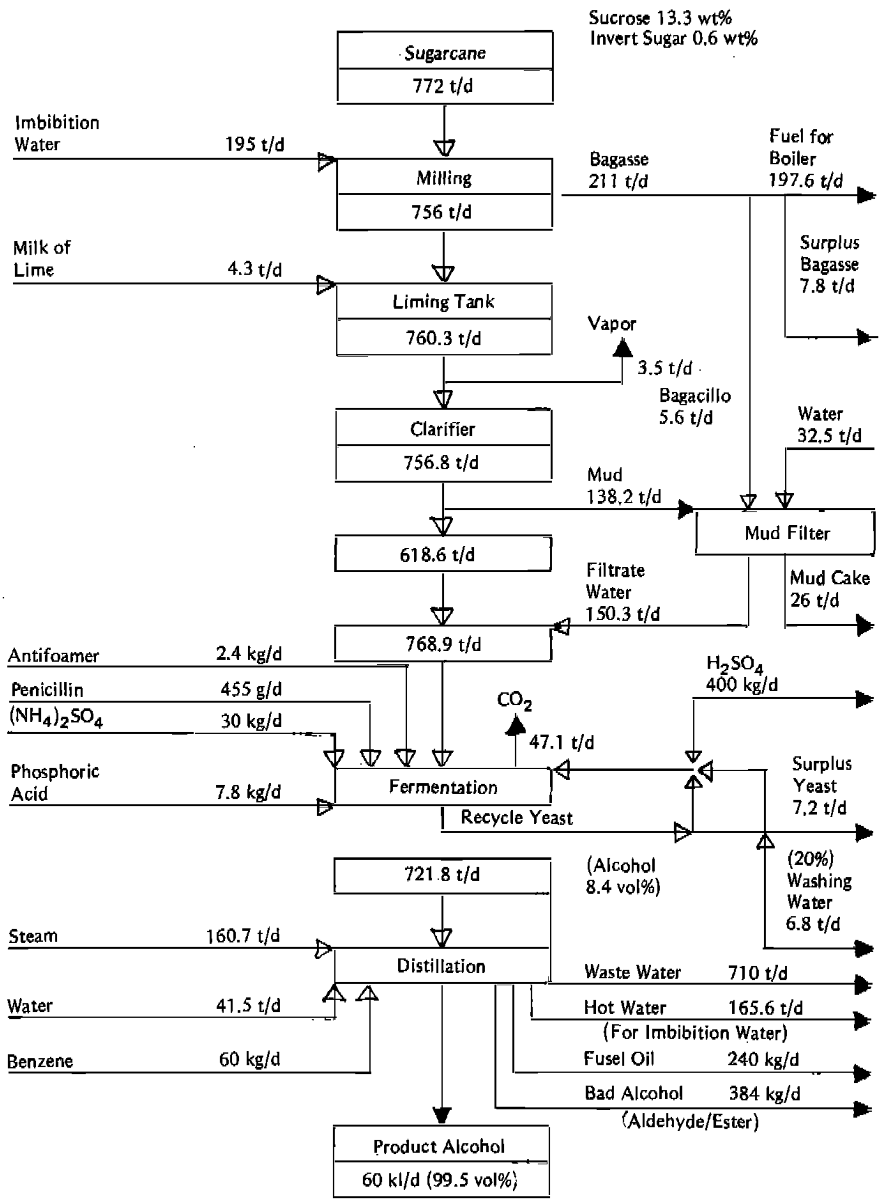
The production process of alcohol from other starch and sugar raw materials is basically the same though the sizes of the fermentation and distillation units, ethanol yields, and material and utility balances may differ depending on the feedstock. Sugarcane, for instance, yields, an average of 60-70 liters of ethanol/ton cane, in contrast to the 370, 280-325, 150-180, and 125-165 liters per ton average yields of corn, molasses, cassava, and sweet potato, respectively.

Based on the country's average crop yields per hectare for sugarcane, sweet potato, cassava and corn of 55, 6, 5, and 1.1 tons respectively in 1979, the respective average ethanol yield per hectare for these crops would be 3575, 855, 825, and 407 liters. Evidently, for the Philippines, sugarcane would produce by far the highest ethanol yield per hectare of land input. Sugarcane, moreover, is speculated to be the most attractive biomass raw material feedstock because it generates its own fuel source, bagasse, which provides more than adequate energy for generating the steam and power needed for the entire alcohol production process. The material and utility balance flow for a proposed 60 kl/day anhydrous alcohol plant in the Philippines is drawn in Figure 4.2.

The Economics of Ethanol Production Under the Philippine Alcohol Program

In analyzing the economics of ethanol production under the alcogas program, this study focuses on the three originally proposed models of alcohol distilleries and considers sugarcane and molasses as feedstock raw materials. Private costs and returns data for each production alternative considered were mainly derived from parameters and cost projections found in several alcohol project proposals. As much as possible, the data were made to reflect technological specifications in the proposals. They were then standardized

Figure 4.2
MATERIAL UTILITY BALANCE FLOW FOR A PROPOSED 60KL/DAY
SUGARCANE BASED ANHYDROUS ALCOHOL PLANT
IN THE PHILIPPINES



in a general "base case" and adjusted to reflect current prices and assumed economic values. Accordingly, the base case for each model embodies assumptions considered most plausible on the basis of recent available information. From the base case, analysis proceeds to evaluate alcohol production under different crude oil, raw material, and foreign exchange parameters and trend scenarios. In addition, comparative advantage of ethanol production in alternative regional sugar districts is examined.

General Base Case Assumptions and Key Parameters

Six distillery model types were selected for analysis. Among these, three are molasses-based — one representing Model I (annexed distillery with 40 kl/day capacity) and two representing Model II (autonomous and annexed, respectively, each with 120 kl/day capacity), the remaining three are sugarcane-based, one of Model II type (120 kg/day) with an integrated farm estate, another a Model II autonomous type with externally supplied cane, and the last a Model III autonomous distillery with 48 kl capacity.

For each distillery, base case investment expenditures and annual production costs and returns were valued in constant prices using 1983 (also the initial investment year) as the base year (t0). Private values were then converted into economic benefits and costs through assumed adjustment factors drawn mostly from Bautista and Power (1979). These include a 10 percent and 20 percent adjustment of domestic capital expenditure and direct labor cost, respectively. A 20 percent premium was assumed on foreign exchange to adjust for distortion in the foreign exchange market. This was in contrast to the 31 percent premium suggested by Medalla (in Bautista and Power) under a policy of optimum intervention. Resulting annual economic cost-benefit streams for the different distillery types are summarized in Appendix 1.

From private price valuations ethanol was revalued in the economic analysis at its gasoline substitution price or at the social ex-refinery cost of gasoline. In late 1980, when the world crude oil marker price (Arabian light crude, FOB) was $32/bbl, the Philippines imported crude oil at $34.10/lb, CIF (21.5¢/liter). Regular gasoline ex-refinery cost was 27.8¢/liter with 24¢ (around 86 percent) comprising the value of imported crude oil (post-tariff) and 3.8¢ (14 percent) the local refinery and inland transport cost. It is on the basis of these relationships that gasoline ex-refinery costs for different crude oil import prices were estimated in Table 4.4. For the base case, a constant oil import price of $30/bbl was assumed as the long-term

Table 4.4
ESTIMATED SOCIAL EX-REFINERY COST OF GASOLINE UNDER DIFFERENT CRUDE OIL IMPORT PRICES
(in US ¢/liter gasoline)

Crude Oil Import Price					
$/bbl	25	27	30	33	35
¢/liter[1]	15.76	17.02	18.91	20.81	22.07
Value of Crude Oil Content per liter of gasoline (post-tariff)[2]	17.65	19.06	21.18	23.31	24.72
Gasoline Ex-Refinery Cost[3]	20.52	22.16	24.63	27.10	28.74
Tariff on Crude Oil Content[4]	3.53	3.81	4.24	4.66	4.94
Social Ex-Refinery Cost of Gasoline	16.99	18.35	20.39	22.44	23.80

Notes: [1]Computed at 158.6 liters/bbl. ($34.10/bbl ÷ 21.5¢/liter)

[2]Computed as: crude oil price/liter x liters crude oil/liter gasoline (1.12 = 24 ÷ 21.5)

[3]Value of crude oil content assumed 86 percent of gasoline ex-refinery cost.

[4]Import tariff assumed 20 percent ad valorem.

import price of crude oil, based on the stable real crude oil world price throughout the 1980s projected by Mac Arroy (1982).

Feedstock raw materials, in turn, were economically valued at border price equivalents since these – in both the cases of molasses and sugarcane – surpassed estimated marginal economic production costs. As previously mentioned, the shadow price of tradable feedstock raw material would be whichever is higher of a) its domestic marginal economic production cost or b) its world price. In estimating the former, sugarcane production cost data were pieced together from Philsucom as well as from the feasibility study incorporating a newly integrated farm estate (Model II – sugarcane), and updated to 1983. Sugarcane's marginal economic production cost till millgate (or till distillery cane processing site) was then computed after decomposing individual cost items into their tradable, domestic, tax, and subsidy components. Assumptions used for such breakdown were mainly taken from Cryde (1983), although some were drawn from the World Bank study (1982) and from examination of recent tax/subsidy rates especially in the petroleum sector.

As in standard social cost-benefit analysis, the economic value of the input was derived as the sum of its tradable, domestic and subsidy components. From sugarcane economic cost at mill gate, the economic cost of molasses ex-mill was estimated, first by adding milling cost taken from Philsucom survey data for CY 1976 updated to 1983 assuming a 7 percent price escalation rate and a foreign exchange conversion rate of ₱11/$. The economic raw sugar processing cost per ton cane was then computed and the equivalent economic cost of molasses as by-product derived assuming an extraction rate of .038 ton molasses per ton cane. Resulting economic cost, estimates of sugarcane and molasses, along with component shares and other assumptions are shown in Table 4.5.

In estimating world price, on the other hand, sugarcane – though nontraded in the world market – was valued at an opportunity cost equivalent to its export value, FOB when converted into raw sugar. This is displayed in Table 4.6 for different raw sugar border prices, 12¢/lb was assumed as the long-term trend price in the base case. Molasses, being exportable, was in turn automatically valued at an assumed long-term export price of $30/ton. Choice of base case values were determined from in depth examination of historical trends which are presented in Appendix 2.

Finally, annual cost benefit streams were discounted to time Φ using an assumed social discount rate of 10 percent. This rate is within the range of social discount rates estimated by Manalaysay (Bautista and Power) of 9.6-11.9 percent and is used by NEDA in economically evaluating new investment projects. The marginal productivity of capital used to gauge the economic acceptability of a project, in turn, was taken to be 17 percent.

