BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER: PN-AAJ-761

2. SUBJECT CLASSIFICATION (695): Ap00-0000-G320

3. TITLE AND SUBTITLE (240)

Energy strategies for the Dominican Republic: report of the national energy assessment

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)

Gordian Associates, Inc.; Berger (Louis) Int. Inc.

6. DOCUMENT DATE (110): 1980

7. NUMBER OF PAGES (120): 120p.

8. ARC NUMBER (170): DR333.7.G661

9. REFERENCE ORGANIZATION (130): Gordian

10. SUPPLEMENTARY NOTES (500)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Energy
Energy needs
Natural resources
Dominican Rep.
Energy consumption
Strategy
Conservation
Policies
Assessments

13. PROJECT NUMBER (150): 598060600

14. CONTRACT NO.(140): AID/SOD/PDC-C-0301

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

DR
333.7
G661

PN-AAJ-761

ENERGY STRATEGIES FOR THE DOMINICAN REPUBLIC: REPORT OF THE NATIONAL ENERGY ASSESSMENT

SEPTEMBER, 1980

COMISION NACIONAL DE POLITICA ENERGETICA
ENERGY DEVELOPMENT INTERNATIONAL
GORDIAN ASSOCIATES, INC.
LOUIS BERGER INTERNATIONAL, INC.

ENERGY STRATEGIES FOR THE DOMINICAN REPUBLIC:

REPORT OF THE NATIONAL ENERGY ASSESSMENT

SEPTEMBER 1980

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Under AID Contract
AID/SOD/PDC-C-0301

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PREFACE

The idea for a National Energy Assessment Project came about as an outgrowth of discussions held between the Comision Nacional de Politica Energetica of the Dominican Republic (CNPE) and the Mission of the United States Agency for International Development when CNPE was first established in 1979. The overall goal of the project was to provide key policy-makers in the Dominican Republic with a body of data and the supporting analyses capable of offering a comprehensive picture of the energy situation as it exists now and is likely to develop over the next decade and beyond. The project represents a collaborative effort of the Comision staff and a team of consultants. The project began in April 1980 with the collection and assembly of information on existing and potentially usable indigenous energy resources, current and planned energy capacities of the Corporacion Dominicana de Electricidad and the refinery at Haina, and the nature of present and projected energy consumption in each of the major energy end-use sectors.

Based on these data, a series of supply-demand balances has been constructed for the years 1990 and 2000 for seven sets of scenario conditions. The first, the base case, assumes that programs already initiated by the government of the Dominican Republic to reduce oil imports would continue in effect. The second assumes the accelerated development of hydroelectricity and coal-fired electric plants, the third, a mix of renewable resource-based technologies, and the fourth, the introduction of energy conservation as a major government priority. The fifth scenario, titled the "limited oil consumption" scenario, seeks to document what would have to happen if national oil imports had to be maintained at or near 1980 levels. The sixth, called the "combined case," presents the results that would occur if the measures considered in the Conservation, Renewable and Hydro/Coal cases were implemented simultaneously. The seventh scenario, a no-action scenario, presupposes that these programs would, for some reason, be slowed or eliminated.

Findings based on these scenarios suggest what actions will have to be taken and at what time they will have to be initiated in order to

bring available energy supplies in the Dominican Republic in line with energy demands. Taken as a whole, the results serve as the basis for laying out a national strategy which would allow the Dominican Republic to make a transition away from its current overwhelming dependence on imported oil.

In identifying possible strategies, the project has several purposes in mind:

- The first is to achieve a consensus among key individuals in both the public and private sectors in the Dominican Republic on two key points: what is the real energy situation, and what can be done about it. While neither the economic costs nor the environmental impacts of the strategies recommended have been dealt with in this project up to now, the results described in this report clearly establish the bounds of what is technically possible, making use of existing technologies to meet further higher demands for energy in the Dominican Republic.

- The second is to expose in unambiguous terms the uncertainties that government leaders will have to take into consideration in adopting any particular strategy. These uncertainties include whether or not oil will be discovered; what the price and availability of coal will be over the next two decades; and what breakthroughs in the development of solar technologies will take place. The answers to these questions will play a critical role in determining the path (or paths) the Dominican Republic should take to achieve a greater self-sufficiency in energy. While the analyses described here cannot eliminate the uncertain consequences of our lack of knowledge of these key factors, they can reveal the differences between low and high-risk strategies.

- The third and perhaps most important reason for defining specific strategies is that they provide a basis for defining an integrated set of technical programs and government policy actions. For example, measures that are capable of achieving a drop in oil imports within the next few years, such as industrial energy conservation, must be integrated with expansion plans for hydro-generated electricity, which is likely to make major contributions to installed electric capacity only in the latter part of this decade and perhaps beyond. Similarly, energy pricing policies aimed at providing access to energy fuels by all socio-economic groups must, at the same time, be capable of providing the revenues to undertake the massive investments in the national energy infrastructure that will be necessary to promote reduced oil dependence.

Addressing the energy situation in the Dominican Republic at the national level as opposed to the regional or local level inevitably means that some key aspects will have been neglected. This does not mean that they are unimportant. Delivering adequate amounts of energy to the rural poor at prices they can afford is a case in point. Clearly, this complex issue deserves much more attention than it is given here.

In the course of collecting the data and information to prepare this report we have relied on a large number of organizations within and outside the Dominican Republic. These include the Banco Central, Secretaria de Estado de Industria y Comercio, Oficina Nacional de Planificacion (ONAPLAN), and Oficina Nacional de Estadistica (ONE). We have also obtained information from the Inter-American Development Bank and World Bank publications, and reports put out by ICIDCA for the UNDP, FCI, consultants in the U.S., and Brookhaven National Laboratory.

This report is intended to satisfy the needs of three audiences; policy-makers in the Dominican Republic, whose decisions are critical if the strategies and programs recommended in the report are to be used as the basis for a national energy policy; individuals in USAID, the Inter-American Bank, the World Bank, and other national and international assistance organizations who have responsibility for passing on energy-related assistance loans and grants to the Dominican Republic, many of which will be crucial to the success of the recommended program; and internal and external private sector interests with major investments in the country's economy, on whose continued support the Dominican Republic remains dependent.

The energy assessment project is expected to be an ongoing activity of CNPE. Later reports will be published, dealing with the economy and institutional aspects of the overall strategies and recommended programs proposed here. Feasibility and pre-investment studies will be undertaken to evaluate the practical steps that have to be taken to implement the recommendations. As a result, there may have to be significant changes in the priorities assigned to programs recommended in this report, or perhaps even major revisions in the strategy proposed. In this sense, this report should be seen not as a final statement but as an initial contribution.

I. BACKGROUND, APPROACH AND METHODOLOGY

Access to adequate amounts of energy is vital to the economic and social development of any society. This is particularly true for rapidly developing countries like the Dominican Republic. Over the next 10-30 years almost all oil-importing countries must seek ways to substantially reduce their dependence on oil. This will require large amounts of capital investments in energy production and distribution facilities. It will also mean heavy and prolonged commitment to developing skilled manpower and management organizations capable of operating and maintaining the new energy systems that will come into operation. Almost every aspect of investment in the future development of the country, ranging from mass transit systems to the patterns of new industrial development, will have to take into consideration the increased costs of energy for both the country as a whole and private enterprises.

Integrated energy planning will have a pivotal role to play in this transition even though it is a fairly new concept in the political arena. This means modifications in the current process in the Dominican Republic whereby planning targets and budgets are considered separately for energy supplies such as coal and hydro-generated electricity, and imported and refined oil products, without taking into account the interaction between investments in energy supply and the energy demands that follow certain kinds of economic development. Future markets for the Dominican Republic's two major exports, sugar and nickel, both of which are relatively energy-intensive, will have to be reexamined in the light of recent global energy developments.

Up to now, most of the important decisions concerning development of the national energy supply system in the Dominican Republic have been taken either by individual companies or by the Corporacion Dominicana de Electricidad and Refineria Dominicana de Petroleo. Government policies have greatly influenced the nature of energy demands through regulation of the imports of energy consuming vehicles, appliances, and

industrial equipment, control of energy prices, and encouragement of import substitution. Coordination of these decisions will be needed in the future to achieve the utilitization of more expensive supplies of commercial energy in more economically efficient ways.

A. NATURE OF THE NATIONAL ENERGY SITUATION IN THE DOMINICAN REPUBLIC

This report addresses the energy crisis now being faced by the Dominican Republic. That crisis is now and will continue to be centered on the high percentage of export earnings going to the purchase of imported oil products. It will not be easy to plan a strategy that can slow down the growth of oil imports and at the same time bring down the outflow of foreign exchange without, at the same time, slowing down economic and social development. A wide range of engineering and technical problems in building large and numerous new energy facilities must be dealt with. Competing economic, political, and regional interests will have to be considered, and new institutions may have to be created to plan, construct, regulate, and allocate energy in all its forms.

Given these complexities, it is not surprising that there are those who advocate a particular simple, one-shot solution. Some favor large investments in solar installations. Others prefer a dramatic push to find and exploit the country's oil. Still others will want to wait and expect additional special considerations from Mexico, Venezuela and other "friendly" oil exporting countries. Finally, there are those who see a wholesale shift to hydropower as offering the best choice for the replacement for oil in the generation of electricity. But, in fact, none of these will suffice as a single remedy, and no other easy fix is likely to develop in the future.

The development of the strategies considered in this report are based on three basic premises:

(1) Whether or not commercially exploitable amounts of oil are discovered in the country, a major effort must be undertaken by the government immediately to reduce dependence on imported oil, and eventually on imported fuels of all kinds.

(2) The transition from an oil-based energy system to an alternative system must be accomplished without substantially slowing down economic and social development of the country, and without the social costs of the transition falling unduly on any single socio-economic group.

(3) The cost of producing energy in any form will continue to rise throughout the transition. These costs will have to be adequately reflected in energy prices if the Dominican economy is to adapt itself to the new energy era.

Although the emphasis of this report is on the upcoming decade, the period beyond has not been ignored. Many plans, set in action in the 80's, are not likely to show results until the 90's. Also, it is possible to develop short-range programs that can bring down oil consumption in the 80's only to have consumption begin to increase again in the 90's. By considering the next two decades, it becomes possible to distinguish between what can and cannot be accomplished by short-term technical solutions and long-term changes in the structure of the economy. These changes will be necessary to permanently weaken the current linkages between GNP growth and energy demand.

The viewpoint of this report is one of conservative pragmatism. The technologies considered are those that have been shown to be workable. Estimates of resources are conservative, as are the projections of energy demand, and in considering strategies, political and institutional barriers were taken into account. This report takes the most realistic view possible of the global energy situation in the 80's and 90's, given the present uncertainties of the international political and economic environment. It is assumed that there will be a series of steady increases in oil prices with 1990 prices estimated at $40/barrel in 1980 dollars in agreement with World Bank estimates. It is also assumed that prices for other fossil fuels will be proportionately increased.

B. SCOPE OF THE ENERGY ASSESSMENT

The starting point for the development of an ongoing national energy planning effort in the Dominican Republic capable of addressing the important issues that have been previously been enumerated is a

national energy assessment. Such an assessment generally begins with the collection and compilation of all primary and secondary data and information on:

- potentially usable indigenous resources;
- current and planned capacities of the nation's infrastructure for producing and distributing energy fuels; and
- the characteristics of current and future demand in the producing and consuming parts of society.

The data are summarized in Chapter II. The assessment then proceeds to analyze the results in terms of a series of energy supply-demand scenarios, each of which is predicated on a distinct set of conditions pertaining to the introduction of new government policies, the global energy situation, the general state of the economy, and the introduction of new energy supply and end-use technologies. Strategies capable of fulfilling broad national energy goals are then examined in the light of the data base and the scenario results.

Aside from seeking to identify strategies and programs of action, the assessment project has a number of equally important objectives, all of which are intended to help CNPE develop the capabilities to conduct energy planning studies and analyses on a continuing basis. These are intended to provide:

- a basic energy data and information base,
- procedures for determining when and how often the data base should be up-dated,
- a framework for analyzing a range of technical, economic, and institutional policy options, and
- on-the-job training for CNPE staff.

Five members of the consultant team spent extended periods in the Dominican Republic working with CNPE staff on the collection and analysis of data on energy resources, supply, and demand. In addition, a

team of eleven short-term consultants spent periods of one or more weeks in the Dominican Republic. Their efforts ranged from a reexamination of the potential sites for mini-hydro installations to inspection visits to factories using large quantities of energy in order to establish their potential for increased energy efficiency. Upon completion of the data collection phase of the project, two CNPE staff members spent a week with the team of consultants in the United States helping to identify the conditions to be used in preparing the supply-demand scenarios. Finally, on preparation of the final results, including the recommended strategies and programs, discussions were again held with the CNPE staff and the team of consultants.

Several mechanisms were used to insure that the assessment activity received comment and suggestions from a number of government units and private citizens. A project oversight committee was formed at the outset of the project. Its role was to review the scope of the project, the options being considered, and the findings. Members of the oversight committee were:

Ing. Jose Ramon Acosta	Secretario Ejecutivo, Comision Nacional de Politica Energetica
Dr. Francisco Jose Castillo	Subsecretario de Estado de Industria y Comercio
Sr. Pedro Julio Bona Prandy	Subsecretario Tecnico de la Presidencia
Lic. Ramon Perez Minaya	Director, Oficina Nacional de Planificacion
Sr. David Coore	Representante, Banco Interamericano de Desarrollo
Ing. Guillermo Paniagua	Administrador General, Corporacion Dominicana de Electricidad
Sr. Luis Crouch	Miembro del Consejo Directivo, Instituto Superior de Agricultura
Sr. Charles Blankstein	Capital Development Officer, Agency for International Development
Sr. Allen Merrill	Capital Development Officer, Agency for International Development
Sr. Luis Arthur	Energia Solar, S.A.

Energy consumption data were collected and analyzed for each of the following sectors:

- Agriculture
- Mining
- Industry
- Construction
- Commercial/Government
- Transport
- Urban households
- Rural households

Combinations of secondary and primary sources were used to obtain a picture of the current situation, to provide a basis for projecting future demand in each individual sector compatible with a given overall macroeconomic performance. These sources were also used when considering proposals to stem increasing consumption of oil such as generating estimates of the potential for increasing energy end-use efficiency in each sector or substituting solar-based devices. A simple model, described later in this chapter, was employed for relating sectoral growth to overall macroeconomic performance.

Energy supply and resource data were analyzed under four categories:

- Hydropower (including sites for mini-installations);
- Fossil resources (including peat and lignite);
- Solar and Wind; and
- Land-based Biomass (including bagasse and fast growing wood species).

Previous studies were utilized in preparing resource assessments. Visits by consultant specialists were used to reevaluate figures obtained from previous studies. Consultant specialists were also used to assess the state of readiness of newly introduced technologies for conditions in the Dominican Republic, especially in estimating the amounts of energy that could be expected to be obtained from the use of solar, wind and biomass resources. Their judgements were also solicited in estimating the rates at which hydro installation and coal-fired electric generation stations could be brought on-line. As noted above, the experts' opinions figured heavily in estimating the potential energy-savings obtainable from the utilization of end-use efficiency measures.

Three reference years were chosen for carrying out the supply-demand analysis. The year 1978 was chosen as the year in which to portray the "current" energy situation because it was the most recent representative year for which a complete set of data was obtainable. The year 1990 was chosen because of the strong interest in government circles of trying to determine what could be done in the 80's to reduce oil imports. The year 2000 was chosen in order to provide an indication of whether policy changes made in the 80's would be capable of permanently raising the effectiveness of commercial energy, so that the growth in GNP would not necessarily involve a proportionate increase in commercial energy consumption.

C. ENERGY DATA BASE

Data collection efforts were based on the following sequential approach:

(1) secondary data collection using existing economic, demographic, social, and technical sources, including all previous sectoral energy data studies;

(2) estimation techniques applied to data made available from fuel suppliers, distributors, and CDE; and

(3) energy surveys and interviews with consumers to fill gaps in the data base.

The specific approach used and the level of detail sought varied considerably from one sector to another depending on:

- size and diversity of energy consuming units within a sector,
- magnitude of electricity or oil products being consumed in the sector,
- sensitivity of the consumers to changes in either the form or the amount of fuels being consumed, and
- the magnitude of the effort needed to increase the precision of the data base.

For example, direct use of petroleum in agriculture (not including sugar) is now less than one percent of total energy consumption in the Dominican Republic. Its use, moreover, is dispersed among numerous farms and other agricultural processing units. Energy consumption in this case was therefore estimated from farm production statistics combined with survey-based information on average petroleum use per unit of crop production output.* Most of the industrial consumption of oil in the Dominican Republic also takes place in a few specific factory locations. As a result, each of the major energy consuming facilities was visited by industrial sector specialists working on the project and data collection. Energy efficiency reviews, and assessment of potential savings were carried out on a plant-by-plant basis.

For household units in both urban and rural areas, the large number of units made the use of formal surveys necessary as a supplement to information obtained from existing socio-economic and demographic data. At the same time, earlier work by Practical Concepts Incorporated and by Banco Central were integrated into the urban and rural household analyses.

D. BASIS FOR PROJECTING FUTURE ENERGY DEMANDS

A variety of models exists for relating macroeconomic performance to future energy demands. Almost all of these, however, require a rich data base, in the absence of which, estimates must be made not only of the missing parameters but of the manner in which these parameters will change in the future. We have, therefore, adopted a procedure which does not seek to forecast energy demand from future levels of macroeconomic activity, but which arrives at a set of sectoral demands that are compatible with a given level of GNP growth. This iterative procedure consists of three steps:

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* Practical Concepts Incorporated, "Energy in the Food System, Dominican Republic," report prepared for the Brookhaven National Laboratory (in preparation).

(1) Target performance was determined for each sector, based on resources available for that sector, anticipated growth in key subsectors, the degree of planned public investment, historical growth, and structural changes typical of economies at a similar stage of development. Sectoral projections were determined after discussions with ONAPLAN, the Banco Central, the World Bank, UNDP, ECLA, and private sources, as well as with the Ministries of Industry, Transportation, and Agriculture. None of the agencies contacted had made projections beyond 1985. Therefore, post-1985 projections are largely based on our own judgement. Targeted overall GDP growth was derived from the sectoral growth targets.

(2) Projected GDP growth was then adjusted in light of the principal growth constraint that the Dominican Republic is likely to face: limited investment financing, insufficient resources to rapidly develop all sectors at once, fluctuations in global economic activity and, most importantly, shortages in foreign exchange which would result if all sector growth targets were realized. Overall growth targets were scaled down to be consistent with reasonable long-term foreign debt position thereby yielding a set of preliminary macro-economic projections.

(3) These preliminary macro-economic projections were then discussed with each sector specialist on the project team in order to determine their consistency with the micro-economic (subsectoral) insights gained by those specialists. The macroprojections were adjusted as necessary to yield a consistent set of final GDP and sectoral projections, which then formed the basis for the 1990 and 2000 Reference Energy Systems and for the economic sensitivity analyses.

E. ANALYTICAL FRAMEWORK

The Developing Countries Energy Planning Framework* used in this assessment was developed at the National Center for the Analysis of Energy Systems at Brookhaven National Laboratory and the Insititute for Energy Research at the State University of New York at Stony Brook. In brief, a national energy production, distribution, and end-use system is viewed as a set of linkages tracing the steps between individual resources and energy demand sectors. The steps correspond to the processes and technologies used to transport, distribute, convert and

---

* An Analytical Framework for the Assessment of Energy Sources and Technology Options for Developing Countries, BNL 50800, Upton, New York, February 1978.

store energy efficiency, and a capital and operating cost attached to the process and equipment required. Both commercial and non-commercial fuels are included. Fuel imports are also given. Figure I-1 shows a simplified Reference Energy System.

In each major sector, energy expenditures are characterized by (1) the fuel inputs, (2) the devices/processes employed, and (3) the output activity level of the factory, farm, transport system, etc. Projections of energy demand and energy system infrastructure development are used to arrive at possible future supply-demand balances for specific target years.

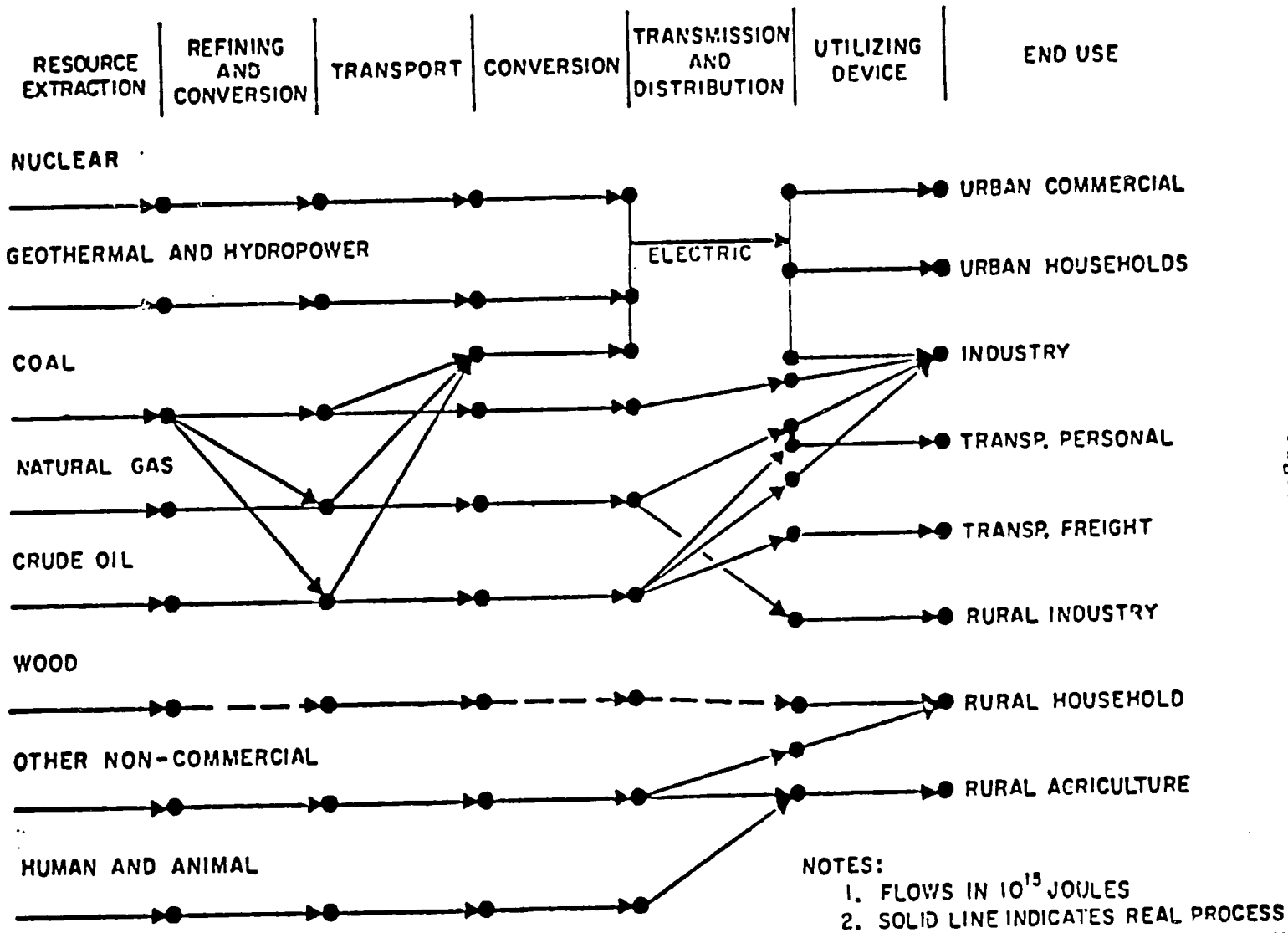
F. ORGANIZATION OF THIS REPORT

The report is divided into four chapters. The first deals with the background of the energy assessment project, the scope of the effort, the approach taken to obtain needed data and information, the methods used for projecting demand, and the analytical framework employed to carry out the analysis. Chapter II summarizes the data on which the analysis is based. Separate sections are devoted to domestic energy resources (hydropower, fossil, solar, and wind and biomass), production and distribution of electricity and refined oil products, and each of the major energy consuming sectors of the economy (industry, transportation, commercial/government, agriculture and rural and urban households). The methodology employed in making the energy demand projections and the underlying macroeconomic assumptions are also briefly described. Separate appendices for each of the demand sectors document the sources of data, survey details, estimation techniques employed, along with a full presentation of the data. The reader interested in reviewing the technical material in support of the summaries should refer to these appendices.

