ESI
Report No.
TA 80-0101 J

PN AAJ 400

PRELIMINARY
ENERGY SECTOR ASSESSMENTS OF JAMAICA

CHAPTER 2

ECONOMIC ASSESSMENT

for

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

CONTRACT NUMBER AID 532-79-11

TASK 2

ENERGY SYSTEMS INTERNATIONAL
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JANUARY 1980

FOREWARD

The eight reports of the Preliminary Energy Sector Assessments of Jamaica conducted by the United States Agency for International Development Energy Team are contained in the following five volumes:

Volume	I	Executive Summary
	II	Economic Assessment
	III	Renewable Energy:
		(a) Solar Energy - Commercial & Industrial
		(b) Solar Energy - Agricultural
		(c) Biogas Applications
		(d) Energy Conversion from Waste
	IV	Coal Prefeasibility Study
	V	Electric Utility Rate Analysis

These studies were initiated by the USAID in conjunction with the Government of Jamaica to further the objectives of Jamaica's Five Year Development Plan and its Energy Sector Plan. The studies also represent USAID's first energy assessment of a developing country.

Due to the diverse technology requirements and the high degree of specialization required by each of the studies, a United States Energy Team of experts was assembled. The individual team members were selected based upon a demonstrated balance between academic and "hands-on" experience in the specific study area.

Energy Systems International (ESI), had overall responsibility for systems planning, project management and integration of all elements of the Preliminary Energy Sector Assessments.

These reports should not be considered as the final product of any study area, but as baseline documents to be used for identifying specific energy programs and projects for implementation in the near-term to assist Jamaica in alleviating its critical energy problem.

Any comments or questions concerning this study should be directed to:

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ACKNOWLEDGMENTS

The success of the Preliminary Energy Sector Assessments of Jamaica was assured through the joint cooperation, professionalism, competence and diligence of the entire U.S. Energy Team and their key Jamaican counterparts. The assessment was a concentrated effort over a fifteen week period in Kingston, Jamaica, during which many government agencies, institutions, private sector organizations and individuals became involved and generously supported study development. The many excellent people involved are too numerous to mention herein, but a few have been singled out for recognition because their outstanding effort and support helped to provide study continuity and progress.

Special thanks go to Dr. Henry G. Lowe, Director, Energy Division of the Ministry of Mining and Natural Resources and to the MMNR staff for providing the inspiration and leadership from the Jamaican side to ensure that there was enthusiastic support and contributions to this study from all Jamaican counterparts. A special note of appreciation goes to Mr. Ahmad Zia Mian, consultant to the MMNR from the United Nations Development Program and to Mr. William Saunders, Managing Director Petrojamaica for their capable technical guidance, support and collaboration with the energy team during the Economic Assessment Effort.

Special thanks must also be given to the United States Agency for International Development, in particular, Mr. Jerome Hulehan, General Development Office, USAID Kingston, Jamaica Mission and Dr. Jerome Bosken, Deputy Director, Energy Office, USAID Headquarters, Washington, D.C., for their encouragement and support of the project and for their assistance throughout the study.

Most importantly, special acknowledgment is given to those who took the time to make important contributions to the study through their interviews and discussions with the U.S. Energy Team members. Some of these people and organizations are identified in Appendix B.

CREDITS

Dr. David J. Edelman, AICP of the PRC Energy Analysis Company was the Principal Investigator for the Economic Assessment Task. Dr. Edelman spent most of the eight week study period in Jamaica and collaborated with the other energy team members to produce this report. Energy Systems International provided the overall guidance to the study and integrated this report with the other companion reports. Additionally, ESI typed, edited and published the final report.

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2.1 EXECUTIVE SUMMARY

2.1.1 Introduction

The purpose of the Preliminary Energy Sector Assessments of Jamaica was to assist the Government of Jamaica (GOJ) in identifying and developing viable alternative energy options for implementation. Any recommended options are to complement the goals of the Five Year Development Plan (1978-1983). A U.S. Energy Team, sponsored by the United States Agency for International Development (USAID) was engaged to support the GOJ, Ministry of Mining and Natural Resources (MMNR) Energy Division by conducting specialized studies in the following areas:

Solar Energy - Commercial and Industrial
Solar Energy - Agricultural
Biogas Applications
Energy Conversion from Waste
Coal Prefeasibility Study
Electric Utility Rate Analysis

All of these studies have been completed and each offers specific recommendations for integration into a "Combined Energy Program". Before action can be taken, however, the MMNR must determine which of these recommendations are compatible with the Five Year Development Plan and its Energy Sector Plan. Additionally, an examination must be made of their relative priorities for future implementation, and if adopted, their effect on the national economy. This chapter, Economic Assessment, serves to address these matters.