Social Profitability Estimates

Table 4.7 summarizes the social profitability estimates of the six alcogas models under basic case assumptions. Present value of annual flows show that molasses-based distilleries have positive net benefit from distillery operations with Model II annexed exhibiting a net benefit of about ₱383.5 million over the life of the project. Model II autonomous yields a net benefit of ₱325.7 million while Model I annexed has the lowest net benefit of about ₱105.3 million over the project period. On the other hand, the sugarcane-based distilleries register large negative net benefits from distillery operations. Model II has the highest negative net benefit of ₱96.6 million, Model III records negative net benefit of ₱74.6 million, and Model II autonomous with farm estate registers ₱66.2 million negative net benefit. It follows from the feedstock distinction that the large positive net benefits of molasses-based distilleries are greatly explained

Table 4.5
ESTIMATED ECONOMIC PRODUCTION COST
OF SUGARCANE AND MOLASSES
(1983 price level)

	Private Value (₱/ha)	Component Shares (%)				Shadow Price Conversion Factor (%)	Economic Value		
		Tradable	Domestic	Tax	Subsidy		Tradable Component (₱/ha)	Domestic Component (₱/ha)	Total (₱/ha)
A. *Sugar Production Cost:*									
Variable Costs									
Direct Labor[1]	1,500	–	100	–	–	70	–	1,200	1,200
Canepoints	265		100	–	–	100	–	265	265
Fertilizers									
Urea	590	72	23	5	7	102	424	177	601
Ammoplus	394	54	41	5	3	98	213	173	386
Potash	443	45	49	6	–	94	199	217	416
Chemicals	140	70	20	10	–	90	98	28	126
Fuels and Lubricants[2]	158	50	20	30	–	70	79	32	111
Tractor Service[3]	537	50	43	7	–	93	269	231	500
Animal Service[4]	299	–	100	–	–	100	–	299	299
Total Variable Cost	4,326						1,282	2,622	3,904

Table 4.5 (Continued)

	Private Value (₱/ha)	Component Shares (%) Tradable	Domestic	Tax	Subsidy	Shadow Price Conversion Factor (%)	Economic Value Tradable Component (₱/ha)	Domestic Component (₱/ha)	Total (₱/ha)
Fixed Costs									
Land Rent	1,050	–	100	–	-	100	–	1,050	1,050
Irrigation and Drainage	54	38	53	9	10	101	21	34	55
Maintenance	241	5	95	–	–	100	12	230	242
Overhead	254	10	80	10	–	90	25	303	228
Depreciation	500	30	70	–	–	100	150	350	500
Interest on Loanable Funds[5]	903	–	100	–	–	125	–	1,004	1,004
Total Fixed Cost	2,902						208	2,871	3,079
Total Product Cost at Farmgate	7,228						1,490	5,493	6,983
Transport Cost to Mill[6]	1,627	50	48	2	–	98	814	781	1,595
Total Delivered Cost at Millgate	8,855						2,304	6,274	8,578
Yield (tons)	63								
Cost Per Ton	140.56								₱136.16
Cost Per Ton at Official Exchange Rate[7]									$ 12.38

Table 4.5 (Continued)

	Private Value (₱/ha)	Component Shares (%)				Shadow Price Conversion Factor (%)	Economic Value		
		Tradable	Domestic	Tax	Subsidy		Tradable Component (₱/ha)	Domestic Component (₱/ha)	Total (₱/ha)
Total Delivered Cost at 20% Foreign Exchange Premium							2,765	6,274	9,039
Cost Per Ton at 20% Foreign Exchange Premium									₱143.47 $ 10.87
B. *Molasses Production Cost:*									
Sugarcane Cost at Millgate							2,765	6,274	9,039
Milling Cost									
Adjusted Cost, 1983[8]							424	5,198	5,622
Foreign Exchange Rate and Premium Adjustment[9]							337	–	337
Total Milling Cost							761	5,198	5,959
Total Economic Sugar Processing Cost, Ex. Mill							3,526	11,472	14,998
Cost/Ton Cane									₱238.06
Extracted Molasses, (tons)[10]									2.39
Cost/Ton Molasses, Ex. Mill									₱ 99.61

Table 4.5 (Continued)

	Private Value (₱/ha)	Component Shares (%)				Shadow Price Conversion Factor (%)	Economic Value		
		Tradable	Domestic	Tax	Subsidy		Tradable Component (₱/ha)	Domestic Component (₱/ha)	Total (₱/ha)
Transport to Distillery (₱20/ton)									20.00
Total Cost/Ton Molasses, Ex-Distillery									₱109.61

Notes: [1] Includes labor for land preparation, planting and replanting, hand weeding, off barring, and milling, and harvesting, cutting, and hauling.

[2] Used for transport of plant materials.

[3] Valued at custom service rate or rental value.

[4] Includes animal-man service for plowing, cultivation, and fertilizer application.

[5] Loanable funds computed as the sum of variable operating cost. Interest cost assessed at 20% interest rate.

[6] ₱25/ton in 1983.

[7] Computed at the official exchange rate of ₱11/$.

[8] Computed assuming a 7% cost escalation rate after applying unit milling cost to 1983 yields.

[9] Exchange rate in 1976 = 7.353. Adjustment includes effect of a ₱11/$ exchange rate as well as a 20% premium.

[10] Assume .038 ton molasses/ton cane.

Table 4.6
BORDER EQUIVALENT VALUE OF SUGARCANE UNDER ALTERNATIVE RAW SUGAR BORDER PRICES
(US $)

Border Price of Raw Sugar, FOB					
US ¢/lb.	8	12	14	17	20
US$/ton.	176.4	264.6	308.6	374.8	440.9
Raw Sugar FOB value in One Ton Cane Equivalent[1]	17.6	26.5	30.9	37.5	44.1
Less value of molasses from one ton cane[2]	1.5	2.2	2.6	3.1	3.7
Less domestic handling and transport of raw sugar from one ton cane[3]	0.6	0.6	0.6	0.6	0.6
Value of sugar in one ton cane equivalent, ex mill	15.5	23.7	27.7	33.8	39.8
Less economic value added in processing cane into raw sugar[4]	5.4	8.3	9.7	11.8	13.9
Border price equivalent of one ton sugarcane at mill gate or distillery cane processing site	10.1	15.4	18.0	22.0	25.9

[1] Assuming a sugar extraction rate of 10 percent.

[2] Assuming an extraction rate of 38 kg. molasses/ton cane and an FOB price of molasses of about 22 percent of the FOB price of raw sugar. This relationship approximates the actual average from 1978-83.

[3] Domestic freight and handling charges for raw sugar in 1980 was around 115/ton. Assuming a charge of $6/ton in 1983 and 10 percent extraction rate, the ton cane equivalent would be $0.6.

[4] Computed as 35 percent of the value of sugar in cane equivalent, ex mill. This is the average mill share of gross proceeds from sales of raw sugar (and molasses).

Table 4.7
BASE CASE DISCOUNTED ECONOMIC COST BENEFIT STREAMS, NET PRESENT VALUE (NPV) AND ECONOMIC RATE OF RETURN (EROR) ESTIMATES BY DISTILLERY TYPE
(In Constant 1983 ₱000)

Discounted Cost-Benefit Streams (tΦ)*	Molasses-Based Distilleries			Sugarcane-Based Distilleries		
	Model I	Model II		Model II		Model III
	Annexed	Autonomous	Annexed	Autonomous w/ Farm Estate	Autonomous	Autonomous
INVESTMENT						
Capital Expenditures	34,566	245,591	249,415	394,418	331,506	143,199
Preoperating Expense	916	–	–	12,258	–	4,441
Preoperating Interest Expense	4,686	40,057	40,576	82,964	54,022	43,128
Initial Working Capital	1,144	6,866	6,437	3,250	1,311	2,668
TOTAL INVESTMENT COST	41,312	292,514	296,428	492,890	386,839	193,436
PRODUCTION COST AND RETURNS						
Ethanol Value	245,783	834,281	834,281	689,489	834,281	190,074
Value of By-Products	–	173,233	173,233	163,018	197,251	–
TOTAL ECONOMIC RETURNS	245,783	1,007,514	1,007,514	852,507	1,031,532	190,074
Raw Material Cost	111,505	378,292	317,963	785,998	951,058	184,736
– Direct Labor	3,955	17,541	17,541	17,859	21,609	3,757
– Chemicals	913	14,740	14,740	12,182	14,740	8,735

Table 4.7 (continued)

Discounted Cost-Benefit Streams (tΦ)*	Molasses-Based Distilleries			Sugarcane-Based Distilleries		
	Model I	Model II		Model II		Model III
	Annexed	Autonomous	Annexed	Atuotnomous w/ Farm Estate	Autonomous	Autonomous
– Utilities	403	22,172	22,172	–	–	–
– Fuels and Lubricants	5,499	155,606	133,973	–	–	–
– Miscellaneous	418	1,925	26,585	7,927	9,592	–
Other Variable Costs	11,188	211,984	215,011	37,968	45,941	12,492
– Maintenance	7,142	57,027	57,966	64,749	78,347	36,562
– Overhead	4,959	31,647	30,254	29,950	52,779	16,625
– Others	5,682	2,856	2,856	–	–	14,264
Fixed Operating Costs	17,783	91,530	91,076	94,699	131,126	67,451
TOTAL ECONOMIC PRODUCTION COSTS	140,470	681,806	624,050	918,665	1,128,125	264,679
NET BENEFIT FROM DISTILLERY OPERATIONS	105,307	325,708	383,464	(66,158)	(96,593)	(74,605)
DISCOUNTED WORKING CAPITAL FLOWS	346	1,494	1,401	4,125	1,077	352
PRESENT VALUE OF ANNUAL FLOWS	104,961	324,214	382,063	(70,283)	(97,670)	(74,957)
NET PRESENT VALUE (NPV)	63,649	31,700	85,635	(563,173)	(484,509)	(268,393)
ECONOMIC RATE OF RETURN (EROR)	1.540,690	0.108,370	0.288,890	(1.142,594)	(1.252,482)	(1.387,503)
EROR in %	154.07	10.84	28.89	(114.26)	(125.24)	(138.75)

*Discounted at 10 percent.

Source of Basic Data: Appendix 1

by the lower raw material costs of molasses compared to sugarcane. While the raw material costs of model II autonomous molasses-based distillery, for instance, reach ₱378 million those of model II autonomous sugar-based distilleries are higher at ₱785 million to ₱951 million.

The notable advantage of molasses-based distilleries in terms of net benefit flows has not been eroded by the working capital flows. Net present value (NPV) of molasses-based distilleries range from ₱31.7 million (Model II autonomous) to ₱85.6 million (Model II annexed) while the NPV of sugar-based distilleries range from –₱268.4 million (Model III autonomous) to –₱563.2 million (Model II autonomous with farm estate). Moreover, the economic rate of return (EROR) estimates are high and positive for molasses-based distilleries compared to the high negative EROR estimates for sugar-based distilleries. Molasses-based distilleries register EROR ranges from around 11 to 154 percent while sugar-based ones exhibit losses from –114 to –139 percent.

Among the profitable molasses-based distilleries, the small-scale annexed distillery shows the highest EROR at 154 percent implying that this is the most socially profitable model, other things being equal. Perhaps, among other factors, this suggests that annexed distilleries are more economically profitable since the capital utilization is higher compared to autonomous units. Moreover, this may imply that small scale plants, say of 30-60 kl/day capacity, are more economical than the large scale units. Finally, contrary to official belief, the advantage of sugar-based distilleries with their own fuel by-products particularly baggasse seems not so important a factor to have *a priori* preference for fuel self-generating plants.

To determine the sensitivity of the social profitability indicators under different parametric scenarios, we estimated EROR of the six distillery model types at various values of important output and inputs. Because of time and budget constraints, the sensitivity analysis is limited to the three most critical values that are considered to have impact on profitability: 1) crude oil import price, 2) export prices of molasses and raw sugar and 3) foreign exchange rate. The base case assumes a $30/bbl crude oil import price, $30/ton molasses price, 12¢/lb raw sugar border price, and a foreign exchange premium of 20 percent over the official exchange rate. For sensitivity analysis, the crude oil import price ranges from $25-$35/lb., molasses price from $20-$60/ton, and raw sugar from 8¢-20¢/lb., and lastly foreign exchange premium of 10-30 percent. For further comparison, some trend scenarios assume 2 and 5 percent p.a. price increases for crude oil imports and raw material feedstocks.

Table 4.8 presents the ERORs for the six model types of alcogas distilleries under the different parametric and trend scenarios. Among the three profitable distillery types under the base case, molasses-based Model I annexed distillery exhibits viability under the greatest number of parametric and trend scenarios. Even the two other profitable molasses-based distilleries under the base case register positive ERORs in few alternative scenarios. In contrast, the sugar-based alcogas plants display negative ERORs under all scenarios with higher losses as the raw sugar price assumes higher levels and not any positive ERORs at the highest price of crude oil imports. To focus on molasses-based Model I annexed, EROR increases as the crude oil import price increases. At $30/ton of molasses export price, the EROR of Model I annexed rises from 54.9 to 229.9 percent when the crude import price increases from $25 to $35/bbl. On the other hand, the EROR decreases as the price of molasses increases since molasses is the main feedstock of Model I annexed. At $30/bbl of crude oil price, for instance, the EROR of Model I annexed declines from 244 to –115.8 percent as the price of molasses rises from $20 to $60/ton. The same relationships occur for the other distillery types including sugar-based plants.

But the changes in EROR among distilleries vary as summarized by the EROR estimates under the trend scenarios. With 2 percent p.a. increase in crude oil real price lead to 235 percent EROR for Model I annexed of molasses-based distilleries while –119 percent for Model III autonomous sugar-based plant. At 5 percent p.a. increase in the real price of crude oil import the corresponding EROR for each distillery type ranges from .384 percent for molasses-based Model I annexed to –80 percent for sugar-based Model III autonomous distillery. The ERORs under the 2-5 percent p.a. crude oil price increases suggest that the social profitabilities of sugar-based distilleries are not satisfactory even within the more realistic crude oil price increase of up to 5 percent p.a. for the next 15 to 20 years.