Chapter III deals with the supply-demand scenarios. It presents energy flows in 1990 and 2000 for the Base Case Scenario and for six alternate scenarios that have been developed, together with the assumptions underlying each case.

Chapter IV, the final chapter of the report, presents the conclusions and recommendations. Included in Chapter IV are a series of

LDC REFERENCE ENERGY SYSTEM (ILLUSTRATIVE)



NOTES:
1. FLOWS IN 10^{15} JOULES
2. SOLID LINE INDICATES REAL PROCESS
3. CONVERSION EFFICIENCIES SHOWN IN PARENTHESIS

Figure 1

charts which attempt to portray the ability of the various scenarios considered to reduce oil imports, and the changes in how energy is utilized within the economy. Chapter IV also spells out the strategies recommended and the programs needed to implement them and the issues raised by the findings of the study.

Table I-1 is a list of energy conversions and equivalents used throughout this report.

Table I-1

CONVERSIONS

1 Kboe = thousand barrels oil equivalent =
= 6.12×10^{12} joules = 5.8×10^{9} Btu = 1.7 Gwh

Petroleum products

1 bbl Reconstituted crude	=	0.967 boe
1 bbl LPG	=	0.691 boe
1 bbl Gasoline/aviation gas	=	0.905 boe
1 bbl Kerosene/jet fuel	=	0.977 boe
1 bbl Gas oil/Diesel	=	1.004 boe
1 bbl Fuel oil/Bunker C	=	1.083 boe

1 bbl LPG = 192.5 lbs of LPG

Coal

1 metric ton = 24.0×10^{9} joules = 3.92 boe

Charcoal

1 metric ton = 28.0×10^{9} joules = 4.48 boe

Wood

1 metric ton = 14.0×10^{9} joules = 2.29 boe

Bagasse

1 metric ton = 7.9×10^{9} joules = 1.29 boe

II. ENERGY RESOURCES, CONVERSION AND FINAL DEMAND

Over the past several years a large number of studies have been done which, taken together, provide a reasonably comprehensive picture of the energy resource endowment of the Dominican Republic. Less attention has been paid to collecting and analyzing data for composing a similar picture for individual energy demand sectors. Energy use in the industrial sector was examined by T.V. Long in 1978 under the sponsorship of the Inter-American Development Bank. A report by Practical Concepts Inc. (PCI) and Brookhaven National Laboratory (BNL) on energy use in the agriculture and rural sectors is near completion. That work was sponsored by the U.S. Agency for International Development. As part of this project PCI-BNL prepared an overview of the energy supply-demand situation in the Dominican Republic along with a summary of what was known about current and future energy use.

Because the available data dealing with the patterns of energy demand were judged to be weaker than those on energy resource availability, it was decided to emphasize the demand area in this project. Data capable of providing the following were sought: 1) a detailed profile of the current energy situation in each major sector of energy consumption; 2) a basis for projecting changes in the patterns of energy end-uses over the next one to two decades; and 3) estimates of the extent to which energy could be conserved, especially through increases in the efficiency of energy end-use, and the extent to which other fuels could be substituted for oil-based products.

To obtain the needed information on energy consumption in urban households, a survey involving household interviews was conducted as part of the project. For the industrial sector, extensive visits to major installations were conducted by specialists on industrial energy use. Interviews with plant managers were held to supplement the data base available from a variety of government sources. For the agriculture and rural sectors, use was made of the results of the PCI-BNL study. The transportation sector data came from a combination of surveys, interviews, and government statistics. A more detailed descrip-

tion of the data obtained and the information sources, collection techniques, and projections is to be found in the appendices.

The large costs associated with performing new assessments of current and potentially utilizeable energy resources precluded taking a "fresh look" at the situation. Therefore, this report relied heavily on in-country visits by experts who were familiar with previous studies of resource potential for hydro, fossil and renewables. Very often the technical limits on the utilization of non-conventional renewable resources are dependent on the state of development of the conversion technology to be employed. Experts familiar with these technologies were employed to prepare such estimates. In subsequent stages of energy assessment activities, when actual economic costs of the options explored in this report are further examined, a more substantial investment of time and effort in assessing resources will be required.

Information on the current capacities and future expansion of central station electricity and refinery facilities was obtained from sources at the Corporacion Dominicana de Electricidad and the Refineria Dominicana de Petroleo. These are factored into both current and projected supply balances. Where values are used in the report that are different from those provided by these organizations, this fact is specifically mentioned.

For the three main elements of the energy system (that is, energy resources, energy conversion, and final demand sectors), the sources of information, a summary of results, and a discussion of the significant findings are described herein. Detailed analytical and source citations are contained in the appendices.

A. ENERGY RESOURCES

Conventional Hydropower

Out of a theoretical hydroelectric generation potential in the Dominican Republic of about 50,000 Gwh per year, it has been estimated that as much as 8,000 Gwh per year can be practically developed. Eight projects with a total capacity of 159 MW are in existence and four

projects with an additional 15 MW are under construction. Damage incurred during Hurricane David has left only three of the existing plants amounting to 17.9 MW in operation. An inventory of domestic hydroelectric resources prepaid by the CNPE in 1980 lists 120 additional sites that have been identified totalling 1860 MW that could generate annually 5560 GWH per year (see Table II-1). Undoubtedly, as more regions of the country are studied in greater detail, additional sites will be identified.

Basic data necessary for the reliable design of hydropower projects in the Dominican Republic are available, but additional stream flow measurements and more information on the sediment load of streams are needed. In addition, more attention should be paid to the determination of the electricity production capability of a project under actual operating conditions, given that alternative uses of water, such as irrigation, compete with electricity production at many of these sites. Load factors, that is, the amount of hours in a year that a plant is generating electricity divided by the total number of hours in a year, would be much higher if better coordination existed between different water using agencies.

The CNPE inventory lists 14 projects that could be completed by 1987 requiring funding of about RD$100 million per year (Table II-2), or RD$1500 per installed kilowatt. For an additional RD$1400 million investment, 861 MW of additional capacity could be available between 1987 and 1990 (Table II-3). Figure II-1 shows the country's annual hydro potential through 1990 under this proposed development plan.

The Corporacion Dominicana de Electridad (CDE) is at present negotiating with the Inter-American Development Bank for RD$65 million for the 18 MW Lopez project. Next in line is the 25 MW Rio Blanco site, for which RD$59 million is sought from the World Bank. The CDE has also completed prefeasibility studies on the upper basins of the Alto Yaque and Bao rivers, on which 8 projects are contemplated which will be able to generate 850 GWH.

TABLE II-1

EXISTING AND POTENTIAL HYDROELECTRIC

PROJECTS

Status of Project	No. of Projects	Installation in Megawatts (kilowatts x 10^3)	Annual Production in Gigawatt Hours (kwh x 10^6)
In Operation	8	159.35	360.0
Being Constructed	4	23.38	186.8[1]
Designed	11	64.05	245.7
Being Designed	13	613.11	1,020.2[2]
Evaluations Completed	8 groups	893.85[3]	2,687.8[3]
Identified - Group 1	74	95.82	837.6
Identified - Group 2	22	194.40	769.0
Totals	132 Plus 8 Groups	2,043.96	6,107.1

1. Includes 110.0 Gwh increased production in existing plant at Tavera.
2. Two projects being reevaluated and the load factor will be increased.
3. Average of maximum and minimum estimates.

TABLE II-2

COMISION NACIONAL DE POLITICA ENERGETICA

PROPOSED HYDROPOWER DEVELOPMENT PROGRAM TO 1987

(Contains hydropower projects that could be completed by 1987 if funding of about $100 Million per year was available.)

No.	Project	Yr for Start of Operation	Generating Capacity, MW	Annual Generation, Gwh	Present Status
1	Bao	1981	See note Table 1	110.0	In construct.
2	Los Ranchitos	1981	0.68	5.9	"
3	Hatillo	1982	8.00	40.9	"
4	Sabaneta	1983	6.40	30.0	"
5	Los Toros	1983	12.05	70.0	Designed
6	7 small projects	1983	9.00	48.7	"
7	Caida J.J. Puello	1983	6.00	44.0	In Design
8	Rio Blanco	1984	25.00	93.0	Designed
9	Lopez	1984	18.00	34.0	"
10	Inoa	1985	59.40	89.0	In Design
11	Tres Caidas	1985	9.83	86.0	"
12	Mao (Moncion)	1986	56.50	140.0	"
13	Jiguey I	1987	142.50	168.5	"
14	Aguacate I	1987	96.50	150.0	"
Total			449.86	1110.0	

Note: No. 6 includes Guayabal, Los Rios, Santana, Nizaito, Majagual, San Rafael, and Caida Boba.

No. 11 includes Brazo Derecho, Jicame, and Guayacanes.

TABLE II-3

COMISION NACIONAL DE POLITICA ENERGETICA

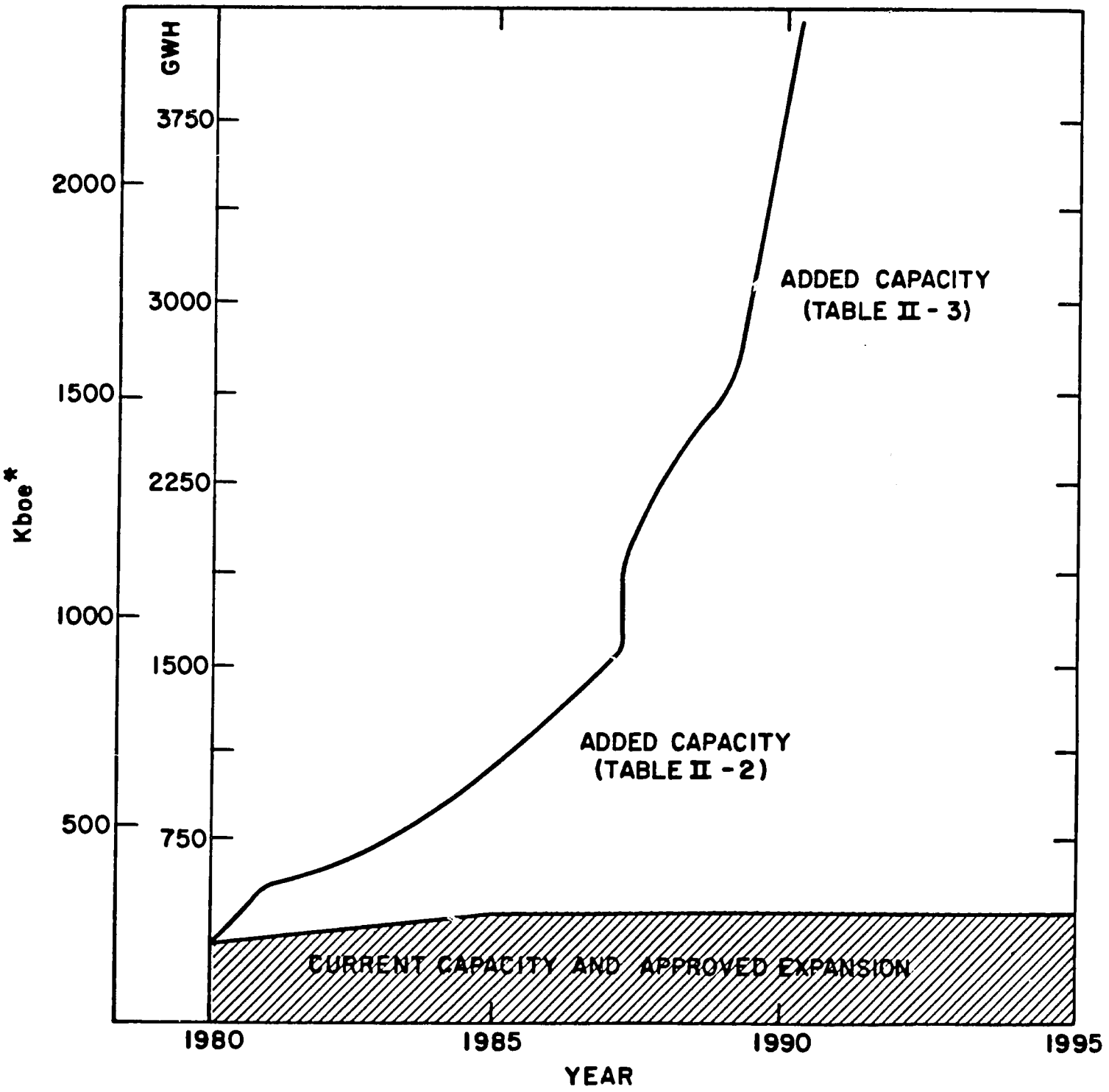
EXTENDED HYDROPOWER DEVELOPMENT PROGRAM, 1987-1990

Contains hydropower projects in addition to those in Table II-2 which could be completed if additional funding of about $1,400 Million was available.)

No.	Project	Year of Possible Completion	Generating Capacity MW	Annual Generation Gwh
1	Yague del St. Quita Coraza	1987	22.1	193.4
2	Yague del Norte La Cienaga	1987	12.0	33.0
3	Manabao	1987	25.0	110.0
4	Jagua-La Pleceta	1987	10.0	42.0
5	Alto Yuno	1988	15.0	62.0
6	Bao-Aguas Caliente	1988	15.0	63.0
7	Amina Abajo	1988	2.7	23.7
8	Sonador	1988	8.2	72.0
9	Presa Boba	1988	6.5	57.5
10	Mulito	1988	2.8	24.5
11	Guarico	1988	3.4	30.0
12	Yague del Sur-Los Bancos	1988	8.0	71.0
13	Tamayo	1988	7.3	64.0
14	Consinto	1989	90.4	328.0
15	Jiguey II	1990	142.5	168.5
16	Aguacate II	1990	96.5	150.0
17	Conjunto: Bao-Jagua-Yague Norte-Jimenoa	1990	380.0	1023.9
18	Sabana Yegua	1990	13.2	70.0
Totals			860.6	2586.5

FIGURE II-1

ANNUAL HYDROELECTRIC OUTPUT



* 1 Kboe = 1.7 GWH

Mini-hydro

The 74 projects identified as Group 1 of Table II-1 have an average size of about 1300 kilowatts. They are the first mini-hydro projects to be marked for further evaluation as sources of electricity for remote areas of the Dominican Republic. By 1990 the Dominican Republic could develop 30-40 of these mini-hydro sites and five additional sites per year thereafter. Care must be taken, however, to clarify institutional responsibilities in the development and implementation of a mini-hydro program. It seems certain that many additional mini-hydro sites will be identified, if sufficient emphasis is placed on their development. The CDE is currently contemplating development of 10 small sites with capacities of 500-1000 KW, three between 1500-2000 KW and one of 4000 KW.

Solar Utilization

The Dominican Republic receives 470 calories per square centimeter per day from the sun on the average, ranging from a minimum of 363 cal/cm^2 per day average in January to a maximum of 538 cal/cm^2 per day average in July. At present, only one solar technology - hot water heating - is well enough established internationally to be tapped immediately, based upon extensive experience and promising economics. A typical domestic hot water (DHW) heater provides a family with 40 gallons of hot water per day, equivalent to 205 KWH per month. There are currently about 70,000 families in the Dominican Republic with water heaters. It is estimated that in 1980 hot water heaters will consume the equivalent of 82 MWH. Almost all of the 300,000 hot water heaters expected to be in use in the year 2000 could be solar powered. An additional 20 percent of the water heating requirement in the commercial sector could rely on solar energy. Figure II-2 shows the annual energy contribution potential of solar water heaters for domestic and commercial use.

A second solar technology - solar ponds - should be able to provide heat and/or electrical power in the next two decades. A pond costing about RD$10 million (1978) to construct could provide about 16 kboe per year in the heat output, or 27 GWH of electrical power annually.

Other solar technologies, including photovoltaics, and other applications - water pumping, fish/crop drying, cooking, refrigeration, etc. - also show promise for the future and are expected to contribute to the energy supply of the Dominican Republic, particularly if the prices of photovoltaics will decrease appreciably.

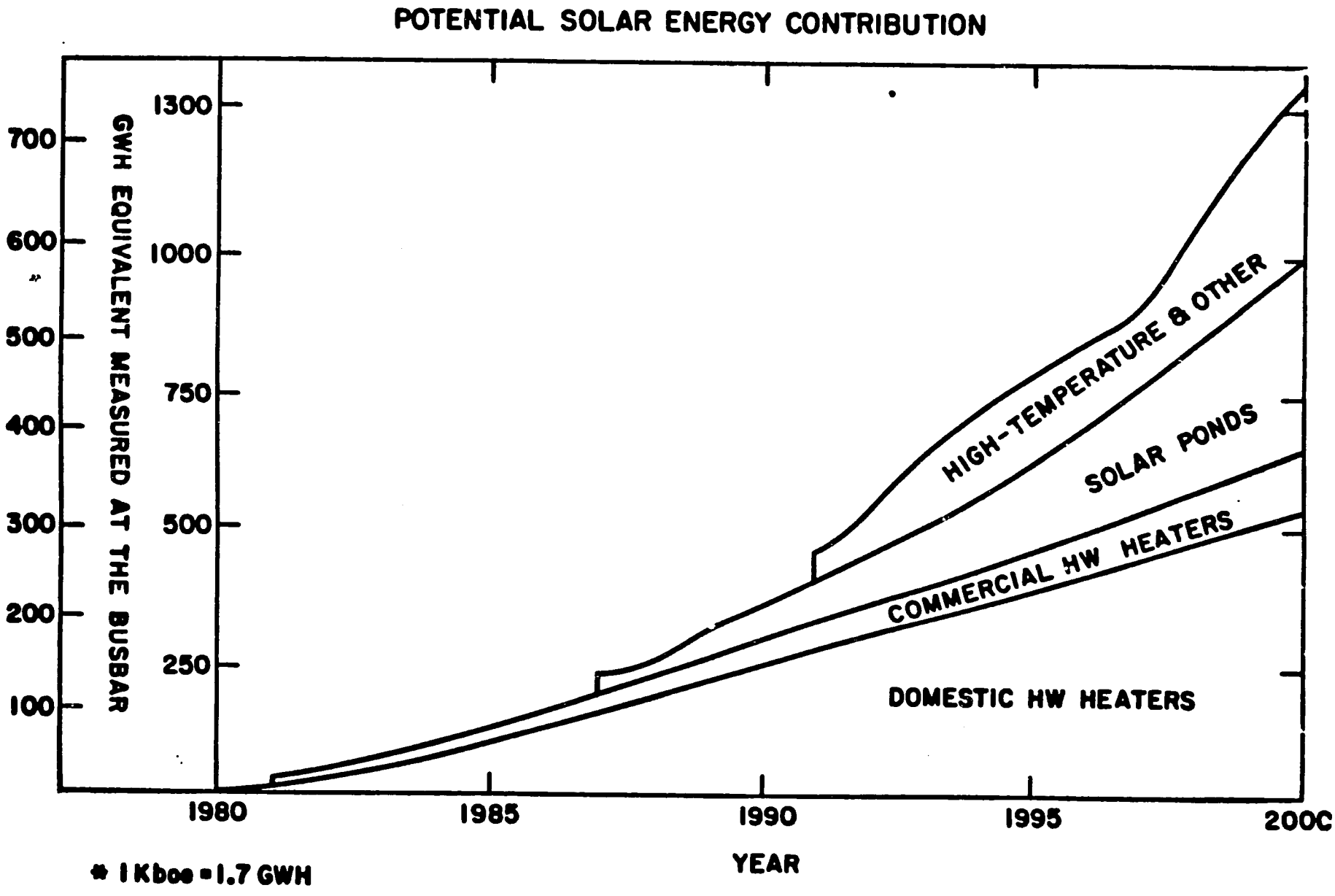
In Figure II-2 it has been assumed that two solar ponds will be operating by 1990 and 10 or 12 more by 2000, and that two solar power towers (or equivalent) could be operating by 2000.

Coal, Peat, Lignite

In 1977, several zones showing indications of carbon-bearing deposits were identified for further study. The Sanchez area is estimated to have deposits of lignite of 50 million tons. This lignite is of

FIGURE II-2

CUMULATIVE SOLAR ENERGY PER YEAR Kboe*



relatively low quality (approximately 3500 Kcal/kg) and is distributed over a wide area, with much of it close to the seacoast and below sea level. Mining activities are likely to be hampered by water incursions. Mining the lignite would be fairly expensive and useful only for localized power production. Peat has been found in the Bajo Yuna area to the west of Sanchez, with reserves estimated at 25 million tons, half the size of the lignite reserve. This peat has an even lower heat content than the lignite. Other locations are still being evaluated, but there is little optimism for significant finds.

Based upon the projected high cost of power production from either of these areas and their relatively remote location, no significant energy contribution by domestic coal, lignite, or peat in the Dominican Republic can be expected.

Oil and Gas

Four Companies - Cariboil (U.S.A.), Canadian Superior Oil (Canada), Las Mercedes (Venezuela), and Quisqueya (Dominican) - currently have concession from the government to drill for oil and gas in the Dominican Republic. Their concessions run for four years, with an option for two more years, and require certain numbers of holes to be drilled to or beyond given minimum depths. Although some oil and gas have been discovered in the past, none has been found recently in commercially exploitable quantities. Out of fifty-two exploratory holes that have been drilled since 1905, only ten have exceeded 6,000 feet. Most were drilled without adequate prior geological and geophysical studies, so that beyond the recent geological work done, there is limited detailed knowledge of subsurface conditions. Canadian Superior Oil is currently drilling a well which will go to at least 12,000 feet, but the density of exploratory wells has not been at all sufficient to explore adequately promising fields.

There are numerous geological indications that oil in commercial quantities should exist. An accelerated exploration program is warranted, in the most promising regions - Cuenca de Enriquillo, Cuenca de

Azua, and Cuenca de San Juan. But despite the rumors that, in fact, sizeable reserves have already been identified, it is premature to postulate a contribution from domestic oil to the country's energy supply.

Wind

It is estimated that there are at least 500 small windmills in rural areas of the Dominican Republic, mostly used for water pumping. These are, however, gradually being replaced with electric and gasoline powered engines.

Adequate wind data for specific locations in the Dominican Republic are not available. Even so, estimates indicate that efficient windmills could be utilized in several regions of the country. They could provide an alternative to extending the central electric grid to some remote areas, provided the required minimum wind speeds and have a high degree of reliability. The gathering of data on wind speed duration and frequency, which would allow estimates of power obtainable on the basis of a suitable windmill size and design, is therefore justified.