2.1.2 Terms of Reference

The purpose of the assessment was to review the specialized studies that have been completed as part of the Preliminary Energy Assessments of Jamaica, and to integrate them into a Combined Energy Program. The intention of this combined program is to further the objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan, and to supplement other existing and planned energy efforts in the country.

2.1.3 Background Information

There have been several limitations on this study. First, the time allocated to this task has been sufficient to carry out a rather basic analysis. A complete, quantitative economic assessment requires the type of detailed data that were in the process of being assembled by the MMNR during the period of this study. A knowledge of the complete structure of energy use and of the intersectorial

energy flows in the economy, as well as an easy-to-use computer program to analyze recommended policy measures are definitely needed. It will take at least a year to complete them. Finally, the specialized studies discussed below are only preliminary assessments. Consequently, the economic inputs they have provided to this report are tentative.

2.1.4 Study Method

The analytical approach taken in this Economic Assessment was to independently review each specialized study. The recommendations of each were then considered relative to the Five Year Development Plan (1978-1983), and its Energy Sector Plan. Next, the effects of these recommendations on Jamaica's energy situation and economy were analyzed.

Once all six sets of recommendations were treated in this fashion, they were reviewed for their compatibility with each other. Where conflicts occurred, they were either modified, or one recommendation was eliminated. In all cases, the changes made were approved by the energy team members who prepared the original recommendations.

A final, comprehensive set of integrated recommendations was chosen for inclusion in the Combined Energy Program. The effects of the entire package on Jamaica's energy situation and on its economy were reviewed. The modifications of the Energy Sector Plan required to accommodate these recommendations were considered, and conclusions were drawn.

2.1.5 Findings

2.1.5.1 The Combined Energy Program

The findings were tabulated as the Combined Five Year Energy Program Summary (Table 2-1). Recommendations were grouped into highest, higher, and high priority categories. The program's initial and operating costs were calculated. It should be noted that the program is conceived as an initial effort that will encourage larger, more comprehensive efforts in the future. This program includes only the specialized studies mentioned above and does not consider other key studies such as wind, mini-hydro, and energy conservation which are being conducted by other agencies for the Government of Jamaica.

2.1.5.2 Effects of the Combined Energy Program On Jamaica's Energy Situation

A number of the recommendations of the Combined Energy Program will appear to have very little direct, immediate effect on Jamaica's energy situation. Nevertheless,

TABLE 2-1

COMBINED FIVE YEAR ENERGY PROGRAM SUMMARY

Priority	Recommendation	Initial Cost	Operating Cost *	Total Cost
HIGHEST		(1979 US$)		
o Solar				
Industrial				
-	Climatic Stations (5)	75,000	50,000	
-	Solar Collector testing program	50,000	20,000	
-	Eliminate solar water heater tax	-	-	
-	Training course for installers	75,000	-	
-	Industrial and commercial feasibility studies	150,000	-	
-	Hospital feasibility studies	50,000	-	
-	Hospital demonstration project (costs included in total hospital program)	-	-	
-	Technical support to J.P.S. solar demonstration (residential)	25,000	100,000	
Agricultural				
-	Air-type solar collector development	440,000	-	
-	Sun drying extension program	12,000	48,000	
-	Product drying R&D	395,000	-	
o Biogas				
-	Five year demonstration and commercialization program	1,457,143	98,285	
o Coal				
-	Negotiations with aluminum companies	-	-	
o Electric Utility				
-	None	-	-	
o Energy Conversion from Waste				
-	None	-	-	
SUBTOTAL		2,729,143	316,285	3,045,428

* For detailed breakdown of proposed program costs by technology, time schedule and origin or currency see Table 2-17 Chapter 2

TABLE 2-1
(continued)
COMBINED FIVE YEAR ENERGY PROGRAM SUMMARY

Priority	Recommendation	Initial Cost	Operating Cost	Total Cost
HIGHER		(1979 US$)		
o Solar				
Industrial				
-	Climatic stations (2)	30,000	20,000	
-	Investigate solar exports	10,000	-	
-	Tax incentives for commerce and industry	5,000	-	
-	Tax incentives for new housing	5,000	-	
-	Consumer energy office	25,000	80,000	
-	Total hospital program design	74,000	-	
Agricultural				
-	Grain dryers	120,542	2,358	
-	Cassava, Brewer's grain and tumeric dryers	400,280	7,720	
o Biogas				
-	None	-	-	
o Coal				
-	Coal plant feasibility estimate and coal contract study	200,000	-	
-	Monitor COM study	(2,000)*		
o Electric Utility				
-	None	-	-	
o Energy Conversion from Waste				
-	Alternative Energies Laboratory	80,000	102,500**	
SUBTOTAL		949,822	212,578	1,162,400