Similarly, in terms of raw material price increases, the ERORs vary among distillery types. At 2 percent p.a. increase in raw material price only two distillery types register positive ERORs, 117 percent for molasses-based Model I annexed and 13.6 percent for Model II annexed, also molasses-based plant. As expected, the sugar-based distilleries exhibit negative ERORs with Model II autonomous yielding 160 percent loss, Model III autonomous 157 percent and Model II autonomous with integrated farm estate registering about 144 percent negative EROR. At 5 percent p.a. raw material price increases, only molasses-based Model I annexed distillery would show positive

Table 4.8
ECONOMIC RATE OF RETURN (EROR) ESTIMATES UNDER ALTERNATIVE PRICE SCENARIOS
(in %)

A. PARAMETRIC SCENARIOS

1. 20% Foreign Exchange Premium

Molasses-Based Distilleries	Model I (Annexed)					Model II (Autonomous)					Model II (Annexed)				
Crude Oil Import Price ($/bbl)	25	27	30	33	35	25	27	30	33	35	25	27	30	33	35
Molasses Export Price, FOB															
a. $20/ton	144.88	185.72	244.00	302.37	319.86	06.41	25.98	53.94	81.91	90.30	17.74	37.05	64.64	92.24	100.51
b. $30/ton	54.90	95.74	154.07	212.39	229.88	(36.70)	(17.12)	10.84	38.80	47.19	(18.02)	01.30	28.89	56.48	64.76
c. $40/ton	(35.07)	5.76	64.09	122.42	139.91	(79.80)	(60.23)	(32.27)	(04.31)	04.08	(53.77)	(34.46)	(06.87)	20.73	29.00
d. $50/ton	(125.03)	(84.19)	(25.87)	32.46	49.95	(122.91)	(103.34)	(75.38)	(47.42)	(39.03)	(89.53)	(70.21)	(42.62)	(15.03)	(06.75)
e. $60/ton	(215.01)	(17.42)	(115.84)	(57.52)	(40.02)	(166.02)	(146.45)	(118.49)	(90.53)	(82.14)	(125.28)	(105.97)	(78.38)	(50.78)	(42.51)

Sugarcane-Based Distilleries	Model II (Autonomous with Farm Estate)					Model II (Autonomous)					Model III (Autonomous)				
Crude Oil Import Price ($/bbl)	25	27	30	33	35	25	27	30	33	35	25	27	30	33	35
Raw Sugar Export Price, FOB															
a. ¢8/lb	(82.69)	(78.34)	(59.38)	(45.66)	(41.55)	(76.58)	(69.87)	(40.64)	(19.49)	(131.48)	(122.26)	(115.51)	(105.89)	(96.25)	(93.36)
b. ¢12/lb	(137.57)	(133.22)	(114.26)	(100.54)	(96.43)	(161.19)	(154.45)	(125.25)	(104.10)	(97.76)	(155.13)	(148.38)	(138.75)	(129.12)	(126.23)
c. ¢14/lb	(164.50)	(160.14)	(141.18)	(127.48)	(123.35)	(202.70)	(195.99)	(166.75)	(145.61)	(139.27)	(171.26)	(164.51)	(154.85)	(145.24)	(142.35)
d. ¢17/lb	(205.92)	(201.56)	(182.60)	(168.89)	(164.77)	(266.56)	(260.03)	(230.61)	(209.47)	(203.13)	(196.06)	(189.31)	(179.68)	(170.05)	(167.16)
e. ¢20/lb	(246.30)	(241.95)	(222.99)	(209.27)	(205.16)	(328.82)	(322.11)	(292.88)	(271.73)	(265.39)	(220.24)	(213.50)	(203.87)	(194.24)	(191.34)

	Molasses-Based Distilleries			Sugar-Based Distilleries		
2. Foreign Exchange Scenarios	Model I Annexed	Model II (Autonomous)	Model II (Annexed)	Model II (Autonomous with Farm Estate)	Model II (Autonomous)	Model III (Autonomous)
a. 10% Foreign Exchange Premium	131.85	6.16	24.2	(112.56)	(133.42)	(147.78)
b. 20% Foreign Exchange Premium	154.07	10.84	28.9	(114.26)	(125.24)	(138.75)
c. 30% Foreign Exchange Premium	174.70	14.56	33.14	(117.90)	(117.98)	(138.34)
B. TREND SCENARIOS						
1. Crude Oil Real Price Increase						
a. 2% per annum	245.10	51.56	69.08	(87.83)	(94.45)	(119.34)
b. 5% per annum	384.33	127.50	144.01	(36.84)	(37.04)	(80.61)
2. Raw Material Border Price Increase						
a. 2% per annum	117.31	(7.63)	13.57	(144.39)	(160.35)	(157.62)
b. 5% per annum	49.64	(42.06)	(14.98)	(202.52)	(225.81)	(195.26)

EROR and at a low level of about 50 percent. The rest of the distillery types would exhibit losses from about 15 percent (molasses-based Model II annexed) to 226 percent (sugar-based Model II autonomous).

The unprofitability of sugar-based distillery types is further expressed under different foreign exchange scenarios. Not unexpectedly, the social profits of the selected six distillery types are directly related to the foreign exchange premium. In other words, EROR increases with the amount of domestic currency devaluation. For molasses-based distilleries, the EROR increases from 6.6-132 percent to 14.6-175 percent as the local currency is devalued from 10 to 30 percent. In contrast, the negative ERORs of the three sugar-based distilleries are not all reduced by higher foreign exchange premium, while autonomous Models II and III straight forwardly reduce their respective negative ERORs as foreign exchange premium increases, the negative EROR of Model II autonomous with integrated farm estate increases with higher foreign exchange premium. Estimated negative EROR of Model II rises from about 112 to 118 percent as the foreign exchange premium increases from 10 to 30 percent of the official rate. Thus, unlike the straightforward relation between EROR, on one hand, and the prices of crude oil imports and raw material feedstocks, on the other, the EROR need not have an *a priori* determined relationship with foreign exchange premium. Perhaps this is largely explained by the dual impact of foreign exchange on both import prices as well as output values. In some instances, the significant effects of foreign exchange on input and output reinforce each other while in others (such as the sugar-based Model II with integrated farm estate) may offset one another. The component of imported inputs to total costs is a critical factor in determining the net impact of foreign exchange rate on EROR of a particular distillery.

In all, it seems that only the molasses-based Model I with annexed distillery plant has shown consistent profitability under the base case and selected alternative scenarios. While the two other molasses-based distillery types exhibit some positive ERORs under particular cases, the sugar-based distilleries are consistently uneconomical under the base and alternative cases.

Domestic Resource Cost (DRC) Analysis

In estimating the Domestic Resource Cost (DRC) coefficients for the base case, domestic and tradable component shares for each item were mainly derived from the World Bank's *Philippine Energy Sector Study* (1982) on the presumption that this study derived breakdowns after in-depth examination of each input's cost structure. Recall, that the DRC is an indicator of the efficiency with which production activities convert domestic resources into net foreign exchange. Hence, through the DRC, one can roughly assess whether an activity in an open economy should be pursued and which alternative for this activity is more desirable in terms of potential for generating or, in this case, saving net foreign exchange. A positive value for the DRC indicates efficiency if less than one, with lower values indicating comparative advantage. Negative values may occur if a) domestic external benefits (externalities) exceed domestic resource costs or b) the opportunity cost value of tradable components exceed the opportunity (or border) value of tradable benefits.

Table 4.9 presents the basic data and the estimated DRC coefficients of the six models of alcogas distilleries under the base case assumptions. As already implied by EROR estimates, the molasses-based models of distilleries exhibit comparative advantage compared to the social inefficiencies of sugarcane-based plants. As expected, the DRC coefficient is lowest for molasses-based Model I annexed of .52, Model II annexed has .609, and Model II autonomous registers a DRC coefficient of .803. In contrast, sugarcane-based Model II autonomous distillery records a DRC coefficient of 22.010. Likewise, Model III autonomous sugarcane-based distillery shows greater than one DRC coefficient but negative at 6.187 while Model II autonomous with integrated sugar farm estate registers DRC coefficient of negative .512. In the light of these coefficients, the results conform to the earlier estimates of ERORs for the respective distillery types and argue in favor of small-scale annexed distillery based on molasses rather than sugarcane feedstocks.

Like with EROR estimates, DRC coefficients are estimated under the selected parametric and trend scenarios in addition to the base case condition. Table 4.10 highlights the DRC coefficients of the six types of alcogas distilleries being considered in the study under the parametric scenarios relating to different prices of crude oil import, raw material feedstocks, and foreign exchange. To begin with, only molasses-based Model I annexed type of distillery appears to have comparative advantage for much of the alternative scenarios while the other five distilleries have comparative advantage for a very limited number of scenarios. Except at $30 or more price for crude oil imports, the two remaining molasses-based distilleries are not economically sound at molasses price of $30/ton or higher crude oil prices and could not make them competitive as their DRC coefficients even as the highest case price of $35/bbl of crude oil import remain nega-

Table 4.9
BASE CASE DOMESTIC RESOURCE COST ESTIMATES BY DISTILLERY TYPE*
(Values are in Constant 1983 ₱000)

MOLASSES BASED DISTILLERIES

	Model I (Annexed)			Model II (Autonomous)			Model II (Annexed)		
	Total Discounted Value (t₱)	Tradable Component	Domestic Component	Total Discounted Value (t₱)	Tradable Component	Domestic Component	Total Discounted Value (t₱)	Tradable Component	Domestic Component
BENEFITS:									
Ethanol Value	245,783	245,783	–	834,281	834,281	–	834,281	834,281	–
Value of By-Products	–	–	–	173,233	–	173,233	173,233	–	173,233
TOTAL ECONOMIC RETURNS	245,783	245,783	–	1,007,514	834,281	173,233	1,007,514	834,281	173,233
COSTS:									
Capital Expenditure	34,566	17,939	16,627	245,591	182,701	62,890	249,415	185,882	63,533
Preoperating Expenses	916	–	916	–	–	–	–	–	–
Preoperating Interest Expense	4,686	–	4,686	40,057	24,420	15,637	40,576	24,829	15,744
Initial Working Capital	1,144	–	1,144	6,866	–	6,866	6,437	–	6,437
TOTAL INVESTMENT COST	41,312	17,939	23,373	292,514	207,121	85,393	296,428	210,711	85,717
Raw Material Cost	111,505	84,473	27,032	378,292	286,586	91,706	317,963	240,880	77,083
– Direct labor	3,955	–	3,955	17,541	–	17,541	17,541	–	17,541
– Chemicals	913	700	213	14,740	11,462	3,278	14,740	11,462	3,278
– Utilities	403	304	99	22,172	16,625	5,574	22,172	16,625	5,547
– Fuels and lubricants	5,499	4,115	1,384	155,606	116,699	38,907	133,973	100,488	33,485
– Miscellaneous	418	–	418	1,925	–	1,925	26,585	–	26,585
Other Variable Costs	11,188	5,119	6,069	211,984	144,786	67,198	215,011	128,575	86,436
– Maintenance	7,142	3,917	3,225	57,027	31,084	25,943	57,966	31,600	26,366
– Overhead	4,959	601	4,358	31,647	3,716	27,931	30,254	3,531	26,723
– Others	5,682	–	5,682	2,856	–	2,856	2,856	–	2,856
Fixed Operating Costs	17,783	4,518	13,265	91,530	34,800	56,730	91,076	35,131	55,945
TOTAL ECONOMIC PRODUCTIONS COSTS	140,476	94,110	46,366	681,806	466,172	215,634	624,050	404,586	219,464
DISCOUNTED WORKING CAPITAL FLOWS	346	–	346	1,494	–	1,494	1,401	–	1,401
NET SOCIAL BENEFIT	63,649	133,734	(70,085)	31,700	160,988	(129,288)	85,635	218,984	(133,349)
DRC COEFFICIENT	0.524063			0.803091			0.608944		