Geothermal

Little detailed analysis has been done on areas showing possible potential for geothermal energy. The most recent evaluations, performed jointly by the Organizacion Latinoamericana de Energia (OLADE), BRGM (Paris), and the Direccion General de Mineria, consisted of preliminary investigation of four sites:

1. Eje Volcanico Yayas de Viajama - Constanza (thermal spring),
2. Graben Cul de Sac - Enriquillo,
3. Recent lava emissions of San Juan,
4. Fuentes de Azua.

Only the first and possibly the second sites show enough promise for immediate further investigation. Surface water temperature of 40° - 45°C indicating hotter water below ground have been measured at the first site. Other promising geochemical and geological indications are also present.

Given the large number of sites in the Dominican Republic showing evidence of recent volcanic activity, there is a good possibility that additional sites with geothermal potential will be discovered. Most of the promising geothermal regions, however, are far from the large population centers. It is well known that the high cost associated with goethermal exploitation prohibits the development of any but the most ideal geothermal sites. These two factors combined with the long lead time between specific site appraisal and the production of electricity from geothermal sources make it improbable that this source of energy will make a significant contribution to the nation's energy supply before the year 2000.

Ocean Thermal Electric Conversion (OTEC)

For a workable OTEC system, an ocean water thermal gradient of about 20°C is required. In the vicinity of the Dominican Republic, a water depth of about 1000 meters is required in order to find such a gradient. The closest point where water 1000 meters deep approaches the cost (within 1.2 km) is between La Cienaga and San Rafael in Barahona where a temperature gradient of 22°C has been observed within 3km of the coast. There are numerous other sites around the island where OTEC is technically feasible. However, OTEC technology is still in an experimental stage. Pilot studies which are being conducted in Hawaii, Puerto Rico, and the Virgin Islands indicate the OTEC electric generators of small and medium capacity may not be economically competitive with other fuels in the near future. OTEC generators are not likely, for these reasons, to make a significant contribution to energy supplies in the Dominican Republic until well into the 21st century.

Wood

Present wood consumption, including that for charcoal, is estimated at 6,120 kboe annually, or 23 percent of total energy consumption in the country. Forests in the Dominican Republic cover approximately 25 percent of the surface area and are located principally in the southwest and along the eastern coast. The previously high rate of deforestation has decreased significantly due to the fact that most remaining

forests are now located away from the major centers of population concentration, and because logging for lumber has been under strict government control since 1967. However, no restrictions exist on firewood cutting -- charcoal is indirectly controlled through restrictions on its transport -- and the present rate of wood consumption is still high relative to the existing resource base. No further expansion of wood consumption from the existing forests can be postulated without also assuming damage to the resource base.

Other factors contributing to deforestation are the 1979 hurricane, which uprooted a large number of trees; the grazing of animals, especially in the dry forests; and clearing of forest land for farming. More stringent measures will have to be taken to prevent a further large reduction in the forested land area.

One promising possibility for increasing wood production is tree farming. The trees could serve as lumber, firewood, charcoal, or as fuel for electricity generating plants. A demonstration project for an energy plantation currently is being considered by the Instituto Superior de Agricultura (ISA).

To assess the potential energy contribution of tree farming, a productivity estimate for some fast-growing species of trees (a maximum of 11.6 cubic metres per hectare) is multiplied by the land area potentially available for tree plantations (526,000 ha). The upper limit of the energy in the wood which could be obtained this way is 13,250 kboe annually. (For further details see Appendix VIII).

Agricultural Wastes

Significant quantities of a number of agricultural residues are generated during harvesting and processing operations. Sugar cane provides by far the most usable residue called bagasse. Agricultural residues left in the fields are not expected to be collected and used for energy generation in the foreseeable future because of the considerable difficulties encountered in collection. They also provide important nutrients and act as ground cover until the next crop grows, and are used for animal feed. Residues which accrue during the

processing of agricultural products, however, can easily be concentrated at the processing location and should be considered potential energy contributors. Potential energy contributions from sugar cane processing residues are outlined in Table II-4. In 1978, bagasse contributed an estimated 5,000 kboe to the country's energy supply, and by the year 2000 the contribution is expected to nearly double, in large part because of solar drying of bagasse, expected to be used extensively by 1990.

B. ENERGY CONVERSION

Electric Generation System

The country's public utility, the Corporacion Dominicana de Electricidad (CDE) supplies all major population centers with electricity from an integrated grid. CDE currently has an installed capacity of 683 MW, of which hydropower constitutes 159 MW, steam plants fired by fuel oil 377 MW and gas turbines and diesel plants 147 MW (See Table II-5). In addition, the mining industry, because of its remote location away from the grid, has more than 90 MW of its own installed, while the sugar industry has about 100 MW dispersed among 15 mills. The latter uses bagasse as its primary energy source. To hedge against frequent power cuts by CDE, many emergency generators have been installed in recent years in the country's factories, office buildings, stores, hotels, and restaurants. Generator sales from late 1973 to the present total 177 MW of capacity in sizes ranging from a few kilowatts to a few megawatts.

The fuel mix of electric generation both for 1975 and for the base year 1978 are shown in Table II-5, and the electricity consumption breakdown by sector, are shown in Table II-6. The share of hydro* as an input to electrical generation has risen only 3 percent since 1975, and in 1978 comprised only 11 percent of the total. Fuel oil going directly to CDE plants and to Falconbridge for sale to CDE is generating 70 percent of total electricity. Although electricity consumption has risen since 1975, the end-use sectoral composition has remained relatively constant.

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* Measured in terms of "petroleum equivalent."

TABLE II-4

POTENTIAL ENERGY FROM BAGASSE

(Energy content of sugar cane and bagasse in kboe)

	1978	1980	1985	1990	1995	2000
Sugar Cane Bagasse	5260	5350	5630	9090*	9560	10040
95.3% of Bagasse Energy Recoverable	5000	5100	5370	8660	9110	9570
Electrical Generation efficiency	23%	25%	28%	30%	33%	35%
Equivalent Electrical Output at Busbar (Gwh)	1960	2170	2590	4490	5200	5780

* Assumes that by 1990 solar energy will be used to dry bagasse to 30% moisture content (formerly 50% moisture content).

TABLE II-5

Installed Electric Capacity, 1980

	MW
Corporacion Dominicana de Electricidad (CDE):	
Hydro	159
Steam plants (fuel oil)	377
Gas turbines (diesel)	147
Total CDE	683
Self-generation:	
Falconbridge	90
Sugar industry	∿100
Emergency generators	177
Total Self-Generation	367

TABLE II-6

FUEL INPUTS AND ELECTRICITY SALES BY CDE

a. Fuels in Electricity Generation, 1975 and 1978

	1975		1978	
	Kboe	Percent	Kboe	Percent
Hydro	315	8	552	11
Diesel	57	1	16	-
Gas Oil	1278	33	960	19
Fuel Oil	2237	57	3403	67
Fuel Oil (Falconbridge sales to CDE)	6	-	155	3
Bagasse (CEA sales to CDE)	0	-	1	-
Total	3893	100	5087	100

b. Sectoral Distribution of Electricity Consumption, 1975 and 1978

	1975		1978	
	Kboe	Percent	Kboe	Percent
Industry	253	37	363	37
Residential	265	38	376	38
Commercial	90	13	126	13
Government	69	10	107	11
Public Lighting	12	2	12	1
Total	689	100	984	100

CDE has been plagued by a number of operating problems over the past several years, including delayed maintenance and repair of equipment, lack of foresight in planning, and the devastating problems left in the wake of a major hurricane. Much of the equipment owned by CDE is outdated. The average baseload steam-turbine, for example, was installed more than 16 years ago. In addition to the problems normally associated with old equipment, the older generators make it imposssible for CDE to realize the operating efficiencies due to improvements in technology. Furthermore, the equipment owned by CDE is poorly maintained. This, in part, accounts for the fact that these baseload plants operate below design load levels and have a longer down-time than would normally be expected.

Due to the excess in demand for electricity over available supply, CDE rotates scheduled power outages for sections of the grid in an effort to keep the load below the available system capacity. Because the schedule is published in advance, Dominicans can often organize their time around the interruptions. Frequently, however, power outages also occur without advance notification. On the average, several unexpected interruptions occur each month.

The electrical grid extends to all major population centers via 34.5 KV and 69 KV transmission lines. Although 138 KV lines have been strung, they are not expected to be in service until 1982, when substations have been completed. The 1974 government-initiated rural electrification program had reached 353 municipalities by 1977, mostly in the northern part of the country, outside the grid.

Transmission and distribution losses at CDE amount to 26.7% of electricity generated. This amount includes about 7% of theft. A combination of management practices and new equipment will reduce, according to the CDE, total losses to 17% by the late 1980's.

CDE is committed to diminishing the country's dependence on foreign oil and has a number of expansion projects:

- Re-design of existing and planned plants to burn coal (expected completion 1983-84);
- Committment to accelerating the development of hydroelectric resources;

- More efficient utilization of bagasse in the sugar industry so that CEA sales to the grid can be augmented; and

- Use of non-conventional energy sources to generate electricity.

Petroleum Refining

Since 1973, an oil refinery has been in operation in the Dominican Republic with a capacity of 30,000 barrels per day. It processes reconstituted crude containing a mixture (in volume) of 60 percent Venezuela heavy crude, 15 percent gas oil, 12 percent heavy naptha, 9 percent light naptha and 4 percent butane. Its output, in volume, is 30 percent fuel oil, 28 percent gas oil/diesel, 6 percent kerosene/jet fuel, 24 percent gasoline and 8 percent LPG. Losses of about 4 percent are sustained, in part in transport and the rest in the internal use within the refining process.*

Yearly inputs of reconstituted crude have climbed from 8,800 kboe in 1975 to 9,440 kboe in 1978, or from 24 to 26 kboe per day. This represents about 65 percent of total petroleum imported into the country; the rest consists mostly of fuels imported directly by the Falconbridge nickel mine (which operates a small refinery of approximately 3200 barrels per day), fuel oil imported directly by the public utility, and a few products not produced by the refinery, such as aviation gasoline, lubricants and asphalts. Domestic consumption of petroleum products, which includes both refinery sales and petroleum product imports is shown in Table II-7 for 1975 and 1978.

Future refinery expansion plans are vague, at present. The large direct imports of fuel oil in recent years and the expectation that future supplies of oil will be heavy crude from Venezuela have influenced plans to develop a heavy oil refinery. Recent government actions, however, may force a reexamination of these plans. New electric generation will be coal-fired; substitution of gasoline-powered taxis for diesel-powered minibuses in public transport will lead to large adjustments in the nature of demand for petroleum products. No new construction of refineries or expansion of existing ones is likely to be started in the next few years.

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* A more detailed description of the refinery process is contained in Appendix II.

TABLE II-7

CONSUMPTION OF PETROLEUM PRODUCTS

(kboe)

	1975			1978		
	Refinery Sales	Petroleum Product Imports	Total	Refinery Sales	Petroleum Product Imports	Total
Gasoline	2373	-	2373	2562	-	2562
LPG	361	-	361	504	-	504
Kerosene	119	-	119	115	-	115
Jet Fuel	241	-	241	300	-	300
Gasoline/Diesel	2571	264	2835	2700	273	2973
Fuel Oil	2529	977	3506	3604	2744	6348
Lubricants and Asphalts	-	946	246	-	450	450
Aviation Gasoline	-	247	247	-	37	37
Reconstituted Crude	-	2919	2919	-	1822	1822
Total Domestic Consumption	8194	4653	12847	9785	5326	15111

C. DEMAND SECTORS

In this section, two related topics are discussed: the current energy consumption pattern broken down into final demand sectors and types of energy resources, and projections of energy demand under a specific set of assumptions called the Base Case.

An overview of energy consumption by major demand sector and energy resources is shown in Table II-8. The industrial sector, comprised of mining and manufacturing, is the largest energy consumer, accounting for 30 percent of the oil, 47 percent of the biomass energy consumption, and 37 percent of the electricity sold by the public utility. The residential sector is the next largest total energy consumer, but 87 percent of the residential energy is from wood (either directly or in the form of charcoal), which is used inefficiently. The amount of useful energy consumed by the residential sector is comparatively small. Transportation, which depends totally on oil-based fuels, accounts for about 28 percent of the oil consumption but only 16 percent of total energy use. An additional 15 percent of total resource consumption is lost in the generation and transmission of public sector electricity.

Out of a total energy demand of 26,240 kboe (1978), 14,570 kboe, or 55 percent, are oil-based fuels. Hydropower resources account for only 2.1 percent, while wood consumption, including that for charcoal, make up 23 percent of total energy consumption. The bagasse produced, as well as being consumed by the sugar industry, constitutes 19 percent of total energy. For more details on the current energy system, see Appendix IX.

In what follows, forecasts of energy demand by sector are made for 1990 and 2000 on the basis of "reference case" macroeconomic projections (see Table II-8a for overall and sectoral economic growth rates assumed in the reference case). For example, the reference case projects real industrial sector economic growth to be an average of 7% per year from 1978-1985. Accordingly, energy consumption in industry has been forecast to be consistent with 7% annual growth in industrial output from 1978-1985.

TABLE II-8

ENERGY CONSUMPTION BY SECTOR AND RESOURCE, 1978

(Direct energy use in kboe)

	Gaso-line	Gas Oil	Fuel Oil & Crude	Other	TOTAL OIL	Hydro	Purchased Electricity	Bagasse	Wood	Charcoal	TOTAL Amount	TOTAL Percent
Agriculture		90									90	-
Industry		438	3941	52	4431		363	5002	175		9971	38
Commercial & Government		311		39	350		245				595	2
Transport-ation	2562	1160	64	337	4123						4123	16
Residential				512	512		376		3200	2740	6828	26
Public Utility		975	3403		4378	552	-984				3946	15
Other	17		222	450	689						689	3
TOTAL	2579	2974	7630	1390	14573	552	0	5002	3375	2740	26242	100

Sources: See Appendix IX

Notes: a. The oil consumption is for electricity generation. Electricity sales totalled 984 kboe, which is entered as a negative number under Public Utility. The column total of 3946 kboe then represents losses in electricity generation, transmission and distribution.

TABLE II-8a

PROJECTED ANNUAL REFERENCE CASE GROWTH RATES

BY SECTOR

(Percentages)

	1978-85	1986-90	1991-2000
Agriculture	4.5	3.0	2.4
Mining	6.5	4.4	0.1*
Manufacturing	7.0	4.7	3.8
Construction	6.5	4.4	3.5
Services	5.5	3.7	3.0

* Ferronickel, by far the largest mining subsector, is assumed to stop growing after 1990 as maximum production levels are reached.

The reference case economic projections provide what are felt to be reasonable assumptions about economic performance - given foreign exchange and other bottlenecks. Sectoral growth from 1978 to 1985 is projected at rates which are consistent with ONAPLAN's estimates in the Plan Trienal. However, continuation of such trends without change in economic structure will lead to a rapid increase in foreign debt and debt service burdens. The reference case assumes this will result in a reduction in the rate at which availability of foreign credit grows. This, in turn, implies that economic growth must be restricted.

In addition to the reference case, several alternative cases have been evaluated. Here, the methodologies used in the sectoral demand projections and the macroeconomic forecasts diverge:

- Sectoral energy demand is still forecast using reference case economic growth projections, but substituting the alternative energy assumptions being examined (such as conservation). This yields a new level of energy consumption under the same set of economic growth assumptions.

- The macroeconomic forecasts, on the other hand, examine changes in economic growth that might result from changing sectoral energy consumption patterns.

The methodology used to generate macroeconomic values under alternative cases is as follows:

(1) annual foreign exchange deficits are held at the same levels as in the reference case.

(2) for each case, specific alternative assumptions as to energy conservation, fuel switching, and so on are introduced.

(3) through an iterative process, a new set of macroeconomic variables is calculated to simultaneously satisfy the external financing constraint of (1) and the new energy use assumptions of (2).

For example, in a case which assumes faster growth in energy prices, current fuel imports will rise faster (other things being equal), and within a given foreign exchange constraint, economic growth will have to be reduced.

The economic growth rates generated in alternative cases should be viewed as indicators of the likely magnitude of the economic impact of deviations from the reference case, rather than as predictions of actual growth rates and levels of economic activity (see Appendix I).

The Base Case projections for the major energy demand sectors are discussed below. No attempt has been made here to present the technical details that went into the projections; they can be found in the Appendices. Appendix I deals with overall macroeconomic projections and the others with specific demand sectors. In the discussion that follows we concentrate on detailing the information which formed the basis for the projections, present the results and briefly discuss their implications.

Industry

The analysis of energy consumption in the industrial sector concentrated primarily on the energy-intensive industries and mining to complement published sources and data provided by petroleum distributors; information on energy use in industry was obtained directly from the factories during on-site visits. The following plants were visited, or furnished information upon request:

Cement:	Fabrica Dominicana de Cemento, Cementos Nacionales, Cemento Cibao,
Mining:	Falconbridge Dominicana, Alcoa Exploration Company, Rosario Dominicana,
Sugar:	Consejo Estatal de Azucar (CEA) Central Romana - Gulf and Western, Concorcio Vicini,
Food and Beverages:	Molinos Dominicanos, J. Armando Bermudez, Cerveceria Nacional Dominicana,
Glass Containers:	Industria Nacional de Vidrio,
Paper:	Industria Nacional de Papel,
Petroleum Refining:	Refineria Dominicana de Petroleo,
Textiles:	Fabrica de Sacos y Tejidos Dominicanos,
Iron and Steel:	Complejo Metalurgico Dominicano (METALDOM).

These subsectors of industry account for well over 90 percent of energy consumption in the sector.

Energy consumption in the different industrial subsectors for 1978 and the projected Base Case demands for 1990 and 2000 are shown in Table II-9. It is apparent that the major energy inputs are fuel oil and reconstituted crude. These make up 90% of the petroleum products consumed. The rest - largely diesel fuel - is used in relatively small amounts scattered throughout the industrial sector.

The single largest petroleum consumer is the nickel mine operated by Falconbridge Dominicana. In 1978 it imported some 1800 kboe of reconstituted crude, the only firm to import crude apart from the refinery. This mix consists of about 25% naphtha, used in the ore reduction process, and 75% fuel oil, used in electricity generation. The fuel oil is used in mining of aluminum ore and gold and for on-site electric generation. The production of nickel in 1978 was unusually low because of depressed world market demands, which is reflected in the low fuel consumption. In previous years, this had been as high as 2900 kboe.

It is assumed that by 1990 the production of this mine will reach the level of former years (about 80 thousand metric tons) and level off from there on.

The cement industry is the second largest user of petroleum, with fuel oil being used for process heat. Only one of the three existing plants has electric generation equipment to meet part of its power needs; the remaining plants are dependent on power from the grid. Two of the plants use the wet process (a more fuel oil-intensive but less electricity-intensive process) while the third uses the more modern dry process. In all three plants, energy use per ton of output can be improved when compared with current international practices. In projecting future energy demand for the cement industry, it was assumed that production will grow at the same growth rate as the construction industry and that energy use per unit of output will decrease by about 15-25 percent.

The sugar industry, while the largest industrial consumer of energy in the country, is the third largest petroleum user. The 5000

TABLE II-9

Industrial Energy Demand Projections
1978 (actual), 1990 and 2000
(kboe)

BASE CASE

	Petroleum Products[a]			Purchased Electricity			Bagasse and Wood[b]		
	1978	1990	2000	1978	1990	2000	1978	1990	2000
Mining	2112	3711	3380	30	29	28			
Cement	927	1518	2390	113	184	290			
Sugar	503	452	430	16	15	140	5007	4507	4342
Food & Beverage	319	538	740	48	86	112	169	301	394
Glass	72	112	170	3	6	8			
Paper	51	49	44	9	8	73			
Petroleum Refining	(278)[c]	(291)	(277)	12	12	12			
Textiles	15	26	34	8	13	17			
Chemicals	20	36	172	7	12	16			
Iron & Steel	34	61	81	39	71	92			
Other & Unaccounted for[d]	377	764	1109	79	262	455			
Total	4430	7267	8550	364	698	1243	5176	4806	4736

a. Includes Fuel Oil, Gas Oil, LPG and reconstituted crude.

b. The sugar industry consumes 99 percent of the bagasse, but hardly any of the wood.

c. The fuel used internally within the refinery is included in the report on Industrial Energy use, but is excluded from the total in this table (it is considered a conversion loss).

d. Obtained as a balance between supplier information and reported uses in Appendix II.

kboe of bagasse cited in the analysis corresponds to the energy content of the bagasse consumed in the sugar mills used to raise steam for process heat and self-generation of electricity (see Chapter II, Section A). Most of the fuel oil is used in the two sugar refineries. Diesel is used in hauling cane and for generating electricity in the off season when no bagasse is produced. The La Romana sugar refinery produces furfural from bagasse as a byproduct, and in turn uses the byproduct of furfural production as a fuel for its boilers.

Sugar production in the Dominican Republic historically has not shown significant long term growth. Rather, it reflects cyclical world market conditions. For the energy projections, production is assumed to remain constant at present levels. The reduced amounts of bagasse projected to be consumed reflect a decrease in the processing needs of the sugar mills due to efficiency improvements.

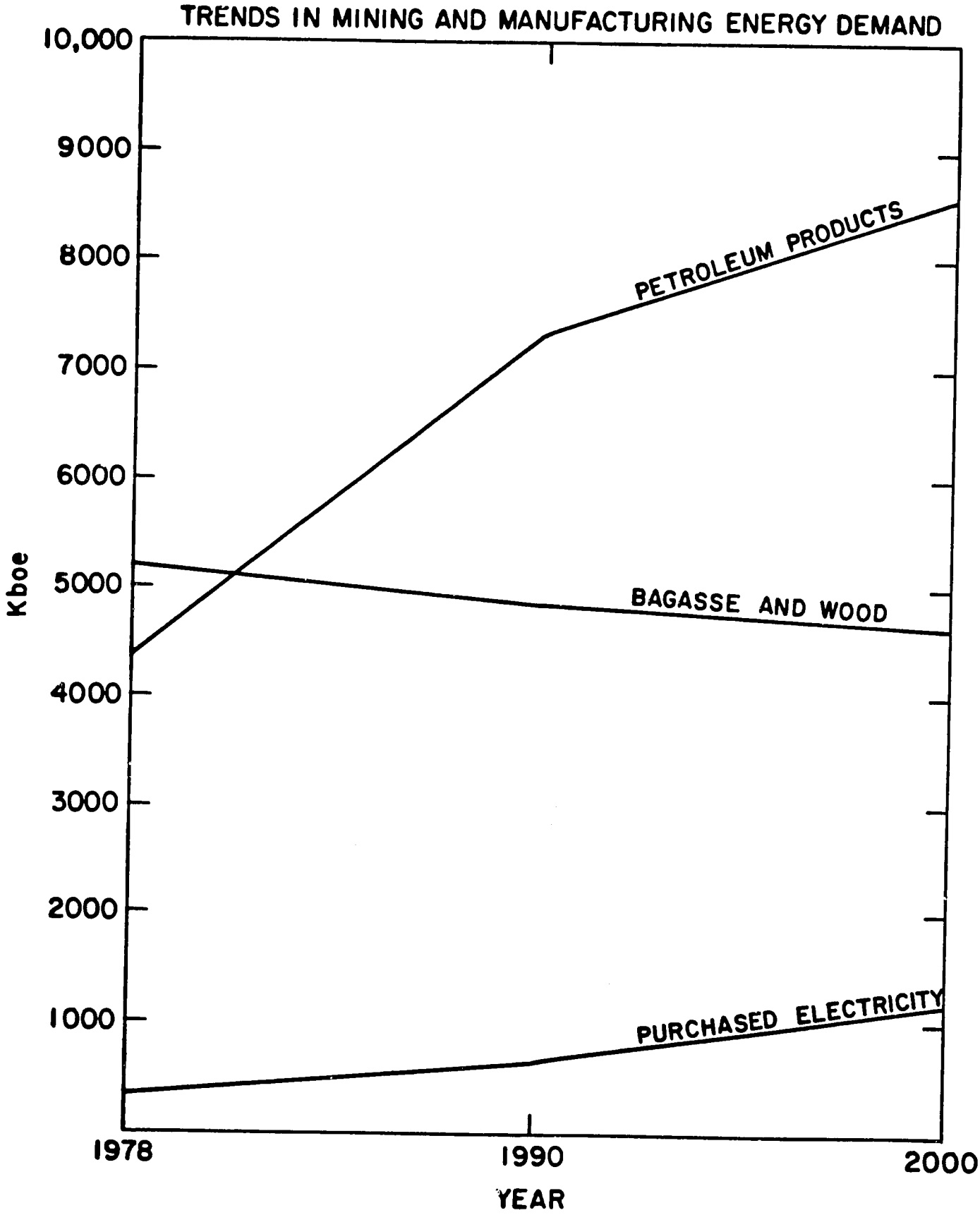
Glass, paper, steel and food preparation industries are assumed to grow at rates projected for the manufacturing sector as a whole. These projections also incorporate improvements in energy consumption, per unit of output, ranging from 10 to 25 percent.