*Amounts in parenthesis are not included in sub-totals, nor totals

TABLE 2-1
(continued)
COMBINED FIVE YEAR ENERGY PROGRAM SUMMARY

Priority	Recommendation	Initial Cost	Operating Cost	Total Cost
		(1979 US$)		
HIGH				
o Solar				
Industrial				
-	Climatic Stations (3)	45,000	30,000	
-	Course for architects and engineers	37,000	-	
-	Installation of solar hot water systems for Jamaica's hospitals	1,500,000	-	
Agricultural				
-	Coffee dryers	236,705	4,295	
-	Cocoa dryers	165,050	2,950	
o Biogas				
-	None	-	-	
o Coal				
-	None	-	-	
o Electric Utility				
-	None	-	-	
o Energy Conversion from waste				
-	None	-	-	
SUBTOTAL		1,983,755	37,245	2,021,000

TABLE 2-1
(continued)

Priority	Total Cost*
Highest	$ 3,045,428
Higher	1,162,400
High	2,021,000
GRAND TOTAL OF PROGRAM	$ 6,228,828

*Excluding figures in parenthesis presented in previous pages of this table.

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they will create a sound base for the steady diversification of the nation's energy sources in the coming decade. In order for Jamaica's large potential resources of solar energy and biogas to be developed, and for more effective use of coal to be realized, these first steps must be taken.

Almost 4.2% of Jamaica's energy imports can be replaced by solar water heating systems (3.5%) and biogas systems (0.7%) if exploited in accordance with the study recommendations. If the net fuel savings of a coal-fired electrical generating plant are included, the potential savings increase to 7.3% of energy imports. If the new electrical utility tariff structure that Jamaica Public Service Company adopts results in even a 1% savings in fuel, the potential savings of the Combined Energy Program amount to 8.3%. Using the 1978 figure of 8,887,200 barrels (net) f.o.e. (non-bauxite energy consumption) for Jamaica's consumption of imported fuel, 737,637 barrels f.o.e. could be saved annually.

Immediate effects will, of course, be much lower. None of the specialists on the U.S. Energy Team feels all of this potential will be captured within the next few years. Nonetheless, if by 1985 thirty percent of hotels (3155 barrels f.o.e.), all hospitals (13,700 barrels), and 4000 additional residences (21,200 barrels) use solar hot water; if enough commercial and industrial systems use solar hot water to save 15% of fuel imports; if 2,741 biogas plants are built (10,702 barrels); if 40 solar air-type dryers are built (130,704 gallons of #2 diesel); if a 65 MW coal-fired electrical generation plant is in operation (3.1% savings in fuel imports); and if the JPS tariff structure allows for a fuel savings of 0.2% of energy imports, the net import bill for energy will be reduced 4.4% annually, or by 389,582 barrels f.o.e.

Of course, this figure merely represents a beginning; it reflects only specific specialized study recommendations in selected energy sectors. It also assumes no technological change. For instance, by 1985 other forms of solar energy besides solar water heating systems and crop dryers may be feasible. Also, other non-energy developments might make additional projects possible. For example, if an efficient waste collection program were undertaken in Kingston, it is believed that a project to convert this waste to energy would become both technically and economically feasible.

In any case, an enormous amount of experience will have been gained by the Jamaican people in implementing alternative

energy technology programs. With completed programs, finished studies, and an established technical capability, Jamaica will be in a position to obtain far greater gains over the following five years.

If the Combined Energy Program outlined here is adopted, by 1985 Jamaica quite possibly could have a well-functioning and professionally operated solar collector testing and certification service. Many plumbers could be trained to install solar water heating systems, and all its hospitals and government-owned (as well as numerous privately-owned) hotels converted to solar hot water. A reasonable number of new and old residences could be installing solar water heaters each year. Further, there should be a growing and increasingly export-oriented solar collector manufacturing industry; an increasing use of solar hot water in commerce and industry; an energy-informed public; an excellent meteorological data base; and energy-sensitive architects and engineers. Twenty-seven hundred household-size and 41 institutional-size biogas plants should also be in place and the country will have the capacity to install many thousands more. There could be an efficient and modern coal-fired electrical generating plant; a sensible electrical tariff structure that helps conserve energy; 40 solar air-type agricultural dryers in place; plus well-functioning R&D programs in air-type solar collector technology, agricultural product drying and other alternative energy technologies.