SUGARCANE BASED DISTILLERIES

	Model II (Autonomous with Farm Estate)			Model II (Autonomous)			Model III (Autonomous)		
	Total Discounted Value (t₱)	Tradable Component	Domestic Component	Total Discounted Value (t₱)	Tradable Component	Domestic Component	Total Discounted Value (t₱)	Tradable Component	Domestic Component
BENEFITS:									
Ethanol Value	689,489	689,489	–	834,281	834,281	–	190,074	190,074	–
Value of By-Products	163,018	–	163,018	197,251		197,251	–	–	–
TOTAL ECONOMIC RETURNS	852,507	689,489	163,018	1,031,532	834,281	197,251	190,074	190,074	–
COSTS:									
Capital Expenditure	394,418	296,473	97,945	331,506	234,392	97,114	143,199	84,213	58,986
Preoperating Expenses	12,258	–	12,258	–	–	–	4,441	780	3,661
Preoperating Interest Expense	82,964	49,523	33,441	54,022	31,326	22,696	43,128	19,539	23,589
Initial Working Capital	3,250	–	3,250	1,311	–	1,311	2,668	–	2,668
TOTAL INVESTMENT COST	492,890	345,996	146,894	386,839	265,718	121,121	193,436	104,532	88,904
Raw Material Cost	785,998	667,666	118,332	951,058	485,119	465,939	184,736	94,229	90,507
– Direct labor	17,859	–	17,859	21,609	–	21,609	3,754	–	3,757
– Chemicals	12,182	9,473	2,709	14,740	11,462	3,278	8,735	6,794	1,941
– Utilities	–	–	–	–	–	–	–	–	–
– Fuels and lubricants	–	–	–	–	–	–	–	–	–
– Miscellaneous	7,927	–	7,927	9,592	–	9,592	–	–	–
Other Variable Costs	37,968	9,473	28,495	45,941	11,462	34,479	12,492	6,794	5,698
– Maintenance	68,749	35,336	29,413	78,347	42,757	35,590	36,562	19,922	16,640
– Overhead	29,950	3,498	26,452	52,779	6,164	46,615	16,625	1,943	14,682
– Others	–	–	–	–	–	–	14,264	–	14,264
Fixed Operating Costs	94,699	38,834	55,865	131,126	48,921	82,205	67,451	21,865	45,586
TOTAL ECONOMIC PRODUCTIONS COSTS	918,665	715,973	202,692	1,128,125	545,502	582,623	264,679	122,888	141,791
DISCOUNTED WORKING CAPITAL FLOWS	4,125	–	4,125	1,077	–	1,077	352	–	352
NET SOCIAL BENEFIT	(563,173)	(372,480)	(190,693)	(484,509)	23,061	(507,570)	(268,393)	(37,346)	(231,047)
DRC COEFFICIENT	(0.511955)			22.009887			(6.186660)		

*Tradable component values are computed at a foreign exchange premium of 20%.

Sources of Basic Data: Appendix 1

World Bank 1982. Philippine Energy Sector Survey.

Table 4.10
DOMESTIC RESOURCE COST (DRC) COEFFICIENT ESTIMATES
UNDER ALTERNATIVE PRICE SCENARIOS

A. PARAMETRIC SCENARIOS

Molasses-Based Distilleries	Model I (Annexed)					Model I (Autonomous)					Model II (Annexed)				
Crude Oil Import Price ($/bbl)	25	27	30	33	35	25	27	30	33	35	25	27	30	33	35
Molasses Export Price, FOB															
a. $20/ton	0.51	0.44	0.38	0.33	0.32	0.84	0.69	0.38	0.29	0.27	0.67	0.58	0.36	0.28	0.27
b. $30/ton	0.76	0.64	0.52	0.44	0.42	5.89	2.70	0.80	0.53	0.48	1.67	1.26	0.61	0.44	0.41
c. $40/ton	1.22	0.97	0.75	0.61	0.58	(2.17)	(3.36)	2.44	1.09	0.93	4.51	6.21	1.15	0.72	0.65
d. $50/ton	2.42	1.65	1.14	0.87	0.81	(1.13)	(1.33)	(6.33)	3.68	2.50	(2.29)	(3.38)	3.16	1.32	1.12
e. $60/ton	11.71	3.86	1.97	1.32	1.21	(0.84)	(0.93)	(1.76)	(5.04)	(11.47)	(1.31)	(1.56)	(9.61)	3.51	2.49

Sugarcane-Based Distilleries	Model II (Autonomous with Farm Estate)					Model II (Autonomous)					Model III (Autonomous)				
Crude Oil Import Price ($/bbl)	25	27	30	33	35	25	27	30	33	35	25	27	30	33	35
Raw Sugar Export Price, FOB															
a. $8/lb	(0.58)	(0.64)	(1.05)	(2.00)	(2.74)	6.81	4.51	1.83	1.28	1.17	(5.46)	(8.49)	(40.66)	12.78	10.35
b. $12/lb	(0.39)	(0.41)	(0.51)	(0.62)	(0.67)	(1.38)	(5.64)	22.01	4.8	3.92	(3.35)	(4.13)	(6.19)	(13.76)	(17.61)
c. $14/lb	(0.35)	(0.36)	(0.43)	(0.504)	(0.53)	(2.96)	(3.41)	(9.96)	25.5	12.34	(2.90)	(3.43)	(4.62)	(7.53)	(8.48)
d. $17/lb	(0.31)	(0.32)	(0.37)	(0.408)	(0.42)	(2.18)	(2.37)	(3.83)	(6.86)	(9.01)	(2.47)	(2.80)	(3.47)	(4.72)	(5.04)
e $20/lb	(0.29)	(0.29)	(0.33)	(0.357)	(0.37)	(1.85)	(1.96)	(2.68)	(3.65)	(4.10)	(2.20)	(2.44)	(2.88)	(3.61)	(3.78)

B. TREND SCENARIOS

	Molasses-Based Distilleries			Sugarcane-Based Distilleries		
	Model I (Annexed)	Model II (Autonomous)	Model II (Annexed)	Model II Atuonomous with Farm Estate)	Model II (Autonomous)	Model III (Autonomous)
1. Crude Oil Real Price Income						
a. 2% per annum	.4191	.4616	.3944	.7873	3.5698	11.4948
b. 5% per annum	.3063	.2574	.2380	.2092	0.7317	3.0756
2. Raw Material Border Price Income						
a. 2% per annum	.6035	1.1858	.7820	(.4273)	(12.4238)	(4.4482)
b. 5% per annum	.7970	3.8110	1.3687	(.3453)	(3.9811)	(3.0568)

tive or less than one for positive coefficients. The prevalence of negative DRC coefficients under the most number of scenarios suggest that the opportunity costs of tradable components particularly raw sugar among others exceed the social value of ethanol products.

On the trend scenarios, however, two sugar-based distillery types display comparative advantage on particular assumptions of crude oil and raw material price increases per annum. Model II autonomous with integrated farm estate sugar-based distillery has DRC coefficient of .787 and .209 under 2 and 5 percent p.a. crude oil price increases respectively. Moreover, with a 5 percent p.a. crude oil price hike, Model II autonomous sugarcane-based distillery turns competitive with DRC coefficient of .732. While higher price increase reduces the DRC coefficients, the opposite occurs for higher raw material price increases. At 2 percent p.a. increase in raw material prices, only two molasses-based distilleries appear competitive as the rest particularly the three sugar-based distilleries are highly noncompetitive. With 5 percent raw material price increase, however, only one distillery namely Model I annexed molasses-based type could remain competitive but at reduced advantage. It seems therefore that at the expected increases in crude oil and feedstock prices there is little choice that most of the proposed alcogas distilleries and their variants could become competitive as alternative fuel sources. Finally, unless the export prices of molasses and raw sugar stagnate or decline, there is not much economic rationale to go on with the proposed alcogas projects.

To be sure, Table 4.11 presents some estimates of the maximum raw material border price equivalent necessary to maintain DRC coefficient equal to unity under alternative oil price scenarios. Prices higher than the maximum price estimates would imply comparative disadvantage for the project under consideration, other things being constant. The higher the maximum raw material prices the greater is the allowable limit before the particular alcogas distillery becomes noncompetitive. It follows from the DRC estimates that the most competitive molasses-based Model I annexed distillery has the highest maximum raw material price compared to the two other molasses-based plants. At $25/bbl oil price, Model I annexed remains competitive at raw material price of not over $36/ton. On the other hand, Model II autonomous becomes noncompetitive with molasses price of over $22/ton while Model II annexed is noncompetitive at molasses price of over $25/ton. With $35/bbl oil price scenario, Model I annexed could maintain competitiveness with molasses price up to about $56/ton. In comparison, at that oil price scenario, the Model II autonomous molasses-based distillery loses its competitiveness with molasses price of over $41/ton while Model II annexed becomes non-competitive with molasses price higher than $48/ton, other things being constant.

For sugarcane-based distilleries, Table 4.11 shows that at $30/bbl price of imported oil, the border price of raw sugar should be lower than 3.4¢/lb in order that Model II autonomous with integrated farm estate distillery could turn competitive. Likewise, raw sugar price should be lower than 5.8¢/lb for Model II autonomous distillery turns into comparative advantage. It is interesting to note that at all selected oil price scenarios, the estimated maximum raw material price for DRC coefficient to equal unity are negative ones in the case of Model III autonomous distillery. This simply implies that the distillery type being considered is too uncompetitive and needs highly subsidized raw material input to become socially viable.

As Table 4.11 summarizes the maximum prices of raw materials necessary to maintain DRC coefficient at unity suggests that in most cases the estimated price limits are far below the prices observed for molasses and raw sugar exports during the decade or so. In most cases, the maximum prices for molasses under the given scenarios are much lower than the historical prices of molasses and raw sugar exports. In 1978-82, for instance, the average annual molasses price ranged from about $42-$101/ton while raw sugar price fluctuated between 7.8¢-24¢/lb. Thus even at the trend scenarios of 2-5 percent p.a. crude oil price increase and at higher foreign exchange premium of 30 percent the maximum prices of distillery feedstock for alcogas are much lower in most cases than the prevailing prices.

For further analysis, Table 4.12 estimates the minimum crude oil import price and real ex-refinery gasoline costs (at 1983 prices) to maintain at least a DRC coefficient of unity. Above such minimum, the DRC coefficient would become greater than one implying that the project under consideration is not socially competitive. Under the different raw material price scenarios, the results suggest that except for some cases in molasses-based Model I annexed distilleries, most cases of the proposed distilleries require high crude oil prices for them to compete in alternative supply fuels. On the other hand, under the different foreign exchange premium and trend scenarios the molasses-based distilleries require lower crude oil prices to compete while the sugar-based ones need higher than the historical and prevailing crude oil prices. On the whole, therefore, the results in Table 4.12 merely confirm the earlier findings on the lack of competitiveness of sugar-based distilleries in general and underscores the

Table 4.11
MAXIMUM RAW MATERIAL BORDER PRICE EQUIVALENT NECESSARY TO MAINTAIN DRC COEFFICIENT AT UNITY UNDER ALTERNATIVE OIL PRICE SCENARIOS
(rounded to nearest centavos)

	MOLASSES-BASED DISTILLERIES					
	Model I (Annexed)		Model II (Autonomous)		Model II (Annexed)	
	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)
A. PARAMETRIC SCENARIOS						
1. 20% Foreign Exchange Premium						
– Critical Prices						
– Oil Price Scenarios						
a. $25/bbl	476.56	36.10	283.63	21.49	329.48	24.96
b. $27/bbl	536.47	40.64	210.81	23.55	361.81	27.41
c. $30/bbl	622.05	47.12	429.19	32.51	502.64	38.08
d. $33/bbl	707.62	53.61	514.81	39.00	604.50	45.80
e. $35/bbl	733.28	55.55	540.50	40.95	635.07	48.11

	SUGARCANE-BASED DISTILLERIES					
	Model II (Autonomous w/ Farm Estate)		Model II (Autonomous)		Model III (Autonomous)	
	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)
– Critical Prices						
– Oil Price Scenarios						
a. $25/bbl	27.91	1.65	70.00	4.13	(141.93)	(8.38)
b. $27/bbl	33.46	1.98	75.55	4.46	(125.88)	(7.43)
c. $30/bbl	57.63	3.40	99.72	5.89	(102.95)	(6.08)
d. $33/bbl	75.11	4.43	117.20	6.92	(77.66)	(4.58)
e. $35/bbl	80.36	4.74	122.45	7.23	(73.14)	(4.32)

Table 4.11 (continued)

MOLASSES-BASED DISTILLERIES

	Model I (Annexed)		Model II (Autonomous)		Model II (Annexed)	
	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)	Critical Raw Material Price (₱/ton)	Border Price Equivalent ($/ton)
2. FXΔ Premium Scenarios						
a. 10%	557.45	46.07	390.14	32.24	455.11	37.61
b. 20%	622.05	47.12	429.19	32.51	502.64	38.08
c. 30%	700.58	48.99	468.23	32.74	550.57	38.50
B. TREND SCENARIOS						
1. Crude Oil Real Price Increase						
a. at 2%	740.93	56.13	553.89	41.96	651.01	49.32
b. at 5%	959.73	72.71	786.41	59.58	927.63	70.28
2. Raw Material Price Increase						
a. at 2%	622.05	47.12	429.19	32.52	502.64	38.08
b. at 5%	622.05	47.12	429.19	32.51	502.64	38.08