For the industrial sector as a whole, total oil consumption increases from 4,431 kboe to 7,310 kboe in 1990 and 8,550 kboe in 2000. This amounts to an annual rate of increase of 3.4 percent. (See Figure II-3). Demand for bagasse, on the other hand, is expected to drop by 13 percent by the year 2000. Purchased electricity demand rises the fastest, from 363 kboe in 1978 to 665 kboe in 1990 and 1,216 kboe in 2000 which corresponds to an average rate of 5.6 percent over the entire period.

Transportation

Interviews were conducted to 1) verify data taken from previous transportation studies carried out in the Dominican Republic and 2) ascertain specific information dealing with transport energy. The Oficina de Transporte Terrestre (ONATRATE), Federacion Nacional de Transporte Dominicano (FENETRADO), Ayuntamiento del Distrito Nacional, Ayuntamiento de Santiago, and the Secretaria de Estado de Obras Publicas provided information on vehicle fleets and government policy.

FIGURE II-3


TRENDS IN MINING AND MANUFACTURING ENERGY DEMAND
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Kboe
PETROLEUM PRODUCTS
BAGASSE AND WOOD
PURCHASED ELECTRICITY
1978
1990
2000
YEAR

The taxi drivers union, Sindicato Unido de Choferes del Districto Nacional (SIUCHODISNA) provided data on the "publico" fleet including number of vehicles, average fuel consumption, and number of passengers transported.

Interviews were conducted with all of the major bus companies to obtain the characteristics of urban and interurban bus fleet fuel consumption. Trucking companies' staff as well as personnel at highway weighing stations were interviewed to obtain load factors and other parameters needed to estimate energy consumed in freight movement.

Energy consumption for transportation was disaggregated into nine categories - urban mass transit, inter-urban mass transit, private automobiles, large trucks, camionetas (small trucks), private autobuses, aircraft, ships and boats, and miscellaneous.

The projection basis for the mass transit categories depend on the number of urban and interurban publicos and buses, average kilometers travelled, vehicle fuel efficiency, passengers carried, total urban population, and the effectiveness of the government plans to rapidly replace publicos with minibuses.

The basis for projection of private automobile fuel use and small truck demand depends on the number of automobiles, vehicle fuel efficiencies, disposable income, and government pricing policies for petroleum products.

The information necessary to make projections on the consumption by freight movement is the size of the cargo carrying fleet, vehicle fuel efficiencies, total tons hauled, and distances travelled.

Jet fuel consumption was projected based on past years, and the information was provided data on from the Banco Central and the refinery. Bunkers Santo Domingo provided fuel consumption for ships and boats for 1978, and the projections assume that consumption will rise with the export levels projected in the macroeconomic section.

Overall fuel demand in the transportation sector is projected to increase from 4,124 kboe in 1978 to 5,648 kboe in 1990 and 8,472 kboe in 2000 - an annual rate of 3.5 percent over the whole period. The increase includes some important changes in the fuel mix (see Table II-10). Largely because of the government's policy of replacing the

TABLE II-10

TRANSPORTATION ENERGY DEMAND PROJECTIONS

1978 (actual), 1990 and 2000
(kboe)
Base Case

	Gasoline			Gasoil			Jet Fuel/Bunker[a]			Total		
	1978	1990	2000	1978	1990	2000	1978	1990	2000	1978	1990	2000
Urban Mass	510	365	575	128	363	569				639	728	1144
Interurban Mass	1069	607	640	248	707	1189				1317	1314	1829
Private Automobiles	596	745	931	20	25	32				616	770	963
Large Trucks				525	992	1396				525	992	1396
Small Trucks (Camionetas)	330	412	514	65	152	244				395	564	758
Private Buses				49	110	217				49	110	217
Aircraft	37	83	164				300	676	1330	337	759	1494
Ships and Boats				125	212	355	64	98	151	189	310	506
Miscellaneous	57	101	165							57	101	165
Total	2600	2313	2989	1160	2561	4002	364	774	1481	4124	5648	8472

a. Jet Fuel is used by aircraft and bunker by ships and boats.

publico automobiles with minibuses, gasoline demand will remain stagnant over the entire period, while gasoil demand is projected to increase 3 1/2 fold. As Figure II-4 shows, the trend of replacing gasoline with gasoil is most pronounced in interurban mass transport, where gasoline consumption is projected to decline by 43 percent from 1978 to 1990 and then remain almost constant from 1990 to 2000. Gasoil consumption in interurban mass transport, on the other hand, is projected to increase at an annual rate of 9.2 percent between 1978 and 1990 and at 5.3 percent between 1990 and 2000.

A rapid increase in gasoil demand is expected for large trucks, camionetas (small trucks), urban mass transport, private buses, and ships and boats. Gasoline demand is also projected to gradually increase over the period from 1978 to 2000 for private automobiles, small trucks and aircraft. Jet fuel consumption amounted to only 8 percent of total fuel demand in transportation in 1978, but it is projected to grow at an annual rate of 7.0 percent up to the year 2000.

Even though energy demand in the transport sector is expected to grow at a modest annual rate of 3.7 percent over the period up to 2000, this will lead to a significant increase in the use of these imported fuels. Although the drastic measures which have already been taken by the government to replace gasoline with gasoil constitute a significant improvement over what might otherwise have been an even more serious drain on the country's foreign trade balance, the magnitude of oil demand in the transportation sector will still be almost as large as the total demand for oil in both mining and manufacturing in 1990 and 2000.

Commercial and Government Sectors

The Commercial and Government sector consists of the following subsectors:

(1) Standard Commercial - offices, retail shops, restaurants;

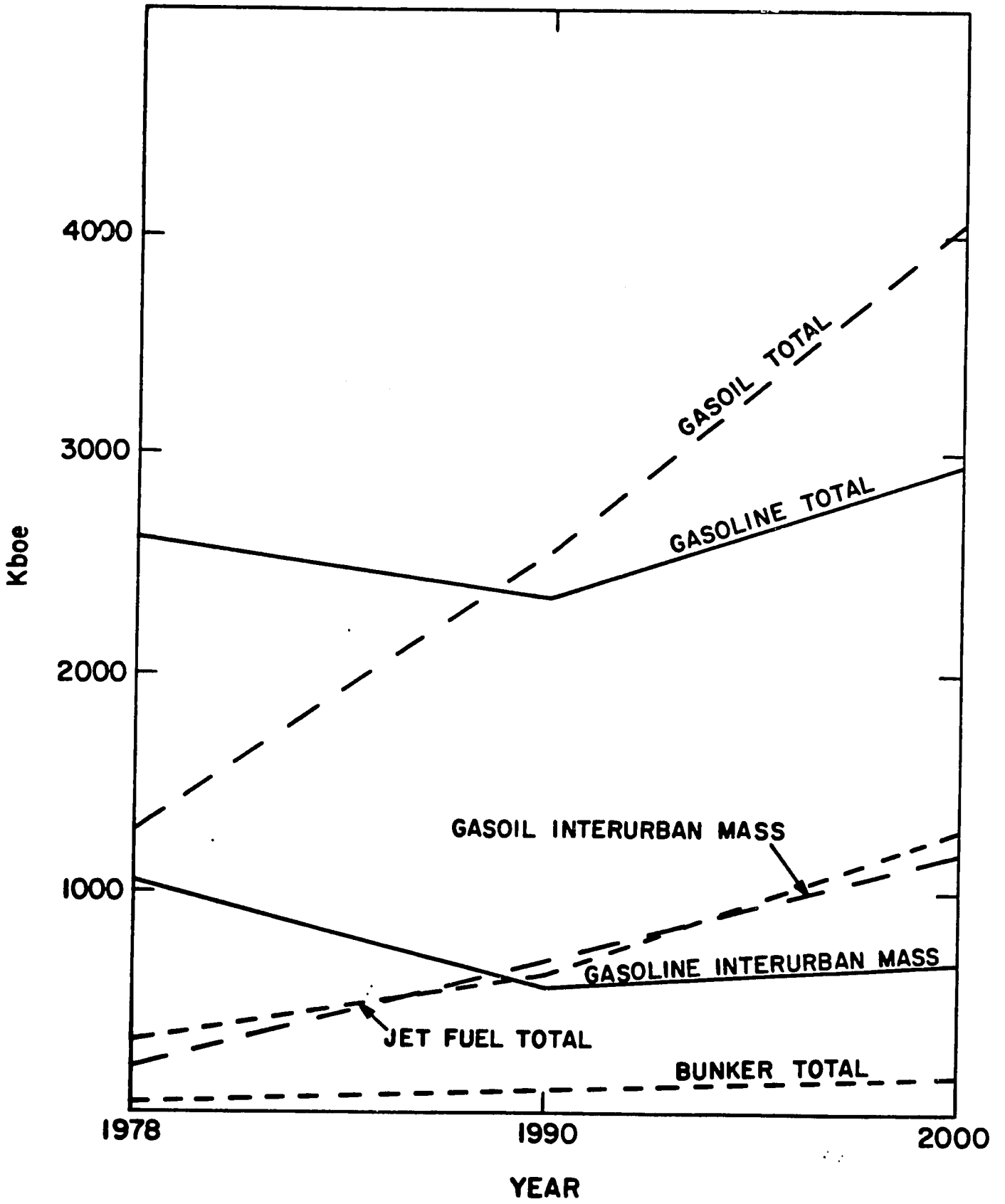
(2) Construction - energy demand of equipment and machinery at construction sites;

(3) Government - national and municipal offices; and

(4) Public Services - water, sewage, garbage, public lighting, road maintenance.

FIGURE II-4

TRENDS IN TRANSPORTATION ENERGY DEMAND



Data for commercial sector energy use comprises mainly information obtained from the suppliers of energy and large consumers. Electricity information was obtained from CDE documents and from unpublished consumption information solicited from the utility. The Banco Central and the Secretaria de Estado de Industria y Comercio along with Obras Publicas y Transporte provide information on fuel use in government and other commercial activities.

LPG, diesel and electricity consumption was extracted from distributors' sales statistics as well as from government reports, and the characteristics of this use were obtained from a water heating study done for the country, an accounting of air conditioner manufacture and import, and an analysis of auxiliary generation equipment.

Most of the current energy demand in the commercial and goverment sectors is evenly divided between gasoil and purchased electricity (See Table II-11). Gasoil consumption was 311 kboe and purchased electricity consumption 245 kboe in 1978. Together they accounted for 93 percent of all energy consumed in this sector.

Energy demand projections for the commercial sector were based on GNP growth rates. Historical trends were used in determining the growth rate of the government's electricity consumption. Gasoil for private auxiliary power generation is projected to be phased out gradually by the year 2000 as public utility generation expands to satisfy the demand for purchased electricity. Under these circumstances, the projected growth rate for electricity in this sector is 7.8% through 2000, 3% for fuel oil, and 6.1% for LPG.

Urban and Rural Households

Information on the energy consumption patterns in urban households was obtained in part from CDE's electricity sales along with LPG distributors' sales to the residential sector. A survey of 660 low-income households was especially conducted for the energy assessment project in Santo Domingo, Santiago, San Pedro de Macoris and Barahona. In addition, useful information was obtained from the Banco Central's national survey of Household Income and Expenditure.

TABLE II-11

COMMERCIAL SECTOR ENERGY DEMAND PROJECTIONS
1978 (actual), 1990 and 2000
(kboe)

BASE CASE

	Electricity			LPG			Gas Oil		
	1978	1990	2000	1978	1990	2000	1978	1990	2000
1. Standard Commercial Activities	126	305	460	39	94	142	114	113	87
2. Construction	N/A	-	-	-	-	-	106	204	288
3. Government	86	285	473	-	-	-	-	-	-
4. Public Services	33	108	180	-	-	-	91	147	216
Total	245	698	1113	39	94	142	311	464	591

Source: See Appendix IV

Rural household consumption data used information obtained from the Banco Central Survey, CDE and a household energy survey conducted by PCI which covered over 900 rural households, both farm and non-farm in three regions.

Energy use patterns in rural households are quite distinct from that of urban households (See Tables II-12 and 13), where household energy use is determined largely by household disposable income and easy access to a variety of energy fuels. For example, in rural households, wood and, to a lesser extent, charcoal are predominant energy sources, as these fuels can be obtained at little or no monetary cost. In urban areas, on the other hand, relatively low prices for LPG are allowing it to replace charcoal as a cooking fuel as household income rises. With the widespread availability of electricity in urban areas, air conditioning and electric applicances have also become important consumers of energy in higher income households.

In terms of absolute quantities of energy consumed, cooking is by far the most important end-use of energy in both rural and urban households because of the low efficiency with which firewood and charcoal, the two most predominent fuels, are used. In terms of energy content, two to four times as much woodfuel as LPG is needed to cook a meal. In rural households cooking with woodfuels accounts for 98 percent of all energy used. In urban households cooking with charcoal accounts for over two-thirds of the total household energy budget.

The next largest use of energy in households is for lighting and other appliances. In the 18 percent of rural households having access to electricity, lighting accounts for 90 percent of electricity consumption since only a small percentage of households own appliances. The remainder of rural households light with kerosene.

In contrast to rural areas, over 90 percent of urban households are electrified. Close to one-half of urban households own televisions and radios, while one-quarter have refrigerators. Together, lights and appliances, excluding air conditioners and water heaters, account for approximately two-thirds of all urban household electricity consumption.

TABLE II-12

URBAN HOUSEHOLD ENERGY DEMAND PROJECTIONS
1978 (actual), 1990 and 2000 (Base Case Projection)
(kboe)

End use	Year	LPG	Kerosene	Electricity	Charcoal	Firewood	Solar
Cooking	1978	390	-	0+	2233	14	-
	1990	1007	-	0+	1155	11	-
	2000	1776	-	0+	983		-
Water heating	1978	6	-	79	N/A	N/A	0+
	1990	-	-	223	N/A	N/A	147
	2000	-	-	361	N/A	N/A	282
Air Conditioning	1978	-	-	46	-	-	-
	1990	-	-	136	-	-	-
	2000	-	-	281	-	-	-
Lighting and Appliances	1978	0+	37	236	-	-	-
	1990	0+	40	610	-	-	-
	2000	0+	40	1013	-	-	-
Total	1978	396	37	361	2233	14.0	-
	1990	1007	40	969	1155	11.3	147
	2000	1776	40	1654	983	6	282

TABLE II-13

RURAL HOUSEHOLD ENERGY DEMAND PROJECTIONS
1978 (actual),1990 and 2000 (Base Case Projection)
(kboe)

End Use	Year	Wood	Charcoal	Kerosene	Electricity
Cooking	1978	3186	507	-	-
	1990	3186	752	-	-
	2000	2860	801	-	-
Lighting and Appliances	1978	-	-	79	15
	1990	-	-	76	30
	2000	-	-	62	38
Total	1978	3186	507	79	15
	1990	3186	752	76	30
	2000	2860	801	62	38

TABLE II-14

AGRICULTURAL ENERGY DEMAND PROJECTIONS

1978 (actual) 1990 and 2000

(kboe)

BASE CASE

Crop	Direct Fuel			Fertilizer		
	1978	1990	2000	1978	1990	2000
Sugar	68.2	81.1	92.5	390.2	463.9	529.3
Tobacco	1.7	2.4	3.1	4.2	5.8	7.7
Rice	9.1	17.3	24.1	82.9	157.3	219.7
Cocoa	0	0	0	0.5	0.8	1.0
Tomatoes	1.1	1.2	1.3	12.5	14.0	15.0
Coffee	0	0	0	3.3	5.4	5.9
Yuca	1.1	1.2	1.2	0.5	0.6	0.6
Corn	1.1	1.5	1.8	1.4	1.9	2.4
Potatoes	0.2	0.2	0.2	2.3	2.3	2.3
Beans	1.6	2.5	3.2	3.5	5.4	7.0
Other, incl. livestock	5.7	5.7	7.6	32.5	32.5	43.2
Total	89.8	113.1	135.0	536.6	689.9	834.1

Water heaters themselves account for 20% of household electricity consumption.*

The basis of urban household energy projections depends on the following parameters: population, rural-urban split, household size, household growth rates, and disposable income. Current population estimates have been made by the Consejo Nacional de Poblacion y Familia (CONAPOFA) and urban-rural trends have been examined in the statistical office's publication La Republica Dominicana en Cifras 1980. Using this information, household growth rates have been estimated. The 1970 census provides a total number of housing units in the country with an urban-rural breakdown, and more recent housing stock information was extracted from a report done for the Banco Nacional de la Vivienda.

It was assumed that disposable income in urban households will grow at the same rate as GNP and that the present trend toward urbanization will continue. Due to these trends and continued low LPG prices, the share of cooking done with LPG will increase, doubling by 1990.

It is expected that despite significant price increases, electricity use will grow quickly in the coming years. Historically, electricity consumption in households has grown one and a half times as fast as GNP. This relationship is assumed to continue. The use of electricity for lighting and applicances is estimated to grow at approximately 13 percent annually until 1985 and thereafter grow at about one-half that rate until the year 2000.

In rural households, a gradual shift from wood to charcoal was assumed, while the use of electricity for lighting was projected to more than double by 2000, implying a decrease in the use of kerosene for this purpose.

By that year, it is estimated that 40 percent of rural households will be electrified.

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* Over the next 20 years, the use of solar water heaters is expected to increase substantially. In the projection of future energy demand using renewables, solar water heaters are assumed to account for one-half of all new installations.

Agriculture

Agriculture output and energy use data were obtained from the Oficina Nacional de Estadistica, the World Bank report for the Dominican Republic, and preliminary findings of a study on "Energy in the Food System in the Dominican Republic" carried out by PCI and Brookhaven.

The projections of energy demand in agriculture are based on existing trends in the production of food products. The trends are taken from the PCI study, based on production data in the 1970's. In projecting the direct fuel consumption and energy consumed indirectly through fertilizers, no attempt was made to alter the overall energy input patterns.

From Table II-14 it is apparent that sugar is and will continue to be the dominant crop in terms of both direct fuel use, consuming 83 percent of the total direct energy requirements of all major crops, and 77 percent of energy indirectly consumed through fertilizer. Fertilizer is, by far, the most important energy input to agriculture: in 1978 energy consumed through fertilizer was six times that of fuel consumed directly. Direct fuel use is primarily diesel used for pumping and soil preparation. This ratio is likely to remain in effect.

III. ENERGY SUPPLY-DEMAND SCENARIOS

There are several pre-eminent questions that must be considered when addressing the energy supply-demand situation in the Dominican Republic: What options exist for holding down increases in imports of oil to the Dominican Republic during the 80's? To what extent can renewable resources substitute for the use of oil in the generation of electricity over the next two decades? Are there key structural factors built into the development of the Dominican economy which will continue to drive energy use per capita steadily upward for the forseeable future?

Answers to these and similar questions will depend in part on the international scene, such as the future prices of oil, sugar and nickel or the rate at which the cost of renewable resource technologies (solar cells, biomass-alcohol conversion units, etc.) will decrease. The answers will also depend on domestic developments in the Dominican Republic, especially on the direction of government policies. Energy-specific policies include alterations in the domestic fuel price structure, regulations imposing energy conservation, restrictions on the importation of solar devices in favor of domestic manufacturers, and directives on the creation of domestic energy production and delivery organizations. Other policy issues might indirectly influence energy supply or demand, such as the allocation of capital resources, decentralized versus centralized industrial development, and import/export strategies. Decision-makers in the Dominican Republic are therefore faced with some predetermined factors over which they have no control as well as a body of options within which they can direct the country's energy future to a certain extent.

A. PURPOSE AND SCOPE OF SCENARIOS

The energy supply-demand scenarios represent a systematic explanation of the likely effects of major policy alternatives in the future. Each scenario is intended to portray an internally consistent energy supply and demand flow for a specific year, taking into consideration the major exogenous factors mentioned above. The current year is 1978, the latest year of complete data, and the target years chosen are 1990

and 2000. Because of the limitations of the data base, however, no attempt has been made at this stage to systematize the procedure within the structure of a formal mathematical model. This may be carried out at a later stage in the assessment project. For the time being we limit ourselves to making assumptions about changes in 1) the parameters driving energy demand in the productive and consuming sectors of the economy (for example, cement production or household usage of appliances); 2) devices, equipment, and processes employed to convert input fuels to useful output forms of energy (e.g. motor drive and heat) and 3) combinations of primary energy resources likely to be employed in providing these input fuels.

The seven scenarios analyzed in this chapter for 1990 and 2000 are:

Scenario 1: Base Case
Scenario 2: Coal/Hydro Case
Scenario 3: Renewables Case
Scenario 4: Conservation Case
Scenario 5: Combined Case
Scenario 6: Limited Oil Case
Scenario 7: No Action Case

All of the scenarios use a common basis for generating energy demand based on specific assumptions about the continued economic and social development of the Dominican Republic and its future population.

The scenarios also share a common perspective on the international environment. Oil prices on the international market are expected to increase by 2 percent per year. Domestic sugar and mining production levels are assumed to remain at historical levels through 2000. Current government policies with respect to domestic production vs. importation of energy intensive materials such as cement, aluminum and steel products, and fertilizers are assumed to remain essentially unchanged. We also assume that the location of major centers of population will remain relatively static, and that the current allocation of funds to urban, agricultural, and transportation infrastructures will not undergo major change. This means no major changes in energy-sensitive parameters such as passenger transport demands, build-up of mass transit systems and shifts toward rapid mechanization of agriculture.

Although this report does not deal with the influence of energy prices in an explicit manner on a micro-level, the scenarios implicitly assume that energy prices will continue to rise over the next decade and beyond, thereby creating adequate incentives for the substitution of more energy efficient devices: coal for oil, and solar for conventional devices, etc.

Beyond these points, the assumptions built into the scenarios diverge somewhat. The Coal/Hydro Case assumes the availability of an insured supply of coal at prices below that of oil when calculated on the basis of BTU content, and that the cost of installed hydro units will not become prohibitive. The Renewables Case makes certain assumptions about the price competitiveness of renewable resource technologies and the ability of domestic distributors to purchase the equipment from overseas sources, or, where feasible, to obtain licenses for domestic manufacturing on reasonable terms.

The Conservation Case takes for granted the presence of both general and energy-specific government policies that remove barriers to the continued inefficient use of energy. These may take the form of restrictions on the import of equipment that is not energy efficient and mandatory regulations controlling the rate of turnover of inefficient boilers, automobiles, trucks and factories.