These are preliminary but important gains that would provide a foundation for Jamaica's energy development. In the absence of this or a similar energy program, few advances could be made.

2.1.5.3 Effects of the Combined Energy Program on Jamaica's Economy

Perhaps the most surprising aspect of the Combined Energy Program is the modest cost for all these improvements in Jamaica's energy situation. The total costs (capital costs plus initial operating costs) of the entire program (Table 2-1) are only U.S. $6,228,828. If only the Bustamante Hospital, rather than all hospitals in the country, were converted to solar water heating during the program, total costs would be reduced to U.S. $4,644,828. Even if the price of oil rises at 8% per year, in 1985 the estimated 4.4% savings in energy imports would be U.S. $7,820,736 (discounted) annually.

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2.1.6 Conclusions and Recommendations

The main conclusion of the Economic Assessment is that the Combined Energy Program is a sensible way for Jamaica to direct its efforts in the energy sector over the next five years, and it should be accepted. The recommendations of the specialized studies that have been incorporated into this program have been shown to produce real benefits. The costs themselves have been found to be modest and the government should be able to find the necessary funding.

The need for immediate action should be emphasized. The GOJ should consider this program without delay and begin implementing the recommendations it accepts. Financing should be sought as soon as possible. With so many recommendations for so many agencies, there may be a problem coordinating the Combined Energy Program, and coordinating this program with other ongoing and planned programs under the Energy Sector Plan. Consequently, to ensure that Jamaica's efforts in the energy sector progress as smoothly as possible, it would be useful to form an Interagency Energy Coordinating Committee. Meeting perhaps monthly, with the nation's Energy Director as Chairman, this group could help resolve any conflicts among participating agencies in the energy effort and provide a forum for the interchange of useful information.

Finally, it is recommended that the Energy Sector Plan be modified, based on consideration of the Economic Assessment Final Report when the government reaches its decision regarding the Combined Energy Program.

2.2 INTRODUCTION

The purpose of the Preliminary Energy Sector Assessments of Jamaica was to assist the Government of Jamaica (GOJ) in energy program development under its Five Year Development Plan (1978-1983). The U.S. Energy Team, sponsored by the USAID, assisted the Energy Division of the Ministry of Mining and Natural Resources (MMNR) by identifying viable alternative energy options for Jamaica. The following six specialized studies were conducted over a fifteen week period.

Solar Energy - Commercial and Industrial
Solar Energy - Agricultural
Biogas Applications
Energy Conversion from Waste
Coal Prefeasibility Study
Electric Utility Rate Analysis

All of these studies have been completed and each offers specific recommendations for potential program and project development. Before action can be taken, however, the MMNR must determine which of these recommendations are compatible with the Five Year Development Plan (1978-1983) and its Energy Sector Plan. It must also know if internal conflicts exist, how these conflicts might be resolved, what the relative priorities of the recommendations are, and how, if adopted, they will affect the nation's economy.

This assessment presents a Combined Energy Program which integrates and quantifies the results of each study, and establishes priorities for energy program implementation.

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2.3 TERMS OF REFERENCE

The purpose of the Economic Assessment is to review the specialized studies that have been completed as part of the Preliminary Energy Sector Assessments of Jamaica and to integrate them into a Combined Energy Program. The intention of this combined program is to further the objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan, and to supplement other existing and planned energy efforts in the country.

The original Terms of Reference for the seven studies for Jamaica are contained in Appendix A. The specific Terms of Reference for the Economic Assessment are listed as Task 2.

2.4 BACKGROUND INFORMATION

There were several limitations placed on the Economic Assessment. The reduction of time from the fifteen weeks planned at the outset to only eight weeks, allowed completion of only a portion of the endeavor originally planned. The scope of work was changed to eliminate the requirement for a complete national economic assessment of the energy sector. Instead, an evaluation of the six specialized studies which included a suggested Combined Energy Program was conducted.

A complete, quantitative economic assessment, however, requires the type of detailed data that are just now being assembled by the MMNR. A complete knowledge of the structure of energy use, and of intersectorial energy flows in the economy, and an accessible and easy-to-use computer program to analyze recommended policy measures are required. These are at least one year from completion.

Finally, all the assessments were conducted as prefeasibility studies. Consequently, the economic inputs provided to this Economic Assessment should be considered tentative.