SUGARCANE-BASED DISTILLERIES

	Model II (Autonomous w/ Farm Estate)		Model II (Autonomous)		Model III (Autonomous)	
	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)	Critical Raw Material Price (₱/ton)	Border Price Equivalent (¢/lb)
2. FXΔ Premium Scenarios						
a. 10%	51.46	3.31	90.77	5.84	(118.27)	(7.61)
b. 20%	57.63	3.40	99.72	5.89	(102.95)	(6.08)
c. 30%	79.94	4.36	108.67	5.92	(107.14)	(5.84)
B. TREND SCENARIOS						
1. Crude Oil Real Price Increase						
a. at 2%	91.32	5.39	125.18	7.40	(56.74)	(3.35)
b. at 5%	156.32	9.23	172.66	10.19	35.46	(2.09)
2. Raw Material Price Increase						
a. at 2%	57.63	3.40	99.72	5.89	(102.95)	(6.07)
b. at 5%	57.63	3.40	99.72	5.89	(102.95)	(6.07)

Table 4.12

MINIMUM CRUDE OIL IMPORT PRICE ($/bbl) AND REAL EX-REFINERY GASOLINE COST (₱/liter) NECESSARY TO MAINTAIN DRC=1.0 UNDER ALTERNATIVE RAW MATERIAL PRICE SCENARIOS

(rounded to the nearest centavos)

A. PARAMETRIC SCENARIOS

1. 20% Foreign Exchange Premium

MOLASSES-BASED DISTILLERIES:	Model I (Annexed)		Model II (Autonomous)		Model II (Annexed)	
– Critical Prices	Gasoline Price (₱/liter)	Crude Oil Import Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Import Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Import Price ($/bbl)
– Molasses Price Scenarios						
a. $20/ton	1.59	17.69	2.18	24.32	2.07	23.11
b. $30/ton	2.00	22.23	2.59	28.86	2.42	26.92
c. $40/ton	2.40	26.77	3.00	33.39	2.76	30.73
d. $50/ton	2.81	31.30	3.40	37.93	3.10	34.54
e. $60/ton	3.22	35.84	3.81	42.46	3.44	38.35

SUGARCANE-BASED DISTILLERIES:	Model III (Autonomous with Farm Estate)		Model II (Autonomous)		Model III (Autonomous)	
– Critical Prices	Gasoline –Price (₱/liter)	Crude Oil Import Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Import Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Import Price ($/bbl)
– Raw Sugar Price Scenario						
a. ¢8/lb	3.84	42.73	3.20	35.65	5.45	60.70
b. ¢12/lb	4.89	54.50	4.26	47.42	6.33	70.47
c. ¢14/lb	5.41	60.28	4.77	53.20	6.76	75.26
d. ¢17/lb	6.21	69.16	5.57	62.08	7.42	82.64
e. ¢20/lb	6.99	77.82	6.35	70.74	8.06	89.83

Table 4.12 (continued)

MOLASSES-BASED DISTILLERIES

	Model I (Annexed)		Model II (Autonomous)		Model II (Annexed)	
	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)
2. FXΔ Premium Scenarios						
a. 10%	1.89	23.01	2.41	29.28	2.25	27.35
b. 20%	2.00	22.23	2.59	28.86	2.42	26.92
c. 30%	2.05	21.13	2.77	28.50	2.58	26.55
B. TREND SCENARIOS						
1. Crude Oil Real Price Increase						
a. at 2%	2.00	22.23	2.59	28.86	2.42	26.92
b. at 5%	2.00	22.23	2.59	28.86	2.42	26.92
2. Raw Material Price Increase						
a. at 2%	2.16	24.08	2.76	30.80	2.56	28.55
b at 5%	2.47	27.50	3.09	34.42	2.84	31.60

SUGARCANE-BASED DISTILLERIES

	Model III (Autonomous with Farm Estate)		Model II (Autonomous)		Model III (Autonomous)	
	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)	Gasoline Price (₱/liter)	Crude Oil Price ($/bbl)
2. FXΔ Premium Scenarios						
a. 10%	4.50	54.76	4.03	49.06	6.17	74.99
b. 20%	4.89	54.50	4.26	47.42	6.33	70.47
c. 30%	5.04	51.78	4.28	46.03	6.70	68.89
B. TREND SCENARIOS						
1. Crude Oil Real Price Increase						
a. at 2%	4.89	54.50	4.26	47.42	6.32	70.47
b. at 5%	4.89	54.50	4.26	47.42	6.32	70.47
2. Raw Material Price Increase						
a. at 2%	5.47	60.97	4.69	52.31	6.83	76.08
b. at 5%	6.59	73.43	5.51	61.41	7.83	87.27

strong comparative advantage of small-scale annexed molasses-based distilleries.

Regional Comparative Advantage in Ethanol Production

The DRC can also be used to investigate the locational problem in investment decisions. In the case of ethanol, it would seem likely that comparative advantage would be determined more by agricultural rather than industrial factors in view of the importance of the feed-stock. Comparative advantage in this study, therefore, is analyzed in different sugar mill districts, conveniently grouped into regions.

Sugarcane production and milling data by mill district were obtained from cost survey worksheets prepared by the Research and Development crew of Philsucom for CY 1976. Assumption used to adjust or convert private into economic costs and break these down into domestic and tradable components are found in Cryde (1983). Resulting economic cane production costs by region for CY 1976 is reproduced in Appendix 3. Regional data represent costs for the following mill districts: Manaoag (Ilocos); Paniqui, Pasudeco, Pasumil, Tarlac, Bataan (Central Luzon); Calamba, Balayan, Don Pedro (Southern Tagalog); Asturias, Bacolod-Murcia, Talisay-Silay, Biscom (Western Visayas); and Bogo-Medellin (Eastern Visayas).

Relative cost ratios (regional cost to national cost) applied on the 1983 sugarcane production cost value in Table 4.5 were used to obtain regional sugarcane production cost estimates for 1983. After adjusting for the 20 percent foreign exchange premium and adding transport cost, regional mill gate prices (or distillery cane processing site) were obtained. The same procedure used in Table 4.5 was then applied to derive the implied regional economic cost of molasses and sugarcane and molasses unit costs, by region broken down into tradable and domestic components for 1983.

Table 4.13 presents the estimated unit costs of sugarcane and molasses by region in 1983. With a national average unit cost of ₱143/ton for sugarcane, the regional unit costs range from ₱119/ton (Ilocos) to ₱156/ton (Eastern Visayas). The low unit costs of sugarcane in Ilocos are largely explained more by the fact that sugarlands in the region are still confined to the more productive areas while in other sugar districts especially in the Visayas, the sugarlands are overextended to include submarginal crop lands. Perhaps one can argue that the sugar districts that represented the region in the survey are not representative judging from the small number of sample size on non-sugar regions such as Ilocos. With regard to molasses unit

Table 4.13
ESTIMATED SUGARCANE AND MOLASSES UNIT COSTS BY REGION, 1983
(Pesos Per Ha.)

	Ilocos			Central Luzon			Southern Tagalog			Western Visayas			Eastern Visayas			Philippines		
	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic
A. *Sugarcane Economic Cost*																		
At Millgate																		
– Equivalent Cost at Farm-gate at OER	3,527	373	3,154	5,157	651	4,506	8,190	1,393	6,797	7,384	2,000	5,384	6,779	1,786	4,993	6,983	1,490	5,493
– Equivalent Cost at Farmgate with 20% Foreign Exchange Premium	3,602	448	3,154	5,287	781	4,506	8,469	1,672	6,797	7,784	2,400	5,384	7,136	2,143	4,993	7,281	1,788	5,493
+ Transport Cost to Mill with 20% Foreign Exchange Premium[1]	954	530	424	1159	644	515	1,913	1,063	850	1,595	886	709	1,361	756	605	1,738	977	781
TOTAL COST AT MILLGATE	4,556	978	3,578	6446	1,425	5,021	10,382	2,735	7,647	9,379	3,286	6,093	8,497	2,899	5,598	9,039	2,765	6,274
Cane yield	38.14			46.37			76.51			63.79			5,443			6,300		
UNIT COST PER TON CANE	119.45			139.01			135.69			147.03			156.11			143.48		
B. *Molasses Economic Cost, Ex. Mill*																		
– Sugarcane Cost at Millgate with 20% Foreign Exchange Premium	4,556	978	3,578	6,446	1,425	5,021	10,382	2,735	7,647	9,379	3,286	6,093	8,497	2,899	5,598	9,039	2,765	6,274
– Milling Cost Adjusted Cost, 1983[2]	3,793	286	3,507	4,342	327	4,015	6,783	511	6,272	5,739	432	5,307	3,943	298	3,645	5,622	424	5,198
Foreign Exchange Adjustment to ₱11 + 20% Premium[3]	227	227	–	260	260	–	406	406	–	344	344	–	237	237	–	337	337	–
Total Milling Cost	4,020	513	3,507	4,602	587	4,015	7,189	917	6,272	6,083	776	5,307	4,180	535	3,645	5,959	761	5,198
TOTAL ECONOMIC SUGAR PROCESSING COST, EX. MILL	8,576	1,491	7,085	11,048	2,012	9,036	17,471	3,652	13,919	15,462	4,062	11,400	12,677	3,434	9,243	14,998	3,526	11,472
Unit Cost/Ton Cane	225			238			230			242			233			238		
Molasses Extracted (tons)[4]	1.45			1.76			2.91			2.42			2.07			2.39		
UNIT COST PER TON MOLASSES, EX. MILL	155	27	128	135	25	110	79	16	63	100	26	74	113	31	82	99	23	26

Sources of Basic Data: Table 4.5 and Appendix 3.

[1] Computed at ₱25/ton x cane yield.

[2] Assuming cost escalator rate of 7% per annum after applying 1976 unit milling cost to 1983 yields.

[3] Exchange rate in 1976 = 7.353 = US $1

[4] Assuming .03 tons molasses/ton cane.

costs, however, it seems that the regional comparative advantage differs relative to sugarcane production. The national average unit cost per ton of molasses ex-mill in 1983 was about ₱99/ton. Only the Southern Tagalog region exhibited a unit cost of ₱79/ton which was lower than the national average while the unit cost ranged from ₱100/ton (Western Visayas) to ₱115/ton (Ilocos). This may suggest that the national average was heavily influenced by the sample farms in Southern Tagalog or that same farms were excluded in the derivation of regional unit cost since these farms were located in other regions.

Given the varying regional costs, Table 4.14 summarizes the estimated DRC coefficients of the six basic models of alcogas distilleries in five different regions. As in the overall DRC estimates, the sugar-based distilleries exhibit higher than one coefficients or negative values implying that in the selected regions they are economically noncompetitive. So investment decision is focused on molasses-based distilleries among the different regions. At the base case, it seems that all three proposed molasses-based distilleries are competitive in all five regions. But among the five regions, Southern Tagalog has the greatest comparative advantage for the three molasses-based distilleries since the DRC coefficients are lowest in this region. Perhaps the low coefficients are largely due to the lowest unit cost of molasses in the region vis-à-vis the others. Western Visayas is the next region with lowest DRC coefficients in the three molasses-based distilleries while Eastern Visayas ranks third with highest comparative advantage. On a regional basis, however, it seems that the regional DRC coefficients suggest that Model I annexed molasses-based distillery is the most appropriate type of alcogas plant to set up. Consequently, the regional DRC coefficients reconfirm the earlier findings on the strong competitiveness of molasses-based small scale annexed distillery.