Three other scenarios are dealt with in this chapter--the Base Case, the Low Oil Consumption Case, and the No Action Case. Each serves a special purpose. The Base Case is intended to show the effects of existing government programs aimed at changing the current supply-demand equation in the Dominican Republic. It also is intended to serve as a reference point for comparing what can be achieved by way of additional actions. The Low Oil Consumption Case is intended to make clear what kinds of changes are required in the way that energy is produced and consumed in the Dominican Republic to maintain oil imports at or near current levels. The No Action Case demonstrates the effects on oil imports of a delay in implementing these on-going programs.

The process of balancing energy supply and demand for a given set of assumptions underlying a scenario and a specific target year

involves an iterative checking and adjusting between the entries on the supply side and specific estimates on energy demand. This allows the identification of data classification and reporting errors, the reconciliation of identical information from different sources or perspectives, and a check whether certain of the assumptions made in each scenario are reasonable.

Without concerted government action, it usually takes a long time for one energy resource to replace another. Existing equipment and knowledge constitute real capital investments that cannot be discarded without incurring heavy economic losses to the national economy. This is particularly true when, as now, we wish to replace oil products which in general were cheaper and easier to handle, with coal, hydro, and renewable resources. Increasing the efficiency of end-use conversion of energy, while generally less disruptive, requires additional capital investment by industry which does not always show up in increased corporate or national productivity.

Recognition of these constraints serves to delineate the specific actions considered in each of the scenarios. It is, for example, difficult to imagine how a radical change in the national stock of freight hauling vehicles can occur in the Dominican Republic by 1985 or even 1990. It is equally difficult to expect that all homes in major urban areas with hot water heaters will employ solar devices by the end of this decade, and there is no technically feasible means for hydro resources to generate a major fraction of the country's electricity before well into the 90's. Although a variety of economic, institutional, and social factors operate to constrain change in an existing national energy supply-demand balance, as noted earlier in this report, we are concerned mainly with establishing the technical limits of each of the major options open to the Dominican Republic to reduce its dependence on imported oil.

B. SCENARIO 1: BASE CASE

The significance of the Base Case scenario is first, that it presents a composite picture showing what energy resources are likely to be employed to meet the increase in energy demand that can be expected

in the Dominican Republic over the next 10-20 years. Second, it provides a point of departure for measuring the impacts of other energy strategies. The picture provided by the Base Case should not be viewed as a prediction of events or even as a "most likely" outcome. Rather, it should be seen as a means of providing answers to policy-makers who ask:

- What will happen to the demand for energy in the Dominican Republic if economic and social developments continue at or near the levels of the recent past?
- What will be the impacts on such critical factors as oil imports if energy-related policies already undertaken by the government proceed according to plan?
- What flexibility is retained by the government to deal with situations that may come about as a result of sudden changes in the global energy situation?

The assumptions that have been used to prepare the Base Case are shown in Tables III-1 and III-2. More detailed information on the assumptions used in projecting energy as well as fuel demands for individual end-use sectors are given in Chapter II, Section C, and in Appendix I. As can be seen, the driving force behind the configuration of future energy in this Base Case (and all other scenarios) are the demand projections prescribed in Chapter II, Section C. What follows concerns the supply resources and technologies that will have to be made available to meet these demands.

The share of electricity assigned to each major end-use sector to meet these increased demands takes into account the expected growth in electricity-specific devices and equipment in households, office buildings, and manufacturing facilities. Electricity demands for new economic activities not currently present in the Dominican Republic are classified under New Demands. Table III-3 lists the projected electricity demands for the Base Case for 1990 and 2000.

Projected sales of electricity amount to a total of 3061 kboe (5206 Gwh) in 1990 and 4854 kboe (8252 Gwh) in 2000 which corresponds to an average yearly growth rate of 9.9 percent from 1978 to 1980 and 5.9 percent from 1990 to 2000. Assuming transmission and distribution losses are reduced to 17 percent, total generation climbs to 2676.6 kboe (6230 Gwh). This amount is 12-13 percent lower than the generation envisioned by CDE in 1990.

TABLE III-1

BASE CASE - PRINCIPAL ASSUMPTIONS

Energy Demands

- Nickel production grows to maximum historical levels by 1990, and remains that high thereafter.
- New industries will consume approximately 670 kboe of electricity in 1980 and 1000 kboe in 2000.
- Household energy use grows in tandem with the rate of new household formation and increases in disposable income.

Energy Efficiency

- "Housekeeping" measures are taken by industries that cut energy waste and new factories use less energy per unit of output, saving approximately 1000 kboe of oil in 1990 and 2000 kboe in the year 2000.
- Publicos are replaced by minibuses for urban transport and by buses for intercity travel, saving 82 kboe in 1990 and 125 kboe in 2000.

Fuel Susbtitutions

- Solar heaters capture a significant portion of the water heating market.
- Fuel for auxiliary electric generation is eliminated by the year 2000.
- The substitution of LPG for charcoal as a cooking fuel continues.

TABLE III-2

BASE CASE -
PUBLIC UTILITY ELECTRIC GENERATING SYSTEM

	Electric Generation (kboe)			Installed Capacity (MW)		
	1978	1990	2000	1978	1990	2000
Hydro	552	2650	5300	160	500	1000
Gasoil/Gas Turbine	960	915	1465	147	**	**
Fuel Oil Steam	3550	3350	3350	377	300	300
Coal Steam	-	1690	2960	-	450*	800

* First Unit by 1983

** Assumed to contribute 5 percent of total Gwh generated by the system

TABLE III-3

BASE CASE

PROJECTED ELECTRICITY DEMAND

(kboe)

	1978	1990	2000
Residential, Urban	361.	969.	1655.
Residential, Rural	15.	29.	37.
Commercial	245.	698.	1112.
Industry	364.	697.	1052.
New Demands[1]	364.	668.	998.
Total	985.	3061.	4854.

1. Assumes that by 1990 there are the following new uses: a caustic soda/chlorine plant, a new refinery and one fabricated metals plant (386 Gwh), new hotels (110 Gwh), irrigation projects (100 Gwh), a solar water heater industry (240 Gwh) and other (300 Gwh). During the second decade of the projection, these new demands are assumed to be created at half the rate of the prior decade, consistent with the lower growth in GNP during that period. Growth in demand for cement is included under industry.

Source: See text, except where noted.

1 kboe = 1.7 Gwh

The additions of energy inputs into the public utility generating system for the first decade are 450 MW of coal-steam plants and 350 MW of hydropower. The 300 MW of fuel oil generation capacity now operating is assumed to continue to be used. Between 1990 and 2000, hydropower becomes the major source for additional generation, increasing by 500 MW to a total of 1000 MW. An additional 350 MW of installed coal capacity raises the total to 800 MW. Peaking gas turbines account for 5 percent of demand.

Table III-4 shows the projected demands for petroleum products. Lubricant and asphalts have been escalated at the rate of growth of the construction industry. It has also been assumed that a high rate of mineral output from Falconbridge will preclude the sale of surplus electricity to the public utility.

Figures III-1, 2 and 3 present the summary balances for the current energy situation (1978), and the Base Case for the years 1990 and 2000. Taken together with projected sectoral energy consumption given in Chapter II, Section C and the above breakdowns of electricity and petroleum products these figures describe an energy supply-demand situation in the Dominican Republic, which is evolving as follows:

- Total energy supply and demand is projected to grow from 28,250 kboe in 1978 to 39,800 kboe in 1990 and 52,700 in the year 2000. This corresponds to annual growth of 2.9 percent from 1978 through 1990 and 2.8 percent thereafter.
  The total growth of energy resources between 1978 and 1990 is 40 percent, and the increase from 1990 to 2000 is 32 percent. These increases are in primary energy resources, which includes values for the energy derived from the use of hydropower. If this is removed from the totals then the percentage increases become 33 percent and 27 percent respectively.

- The fastest growing energy resource is, in fact, hydropower which is scheduled to grow at an annual rate of 14 percent through 1990 and 7 percent thereafter.

- Petroleum demand grows at an annual rate of 2.6 percent through 1990 and 2.8 percent in the decade following. This relatively moderate rate of increase in the use of petroleum products is due in substantial part to the substitution of coal for oil for electricity generation. This will require imports of 1.3 million tons of coal per year by 1990 and 2.4 million tons of coal per year in the following decade.

TABLE III-4

BASE CASE-

PETROLEUM PRODUCTS PROJECTIONS* (KBOE)

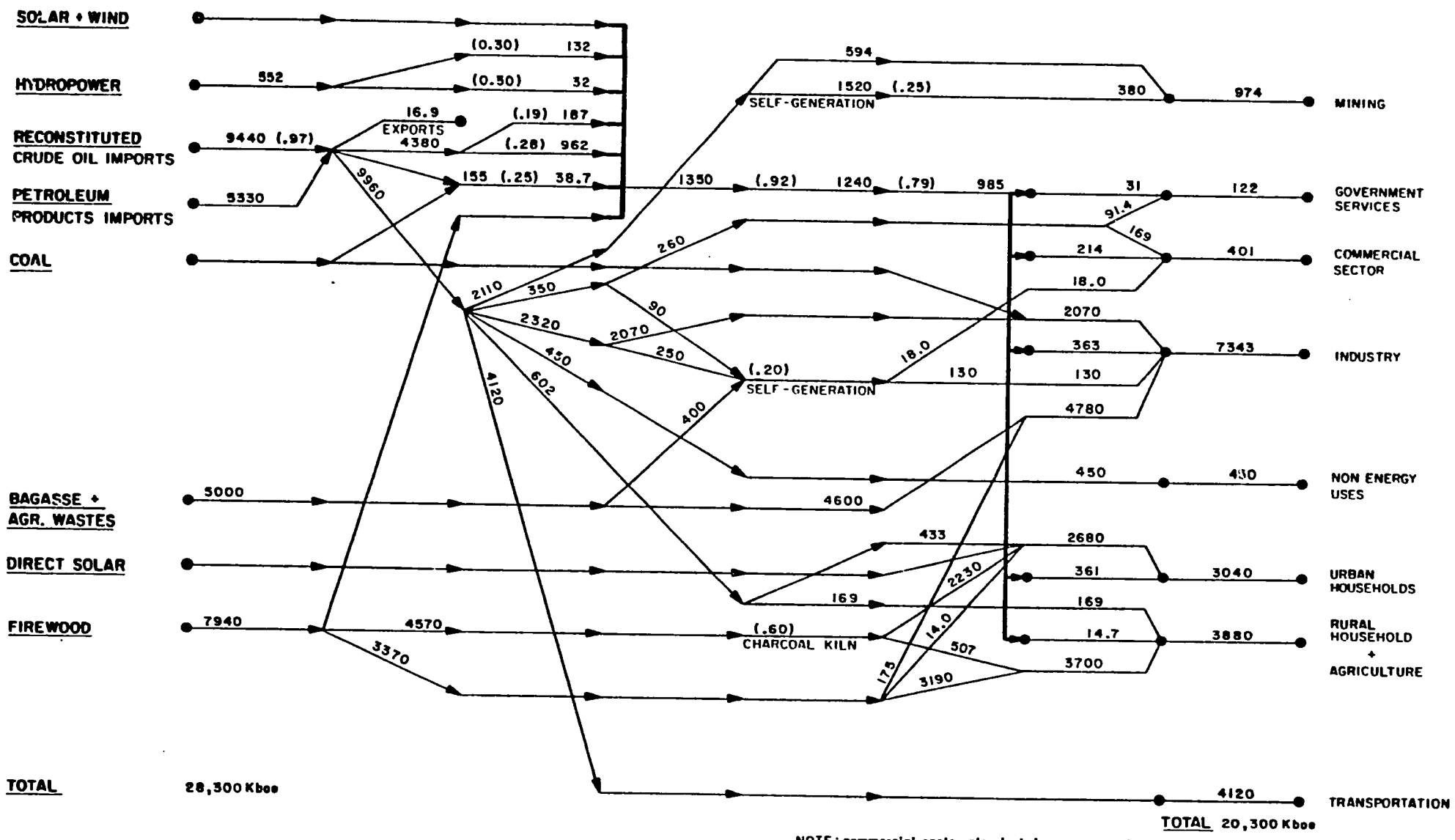
1978, 1990 and 2000

	1978				1990				2000			
	LPG	Gasoline	Gasoil	Fuel Oil	LPG	Gasoline	Gasoil	Fuel Oil	LPG	Gasoline	Gasoil	Fuel Oil
CDE	-	-	976	3403	-	-	915	3350	-	-	1465	3350
Mining	-	-	207	1906	-	-	380	3330	-	-	348	3030
Industry	-	-	232	2035	98	-	500	3000	-	-	826	4810
Commercial/ Government	-	-	311	-	93	-	460	-	140	-	590	-
Transportation	-	2562	1159	64	-	2230	2350	98	-	2820	3650	150
Household	397	-	-	-	1010	-	-	-	1770	-	-	-
Agriculture	-	-	90	-	-	-	113	-	-	-	135	-

* Other petroleum products not included

1. Jet Fuel: 337 (1978), 760 (1990) and 1500 (2000)
2. Lubricants & Asphalts: 450 (1978), 870 (1990) and 1220 (2000)
3. Kerosene: 115 (1978), 115 (1990) and 100 (2000)

ENERGY BALANCE DOMINICAN REPUBLIC (KBOE)
1978



NOTE: commercial sector also includes government buildings and construction industry.

Figure III - 1

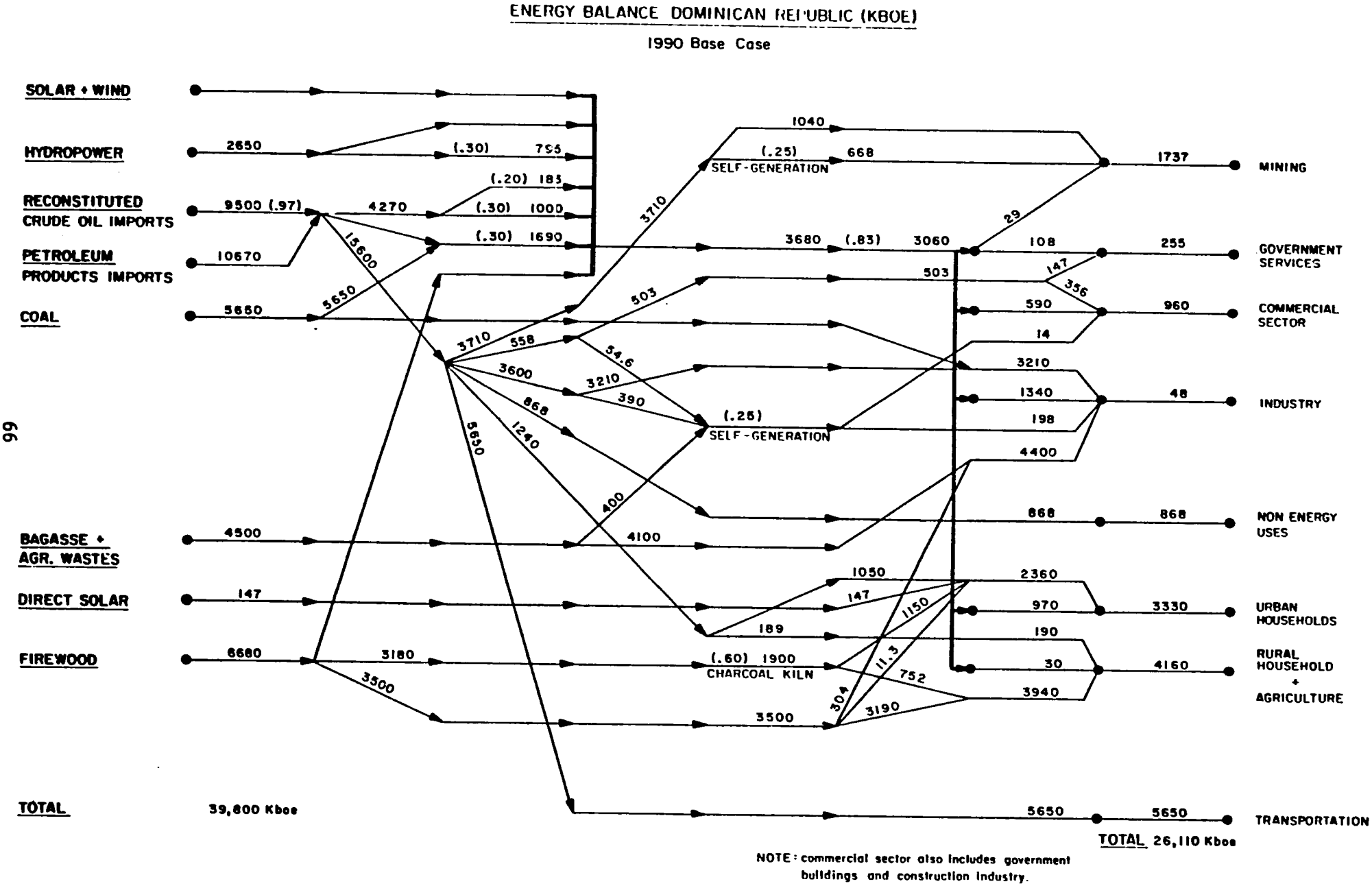
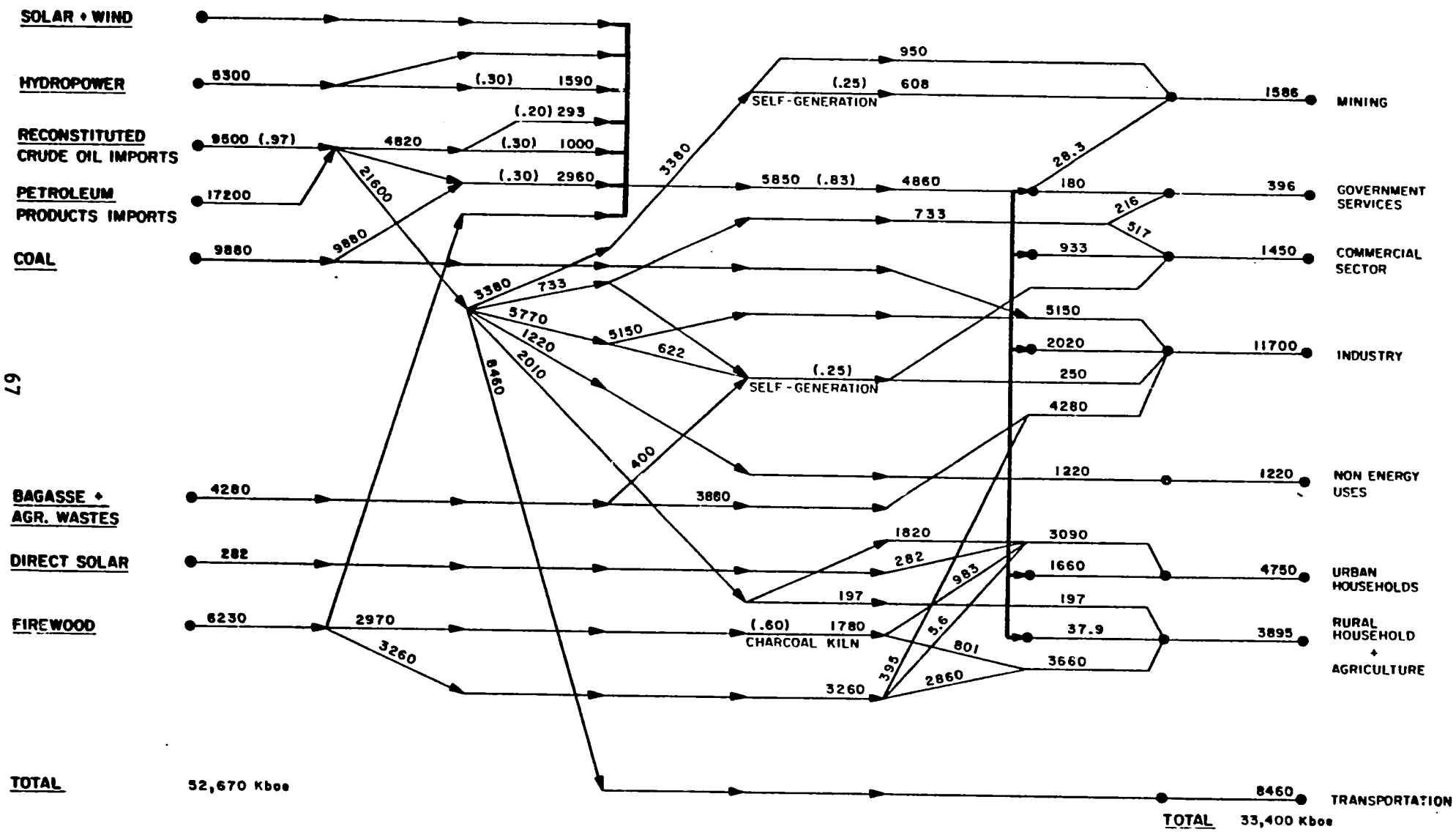

ENERGY BALANCE DOMINICAN REPUBLIC (KBOE)
1990 Base Case
SOLAR + WIND
HYDROPOWER
2650
(.30)
795
(.20) 185
RECONSTITUTED CRUDE OIL IMPORTS
9500 (.97)
4270
(.30) 1000
(.30) 1690
PETROLEUM PRODUCTS IMPORTS
10670
15600
COAL
5650
5650
3710
558
3600
868
1240
5650
503
54.6
3210
390
400
4100
BAGASSE + AGR. WASTES
4500
DIRECT SOLAR
147
FIREWOOD
6660
3180
3500
TOTAL
39,800 Kboe
1040
(.25)
668
SELF-GENERATION
3680
(.83)
3060
503
(.25)
SELF-GENERATION
868
1050
147
189
(.60) 1900
CHARCOAL KILN
3500
29
11.3
304
1150
752
3190
1737
MINING
108
147
356
255
GOVERNMENT SERVICES
590
960
COMMERCIAL SECTOR
14
3210
1340
198
48
INDUSTRY
4400
868
868
NON ENERGY USES
2360
970
3330
URBAN HOUSEHOLDS
190
30
4160
RURAL HOUSEHOLD + AGRICULTURE
3940
5650
5650
TRANSPORTATION
TOTAL 26,110 Kboe
NOTE: commercial sector also includes government buildings and construction industry.

Figure III - 2

ENERGY BALANCE DOMINICAN REPUBLIC (KBOE)

2000 Base Case



NOTE: commercial sector also includes government buildings and construction industry.

Figure III - 3

- In spite of the substitution of mini-buses for publicos, oil used in transportation increases by 37 percent between 1978 and 1990, and even faster by 53 percent in the decade 1990-2000.

- Because of the newer facilities producing and distributing electricity, the average efficiency of conversion of energy resources to delivered electricity increases significantly. Production efficiency increases by 7 percent, and lines losses are reduced by 23 percent.

- Not only does the fraction of electricity produced by self-generation decrease considerably, but the efficiency of these units is scheduled to increase by 25 percent.

- Firewood, bagasse, and other agricultural waste, which currently account for 45 percent of total primary energy resources used in the Dominican Republic, are scheduled to decline to 28 percent in 1990 and to 20 percent by the year 2000. The substitution of LPG for charcoal in urban households is reducing the demand for charcoal, thereby reducing the use of firewood. Although as much energy is obtained from the use of bagasse as is currently the case, the overall tonnage of bagasse is projected to decline by 10 percent.