2.5 STUDY METHOD

2.5.1 Objectives

The objectives of the approach taken in the Economic Assessment are to address the issues raised in the Introduction in a logical and comprehensive fashion; to present the MMNR with a final package of prioritized recommendations for policies and actions consistent with the objectives of Jamaica's Five Year Development Plan (1978-1983) and its Energy Sector Plan; to indicate their implications for Jamaica's energy situation and for its economy in as much detail as possible given the limitations placed on this study; and to suggest modifications to the Energy Sector Plan (if necessary) in order to accommodate the recommendations.

2.5.2 Explanation of Approach

The analytical approach taken was first to review each individual specialized study by itself. The recommendations of each were then considered in relation to the Five Year Development Plan (1978-1983) and its Energy Sector Plan. Next, the effects of these recommendations on Jamaica's energy situation and economy were analyzed.

Once the six sets of recommendations were treated in this fashion, they were reviewed for their compatibility with each other. Where conflicts arose, they were either modified, or one was eliminated. In all cases, any changes that were made had the approval of the consultants who prepared the original recommendations.

A final, comprehensive set of integrated recommendations was then chosen for inclusion in a Combined Energy Program. Groups of highest priority, higher priority and high priority recommendations were identified.

The effects of implementing the entire package on Jamaica's energy situation and on its economy were reviewed. Modifications to the Energy Sector Plan which might be necessary to accommodate these recommendations were considered, and conclusions were drawn.

2.5.3 Personnel Interviewed

While conducting the study, meetings were held with representatives of numerous agencies and institutions to develop a data base for the economic analysis. A partial list of personnel interviewed and with whom the team experts interacted in preparing the report are shown in Appendix B.

2.6 OBJECTIVES OF THE FIVE YEAR DEVELOPMENT PLAN (1978-1983) AND ITS ENERGY SECTOR PLAN

2.6.1 The Five Year Development Plan (1978-1983)

The Government of Jamaica owns or controls many of the basic industries (public utilities, export agriculture, bauxite mining, tourism, etc.). The government also appropriates a significant share of national income as taxes and it accounts for a large share of national expenditure (47 percent of GDP). Nevertheless, the private sector accounts for the bulk of production of Jamaica's goods and services. A national plan for such an economy, then, is usually developed to serve as a framework for economic development over a specified period -- normally five years. Thus, the plan is a guide for government policies and for inducements to the private sector to attain national development goals.

These goals, as specified in Jamaica's Five Year Development Plan (1978-1983), are:

(1) to generate positive growth in the economy;
(2) to link the process of growth to the provision of basic needs for the population;
(3) to reduce the unemployment rate;
(4) to redistribute income; and
(5) to develop a self-reliant economy.

These goals are, of course, very broadly stated and are rather difficult to attain. To transform them into more specific guidelines for public and private planning, numerous sectorial plans (agriculture, manufacturing, housing, energy, water, education, etc.) have been devised. These outline the objectives that should be achieved in the various sectors or areas of the economy to support the nation's overall development goals, and suggest policies, programs and projects to accomplish them. These Preliminary Sector Assessments of Jamaica have been undertaken to help the Energy Division of the Ministry of Mining and Natural Resources in its program and project development within the Energy Sector Plan.

2.6.2 Objectives of the Energy Sector Plan

The objectives of the Energy Sector Plan are summarized as follows:

(1) to enhance energy conservation;
(2) to reduce the energy intensity of the economy while sustaining economic growth;

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(3) to rationalize energy prices to achieve economic allocation of energy resources while cushioning the cost of energy to low income groups to the greatest extent possible;
(4) to diversify the present energy supply mix away from imported petroleum;
(5) to develop economically feasible non-conventional energy sources adapted to local needs, through technology transfer;
(6) to accelerate exploration for, and development of, indigenous energy supply sources; and
(7) to maximize energy self-sufficiency through the development of non-conventional energy sources.

2.7 ECONOMIC ASSESSMENT OF EACH SPECIALIZED STUDY

A total economic assessment of each of the specialized studies was conducted. In this section, each study is treated individually. A technical discussion of the recommendations and their compatibility with the objectives of the Five Year Development Plan and its Energy Sector Plan are presented.

The team members incorporated all recommendations proposed in the specialized studies into a five year energy program plan. The implementation costs of these plans were estimated and the effects of the recommended actions on Jamaica's economy measured.