Table 4.14
DOMESTIC RESOURCE COST ESTIMATES OF ALCOGAS PRODUCTION BY REGION

	Ilocos	Central Luzon	Southern Tagalog	Western Visayas	Eastern Visayas	Philippines
Molasses-Based Distilleries:						
Model I (annexed)	0.57	0.56	0.51	0.52	0.53	0.52
Model II (autonomous)	0.85	0.84	0.79	0.80	0.81	0.80
Model II (annexed)	0.67	0.65	0.59	0.61	0.62	0.61
Sugarcane-Based Distilleries:						
Model II (autonomous with farm estate)	(3.40)	(6.81)	(4.40)	(3.64)	(5.05)	(4.33)
Model II (autonomous)	(120.52)	8.60	20.60	121.98	13.65	22.01
Model III (autonomous)	(5.30)	(8.11)	(6.25)	(5.54)	(6.81)	(6.19)

Chapter 5

EVALUATION OF THE PHILIPPINE COCODIESEL PROGRAM

Unlike the alcogas program, the cocodiesel program lacks an institutional backup and a more concrete scheme of implementation. Apparently, the *ad hoc* nature of the cocodiesel program depended on the coconut world market and domestic coconut production. So unlike the alcogas program, which is coordinated by several government agencies such as PNAC and Philsucom, the cocodiesel program is under the administration of the Philippine Coconut Authority (PCA). This chapter denotes broad analysis of the cocodiesel program since the program has become merely a part of the package to rationalize the coconut oil milling industry rather than as a program primarily intended to diversify energy sources. The first section briefly discusses the cocodiesel program. Then, the next one summarizes the production process of cocodiesel production. And finally, the last section presents the broad evaluation of the program in terms of comparative analysis of exportable coconut oil vis-à-vis cocodiesel usage.

The Philippine Cocodiesel Program

The original version of the Ministry of Energy's *Ten-Year Energy Program 1979-1988* (published February 1979) never explicitly mentioned cocodiesel as potential alternative non-conventional fuel. With the sluggish world coconut oil market and aggravated by excess coconut milling capacities, the government suddenly included coconut oil as a major non-conventional fuel. In fact, in the updated *Philippine Energy Development Program 1982-1987* (published April 1982) the cocodiesel program has assumed a greater part than the well conceived alcogas program.

Table 5.1 summarizes the projected energy contribution of non-conventional energy sources during 1982-87. The Energy Plan projected a constant barrel of coconut oil equivalent of about 343 thousand barrels during the planning period. Since the total non-conventional energy systems are expected to have increasing contribution from about 627 to 1,941 TBOE, the share of coconut oil is projected to decline. In 1982, coconut oil should contribute 55 percent to the total non-conventional energy which steadily would decline to nearly 18 percent in 1987. However, compared to alcohol fuel which is the next most important non-conventional motor

Table 5.1
PROJECTED ENERGY CONTRIBUTION OF NON-CONVENTIONAL ENERGY SYSTEMS
(In Thousand Barrels of Oil Equivalent)

	1982	1983	1984	1985	1986	1987
Coconut Oil	343.27	343.27	343.27	343.27	343.27	343.27
Alcohol	34.98	47.22	47.22	47.22	47.22	47.22
Solar Water Heating	1.78	2.51	3.67	4.10	4.54	5.12
Biogas	26.88	29.60	32.96	34.78	36.59	38.41
Producer Gas	6.36	9.53	12.94	17.93	24.29	32.01
Pyrolysis	0.80	1.60	3.20	4.79	7.17	10.34
Windmill (Electric Generation)	0.08	0.35	1.24	1.91	3.23	3.30
Windmill (Water Pumping)	0.08	0.10	0.11	0.12	0.12	0.13
Agri-drier	0.48	0.72	1.07	1.31	1.54	1.78
Solar Drier	0.20	0.22	0.27	0.33	0.44	0.60
Photovoltaic	0.01	0.01	0.02	0.02	0.03	0.04
Sub-Total	414.92	435.13	445.97	455.78	468.44	482.22
Dendrothermal	212.00	401.00	635.00	891.00	1,168.00	1,459.00
TOTAL	626.92	836.13	1,080.97	1,346.78	1,636.44	1,941.22

Source: Ministry of Energy. *Philippine Energy Development Program 1982-1987* (April 1982).

vehicle fuel, coconut oil contributes more to the total non-conventional energy systems. Coconut oil would account for more than seven times the amount of alcohol fuel even after the fuel implementation of the programs.

The greater emphasis on cocodiesel against alcogas has been explained by the reported gasoline surplus in early 1982. On the other hand, domestic refinery production of diesel has been falling short of demand, requiring additional diesel imports. Consequently the Cabinet initiated the cocodiesel program on a nationwide scale in mid-1982. Actual use on pilot scale in 1981 officially demonstrated the feasibility of using the cocodiesel blend on stationary and motor engines. Fleet buses of Pantranco North Expressway Corporation, Metro Manila Transit Corporation, and the Philippine National Railways were used in the experiment. A blend of 30 percent coconut oil and 70 percent diesel fuel was considered technically feasible. However, it was officially admitted that this 30-70 percent blend reduced mileage by some 5 percent compared to petroleum diesel.

Initially, the United Coconut Oil Mills were to supply at least 40,000 metric tons to be used as cocodiesel blend during the latter half of 1982. On an annual basis, this coconut oil volume would have accounted for only 2 percent. During the period, coconut oil deliveries were estimated to cost ₱3.01 per liter, slightly higher than ex-refinery diesel costs, but retail prices were kept at current diesel fuel prices. Specific taxes and special fund imposts applicable to petroleum diesel were not applied to cocodiesel. It was reported that the price support or subsidy was put at about ₱19.1 million annually. The foreign exchange savings due to foregone diesel imports, at current prices, were estimated at about $20 million (roughly ₱166 million at the current official exchange rate).

In mid-1982, the Cabinet decision assured that the cocodiesel program will be pushed through regardless of the market conditions of world coconut. To this end, a minimum of 60,000 metric tons of cocodiesel is mandated independent of the vagaries of the world markets for coconut oil or diesel fuel. Moreover, to assure uniform product quality, the Bataan, Shell, and Caltex refineries were pinpointed to blend coconut oil with diesel fuel. Given the start up period, it was scheduled that cocodiesel should be available at filling stations nationwide by July 1982.

Near the end of 1982, however, it seems that the cocodiesel program has been re-oriented as a way to rationalize the coconut oil milling industry than as an energy development program. A Presidential Directive issued on 1 September 1982 ordered that the cocodiesel program forms part of the rationalization program of the coconut industry. More important, it specified that production of intermittent exporters of coconut products and the excess production of those primarily producing for the domestic market should be channelled to the cocodiesel program. To implement this directive, PCA promulgated rules and regulations and identified the coconut oil mills/millers and desiccators that should participate in the cocodiesel program.

The criteria of PCA for coconut mills/millers and desiccators included in the program are as follows: (1) must not be operational for the past two calendar years at more than 65 percent of annual rated capacity, (2) must not have exported at least an average of 40,000 metric tons per annum of coconut oil based on their last two calendar year performances as indicated in their PCA reports. Some 47 coconut mills/millers and desiccators were identified by PCA in October 1982 as participants of the cocodiesel program. It seems the cocodiesel program was unattractive as the PCA had required to enlist participants to the program. Most of the firms included, almost by definition, were either inefficient and/or new entities.

So far, however, official report on the cocodiesel program from 25 October 1982 to 10 February 1983 indicated that only four of the participants, namely Procter and Gamble PMC, Philippine Refining Co., Imperial Vegetable Oil Co., and Southern Leyte Co., delivered coconut oil to the cocodiesel program. Moreover, volume of delivery was not encouraging 9,000 MT (November), 3,350 MT and 9,100 MT (January 1983). Definitely, the actual deliveries were way below the 40,000 MT minimum requirement called for in the cocodiesel program. And in February 1983, due largely to the protests of bus operators and other intended users, there were no deliveries of coconut oil for the cocodiesel program and the program was virtually shelved for prosperity.

Cocodiesel Production Process

Cocodiesel is a mixture of coconut oil and diesel fuel. Unlike the feedstocks in alcohol fuel, the coconut oil raw material needs no further chemical or physical processing. The production process requires only 1) the raw materials, coconut oil and diesel fuel, 2) a large container or mixture tanks, 3) storage tanks, 4) stirring equipment or a blending machine, 5) measuring instruments, and 6) filters or funnels. It is important to note, however, that the containers or tanks must be clean and dry as the presence of moisture in the fuel will damage engine parts. Metal containers must also be free from rust.

In a huge container, coconut oil is stirred thoroughly with diesel fuel according to the blending proportion desired. The mixture is then allowed to stand for a while to enable particulates to settle at the bottom of the container. With a filtering funnel, the cocodiesel mix is strained into the storage container. No particulates should pass through the strain since they will clog engine filters and might cause trouble to the engine. Storage containers should be sealed and located away from sources of fire.

Since coconut oil is a non-conventional energy source, it is important to know the processes involved in its production. There are two methods of coconut oil expelling, namely, the wet and the dry processing. Wet processing is highly capital intensive and it is rarely used in developing countries. It is also more complicated than the conventional extraction of oil from copra or the dry processing method.

There are numerous methods of wet processing of which the more popular ones are: the primitive method, Robledano-Luzuriaga method, Krauss-naffei, KM/CFTRI, Chayen-ir, ICAITI process, Carver-Greenfield process, etc. Although the wet process methods are modern and scientific, it seems they are uneconomical to use because they are more capital intensive and are more advantageous for *edible* coconut oil. In short, for cocodiesel, the dry methods appear the most cost effective.

Although there are two general dry processing methods (non-hydraulic and hydraulic), the production flow is somewhat similar. To extract oil, the coconut meat or kernel is dried up to 5 percent moisture content (copra). Oil is extracted from copra through the use of a mechanical press or expeller or through a combination of an expeller and solvent. The copra is cleaned, ground, and steam-dried before it is fed into a high pressure screw press or expeller machine. The resulting oil is filtered of residue and stored in tanks. After the first extraction, the residue or copra cake still contains substantial amounts of oil. The solvent method is used to extract residual oil. The copra cake is steam-heated with a suitable solvent, usually hexane, and the oil in the cake is dissolved. Then the solvent and the oil are separated from the solid pieces of copra cake. The solvent is then removed for re-use by evaporation. Finally, the extracted oil is filtered and stored in tanks.

Evaluation of the Cocodiesel Program

Unlike the alcogas projects, the cocodiesel program is relatively easier to evaluate since the program seems to face technical infeasibility. While not officially accepted, the feasibility of cocodiesel program is highly questionable even on the first step of technical evaluation. Reliable reports indicate that while laboratory experiments conducted show encouraging results, the commercial implementation, however, was bogged down for technical reasons. Among the technical snags, the storage of coconut oil in commercially large containers shows some destructive elements that are very expensive to eliminate or even reduce at acceptable levels. More important, engine endurance remains a big factor. Among the problems noted are carbon buildup, coking of fuel-injector nozzle; clogging of fuel lines, and contamination of crankase oil with vegetable oil resulting in polymerization and possible engine failure. Even the well-heralded "dieselite" program which uses up to 90 percent of coconut oil proposed by Globus Resources Ltd. (of New York) has been rejected by the Philippine officials on questions of technical feasibility more than economics.

To be sure, however, while technical snags may hamper the viability of the cocodiesel program, it seems worthwhile also to consider the economic angle in case the program solves the technical questions in the near future. Assuming that the cocodiesel program would turn technically feasible, the economic evaluation appears relatively simple compared to the alcogas program. For one, while the alcogas program needs huge capital and other scarce resources to transform feedstocks into ethanol, cocodiesel fuel, as summarized in the previous section, simply requires mixing/blending facilities. So in evaluating the cocodiesel program the use of DRC, NPV, EROR are not as relevant as in alcogas projects. Clearly, the cocodiesel program is merely a question of decision whether to export coconut oil or blend it with petrodiesel for domestic use. In short, the main issue is what to do with the domestically produced coconut-oil — exportation or consumption. Accordingly, regardless of market distortions, exportable coconut oil is equally affected as it is if it were domestically consumed as fuel blends. It therefore follows that the simple but proper way to evaluate the cocodiesel program is to compare the benefit of displacing imported diesel fuels with the costs of forsaking equivalent units of coconut oil for export earnings.

To begin with, however, it is quite relevant to note that the coconut oil production in the country has been considered economically viable inspite of unfavorable government policy matrix. Studies by independent researchers suggest that the Philippines has great comparative advantage in producing coconut oil products. Bautista and Tecson in (Bautista, Power, and Associates 1979) estimated a DRC of ₱3.48 for coconut oil industry in 1974. With an estimated shadow exchange rate of ₱8.86 to $1 in 1974, the DRC coefficient is very low at .39 implying strong comparative advantage in coconut oil production. A more detailed analysis of the industry estimated the DRC coefficient for copra in 1976 and for various Philippine regions. Although the results seem out of date and refer to copra only (rather than coconut oil), the estimated results give some idea on the comparative advantage of the Philippines in the production of coconut oil. Table 5.2 reproduces the estimated DRC and coefficients by Clarete and Roumasset (1983). It shows that the six leading coconut regions have strong comparative advantage in supplying the major feedstocks for coconut oil milling. DRC coefficients range from .54 (Visayas) to .57 (Southern Luzon).