- Finally, although substantial amounts of coal and hydropower have been introduced, the fraction of total energy resources being met by imported oil remains near 50 percent. In absolute terms, these imports increase by 36 percent between 1978 and 1990 and 34 percent from 1990 to 2000. The large increases during the 80's are due to direct use of petroleum products rather than use by the public utility. Noteworthy are the 100 percent increase in urban households, the 55 percent increase in industry, the 75 percent increase in mining and the 37 percent increase in transportation (in spite of the assumed substitution of mini-buses for publicos). Between 1990 and 2000 the most significant increases come from transportation (50 percent), industry (60 percent), and urban households (62 percent).

C. SCENARIOS 2, 3 & 4: COAL/HYDRO, RENEWABLES, AND CONSERVATION CASES

It is important that policy-makers understand the technical limits of strategies aimed at (a) substituting for oil and fuels likely to be in more plentiful supply, (b) maximizing the use of indigenous resources, or (c) reducing demand for energy by increasing the efficiency of its end-use. These technical limits are imposed primarily by engineering as opposed to economic and/or institutional constraints. They arise out of the need to consider such factors as

the time required to construct hydro installations, coal-burning electric generation plants, port facilities to handle coal, etc. They also take into consideration the state-of-the-art of newly developing energy conversion technologies, as well as the useful lifetimes of existing facilities, equipment, and devices that consume energy in producing useful goods and services.

Taken together, these three scenarios bracket what should be technically feasible to accomplish within the next two decades to reduce the dependence of the Dominican Republic on imported oil without curtailing the projected demand given in Chapter II, Section C. The coal/hydro scenario examines how quickly oil consumed in the production of electricity at CDE and in large industries can be reduced through the construction of new hydropowered and coal-fired stations. The renewables scenario is also primarily directed toward reducing the need for oil in the production of electricity through the use of especially grown biomass and solar ponds. Finally, the energy conservation scenario concentrates on exploring ways for increasing the end-use efficiency of energy in households, factories, and transportation systems.

Tables III-5, 6 and 7 summarize the assumptions that have been used in preparing each of these three scenarios. The results expressed in terms of energy resource utilization are given in Table III-8.

Coal/Hydro Case

By 1990 it is assumed that two operating fuel oil units will have been retrofitted to the use of coal. This will add an additional 160 MW to the installed coal-fuel installations, raising this total to 610 MW. By the year 2000, this will have been increased to 960 MW. The total electricity generation from coal at CDE under this scenario is scheduled to become 2300 kboe in 1990 and 3068 kboe in 2000. Coal will also replace a substantial amount of the oil currently used in cement production, equivalent to 1100 kboe in 1990 and 1900 kboe in the year 2000, and in the generation of electricity at the Falconbridge installation equivalent to 1200 kboe.

TABLE III-5

COAL & HYDRO CASE - PRINCIPAL ASSUMPTIONS

HYDROPOWER

- Electricity output exceeds base case levels by 291 kboe in 1990 and 2955 kboe in 2000 as a result of rapid hydro expansion.

COAL

- 160 MW of oil-fired electric capacity are retrofitted to coal by 1990 and this additional 160 MW is added by 2000 over and above the coal capacity assumed in the base case.
- Coal substitutes for oil in cement production and ferronickel mining electric self-generation, saving 2300 kboe in 1990 and 3100 kboe in 2000.

TABLE III-6

RENEWABLES CASE - PRINCIPAL ASSUMPTIONS

- Solar water heaters capture 50 percent of new unit sales in households.
- Wood from tree farms fuels a 50 MW base load power plant by 1990 and an additional 50 MW unit by 2000.
- Solar Ponds and photovoltaics provide 5 MW of capacity by 1990 and 5 MW more by 2000.
- Bagasse drying and boiler retrofits provide an additional 300 Gwh per year to the electric grid with no additional fuel requirement.
- 30 Minihydro sites are developed by 1990 and 75 by 2000 which are isolated from the grid.
- 500 Windmills of 5 kw capacity each are installed by 1990 and 2000.

TABLE III-7

CONSERVATION CASE - PRINCIPAL ASSUMPTIONS

INDUSTRY

- Retrofits that increase energy efficiency take place in all major industries, reducing industrial energy consumption 1000 kboe in 1990 and 1000 kboe in 2000 over base case levels. Oil accounts for two thirds of these savings.

TRANSPORTATION

- Publicos are replaced by various types of buses at a faster rate than in the base case; the fuel efficiency of remaining publicos is increased by 20 percent by 1990.
- Discretionary travel per private automobile is reduced to two thirds of the 1978 distance and fuel efficiency increases 3 percent per year, both effects to be achieved through government policies.
- A backhauling system is arranged for the trucking fleet, and higher load factors and larger trucks are used where possible.

HOUSEHOLDS

- New air conditioners are 20 percent more efficient and hot water tanks are insulated.

COMMERCIAL

- Lighting levels are reduced by 10 percent and new air conditioners are 20 percent more efficient.
- Hot water preheaters save 30 percent of fuel used for this purpose.

AGRICULTURE

- No change.

As documented in Appendix VIII, the maximum attainable hydropower output by 1990 will be 1500 Gwh, the equivalent of 880 kboe. This is up only 12 percent from estimates given in the Base Case. During the 1990's, it should be possible to achieve a large expansion in hydropower capacity with output reaching a level of 4200 Gwh or 2500 kboe by the year 2000. This corresponds to an installed capacity of 1600 MW.

Renewables Case

In addition to using fast-growing wood and solar ponds to replace petroleum use in the generation of central station electricity, this scenario envisages substantial penetration of solar hot water devices into the household, commercial and industrial sectors. Other technologies which are scheduled to be used (particularly in rural areas of the country) are windmills, solar driers for bagasse and, to a very limited extent, photovoltaic solar cells.

By 1990, the most important contribution to reducing oil imports will come from the application of solar drying to bagasse to increase its useful energy content. The potential contribution of the solar-dried bagasse could go as high as 300 Gwh or 175 kboe. Next is a steam plant of 50 MW installed capacity using fast-growing wood grown on special tree farms. Three solar ponds, each 5 MW, follow. By the year 2000, the contribution of fast growing wood to the national grid is scheduled to double and 14 solar-based electric producing installations with a capacity of 70 MW will be in operation.

Because some penetration of solar hot water heaters was assumed in the Base Case, the contribution from the direct use of solar energy in this scenario comes mainly from the use of the solar devices to produce low temperature heat in industry.

Although the magnitude of the energy delivered in rural areas of the Dominican Republic by the use of renewable resources will not be large in relation to total national energy consumption, their use may offer one of the few ways that rural households, industries and farms in remote areas will be able to obtain electricity. Thirty sites for

minihydro installations are envisaged in 1990 producing 68 Gwh (40 kboe) and more than doubling by 2000. Windmills, photovoltaics, biogas, and other medium- and small-scale renewable technologies, though expected to be in use on a reasonably broad basis, will not collectively make a significant contribution to reducing the use of oil.

Conservation Case

The measures considered are all aimed at reducing the demand for petroleum products and electricity at the earliest possible time. In contrast to those considered in the Base Case, some of these measures involve substantial capital investments to retrofit existing plants and introduce new, more energy-efficient processes in new factories. Only the rural household and agriculture sectors have not been considered in assessing the potential for energy conservation savings. It is worth noting that only measures affecting end-use efficiency have been considered, and not those which would result in a curtailment of goods and services provided by the use of energy.

In industry, cogeneration and other waste heat applications are scheduled to be implemented in a number of the most energy-intensive industries in the Dominican Republic, specifically the petroleum refinery, textile and chemical industries. Near-term energy savings in these and other industries will come about from the institution of better regulation and use of energy by plant engineers, better equipment maintenance procedures, and replacement of inefficient boilers. In the longer term, energy savings will be achieved through redesigning the older plants whose output per unit energy input falls well below international standards. An example is the redesign of cement-making plants to use the semi-dry process. Energy savings in industry and mining amounting to 1150 kboe of direct oil consumption are achievable in 1990, and to 2300 kboe by 2000.

In the Base Case, substantial savings of petroleum products were achieved through the substitution of mini-buses for publicos. The Conservation Case further includes an expanded urban mass transit system using buses on a widespread basis. Savings in 1990 from this transportation mode shift come to 600 kboe in 1990. It is estimated

that a gradual shift in the stock of automobiles toward smaller, more energy-efficient models will achieve an additional savings of 300 kboe of oil. Together, these transportation savings are capable of reducing the Base Case transportation demands by 20 percent by the year 1990 and by 25 percent in the year 2000.

Savings of energy in urban households will not be substantial unless the rapidly increasing use of electrical applicances is curtailed. However, more efficient air-conditioners and the use of pre-heaters for commercial sector and government water heating can produce savings in electricity corresponding to 50 kboe.

Table III-8 shows the effects of these three scenarios on energy resources for the years 1990 and 2000. Taken together with the figures provided in the text above, the picture that emerges can be summarized as follows:

- Conservation measures could reduce the demand for petroleum products by 15 percent over Base Case levels by 1990 and by 25 percent by the year 2000. These savings result in only a 5 percent reduction in electricity demand by 1990 and a 10 percent reduction by 2000. Although it is technically possible to achieve these savings at an earlier date, this would require that immediate action be taken to implement a strong energy conservation plan.

- Even the ambitious program envisaged in the Renewables Case is capable of reducing oil imports by only 10 percent in 1990 and 12 percent in 2000. These values should be considered as upper technical limits, barring a major break-through in the development of renewable technologies such as OTEC, photovoltaics or solar-power towers. More certainty can be attached to the contributions to be realized by the solar drying of bagasse.

- The use of renewable resources, including mini-hydro, is likely to deliver electricity the soonest to users in rural areas not now connected to the public utility grid.

- A key factor leading to the need for increasing the capacity of coal-fired units in the 90's is the relatively long time lag in increasing hydropower outputs. If more hydropower were delivered sooner, or, alternatively, if the growth in demand for public utility electricity during the next few years could be reduced, the need to become dependent on imports of coal could be cut back. As a result of the retrofits included in the Coal/Hydro Case, coal imports will increase by 75 percent over the Base Case in 1990, while oil imports drop by 22 percent. In 2000, coal is due to increase by 36 percent and oil reductions by 25 percent.

TABLE III-8

BASE CASE, CONSERVATION AND RENEWABLES, RESOURCE SCENARIOS

(kboe)

Resource	1978	1990			2000		
		Base Case	Conservation	Renewables	Base Case	Conservation	Renewables
Hydropower	552	2650	2650	2780	5300	5300	5630
Oil	14770	20171	17100	18100	26683	20700	23500
Coal	0	5645	5650	5650	9880	9880	9880
Biomass	5000	4504	4500	5680	4281	4280	5460
Solar	0	147	147	517	281	282	134
Firewood	7940	6678	6700	7240	6232	6230	351
Wind	0	--	--	13	--	--	52
Total	28300	39759	36600	39900	52657	46700	53000

D. SCENARIOS 5, 6 and 7: COMBINED, LIMITED OIL CONSUMPTION, AND NO-ACTION CASES

The previous two sections have mentioned different time frames during which various measures intended to affect energy supply and demand will have their maximum impact. In general, conservation in industries will have the earliest impact on energy use in the Dominican Republic. These are followed by replacement of oil by coal at major self-generating facilities. Retrofits of oil-fired plants to allow the use of coal come next. Substantial output of electricity from hydropower will not come until the 90's. The same is true for most of the renewable resources to be utilized in the generation of electricity.

In the Combined Case -- the assumptions for which are spelled out in Table III-9 -- all the actions called for in the Coal/Hydro, Renewables and Conservation Cases are assumed to be implemented at the same time. The overall effect is to cause a larger reduction in the need for coal-steam plants to generate electricity than that assumed in the Coal/Hydro Case. This results from generation of electricity from renewable sources. Oil used in the Combined Case is 65 percent of that shown in the Base Case in 1990 and 2000. Coal is 50 percent higher than the Base Case in 1990 and about the same in the year 2000. By emphasizing energy conservation in industries, where it is most easily achievable at an early date, the Combined Case substantially reduces the demand for electricity. This reduces the demand not only for fuel oil to generate electricity, but also for coal imports intended to replace fuel oil. The Limited Oil Consumption and the No-Action cases have more limited purposes than the other scenarios considered in the assessment project. The former considers what actions would have to be taken (over and above those projected in the Combined Case scenario) to maintain oil imports into the Dominican Republic at or near current levels. The latter considers the effect on the energy supply-demand situation should even the minimal energy-improvement actions envisaged in the Base Case not be taken.

TABLE III-9

COMBINED CASE - PRINCIPAL ASSUMPTIONS

The Combined Case includes oil saving measures excerpted from the Conservation, Renewables and Coal/Hydro Cases. Conservation measures are introduced first, followed by the hydropower envisaged in the Coal/Hydro Case. The amount of coal that must be used to satisfy remaining fuel demand is thus less than that required in the latter case.

End Use Efficiency

- All measures introduced in the Conservation Case for Industry, Transportation, Households and Commercial sectors are included here except where industries substitute for coal.

Fuel Substitution

- Selected industries substitute coal for oil as in the Coal/Hydro Case. All new industries use coal instead of oil.

Electric Generation

- Rapid expansion of hydropower as in the Coal/Hydro Case together with electric generation features of the Renewables Case. Coal is used to satisfy remaining electricity demand.

The assumptions used in constructing the Limited Oil Consumption Case are shown in Table III-10. They deemphasize the linkages between electricity demand and growth in economic output and disposable income. While the demand for electricity in the residential and commercial government sectors grows at 9 percent and 11 percent per year, respectively, from 1980 to 1985 (same as the Base Case), in the industrial sector, electricity set aside for new demands is almost eliminated through 1985. Electricity demands for the remaining industrial sectors in 1985 is obtained by interpolating the Conservation Case results for 1990. In this way, only 60 Gwh of electricity need be added to the system through 1985.

Direct use of petroleum products in 1985 is interpolated from the savings estimated in the Conservation Case for industry, mining, and transportation for 1990. This implies that the measures needed to achieve these savings, such as industrial retrofits and redesigns, replacement of publicos by buses, increased fleet fuel efficiency, etc. must take effect at an earlier date.

Finally, the Limited Oil Consumption Case requires that the first coal-fired electric generating plant at Itabo would come on line in 1983 or 1984 at the latest, which is in accordance with CDE plans. Also, CEA must be in a position to provide 100 Gwh to the public utility or one-third of its estimated surplus generating potential by 1985. CEA's capacity to produce electricity is assumed to increase through the use of solar dryers to increase the energy content of bagasse and retrofitting of its boilers.

The 1985 use of petroleum, electricity and coal are shown in Table III-11 for the Limited Oil Consumption Case. Oil imports remain at 1978 levels. There is a drop of 10 percent in the fuel oil used in CDE facilities, and petroleum demands in industry, mining and transportation -- the three major oil consuming sectors -- are up by 13 percent, 29 percent, and 4 percent respectively from 1978 demands.

The measures outlined above will not be sufficient to maintain oil imports at current levels in the long-run. Direct oil use in industry, and transportation in particular, continue to drive up the demand. The only alternative is to replace the direct use of oil in industry by

TABLE III-10

LIMITED OIL CASE - PRINCIPAL ASSUMPTIONS

Electricity Demand

- Demand is assumed to be limited by available generating capacity through 1985, after which it returns to Base Case growth rates.
- "New Demands" by industry included in the Base Case are reduced substantially.
- Growth in the electricity demand of residential and commercial sectors is slower than in the Base Case, occurring at 9 percent and 11 percent per year for 1980-85, but assuming that 1980 demands are not much higher than they were in 1978.

Electric Generation

- An 116 MW coal-fired plant comes on line by 1983 or 1984 at the latest.
- 100 Gwh/year are sold to the grid by CEA by 1985
- Gas turbines are phased out and replaced by hydro peaking units and load management.

End Use Efficiency

- Approximately one half of energy savings achieved in the Conservative Case occur by 1985.

Fuel Substitution

- All new industries as well as present glass, iron and steel, and large food and beverage industries use coal (in addition to the ones the Coal/Hydro Case assumes convert to coal).

TABLE III-11

LIMITED OIL CONSUMPTION CASE

	1985		
	PETROLEUM	ELECTRICITY	COAL
Industry	2620	570	-
Mining	2730	-	-
Transportation	4280	-	-
Commercial	520	415	-
Urban Households	690	590	-
Rural Households	80	24	-
Agriculture	100	-	-
Electric Generation	3830	-	900
	14850	1600	900

Includes mining and "new uses"
(30 Gwh for irrigation projects and 33 Gwh for tourism)

coal on a large scale. This means that all new industries will use coal as well as the mining, cement, glass and large food and beverage industries. The gas turbines used to satisfy peaking demands for electricity must be phased out. The result is that one-half of the petroleum consumed in the form of diesel gasoline will go to satisfy transportation demands and one-third in the form of LPG, will be used for cooking.

In effect, coal will be substituted for oil wherever it is technically feasible. The fact that oil imports are just maintained at the same level even under such sharply changed patterns of fuel use, underscores the importance of the rapidly increasing demands for energy in transportation and urban households that will take place throughout the rest of this century.

In the No Action Case, it is assumed that future patterns of energy consumption are similar to those of 1978, and that total fuel demand grows at historical rates. Detailed assumptions are presented in Table III-12. In terms of oil use, this case represents the opposite end of the spectrum from the Limited Oil and Combined Cases. Even when compared to the relatively moderate Base Case, the No Action Case results in oil consumption that is 44 percent over Base Case Levels in 1990 and 50 percent over them in the year 2000.

In the No Action Case, there is no organized urban mass transit except gasoline powered publico taxis. Because of this difference in transportation mode, gasoline consumption is substantially higher than in the Base Case while diesel use is somewhat lower. The net savings of 1770 kboe in 1990 and 3900 kboe in 2000 that this substitution of modes and fuels brings about in the Base Case is foregone here.

It is assumed that energy use per unit of output in industry remains the same, in the projected period, as in 1978 in both existing and new factories. No "housekeeping" conservation takes place, and no changes in production methods or facilities occur as a result of higher energy prices. Both petroleum and electricity demands exceed Base Case Levels by approximately 14 percent in 1990 and 21 percent in the year 2000.

TABLE III-12

NO ACTION CASE - PRINCIPAL ASSUMPTIONS

Industry

- No housekeeping conservation.
- No changes from current energy use per unit of output, including those of expanded capacity.

Transportation

- No minibuses, publicos for all mass transit.
- No improvement in fleet efficiency.

Electric Generation

- Base Case levels for hydro output
- All other generation via fuel oil plants.

The largest impact of the No Action Case is on fuels used to generate electricity. While some expansion of hydropower is assumed, the remainder of electricity is generated by oil steam plants and gas turbines, as is the case today. Total petroleum for electricity exceeds the Base Case Level by 4270 kboe in 1990 and 12,100 kboe in 2000.

The aggregate effects of these Combined, Limited Oil and No Action Cases on fuel consumption are presented in Table III-13. Note that while total fuel consumption is in the same range under all three scenarios, oil demand in the No Action Case is approximately two and one half times as large as that occurring under the Combined and Limited Oil Cases. Other salient points of these three cases can be summarized as follows:

- The important features of the three generic scenarios that are brought together in the Combined Case can be implemented at the same time and reduce oil demand to 65 percent of the Base Case level. Conservation or end use efficiency measures can most quickly achieve substantial savings.

- By reducing the growth of electricity demand at an early date through end-use efficiency improvements, and by introducing new hydropower as fast as possible, less coal-fired capacity is required to satisfy demand in the interim until hydropower projects with long lead times can be brought in line.

- Constrained by available generating capacity until 1985, electricity demand in the Limited Oil Case is not allowed to grow at the rate that is assumed in all other cases. Additionally, the measures that save electricity and oil by 1990 in the Conservation Case, such as industrial retrofits and replacement of publicos by buses, occur at an even faster rate.

- Even assuming that all the above measures are taken and that coal replaces oil wherever it is technically feasible, the demands of the transportation and household sectors for diesel, gasoline and LPG will continue to grow dramatically. By the year 2000, these fuels will account for approximately 80 percent of oil demand.

- Oil Consumption in the No Action Case is 120 percent higher than the Combined Case oil demand in 1990 and the year 2000.

TABLE III-13

COMBINED, NO ACTION AND LIMITED OIL SCENARIOS

(kboe)

	1978	1990			2000		
		Combined	No Action	Limited Oil	Combined	No Action	Limited Oil
Hydropower	552	2940	2650	2940	8240	5300	8240
Oil	14770	12900	28700	11600	18000	39500	13500
Coal	0	8430	-	9140	9800	-	10800
Solar	0	517	-	517	1180	-	1180
Biomass Electric	0	559	-	559	1180	-	1180
Other Biomass	12940	11200	5350	11200	10500	5500	10500
Total	28300	36500	36700	36000	48800	50300	45400

IV. STRATEGIES, ISSUES, AND RECOMMENDATIONS

What emerges out of the scenarios enumerated in Chapter III are the basic realities that need to be confronted in designing a comprehensive strategy for the Dominican Republic during the remaining years of this century. These realities are discussed and interpreted in the first section of this chapter. They culminate in a proposed strategy which spells out the major areas in which the country must take action. The second section delineates a set of issues which must be addressed by the Dominican Government if the proposed strategy is to become the basis of a national energy policy. The final section of this chapter describes a series of first steps to be taken in the near future to begin implementation of specific programmatic recommendations that follow from the strategy.

It is worth reiterating that the strategic and programmatic recommendations included in this report are based on the current findings of the Dominican Republic Energy Assessment Project. These rest on technical analyses of the available options, a major ingredient of which has been the judgement of technical experts. No attempt has been made in the project, as yet, to ascertain the effects on the Dominican economy that would ensue from the very sizeable investments necessary to undertake this restructuring of the Dominican energy system. Nor have the costs and benefits of competitive resource/technology combinations been explored in any but a cursory fashion. Those specific conclusions and recommendations judged to be especially sensitive to such economic considerations have been singled out as requiring more detailed analysis.

A. AN ENERGY STRATEGY FOR THE DOMINICAN REPUBLIC

The rapidly growing levels of oil imports and their effect on the national balance of payments lie at the heart of the energy problem in the Dominican Republic. Petroleum products currently account for all but a minor fraction of the commercial energy used in the country. Approximately 70 percent of oil consumed goes into the producing sectors of the Dominican economy. These include mining, manufacturing, agriculture, the commercial sector, and freight transport. The remaining 30 percent goes to nonproducing activities (urban households

and passenger transport). In 1980 oil imports to the Dominican economy will cost more than $500 million in foreign exchange. This corresponds to more than 40 percent of anticipated export earnings.

The current structure of the Dominican economy, moreover, is such that its productive growth is strongly tied to continued annual increases in the consumption of oil. During the period between 1975 and 1978, when GNP was growing at an average rate of 5.5 percent per year, oil consumption grew at 4.3 percent per year. According to World Bank sources, this rate of increase exceeded the average annual growth of oil for the oil importing developing countries as a whole.

In fact, the aggregate rate of oil growth to 1978 would have been about 20 percent higher if it were not for the sharp reduction in the use of fuel oil at Falconbridge that year. Even so, the use of heavy fuel oil during this period grew at the rate of 18 percent per year, driven in large part by rapid increases in direct use in industry and in the generation of electricity. Furthermore, while gasoline consumption has fallen off 5 percent in the first quarter of 1980 compared to the first quarter of 1979, consumption of diesel fuel has increased by 14 percent and LPG sales by 11 percent in the same period.