2.7.1 Solar Energy - Commercial & Industrial

2.7.1.1 Summary of Recommendations

The prefeasibility study on Solar Energy for Commercial and Industrial applications produced the following recommendations:

(1) Establish 10 climatic stations to record solar radiation levels and ambient temperatures.

Approximately 10 climatic stations would provide adequate solar radiation and ambient temperature data for the major portions of the island. The Meteorological Office should collect and assemble all data for public distribution. Without accurate solar radiation data, solar system performance cannot be accurately determined.

(2) Establish solar collector performance testing and certification program.

Solar collector performance data do not exist. The Jamaica Bureau of Standards (JBS) should establish a collector testing program as soon as possible. JBS has expressed an interest in establishing a testing program based on the ASHRAE 93-77 testing procedures developed in the United States. JBS personnel should visit the U.S. and possibly be trained to ensure in-depth knowledge of standard testing procedures.

(3) Eliminate the existing 37.5% tax on water heater tanks utilized in solar water heater systems.

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This tax is imposed on all water heaters. In order to reduce the overall cost of solar water heaters, this tax should be eliminated.

(4) Establish consumer energy information office.

In order to acquaint the public with energy conservation and alternative energy sources an energy information center should be established. Energy professionals should be interviewed on T.V., radio, and in the newspapers to explain existing energy consumption and methods of reducing consumption by using conservation and alternative energies. Discussions should focus on alternative energy system costs, pay backs and what the overall impact on Jamaica would be if all people conserved energy.

(5) Establish training courses for solar system installers.

An in-depth, hands-on training course for solar system installers would eliminate many problems experienced in the field. Satisfactory completion of this course could lead to solar installer certification which in the long run would provide some consumer protection.

(6) Establish a college level energy conservation and solar application program for architects and engineers.

With the island-wide acceptance of air conditioning, architects and engineers no longer appear to be concerned with proper natural ventilation, orientation and sun-shading of buildings. CAST could sponsor one or two courses each semester, primarily focused on energy conservation and solar applications to heighten the awareness of design professionals.

(7) Start in-depth feasibility studies and evaluations of all industrial processes and commercial systems to determine most economically justifiable solar hot water applications.

Each industrial and commercial building should be evaluated to determine if a solar system installation would be physically feasible. If the particular site evaluation is positive, an in-depth

feasibility study should be undertaken to determine actual heating loads, solar system size and cost, and system pay back. It is recommended that only cost effective solar systems be installed to eliminate any negative publicity regarding the high cost and minimal rate of return on solar energy systems.

(8) Start in-depth feasibility studies and evaluations of all hospitals to determine most economically justifiable solar hot water applications.

Each hospital should be evaluated to determine if a solar system installation would be physically compatible with the existing structure, and an in-depth feasibility study should be done to determine actual heating loads, solar system size and cost, and system pay back. Although most hospitals use electricity to heat water, thus making a solar system economically justifiable, a small percentage may not be readily retrofitted for solar water heating.

(9) Investigate possible export of solar products manufactured in Jamaica.

The solar manufacturers, in cooperation with the Ministry of Trade and other various ministries, should investigate the possibility of exporting solar equipment and systems to other Caribbean countries and South America. By expanding the solar market to a much larger area, manufacturers could expand production facilities and reduce manufacturing cost, thus reducing the cost of solar systems to the Jamaican consumer. It is critical that the Government of Jamaica also examine and reduce import and export barriers in order to achieve an effective Jamaican international solar commercialization program strategy.

(10) Provide ongoing technical support to the Jamaica Public Service Company (JPS) solar demonstration program.

JPS is starting an island-wide solar demonstration program for the residential sector. The program would provide a low interest rate and three year loans for installation of water heating systems in single-

family and small multi-family structures. Due to the limited program budget of J. $250,000, it was recommended that instead of lending the program funds directly, JPS should investigate the possibility of using these funds as a loan guarantee or interest subsidy. This would serve as an incentive for commercial lending institutions to provide considerably larger funds for the demonstration program, while minimizing the possibility of loss to the lending institutions.

(11) Establish tax incentives for cost effective commercial and industrial solar applications.

(12) Establish tax incentives for solar hot water systems installed in new housing.

(13) Start Solar Hot Water Demonstration Program.

In order to maximize the impact of solar water heating and provide sufficient public information, it is recommended that a solar water heating system be installed at a hospital presently using electricity to heat water. The recommended hospital is the Bustamante Hospital for Children. The preliminary system design for a typical ward at the Bustamante Hospital for Children has been completed and is enclosed as Appendix G of Chapter 3.