The strong comparative advantage of the economy in coconut oil production, however, does not necessarily reflect the social viability of the cocodiesel program. As already indicated, the more appropriate test is the comparative attractiveness of blending coconut oil with diesel for domestic sale rather than exporting the semi-raw material products. In this respect, there is an estimate of the net foreign exchange losses of the cocodiesel program under various coconut oil prices. In the computation, the following assumptions are used: 1) annual investment of ₱1.315 million for three storage tanks, 2) ₱32/100 kg. price of copra and typical yield of 0.62 kg. coconut oil/kg. of copra, 3) diesel cost CIF of $32.45/bbl, 4) specific tax of ₱0.255/liter, special fund of ₱0.035/liter, and consumer price equalization fund of ₱0.168/liter, and 5) exchange rate of ₱10 to $1.

Table 5.3 summarizes the results of the estimates of net foreign exchange losses due to the cocodiesel program under different possible coconut oil prices (CIF New York). With the minimum 60,000 MT/year target output, the direct foreign exchange annual costs increase from $16.9 million to $146.4 million as coconut oil price increases from 20¢/lb. to 30¢/lb. As the targetted capacity increases to the maximum of 141,500 MT/year, the estimated foreign exchange losses become higher — from $39.9 million to $345.4 million per year. The volume of expected foreign exchange foregone due to the use of coconut oil in the cocodiesel program seems large enough to question the economic wisdom of the project. They represent a substantial amount to have significant impact on the balance of payments. Moreover, the cocodiesel program carries with it substantial reduction in government revenues due to foregone taxes associated with the program. Even with the minimum target of 60,000MT/year of cocodiesel output, the foregone taxes were put at ₱61.0 million

Table 5.2
DOMESTIC RESOURCE COSTS IN COPRA PRODUCTION BY REGION: 1976
(Per Metric Ton)

	Southern Luzon	Mindoro	Central Visayas	Western Visayas	Samar	Northern Mindanao
Costs (Pesos)						
Labor[1]	513.57	505.37	416.69	293. 5	360.07	332.32
Rent	726.30	653.67	847.97	932.52	908.29	969.22
Interest	75.68	75.68	27.35	35.27	49.23	42.96
Depreciation	94.43	94.43	63.08	68.75	54.82	41.24
Others	6.19	2.04	7.15	3.98	7.33	6.21
Marketing	110.00	160.00	90.00	110.00	130.00	120.00
Subtotal	1,526.17	1,491.19	1,452.84	1,444.07	1,509.74	1,511.95
Operator's Opportunity Cost[2]	76.31	74.56	72.64	72.20	75.49	75.60
Total	1,602.48	1,565.75	1,525.48	1,516.27	1,585.23	1,587.55
Returns (US $)[3]	258.97	258.97	258.97	258.97	258.97	258.97
DRC (Pesos/US $)	6.19	6.05	5.89	5.86	6.12	6.13
Comparative Advantage[4]						
DRC/OER	0.83	0.81	0.79	0.79	0.82	0.82
DRC/SER	0.57	0.55	0.54	0.54	0.56	0.56

[1]The Harberger shadow wage rate is used. The figures reported here are corrected for household and operator's labor and for interest of the wages to labor (54 percent of hired labor costs).

[2]It is estimated at 5 percent of subtotal cost.

[3]Three year average of f.o.b. copra prices centered at 1976.

[4]Assuming a shadow exchange rate of ₱10.94 or 32 percent over the official exchange rate (= ₱7.44).

Source: R.L. Clarete and J. A. Roumasset, "An Analysis of the Economic Policies Affecting the Philippine Coconut Industry," Philippine Institute for Development Studies Working Paper No. 8308, 1983.

Table 5.3

ANNUAL FOREIGN EXCHANGE COSTS AND FOREGONE TAXES WITH THE IMPLEMENTATION OF THE PHILIPPINE COCODIESEL PROGRAM

(In Million Pesos/Year)

	Coconut Oil Price (¢/Lb. CIF, New York)					
	20.0	22.0	24.0	26.0	28.0	30.0
Net Foreign Exchange Costs with Levy (₱/Liter)	0.259	0.655	1.052	1.448	1.844	2.240
At Minimum: 60,000 MT/Year						
Direct Foreign Exchange Costs	16.9	42.8	68.7	94.6	120.5	146.4
Foregone Taxes	61.0	61.0	61.0	61.0	61.0	61.0
Total Impact	77.9	103.8	129.7	155.6	181.5	207.4
At Maximum: 141,500 MT/Year						
Direct Foreign Exchange Costs	39.9	101.0	162.2	223.3	284.4	345.4
Foregone Taxes	143.7	143.7	143.7	143.7	143.7	143.7
Total Impact	183.6	244.7	305.9	367.0	428.1	489.1

per year. Considering the foreign exchange losses and huge foregone taxes, the cocodiesel program seems economically unattractive especially at higher coconut oil prices.

Chapter 6

CONCLUDING REMARKS

The main rationale of the alcogas and cocodiesel programs is to develop an indigenous renewable energy source to partially substitute for petroleum imports so that net foreign exchange may be saved. As a natural consequence, moreover, the production of alcogas and cocodiesel from biomass is envisoned to wield a host of benefits on other socioeconomic concerns. These include: a) diversification and stabilization of the sugar and coconut oil markets and start of related chemical industry; b) increase in rural employment and incomes, enhancement of rural employment skills through the introduction of new technologies, improved income distribution, and abatement of rural to urban migration; c) improvement in land productivity through more efficient land use and research and extension support services; d) mobilization of rural savings through induced small-farmers equity investment in distillery complexes; and e) increase in industrial output through local components fabrication and development of ancillary industries. Despite these attractions, the present state of biomass technology tends to greatly limit the effective implementation of the alcogas and cocodiesel programs. And this may further be constrained by conflicting political-economic interests.

For one, in the immediate future, practical difficulties in organizing successful agro-industry-energy systems would hinder alcogas and cocodiesel production on a large economic scale. Except for Brazil, there is a general dearth of experience in the construction of alcogas plants of different sizes and in different locations. Similarly, with the rejection of Globus proposed dieselite project, there seems to be no reputable commercial experience of cocodiesel in any of the major coconut oil importing and exporting countries. Hence, a great deal of uncertainty concerning the reliability of cost estimates prepared by project proponents exists. This uncertainty is greater for plants based on raw materials other than sugarcane, molasses, and coconut oil since practically no industrial scale experience with such plants are available anywhere. Even then, factors such as the availability of local equipment and local construction, engineering, and managerial capabilities as well as inherent locational differences may have a significant effect on project costs. Evidently, the overall effect of these uncertainties has been to drastically scale down regional program targets, discourage search by project proponents for materials other than sugar juice and molasses as biomass feedstocks, and limit the distilleries rehabilitated and so far planned to those with small scales.

The possibility of biomass production on a large scale has furthermore raised the question of whether and to what extent such a development is likely to increase competition for land and other agricultural resources that could otherwise produce food or commercial crops. The recurrent issue presented by some sectors is whether the Philippines has enough agricultural resources to engage in energy crop production at reasonable costs without harming traditional production structures in domestic and export markers. Also, there are issues questioning the actual social impact of the program's expected income generation and redistribution and whether these issues are real or not. There remains the underlying suspicion that the energy, industry, and agricultural sector's participation in the fuel program is independently influenced by conflicting bureaucratic interests. Fortunately, the effects of these may have been to inhibit bureaucratic coordination as well as delay program implementation and acceptance of large scale projects.

Given these considerations, it becomes apparent that economic criteria alone cannot spell out successful implementation of the Philippine non-conventional fuel program. Nevertheless, analysis of the economics of biomass-based alternative fuel under different production alternatives and assumptions is a stepping stone to policy actions.

Appendix 1
BASE CASE ESTIMATED ECONOMIC COST-BENEFIT STREAMS BY DISTILLERY TYPE
(at constant 1983 ₱000)

	Molasses-Based Distilleries		
	Model I (Annexed)	Model II (Autonomous)	Model II (Annexed)
TECHNICAL SPECIFICATIONS			
Investment Period	1 year	1 year	1 year
Distillery Life	15 years (tl-15)	16 years (tl-16)	16 years (tl-16)
Fermentation Process	Yeast Recycle	Continuous Batch	Continuous Batch
Nominal Capacity	12,000 Kl/year	39,600 Kl/year	39,600 Kl/year
Operating Period	300 days/year	330 days/year	330 days/year
Raw Material Requirement	34,030t/year	122,100t/year	102,630t/year
Ethanol Yield	324 l/t molasses	324 l/t molasses	476 l/t molasses
Marketed By-Products	None	19,800t CO_2/year	19,800t CO_2/year
		1,584t Yeast/year	158t Yeast/year
ECONOMIC COST-BENEFIT STREAMS			
INVESTMENT	tΦ	tΦ	tΦ
Capital Expenditures	34,566	245,591	249 415
Preoperating Expenses	916	–	–
Preoperating Interest Expense	4,686	40,057	40,576
Initial Working Capital	1,144	6,866	6,437
TOTAL INVESTMENT COST	41,312	292,514	296,428

Appendix 1 (continued)

	Molasses-Based Distilleries		
	Model I (Annexed)	Model II (Autonomous)	Model II (Annexed)
ANNUAL PRODUCTION COSTS AND RETURNS			
CAPACITY BUILD-UP	51:100%	tl:100%	tl:100%
Ethanol Value	32,314	106,635	106,635
Value of By-Poducts	–	22,142	22,142
TOTAL ECONOMIC RETURNS	32,314	128,777	128,777
Raw Material Cost	14,660	48,352	40,641
– Direct labor	520	2,242	2,242
– Chemicals	120	1,884	1,884
– Utilities**	53	2,834	2,834
– Fuels and Lubricants**	723	19,889	17,124
– Miscellaneous	55	246	3,398
Other Variable Costs	1,471	27,095	27,482
– Maintenance	939	7,289	7,409
– Overhead	652	4,045	3,867
– Others	747	365	365
Fixed Operating Costs	2,338	11,699	11,641
TOTAL ECONOMIC PRODUCTION COSTS	18,469	87,146	79,764
ANNUAL NET BENEFIT DISTILLERY OPERATIONS	13,845	41,631	49,013
ADDITIONS TO WORKING CAPITAL	–	–	–
(Working Capital Build-up at End of Distillery Life)	(t15) 1,444	(t16) 6,866	(t16) 6,437

lix 1 (cont nued)

	Sugarcane-Based Distilleries		
	Model II (Autonomous With Farm Estate)	Model II (Autonomous)	Model III (Autonomous)
HNICAL SPECIFICATIONS			
ıvestment Period	3 years	1 year	3 years
istillery Life	16 years (t3-18)	16 years (tl-16)	20 years (t2-21)
ermentation Process	Continuous Batch	Continuous Batch	Yeast Recycle
lominal Capacity	39,600 Kl/year	39,600 Kl/year	9,600 Kl/year
perating Period	330 days/year	330 days/year	200 days/year
aw Material Requirement	598,000t/year	598,000t/year	123,600t/year
thanol Yield	66 l/t cane	66 l/t cane	78 l/t cane
larketed By-Products	23,700t CO_2/year 1,188t Yeast/year	23,700t CO_2/year 1,188t Yeast/year	None

Appendix 1 (continued)

	Sugarcane-Based Distilleries						
	Model II (Autonomous With Farm Estate)			Model II (Autonomous)		Model III (Autonomous)	
ECONOMIC COST-BENEFIT STREAMS							
INVESTMENT	tΦ	tΦ	tΦ	tΦ	tΦ	tΦ	tΦ
Capital Expenditures	43,672	10,109	413,283	331,506	42,382	81,904	31,894
Preoperating Expenses	2,858	4,358	6,580	–	876	3,921	–
Preoperating Interest Expense	7,437	10,511	79,825	54,022	6,143	18,463	24,443
Initial Working Capital	–	–	3,933	1,311	–	–	3,228
TOTAL INVESTMENT COST	53,967	24,978	503,621	386,839	49,401	104,288	59,565
ANNUAL PRODUCTION COSTS AND RETURNS							
CAPACITY BUILD-UP	t3:100%			tl:100%		t6:100%*	
Ethanol Value	106,635			106,635		25,851	
Value of By-Products	25,212			25,212		–	
TOTAL ECONOMIC RETURNS	131,847			131,847		25,851	
Raw Material Cost	121,561			121,561		25,125	
– Direct labor	2,762			2,762		511	
– Chemicals	1,884			1,884		1,188	
– Utilities**	–			–		–	
– Fuels and Lubricants**	–			–		–	
– Miscellaneous	1,226			1,226		–	

Appendix 1 (continued)

	Sugarcane-Based Distilleries		
	Model II	Model II	Model III
	(Autonomous With Farm Estate)	(Autonomous)	(Autonomous)
Other Variable Costs	5,872	5,872	1,699
– Maintenance	10,014	10,014	4,724
– Overhead	4,632	6,746	2,148
– Others	–	–	1,843
Fixed Operating Costs	14,646	16,460	8,715
TOTAL ECONOMIC PRODUCTION COSTS	142,079	144,193	35,539
ANNUAL NET BENEFIT FROM DISTILLERY OPERATIONS	(10,232)	(12,346)	(9,688)
ADDITIONS TO WORKING CAPITAL	t3:3,670	tl:703	t6:48***
(Working Capital Build-up at End of Distillery Life)	(t:18) 7,603	(t:16) 2,014	(t:21) 3,228

*Capacity build-up is as follows: 67% (t2); 91% (t3); 95% (4); 98% (t5); 100% (t6).