As documented in the No-Action Case described in Chapter III and shown in Figure IV-1, the amounts of oil required to fuel a 5 percent growth in GNP per year would require imports of 20 million barrels per year in 1985 and 29 million barrels by 1990 as compared to 14.7 million barrels in 1978. Assuming an increase of 2 percent per year (1980 dollars) in the price of oil on the international market, this would mean an imported oil bill of $690 million (1980 dollars) by 1985 and $1.6 billion by 1990. It is unlikely that a continuation of the levels of economic growth that the Dominican Republic has experienced over the past decade would be possible under such pressures. The recent actions of the Venezuelan and Mexican governments to provide stability and possible financing of oil supplies to the country will not, by themselves, affect this conclusion.

Fortunately, the Government has initiated a number of programs which have the potential for reducing the rate of increase of oil

imports over the next decade. These actions are reflected in the Base Case in Figure IV-1. The substitution of more energy-efficient mini-buses for the fleet of older passenger automobiles used as publicos will reduce oil imports by 7 percent by 1990 from what they would be in the No-Action case. Construction of coal-fired steam plants by CDE will further reduce oil imports by 24 percent by 1990. When combined with a third initiative to introduce better energy management practices in industry and CDE, these actions could reduce oil imports in the Dominican Republic in 1985 by 2 million barrels and 1990 by 9 million barrels from the projected levels in the No-Action case. Given the costs of purchasing the mini-buses and the coal, and the resultant increase in debt service from the use of external capital to finance the construction of coal-fired plants, these oil savings may not lead to a large immediate improvement in the balance of payments situation. Nevertheless these actions clearly represent a crucial step in the direction of reducing dependence on oil imports. Given the time lag in achieving the benefits of these programs, any attempt to use the current softening in international oil prices as a reason for delaying their implementation would leave the nation's economy in a more vulnerable situation in the event of a repeat of the sharp increases in oil prices of the last few years.

The fact that these "minimum" programs result in a large reduction in the level of national oil consumption should not be allowed to obscure their one-shot nature. As indicated in Figure IV-1, the projected increase in oil consumption in the period 1990-2000 demonstrates that the basic structural elements in the economy which are driving oil consumption upward will continue. The savings effect of the introduction of mini-buses and better energy "housekeeping" practices--which looms large in comparison with current total national oil consumption, gets progressively eroded in time in the face of the rapid rates of increase in total oil demand. Moreover, even if these programs achieve their potential savings of oil in the 80's, oil consumption in 1985 is still estimated to increase by 16 percent over 1978 levels and in 1990 increase by 37 percent over 1978 levels.

The new initiatives for reducing oil dependence investigated in Chapter III fall into three categories - conservation, renewable resources, and coal/hydro. Each has its own potential for reducing oil

FIGURE IV-1
Petroleum Demand

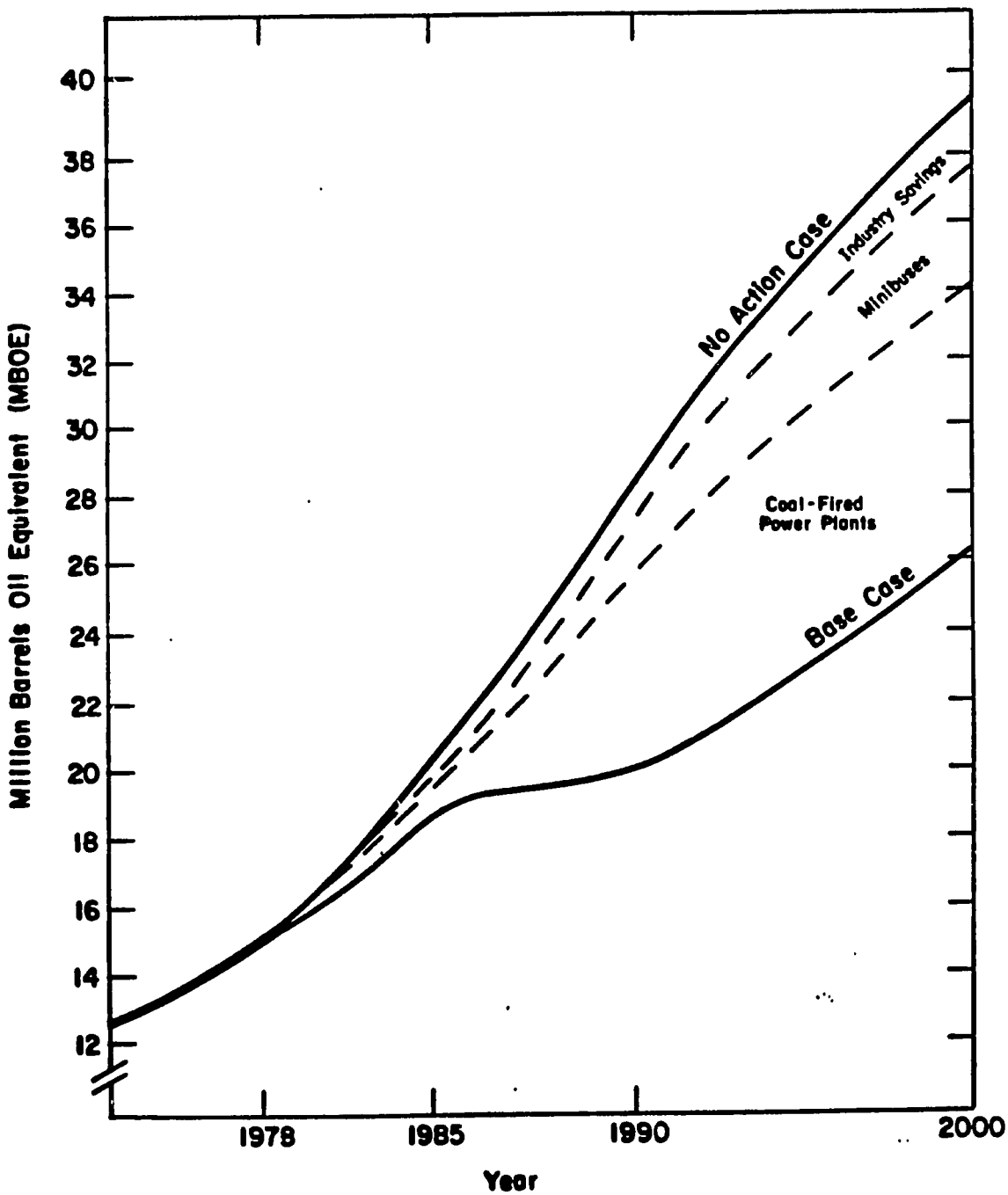
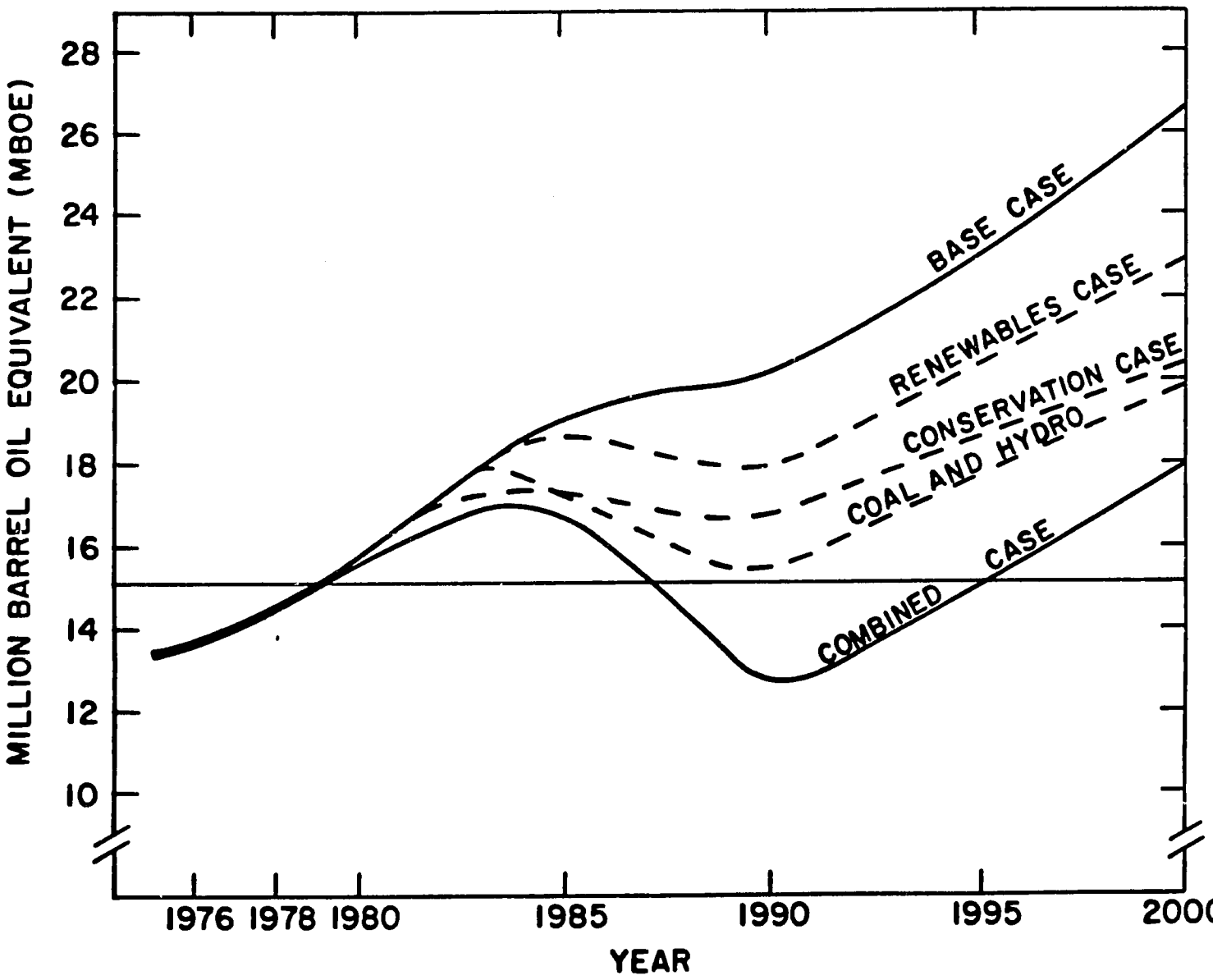


FIGURE IV-2

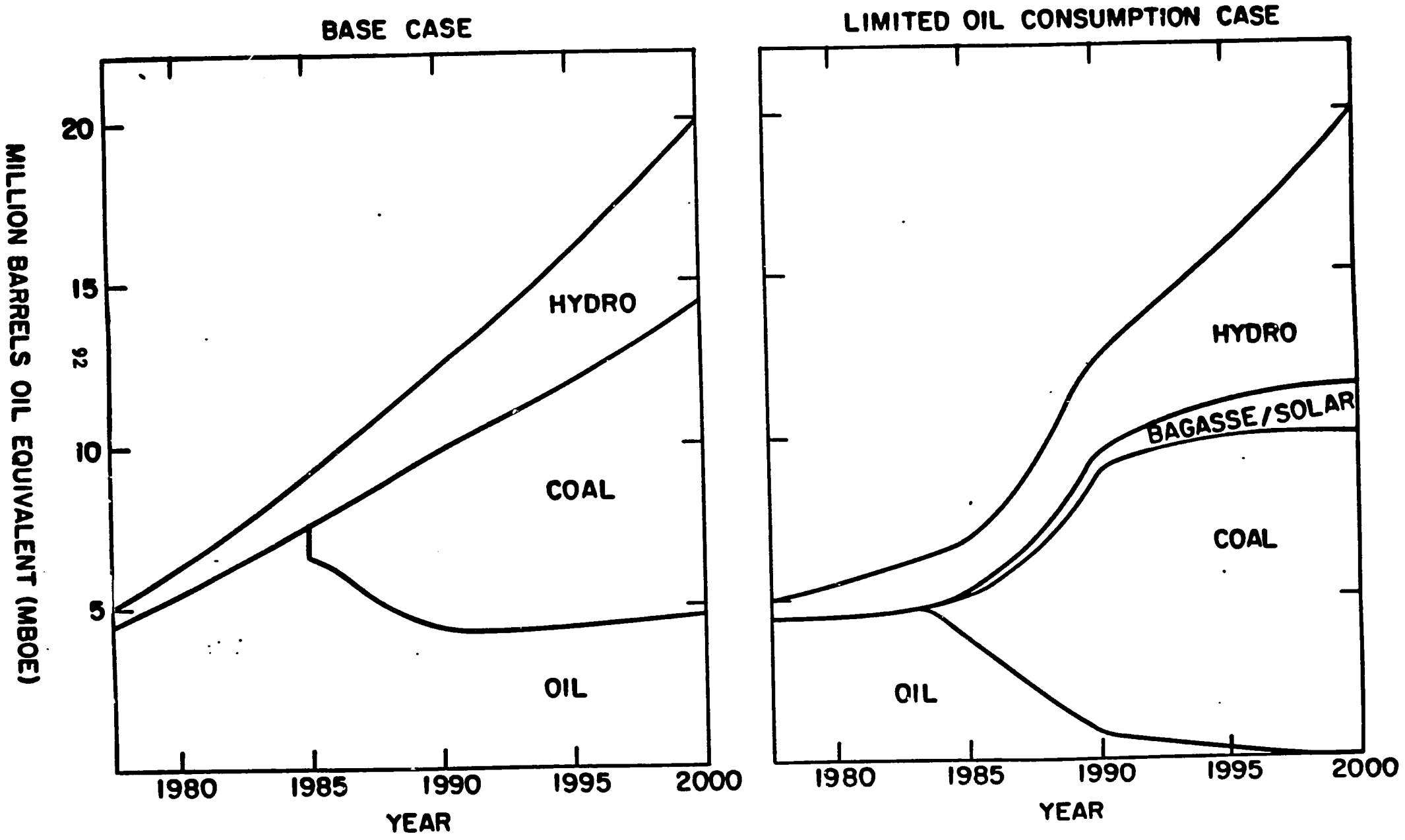
PETROLEUM DEMAND ALTERNATIVES
GENERIC SCENARIOS



imports in the short-and long-term. As shown in Figure IV-2, conservation measures are not only capable of affecting oil demand in the short-term, they can also result in a permanent lowering of the oil-intensiveness of economic growth. Coal is an intermediate measure. Hydrogeneration of electricity and the use of a large number of renewable options are long-term measures. Each of these approaches has its energy security aspects. Conservation, hydro and renewables clearly move the Dominican Republic closer to a posture of energy independence, whereas the construction of central station fired plant locks the country into a 20-25 year dependence on foreign suppliers of this fuel. Each scenario also differs in the number of domestic jobs that would be produced by large scale efforts. Conservation programs will require the greater use of local products and local labor than large coal-fired and hydro installations. Development and use of renewable resources can be more labor intensive. Lastly, each scenario has its own organizational requirements.

In terms of achieving a reduction in oil consumption by 1990, the coal/hydro option stands out as reflected in Figure IV-2. As shown in Figure IV-3 this reduction can, in fact, be almost solely attributed to the substitution of coal for oil in the production of electricity both in central stations and in selected industries. In effect, imported coal can replace imported oil and bring import levels back down to 1978 levels. Until 1985, however, the effects of coal substitution are still very small. Large-scale hydro installations, as indicated in Figure IV-3, would not make any major changes in the level of oil imports until well into the 1990's. Renewable resources can drop oil imports by 10 percent or more, depending on government efforts. Renewable projects should not be compared among themselves but rather to conventional oil and for technologies that they are substituting. Conservation measures can, as shown in Figure IV-2, lower oil demand in 1985 by 10 percent and in 1990 by 15 percent from Base Case levels. At the same time, as has been mentioned, they also have the potential for weakening the linkages between energy and economic growth. This is clearly reflected in the lower rates of growth in oil consumption in the post-1990 period.

FIGURE IV-3
RESOURCES TO ELECTRICITY GENERATION



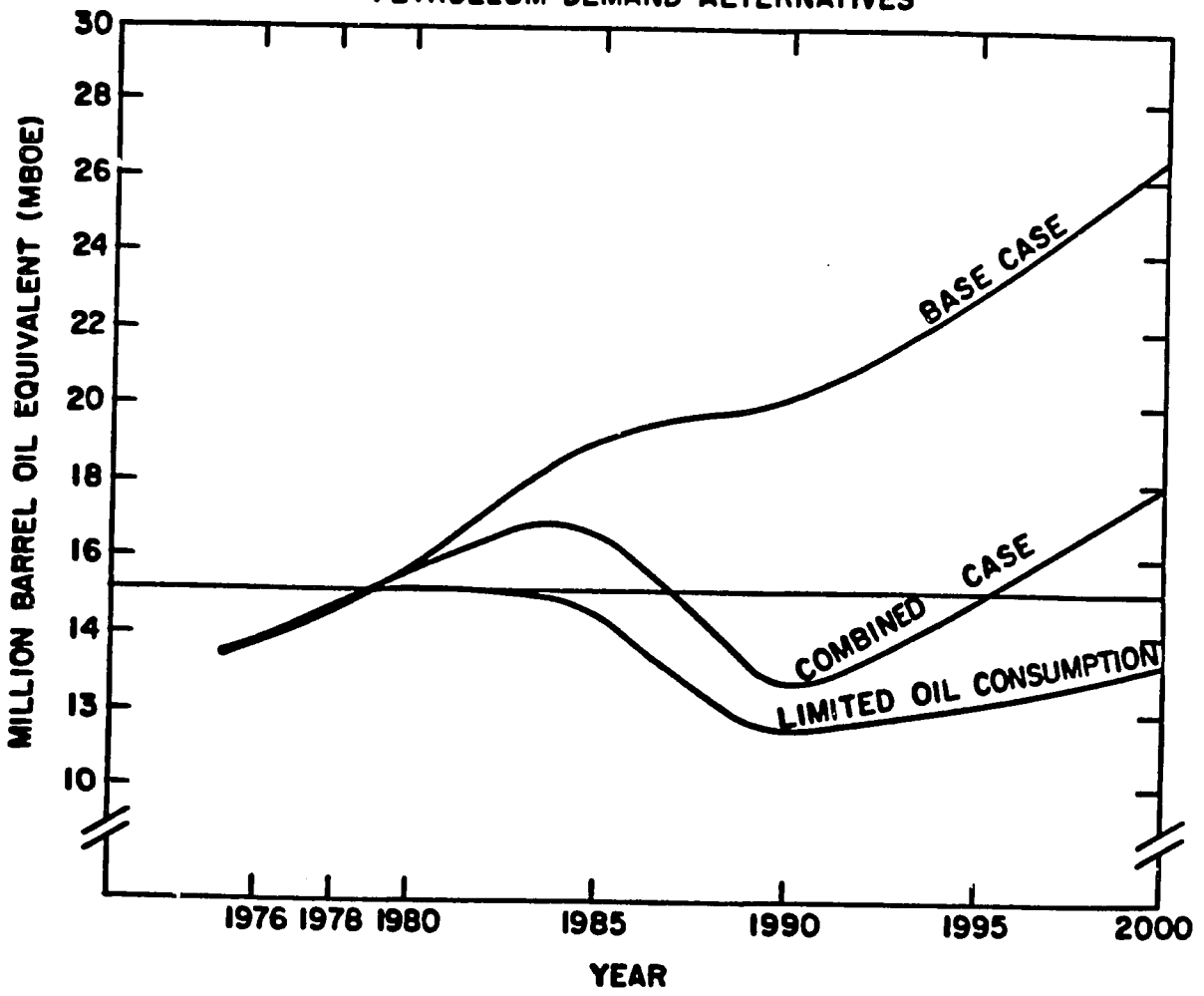
That a combination of complementary and conservation, renewable and coal/hydro programs will succeed most in reducing oil imports, both in the short-and long-term, is not surprising. What is surprising, as shown in Figure IV-4, is that following the significant reduction achieved in oil imports by 1990 (to 85 percent of 1978 oil imports), oil demands start to increase again in the 1990's. The reduction can be attributed in large part to the heavy replacement of coal for oil not only in the generation of on-site and central station electricity, but in the production of high temperature heat for industry. The remaining oil left in the energy system by 1990 is predominantly for providing diesel fuel to mass transit, buses, trucks, and passenger automobiles and in LPG for cooking. The fact that demands for energy consuming services in each of these two areas continue to rise is a reflection of continued economic and social development of the country.

It is questionable whether there are potentially more effective programs than those identified in the Combined Case. Clearly, it is technically possible to identify a set of actions which could maintain oil imports beyond 1990 at or below 1978 levels. The comparison of the Limited Oil Consumption Case with the Combined Case, in Figure IV-4, shows this to be true. However, it must be remembered that the Limited Oil Consumption Case permits no delay in implementing major industrial energy conservation retrofits and the bringing on-line of the Itabo plant by 1983 or 1984 at the latest. Nor is it clear that the lower growth rates of electricity for new industries in the next few years, which have been presumed in the Limited Oil Consumption Case, are attainable without significant attendant dislocations to the Dominican economy.

Even so, some of the results achievable by the Limited Oil Consumption Case are worthy of note. They point out the virtue of restraining the growth of electricity in non-producing areas of the Dominican economy over the next five years. The advantage of such restraint may not be found so much in lowering oil imports but in delaying and eventually eliminating the need for additional coal-fired

FIGURE IV-4

PETROLEUM DEMAND ALTERNATIVES



electric generating capacity at CDE as new hydro-generated electricity capacity comes on line. This would avoid excessive reliance on what would otherwise have to be a long-term commitment to imported coal.

There is considerable merit in reducing the linkages between economic growth and oil demand in the period beyond 1990 as shown in Figure IV-4 for the Limited Oil Consumption Case. Such a program would involve major changes in the structuring of inter-urban transportation (changes in the location of industrial growth) and the application of technologies more advanced than the ones already considered in this assessment (e.g., hydro-based electric powered vehicles, solar power towers, etc.). Both require long periods of planning and preparation which makes their consideration at an early stage important.

It is evident that an energy strategy directed toward a National Energy Policy for the Dominican Republic must contain at least the following elements:

Short-Term

1. Vigorous pursuit of on-going programs to substitute minibuses for the existing stock of publicos and the scheduled construction of the first CDE coal-fired plant.

2. Implementation as soon as possible of housekeeping conservation measures at CDE, CEA, and other major energy consuming government-owned plants and installations.

3. Substitution of coal for fuel oil where technically feasible (and economical), especially in mining, cement, and sugar operations.

4. Utilization of solar drying of bagasse to increase effective energy content of this resource.

5. Acceleration of the introduction of solar hot water heaters into households, hotels, and factories using large amounts of low temperature heat.

6. Acceleration of feasibility studies for the development of renewable resources.

7. Initiation of design and engineering studies to enable the existing refinery to meet future needs as determined by the impact of these strategy elements.

Medium-Term

1. Implementation of retrofit and institution of conservation measures in government and privately owned plants consuming significant amounts of energy.

2. Acceleration of the development of conventional and mini-hydro resources.

3. Construction of an energy-farm for electric generation and charcoal production and initiation of an energy-farm development program for the next two decades, and an autonomous plant for use of sugar cane.

4. Reduction of electricity use in households and the commercial sector.

5. Substitution of larger trucks able to accept higher loads for inter-urban transportation and buses for intra-city passenger transport.

6. Development of projects that demonstrate different applications of solar energy such as:

   a. solar pond
   b. solar grain drier
   c. photovoltaic cell water pumping
   d. solar refrigeration and air conditioning

7. Utilization of coal only for electric generating demands not met by hydro.

Long-Term

1. Utilization of new technologies to increase use of renewables.

2. Planning of alternative modes for transporting goods and equipment within the country.

3. Exploration of the applicability of electric powered vehicles to fulfill transport requirements in the Dominican Republic.