(14) A solar cooling demonstration program should not be considered at this time.

Due to the present solar cooling system cost and very low system efficiencies, it is recommended that information on various publications and literature be evaluated continuously, but solar cooling should not be considered in Jamaica except for experimental, scientific and demonstration purposes.

2.7.1.2 Compatibility of Recommendations with Objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan

The recommendations of the Industrial Application part of the Solar Energy Study are compatible with the objectives of the Energy Sector Plan in several ways. The program will enhance energy conservation, help

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diversify usage of various energy forms in Jamaica and develop an economically feasible renewable energy sources program adaptable to local needs. Finally, although the program does not significantly reduce the energy intensity of the economy, it does encourage a shift in use from conventional to renewable energy sources.

2.7.1.3 Economic Factors Derived from Industrial Applications Study

2.7.1.3.1 Potential Solar Water Heating Sites: Eight feasibility studies on solar water heating in commercial, industrial and institutional applications were conducted. The results of these studies are shown in Table 2-2. Detailed information on the subject is provided in Volume III, Part A, Appendix H.

The pay back period for solar hot water usage depends upon the type of fossil fuel being used. When displacing electric power or LPG fuel, the pay back would be between 1.9 and 2.6 years. Diesel fuel would take approximately 6.0 to 6.1 years, and Bunker C oil would take approximately 15.4 to 15.8 years for system pay back.

2.7.1.3.2 Potential Solar Cooling Sites: Three feasibility site studies for solar cooling were performed; the results are shown in Table 2-3. A detailed analysis will be found in Volume III, Part A, Appendix I. The pay back period for solar cooling was concluded to be in excess of 63 years, which does not make it feasible at the present level of technological development.

2.7.1.3.3 Solar Potential For Building Sectors: The summary results of the building sector analysis are shown in Table 2-4.

It can be seen that the residential, institutional and commercial sectors can utilize solar water heating on a cost effective basis. The pay back periods range from 2.2 to 3.8 years. On the other hand, the industrial sector shows marginal cost effectiveness with a pay back period of 7.14 years.

TABLE 2-2

SUMMARY OF SELECTED SOLAR HOT WATER FEASIBILITY STUDIES

Location*	100% Replacement by Solar Collector to Fossil Fuel System			Most Cost Effective Solar System		
	Collector Area (ft^2)	System Cost J. $	Pay Back (years)	Collector Area (ft^2)	System Cost J. $	Pay Back (years)
Negril Beach Village (D)	3,570	80,400	6.7	2,000	41,000	6.0
Montego Bay Club (E)	2,100	58,260	2.6	2,100	58,260	2.6
Coconut Cove Hotel (D)	900	18,000	6.1	900	18,000	6.1
Prelawny Beach CLUB (L)	4,300	96,750	3.1	2,000	41,000	2.7
Intercontinental Hotel Ocho Rios (B)	3,555	78,210	17.0	2,000	41,000	15.0
Bustamante Hospital For Children (E)	318	7,000	2.5	318	7,000	2.5
Cornwall Regional Hospital (E)	6,350	158,750	2.3	2,000	41,000	1.9
Desnoes and Geddes Bottling Co. (B)	12 700	334,000	21.0	2,000	41,000	15.4

*Existing fuel or energy utilized
(B) Bunker C Oil
(D) Diesel Oil
(E) Electricity
(L) LPG

TABLE 2-3

SUMMARY OF SELECTED SOLAR COOLING FEASIBILITY STUDIES

Location	Collector Areas (ft^2)	System Cost J.$	System Pay Back (years)
Cornwall Regional Hospital	40,000 (Flat Plate)	3,500,000	63
Cornwall Regional Hospital	16,000 (Concentrating)	2,520,000	71
Ministry of Education and SRC Office Buildings	750 (Flat Plate)	75,625	210
Ministry of Education and SRC Office Buildings	300 (Concentrating)	57,250	will not pay back
Agricultural Marketing Corporation	2 KW PV	87,500	117

TABLE 2-4

SOLAR POTENTIAL FOR BUILDING SECTORS

Building Sector*	Collector Areas (ft^2)	System Cost J.$	System Pay Back (years)
Residential (E)	1,270,000	30,480,000	2.2
Institutional (Hospital) (E)	110,000	2,640,000	2.2
Commercial (Hotels) (E) (L) (D)	118,270	2,838,500	3.8
Industrial (D)	113,110	2,713,400	7.14