**Electric power and fuel for steam in sugarcane based plants are generated by bagasse. Water requirements are assumed obtained from distillery site.

***Working Capital changes are as follows: –793(t2); 577(t3); 96(t4); 72(t5).

Appendix 2
HISTORICAL OIL AND GASOLINE PRICES
1970-1983

			Regular Gasoline Price Buildup (₱/Liter)[2]						
	World Crude Oil Market Price[1] ($/bbl)	CIF Import Price ($/bbl)	Direct Oil Company Take	Consumer Price Equalization Fund (CPEF)[3]	Specific Tax	Energy Development Fund	Wholesale Posted Price	Margin	Retail Price
1970	n.a.	1.89	.195	–	.08	–	.28	.05	.33
1971	n.a.	2.35	.22	–	.08	–	.30	.05	.35
1972	n.a.	2.47	.22	–	.08	–	.23	.22	.35
1973	2.22	3.18	.23	–	.10	–	.32	.08	.40
1974	9.48	10.27	.64	–	.27	.04	.95	.02	.97
1975	10.72	11.18	.78	–	.29	.04	1.12	.06	1.18
1976	11.50	11.97	.95	–	.33	.05	1.32	.07	1.39
1977	12.40	12.81	.99	–	.44	.07	1.50	.08	1.58
1978	12.70	12.98	1.00	–	.50	.09	1.59	.08	1.66
1979	16.67	19.08	1.23	.10	.55	.28	2.16	.13	2.29
1980	28.00	30.99	2.03	.86	.83	.44	4.16	.20	4.36
1981	32.17	34.95	2.31	1.04	1.02	.44	4.81	.17	4.98
1982	34.00	33.79	2.31	1.02	1.06	.44	4.83	.02	4.85
1983 (July)	29.00	32.00	3.60	–	1.34	.68	5.62	.35	5.07

[1]Weighted average price of Arabian light crude oil.

[2]Weighted average for the year.

[3]In 1979 the CPEF was created to equalize the differential between the various crudes purchased by oil companies and the marker crude. In late 1980, the fund was used to subsidize oil companies by the amount of difference between the peso cost of crude oil imports when the dollar exchange rate stood at ₱7.65 and that at the time of importation as of June 1983, the subsidy stood at 27.5 centavos as the average of all for oil products. Shortly after, the CPEF was abolished and incorporated into the direct oil company take component of gasoline price.

Source: Philippine National Oil Commission.

Appendix 3
HISTORICAL SUGAR AND MOLASSES EXPORT PRICES
1970-1983

	Raw Sugar			Molasses
	World Price*		FOB Price	FOB Price
	¢/Lb.	$/Ton	$/Ton	$/Ton
1970	3.75	82.67	151.88	16.67
1971	4.52	99.65	155.67	16.57
1972	7.41	163.36	171.99	19.88
1973	9.59	211.42	186.32	31.15
1974	29.60	652.56	478.16	42.23
1975	20.49	451.72	597.33	50.25
1976	11.58	255.29	292.94	30.79
1977	8.11	178.79	209.32	37.30
1978	7.81	172.18	175.14	41.36
1979	9.66	212.96	183.91	58.08
1980	24.12	531.75	347.79	74.21
1981	16.89	372.36	436.64	100.67
1982	10.70	235.89	342.23	52.02
1983 Jan.-June	7.67	169.09	245.32	43.94
Aug.	11.00	242.51	264.55	n.a.

*FOB Carribean Ports.

Sources: NCSO, *Foreign Trade Statistics of the Philippines.*
FAO, *FAO Trade Yearbook.*

Appendix 4
IMPLIED ECONOMIC COST OF CANE PRODUCTION BY REGION
CROP YEAR 1976/1977
(₱/Hectare)

	Ilocos			Central Luzon			Southern Tagalog		
	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic
Variable Costs									
Direct labor	683	–	683	726	–	726	1,089	–	1,089
Canepoints	10	–	10	104	–	104	7	–	7
Fertilizer	386	249	137	722	485	237	1,589	1,084	505
Chemicals	–	–	–	1	–	1	33	21	12
Animal-man service	282	–	232	306	–	306	554	–	554
Tractor custom service	362	86	276	414	98	316	612	145	467
Total Variable Cost	1,673	335	1,338	2,273	583	1,690	3,884	1,250	2,634
Fixed Costs									
Land rent	863	–	863	1,641	–	1,641	2,146	–	2,146
Depreciation	22	–	22	43	–	43	210	–	210
Interest on loanable funds	606	–	606	665	–	665	1,107	–	1,107
Irrigation charges	–	–	–	4	1	3	–	–	–
Total Fixed Cost	1,491	–	1,491	2,353	1	2,352	3,463	–	3,463
Total Economic Cost at Farmgate, 1976	3,164	335	2,829	4,626	584	4,042	7,847	1,250	6,097
Yield per ha (tons cane)	37.41			45.48			75.04		
Unit cost (₱/ton cane)	84.58			101.72			97.91		
Relative cost ratio	0.51			0.74			1.17		
Economic milling cost	2,317	175	2,142	2,652	200	2,452	4,143	312	3,831

Appendix 4 (Continued)

	Western Visayas			Eastern Visayas			Philippines		
	Total	Tradable	Domestic	Total	Tradable	Domestic	Total	Tradable	Domestic
Variable Costs									
Direct labor	401	–	401	431	–	431	548	–	548
Canepoints	86	–	86	92	–	92	77	–	77
Fertilizer	2,697	1,658	1,039	2,316	1,443	873	2,289	1,428	861
Chemicals	8	5	3	31	20	11	11	8	3
Animal-man service	638	–	638	497	–	497	578	–	578
Tractor custom service	331	78	253	556	131	425	392	93	299
Total Variable Cost	4,161	1,741	2,420	3,923	1,594	2,329	3,395	1,529	2,366
Fixed Costs									
Land rent	910	–	910	991	–	991	969	–	969
Depreciation	230	–	230	87	–	87	198	–	198
Interest on loanable funds	1,102	–	1,102	1,046	–	1,046	1,048	–	1,048
Irrigation charges	221	53	168	34	8	26	154	37	117
Total Fixed Cost	2,463	53	2,410	2,158	8	2,150	2,369	37	2,332
Total Economic Cost at Farmgate, 1976	6,624	1,794	4,830	6,081	1,602	4,479	6,264	1,566	4,698
Yield per ha (tons cane)	62.56			53.38			61.79		
Unit cost (₱/ton cane)	105.88			113.92			85.19		
Relative cost ratio	1.06			0.97			1.00		
Economic milling cost	3,505	264	3,241	2,408	182	2,226	3,434	259	3,175

Notes: Regional data represent implied average economic costs for CY 1976 in the following mill districts: Ilocos –Manaoag; Central Luzon – Paniqui, Pasudeco, Pasumul, Tarlac, Bataan; Southern Tagalog – Calamba, Balayan, Don Pedro; Western Visayas – Asturias, Bacolod-Murcia, Talisay-Silay, Biscom; Eastern Visayas – Bogo Medellin. Costs for the Philippines are the weighted average of regional costs, with regional production shares to total production in CY 1976 used as weights.

Sources of Basic Data: Private sugar production and milling data by mill district were obtained from cost survey worksheets prepapred by the Research and Development Crew of the Philippine Sugar Commission (Philsucom) for CYs 1976 and 1977. Assumptions used to adjust or convert private into economic costs and break these down into domestic and tradable components are found in Cryde (1983).

BIBLIOGRAPHY

Alonzo, R. "On Measuring Shadow Wages of Philippine Labor," *NEDA Journal of Development*, Vol. 1, No. 1, 1974.

Armas, A. and D.J. Cryde. "Economic Incentives, Wage Policy and Comparative Advantage in Philippine Agriculture," Council for Asian Manpower Studies Discussion Paper Series No. 81-03, June 1981.

Asian Development Bank, *Regional Energy Survey.* (Manila: ADB, 1981).

Baldwin, R. *Foreign Trade Regimes and Economic Development in the Philippines.* (New York: National Bureau of Economic Research, 1975).

Bautista, R., J. Power and Associates. *Industrial Promotion Policies in the Philippines.* (Manila: Philippine Institute for Development Studies, 1979).

Ben, R. *et al. Production and Utilization of Synthetic Fuels – An Energy Economic Study.* (New York: Wiley Halsted Press, 1981).

Cryde, D. J. "Implications of Input Interventions on Production Efficiency in Philippine Agriculture," Unpublished MA thesis submitted to the University of the Philippines School of Economics, 1983.

Federal Energy Administration. *Project Independence Report.* (Washington D.C.: Government Printing Office, November 1974).

Hammond, A. "Alcohol: A Brazilian Answer to the Energy Crisis," *Science*, Vol. 195, February 11, 1977.

International Labour Office. *Sharing in Development: A Programme of Employment, Equity, and Growth for the Philippines.* (Geneva: ILO, 1974).

Little, I. and J. Mirrlees. *Manual of Industrial Project Analysis in Developing Countries.* (Paris: Development Centre of the Organization for Economic Cooperation and Development, 1968).

MacArroy, P. W. *Crude Oil Price as Determined by OPEC and Market Fundamentals.* (Massachusetts: Ballinger Publishing Co., 1982).

Makasiar, G. "Structural Response to the Energy Crisis: The Philippine Case," Paper presented at the 13th Pacific Trade and Development Conference (Manila, Philippines: January 24-28, 1983).

Merril, R. and T. Gage. *Energy Primer, Solar, Water, Wind and Biofuels.* (New York: Delta, 1978).

Merrow, E. *Constraints on the Commercialization of Shale Oil.* (California: Rand, 1978).

Ministry of Energy. *The Philippine Energy Development Program 1982-1987.* (Makati: Ministry of Energy, 1982).

MIT Energy Laboratory Policy Study Group. *The FEA Project Independence Report: An Analytical Review and Evaluations Energy Laboratory Report* (MIT-EL-75-017, May 1975).

National Economic and Development Authority. *A Guide to Project Development.* (Manila: NEDA, 1978).

Organization for Economic Cooperation and Development. *Manual of Industrial Project Analysis.* (Paris: OECD, 1969).

Palz, W. *Solar Electricity: An Economic Approach to Solar Energy.* (London: Butterworth, 1978).

Pearson, S. *et al.* "Comparative Advantage in Rice Production: A Methodological Introduction," *Food Research Institute Studies* XV, 2, 1976, pp. 128-283.

United Nations Industrial Development Organization. *Guidelines for Project Evaluation* (New York: United Nations, 1972).

Vermon, R. ed., *The Oil Crisis* (New York: W. W. Norton, 1976).

Walton, A. L. and E. H. Warren. *The Solar Alternative: An Economic Perspective* (New Jersey: Prentice-Hall, 1982).

World Bank. *Philippine Energy Sector Survey* (Report No. 3199-PH, IPD, February 1982).

———. *Brazil: Alcohol and Biomass Energy Sector Reviews* (Report No. 3001-BR, IPD (May 1980).

———. *Alcohol Production from Biomass in the Developing Countries* (Washington D.C.: World Bank, 1980).

———. *Prospects for Traditional and Non-Conventional Energy Source in Developing Countries.* World Bank Staff Working Paper No. 346 (July 1979).

Yand, Y. and S. Trindale. "Brazil Gasohol Program," *SEP* (April 1979).