B. ISSUES

The strategy outlined above is based on analyses that comprise an extensive set of both implicit and explicit assumptions. How would the elements of this strategy change if we had adopted a different set of assumptions? Examples of other such suppositions would include the

effect of oil being discovered in the Dominican Republic; or the shutting down of Falconbridge due to changes in the international market for nickel; or the assumption that the Dominican Republic economy would become less energy intensive; or new restrictions being placed on oil imports. Uncertainty of the outcome on each of these questions raises a number of issues that have to be considered in evaluating the strategy that has been outlined above. The aim of the summary statements offered in this section is to explore briefly the effect of alternative assumptions on the assessment analyses, with a view toward delineating the issues to be explicitly addressed by policy-makers.

Future Production of Ferronickel

If future production of ferronickel at the Falconbridge installation drops substantially below the estimates used in our projections of energy demand, the effects on the energy situation in the Dominican Republic could be marked. Mining is projected in the Base Case scenario to be the second largest single user of petroleum products in the Dominican Republic, in 1990 consuming more than 18 percent of the national total. These values are based on a projected production of 80,000 tons of ferronickel per year, a level reached in 1974. This is much higher than the 37,000 tons produced in 1978. The projected energy demand also assumes a steady reduction in the energy inputs per ton of output as a result of the application of increased energy efficiency measures.

Given the fluidity of the international situation with respect to the world-wide supply and demand for nickel, which has been a principal determinant in the wide variations in production at Falconbridge, projected energy demand may not be fully realized. The consequences that would follow from a prolonged drop in ferronickel production are as follows:

- Plans to redesign or retrofit equipment at Falconbridge to make it more energy efficient and/or allow use of coal in the generation of electricity might be set aside or postponed on the basis that such actions would not be cost-effective. In such a case, oil would continue to be used at Falconbridge but in

lesser amounts proportional to reduced ore production. The reduction would depend also on the amount of electricity generated at the Falconbridge facilities for sale to CDE.

- The use of Falconbridge as a back-up system to CDE will be less and less justified as more coal and hydro-installed capacity is put on-line by CDE. Under such conditions CDE will face a decision as to whether it should invest its own capital in the coal conversion of the Falconbridge facilities and thereby make them a regular part of the public utility system.

- It is clear that given the considerable export earnings that come from the mining production at Falconbridge, hydro-generated power may offer real advantages to the company and the Dominican government in the long-run, because competing producers around the world will be turning more to hydro. With the passage of time, mining production in the Dominican Republic may become more and more energy-intensive due to progressively lower grades of ores being processed. If mining operations can be made independent of the use of imported fuels - a situation that is occuring in many mineral exporting countries - it will strengthen the competitive position of mining operation in the Dominican Republic can be enhanced. To the extent that this case has merit, the transition to coal and major investments in improvements in end-use efficiency should be postponed until major additions of hydropower come on-line in the 1990's.

The energy supply-demand problems at Falconbridge could also be treated separately from the national energy supply-demand situation. A technical and economic examination of the supply alternatives could be made with reference to future energy demands associated specifically with different production levels of ferronickel. Costs and benefits of alternative courses of action open to Falconbridge Dominicana could be assessed with respect to both the interests of the company and their impact on energy policies of the Dominican Government.

Impact of the Discovery of Oil in the Dominican Republic

A high priority has been assigned in the National Assessment project to exploring strategies for reducing the import of petroleum products. What happens if substantial amounts of economically recoverable oil are discovered in the Dominican Republic during the next several years? Suppose, for example, that annual production of domestic oil in 1990 constitutes a significant fraction of domestic oil consumption, say, 10 to 25 percent.

Direct effects of oil discoveries of such magnitudes would first be apparent in an improvement in the nation's balance of payments situation. Improvements in this area, however, will inevitably reduce the pressures to accelerate energy conservation and/or retrofit existing oil-fired plants for coal use. The opportunity costs of such delay to the country could be considerable. The resultant higher consumption of domestically produced oil that could have been sold in world markets would also represent a loss to the country as a whole in terms of foreign exchange. Furthermore, if domestic oil prices were to be set below world market levels, as continues to be the case in many oil producing countries, the real economic losses sustained could be even higher.

It is thus clear that measures to develop hydro and renewables and to substitute coal for oil by constructing new central station electricity facilities would still be called for. The same would apply to measures to consume less oil by investing in increasing the efficiency of energy end-use in industry and transportation. Domestic oil could be used primarily to satisfy the residential dependence on liquid fuels in transportation and urban households.

Furthermore, the rapid shifts in the projected mix of petroleum products being consumed in the Dominican Republic would make it technically difficult as well as expensive to undertake local refining of domestically produced crude. It might prove more feasible to "exchange" crude oil produced in the Dominican Republic for the refined oil products of equal value.

The question must therefore be raised as to whether a national energy policy for the Dominican Republic should take into consideration the possibility of oil discovery in the country. The advantage of disregarding it is that eventual discovery will be less prone to disrupt or delay programs already underway to reduce the dependence on imported oil. The principle disadvantage of relying on domestic oil potential lies in the false hopes raised that might diminish support for potentially unpopular government actions to reduce dependence on petroleum.

Management of Future Energy Demands

Although the amount of commercial energy consumed in the Dominican Republic on a per capita basis is still relatively low, it is scheduled to grow at a rapid rate. As noted earlier, the basic driving forces of energy demand are structural in the sense that they are embedded in long-standing patterns of economic and social development. The patterns referred to in previous sections - rapid urbanization, build-up of domestic energy-intensive industries as an alternative to imports, increases in consumer demand for durable products that require energy for their operation - evolved in the 60's and early 70's in many of the developing countries during a period of rapid economic growth and low energy prices. Some energy-intensive industries were, in fact, encouraged to develop through subsidies in the form of low prices for electricity.

These factors account for the steadily rising income elasticity of national energy demand alluded to earlier in this chapter. The issue this presents goes deeper than whether energy prices should reflect marginal costs of energy. It raises the question whether targets set by planning units throughout government should reflect the new energy era through revised goals. A substantial reduction in projected energy demands would result from such actions. The specific issues to be addressed are: 1) whether the future mix of energy-intensive basic material industries on the one hand and manufacturers of durable and non-durable goods on the other should be altered; 2) whether the growth of rural as opposed to urban-based industries should be encouraged; and 3) whether import restrictions on capital equipment should take into account the lifetime fuel consumption.

Resiliency of the Dominican Economy to Restrictions on Oil Imports

The Limited Oil Consumption scenario described in Chapter III demonstrates that although it may not be desirable to attempt to restrict oil imports to 1978 levels, it is possible to do so without inflicting irreparable damage on the Dominican economy. The resiliency of the Dominican economy to sudden restrictions on oil imports is an issue worth addressing in order to shed light on those areas of energy

end-use where curtailment of demand would impose the least damage on the economy if such actions become necessary. Oil import restrictions could result either from changes in the international oil supply-demand situation or from reduced export earnings.

The issue is, in essence, whether it is worth considering stand-by measures specifically aimed at curtailing the growth of demand in areas of least potential damage in order to achieve an economy resilient to sudden drops in oil import.

C. PROGRAMMATIC RECOMMENDATIONS

Throughout this report we have argued for a balanced set of programs for effecting a transition away from the country's almost exclusive dependence on imported oil to a more independent position. It is clear that indigenous sources of hydro-power and biomass can vastly decrease this need for oil. Large savings can be achieved in the short- and long-term from increases in energy end-use efficiency. In the late 80's and early 90's there is no alternative to the heavy use of imported coal, except to curtail demand in the non-producing energy sectors. It may be possible, as noted previously, to reduce somewhat the relationship between commercial energy use and economic growth, but even if actions are taken soon with this in mind, the results will not be evident for years to come. Neither disagreement over the technical appraisals used in our analyses, nor detailed economic analyses, nor reassessments of the international environment are likely to change the basic character of these choices.

A delay in implementing new programs consistent with the strategy articulated earlier in this chaper could have serious consequences in the near as well as the long term. A delay of two years in initiating programs other than those included in the Base Case would result in a 7 percent increase in oil use over 1978 values, or 1060 kboe of oil, which would add nearly $36 million to the cost of imports to the country. A delay would also result in increased shortages of electricity, encouraging greater use of oil, in the self-generation of CDE supplied electricity. Such a delay would increase the vulnerability of the country to externally imposed restrictions on oil imports or sharp increases in international oil prices, such as have occurred over the past year.

The recommendations that follow call for a set of initial actions to be taken in a number of specific areas. These are in the form of feasibility studies, pre-investment analyses, and management and organizational evaluations. In some areas, we recommend immediate actions which will involve a more extended commitment by the Government. The purpose of these "first steps" is not to continue to "study" the problem further before reaching decisions, but to begin to implement the strategy already outlined. The analyses and information gathering activities (conclusions derived from the recommended studies) are intended to permit formulation of detailed programs in the areas specified, each with its own objectives, implementation schedule, and cost estimates.

Coal

Studies should be initiated with the objective of determining the technical and economic feasibility of using coal for:

- New CDE thermal electric generation facilities of greater than 10MW. This includes, of course, the presently planned 125 MW CDE unit.
- The conversion of oil-fired units belonging to CDE which are less than 15 years old. This includes the two 80 MW units at Haina which were constructed in 1976.
- Boilers at the Falconbridge facility, subject to the qualifications contained in the section on "issues." To reduce the large capital cost associated with transporting coal to this facility, the use of a coal-oil mixture should be explored.
- The Central Romana sugar mill. New coal boilers should be considered for adding to the existing bagasse-fired turbine generation as a means of providing power to the CDE grid during the non-bagasse producing seasons.
- All new self-generating units of greater than 10 MW capacity.
- A possible substitute for fuel oil used in the production of process heat in each of the three existing cement facilities in the country.

On a country-wide basis, a preliminary study should be conducted to determine potential suppliers of coal, overseas and domestic transport networks, and port facility requirements for the estimated total quantities which will have to be handled. On the basis of the results, a more detailed engineering study should be commissioned to cover coal

receiving, storage handling, and domestic transport to the points of use. Special attention should be paid to exploring alternative coal supply sources in Colombia, Mexico, and the United States with respect to prices, quality, transportation costs, and the long-term security of supply. The latter aspect is of particular importance. Coal supplies are subject to interruption either at the mine or in transport due to strikes, mechanical failures, or lack of availability. Under such circumstances, coal would have to be purchased on the spot market at higher prices. To minimize shortages, central stockpiling of coal should be considered as well as the use of dual-fired burners capable of using either coal or fuel oil.

The use of coal has substantially greater environmental consequences than oil. These could have deleterious effects on the health of population groups located near large coal facilities, on agricultural production, and on water supplies. The effects can be reduced by scrubbers and other methods of environmental control.

The first steps to be taken are as follows:

- Select a number of favorable sites suitable for early conversion to coal (including those already in the planning stage).
- Estimate the quantities of coal that would be required to supply these units.
- Explore infrastructure requirements for overseas transport, and internal handling, storage, and internal transportation.
- Establish prices and financing terms available from a number of sources in several countries.
- Assess potential environmental impacts.
- Estimate production cost per Kwh.

Energy Conservation

Priority in increasing the efficiency of fuel use should be assigned first to industrial installations consuming large amounts of electricity and/or fuel oil, second to all phases of CDE's operation and third to transportation.

There are three conservation measures in each of these areas:

- Housekeeping measures which create energy awareness and incentives to reduce energy use by individual operator and manager.
- Investments in new equipment, which reduce the unnecessary use of fuels in an existing operation.
- Major technology or system changes introduced through redesign of existing facilities.

Detailed energy audits should be conducted at all cement producing plants, glass-making plants, major food and beverage preparers, the petroleum refinery, and major facilities involved in manufacture and/or processing of basic materials (steel products and chemicals). Each audit should provide: 1) a basic picture of how fuels are used within the facility, 2) recommendations for actions falling into each of the above categories, including technical as well as economic feasibility, and 3) estimates of the overall costs associated with the fuel savings to be achieved.

On the basis of the National Energy assessment findings, the following areas were judged to be worthy of more detailed study:

- The Cementos Cibao could be converted to utilize the semi-dry process, thereby saving large quantities of energy.
- The present operation at the Fabrica Dominicana del Cemento is highly energy inefficient and deserves immediate attention.
- Improvements in plant operations at CEA recommended in a recent United Nations Development Program (UNDP) study are technically sound; subsequent economic analyses show them to be cost-effective and they should be implemented as soon as possible.
- The recovery of thermal energy from high temperature tailings at the Falconbridge facility would result in significant energy savings as would the recovery and use of waste heat.
- The use of heat pumps in distilleries and the brewing industry to recover heat from condensers for use in reboilers should be examined.
- The recovery of heat from ovens and stacks in the food industry can be used to preheat boiler feedwater.

- Furnaces used in the glass container plant could be substantially improved in their energy efficiency.

- Cogeneration possibilities exist in the refinery operation, textile production, and chemical processing facilities.

- Replacement of electric motors in many light manufacturing industries with new energy efficient designs could reduce their use of electricity.

At the national level, an industrial energy efficiency plan for the Dominican Republic should be developed. Such a plan would:

- develop targets for energy savings attainable in each major industrial group or, in the case of large plants, on an individual facility basis;

- lay out capital investment programs (on the part of individual firms and the government) required to achieve these results; and

- prepare recommendations for government incentive programs to encourage cooperation on the part of plant managers and owners.

Like those of public utilities in many developing countries, CDE's oil-fired plants require considerably more fuel input per delivered Kwh produced than equivalent operations in the United States and Europe. Up to 20 percent of the fuel used in the generation of electricity at CDE plants could be saved from lower line losses, improvements in maintenance, updating of equipment, improved load management and reductions in nonreportable uses of electricity. A complete review of all phases of CDE's operation is warranted. The review should include managerial as well as technical aspects of the operation. Specific attention should be given to CDE's planning unit. With a relatively large number of new generating units due to come on line, over the coming years, shut downs for retrofit of oil-fired plants, and increased demands on grid-supplied electricity that will accompany the conversion to coal of a number of self-generating units, the possibility of more frequent and more widespread outages will increase. Improved planning will be required to deal with these situations.

CDE should also explore creating a separate conservation department which would be responsible for introducing measures aimed at improving the efficiency of the end-use of electricity. These might include "time-of-use" pricing, promotion of more efficient devices in homes, buildings and light industry, and encouragement of the installation and up-dating of cogeneration equipment with a view toward these units selling surplus electricity to the grid.

Achieving significant fuel savings in transportation in the Dominican Republic can only be achieved if: 1) there are sharp increases in the use of regular-sized buses for passenger transport within and between urban centers; 2) load factors of trucks carrying freight between Santo Domingo and other parts of the country are substantially increased and; 3) larger, more fuel-efficient trucks are used to move goods and material between cities.

A first step towards the development of policy options available to the government would be an appraisal of the cost of operating private and government vehicles, of the fuel savings that would result if control measures were taken, and of the additional cost to the transport sector that the measures might involve. Because of the lack of data on passenger and freight transport in the Dominican Republic, this information is likely to require additional survey work.

Conventional Hydropower Development

Development of conventional hydropower in the Dominican Republic offers the country its most important possibility for achieving independence from imported resources used for the generation of electricity. The investment of capital and CDE's managerial skills in bringing coal-fired units on-line in the 80's should not slow the pace of development of new hydro-generating facilities. This would only increase the long-term dependence of the country on imported coal.

It appears that there are no major problems with accelerating the development of conventional hydropower. As pointed out in Chapter II, Section A, and detailed in Appendix VIII, basic data on river flows and suggested sites are available, and preliminary project designs appear to be adequate. Some concern has been expressed by technical experts that

insufficient attention has been paid to using the hydro installations for flood control, irrigation, and industrial use, but these do not seem to be problems which cannot be overcome. The essential difficulty appears to lie with the management of existing hydro resources and the planning of new ones. Even before the recent hurricane, low load factors indicated considerable room for improvement.

A thorough review of current and planned hydro installations with a view toward developing a more dynamic management approach to the development of conventional hydropower is recommended. The study should examine management aspects of hydropower development now in operation including procedures for site evaluation, site development planning, construction management, grid integration, and facility maintenance and operational management. The study should also deal with institutional questions vis-a-vis the jurisdictions and responsibilities of CDE and INDHRI in this area. So as not to interfere with the schedule of current hydro projects, this study should proceed as soon as possible.

Renewable Resources

Four programs involving the use of renewables are recommended as having the potential for producing significant amounts of energy for the Dominican economy within the next 10 to 15 years:

- Energy Plantations: the CNPE project to develop a pilot-scale plantation should be continued. At the same time, efforts should begin to consider the development of a plantation whose output would be dedicated to electric generation on the scale of 50 MW. In parallel, efforts should be continued to attempt to define the land areas in the Dominican Republic that could be made available for energy plantations, and under what conditions this process could proceed. Research on which kinds of trees will produce the highest energy outputs on a sustained basis is also needed. Given strong and active programs in each of these areas, there is no reason to believe that it would not be technically, economically or socially feasible to power several 50 MW units.

- Solar Drying of Bagasse: several designs of solar dryers should be tested in the near future with due consideration being given to reducing the handling of the large amounts of bagasse to be dried. Assessments of the economics of bagasse drying should proceed on the basis that technical design problems can be overcome within the next few years. The assessments should concentrate on the extra costs associated with collection, handling,

and transport of the bagasse. Provided that a pilot operation can be in place within the next 2 to 3 years, it should be possible to begin to decide on whether to proceed with large-scale solar-drying before 1985. Close cooperation between CEA and CNPE is essential if these efforts are to proceed smoothly and without delay.

- Mini-hydro Development: The focus of the mini-hydro program should be on providing electricity to remote areas not connected to the national grid. A first step in selecting sites for mini-hydro installations has been taken with the compilation of an inventory of possible sites. This inventory should be up-dated and more complete technical data on attractive sites obtained. Additional criteria should be established for determining whether a mini-hydro site should be given priority over others. The factors to be considered are; 1) potential economic benefits accruing to the local population from having electricity available; 2) effects on other, competing water uses; 3) relative isolation from CDE grid; 4) construction operation, and maintenance costs; and 5) presence of other activities supporting development in the area to be served. Before final selection of the initial sites for locating mini-hydro generators, a study should be made outlining the advantages and disadvantages of assigning lead responsibility development of the mini-hydro program to different Dominican institutions, such as CDE, INDHRI or CNPE. Given the resolution of this institutional problem, it should be possible to develop a program of 30 to 40 sites, the number used as the basis of the national energy projections discussed earlier in this report.

- Solar Ponds: Research and development should proceed with the goal of developing one small-sized (5 MW capacity) pond to provide electricity to rural areas not now served by the CDE grid. A pre-feasibility study now underway, funded by the Inter-American Development Bank, will identify possible sites for a pilot pond. The existence of two salt-producing areas, one on the south coast and one on the north coast, as well as the salt lake of Enriquillo, appears to offer excellent possibilities for solar ponds. These efforts should also be accelerated with a view to operating the first solar pond by the end of this decade.

Movement Toward a Rational Basis for Energy Prices

The issue of energy prices, though not directly taken into account in these analyses, has loomed large in the background of our discussions. Implemention of the strategy developed earlier in this chapter calls for large, continuing investments of capital on the part of government, public and private international financial institutions, as well

as the private sector in the Dominican Republic. Individual purchasers of household appliances, automobiles, trucks, air-conditioners, hot water heaters, etc. will also be expected to spend money for new units. At the same time, it has been assumed that the price of oil on the international market will keep increasing at 2 percent per year in 1980 dollars, with coal following at a somewhat reduced rate. Fuel switching on a large scale -- fuel oil to coal, gasoline to diesel, wood and charcoal to LPG, etc., is projected.

The energy pricing structure is one of the most important resources available to the government to effect desirable fuel transitions. Along with the imposition of mandatory controls, pricing policy can permit the government to limit economic and social dislocations associated with the restructuring of the nation's energy system.

At present, prices for petroleum products and electricity in the Dominican Republic are fixed by the government under decrees emanating from the President's office. There are two main features of the government's pricing present policy: one is to keep the refinery and the public utility solvent without direct government subsidy; the other is to minimize the hardship of high energy prices on the poorer segments of the population. These objectives have been met, in the case of petroleum products, by raising gasoline prices with each rise in the price of imported oil. In the case of electricity, residential rates in general have been kept lower than the rates to the productive sector of the economy. High residential usage, to which rates nearly double the average are applied, is an exception.

The present pricing structure, however, is not adequate to compensate CDE for the rising prices of oil and the utility is therefore incurring large losses. This is not the case for the refinery, although the current differential between gasoline ($2.39/gallon) and other fuels, notably diesel ($0.86/gallon) and LPG ($0.825/gallon), has encouraged a recent rapid shift to use of diesel fuels. (In the first three months of 1980, gasoline sales dropped 5.2 percent while diesel sales rose by 13.9 percent and conversions of vehicles to LPG were rising rapidly.)

Clearly, a very large gap exists between what is needed in the way of an overall rational pricing policy and what presently exists. Steps should be taken to develop a framework to serve as the basis for revisions in energy prices on a continuing basis. The framework should take into account: 1) the need to encourage a positive response on the part of industrial and individual consumers in support of the strategy elements outlined earlier in this chapter; 2) the special energy requirements of certain industries and socio-economic groups; 3) the need to repay loans to international financial institutions for capital investments in the energy supply infrastructure and for the equipment changes for increased energy efficiency; and 4) the desire to encourage economically efficient patterns of industrialization and consumer consumption of energy.

The first steps to be taken in developing such a framework are:

- identifying a suitable analytical tool for calculating economically efficient prices for various energy fuels;
- collecting information relating to price elasticities of energy demand, impacts of the price incentives on allocation of available capital, and the extent to which utilization of existing capital stock is dependent on current subsidized price structures, etc.;
- determining those aspects of energy consumption which are best dealt with by mandatory controls. These could include restrictions on imports of energy-inefficient appliances and industrial equipment, the use of "lifeline" rates for insuring access to energy by the poor and other key consumers of fuels, and regulations governing the use of certain fuels for non-essential purposes; and
- establishing general guidelines for energy pricing policies.

A National Energy Investment Plan

Given the large number of capital-intensive energy projects that will have to be financed in the Dominican Republic over the next decades, and the need to integrate energy supply projects with energy conservation efforts and energy pricing policies, it may no longer be feasible to carry out energy sector investment planning on a sector-by-sector basis as is now the case. A national energy investment plan for the Dominican Republic would contain:

- an evaluation along conventional lines of the least costly means of satisfying projected demands for energy;
- a list of projects thus identified for which external financing is to be sought, along with technical assessments;
- a schedule of projects to be undertaken, estimates of annualized capital requirements, projected debt service obligations, etc.
- descriptions of the revenue-raising mechanisms to be employed to repay the debts incurred;
- a description of the organizations which will be in charge of planning and managing the design, construction and operation of facilities and programs for which investments are being sought; and
- the basic elements of the pricing policies for all energy fuels to be adopted by the government as part of the plan.

An important purpose of the national energy investment plan would be to obtain a combined commitment on the part of public and private banks and assistance agencies to provide the capital needed to implement all components of the plan. Such a comprehensive approach would differ from the project-oriented financing now in effect. The bulk of external financing would still go to the electric power sector, as it does now. However, the investment would be tied in with the implementation of conservation efforts and pricing policies as well. This approach would permit expenditure of some of the capital funds commited over a long term conventional and mini-hydro installations, pilot plant operation of energy farms, solar bagasse and crop drying operations, and solar ponds, thereby avoiding the usual delays in securing individual grants and loans for separate projects.

We recommend that the initiation of such a national enery investment plan begin as soon as possible.