*Assumed existing fuel type
(D) Diesel
(E) Electricity
(L) LPG

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2.7.1.4 Economic Assessment

The Solar Energy (Industrial Application) Study treated four sectors of the Jamaican economy -- the residential, institutional (hospitals), commercial (hotels) and industrial sectors. The feasibility studies conducted indicate the following potential annual savings in imported oil or its equivalent:

Table 2-5
Energy Savings By Sector
(solar hot water systems)

Sector	Savings (barrels f.o.e.)
Residential	159,000
Institutional (hospitals)	13,700
Commercial (hotels)	10,107
Industrial	7,035
TOTAL	189,842

With commercial energy use in 1978 at about 16,261,000 barrels of fuel oil equivalent (f.o.e.), 99 percent of which was imported (hydroelectric power accounted for the other one percent), the 189,842 barrels f.o.e. that might be saved represents about 1.2% of imported energy used by the entire economy that year.

However, 44.8% of all imported energy was used in the aluminum industry, and purchased by the aluminum companies. Consequently, the net fuel imports for Jamaica in 1978 were only 8,886,200 barrels, and the energy savings to Jamaica represented by the 189,842 barrels is actually 2%. More detailed and comprehensive feasibility studies of the commercial and industrial sectors could raise this figure as high as 3.5%. Clearly, this represents a significant potential annual energy import savings.

2.7.1.4.1 Effects of Recommended Actions on Jamaica's Economy: Using the 1978 figure of 8,887,200 barrels (f.o.e.) for Jamaica's consumption of imported fuel, and the rapidly approaching figure of U.S. $20 (1979 dollars) per barrel of oil in Jamaica, a 2.0% annual savings in energy imports (189,842 barrels) is equivalent to U.S. $3,785,900. A 3.5% annual savings would be U.S. $6,221,040 that could be spent for other imported inputs essential to Jamaica's economic development.

Again, with an annual fuel import bill of over 300 million U.S. dollars, the savings stated above are rather small, but certainly significant.

As a result of the study, an extensive program to capture this potential has been recommended. Some of the recommendations would be implemented by the Ministry of Mining and Natural Resources, and others by a variety of Jamaican Government agencies. A brief analysis of the costs (in 1979 U.S. dollars) of implementing all of the recommendations in the suggested program follows.

(1) Establish 10 climatic stations.

10 stations at $15,000 = $150,000. All these could be purchased (from abroad) and installed in a single year; thereafter, operating costs would be $25,000 per year.

(2) Establish a solar collector testing and certification program.

The equipment necessary for this would cost about $50,000 and could be installed in a year. The costs of operating the facility and testing the collectors would be about $5,000 per year.

(3) Eliminate the existing tax on water heater tanks in solar systems.

This tax (10% sales tax + 27.5% consumption duty) is imposed on <u>all</u> water heaters. If it were eliminated, it would reduce the overall cost of solar hot water systems. The revenue foregone could be made up by adding a further tax to the water heaters on <u>non</u>-solar systems.

(4) Establish a consumer energy information office.

The cost of establishing this office and operating it for the first year would be about $25,000; thereafter, operating costs would be approximately $20,000 per year.

(5) Train system installers.

The cost of a one year program to train system installers through short courses would be about

$75,000. In succeeding years, apprentices would acquire this knowledge through their colleagues.

(6) Training architects and engineers.

The College of Arts, Science and Technology (CAST) should develop and offer an appropriate course to heighten the awareness of design professionals to solar energy. It should take one year to develop the course. Fees would be charged to the participants as in an normal CAST course. First year costs might be $37,000.

(7) Feasibility studies for solar hot water applications to:

Industry = $75,000 equally divided over 2 years;
Commerce = $75,000 equally divided over 2 years.

(8) Hospital studies program for Jamaica.

Feasibility studies followed by system design and installation should be completed for all hospitals in Jamaica. The feasibility studies would take one year and cost $50,000. However, after the first six months, the design phase could begin. This would take a year and cost $74,000. Installation of systems for all hospitals would cost about $1,500,000 and take two years. It could begin at the sixth month of the design phase. The whole program appears as follows:

Year	0	.5	1	1.5	2	2.5	3
Feasibility	$50,000						
Design		$74,000					
Installation				$1,500,000			

Costs:		
	1st year	$ 87,000
	2nd year	787,000
	3rd year	750,000
	TOTAL	$ 1,624,000

(9) Investigate the possible export of solar products manufactured in Jamaica.

This study should be undertaken by the Trade Administration or some other appropriate agency of the Government of Jamaica. Its cost is likely to be about $10,000. However, it should be funded out of ordinary budgetary allocations.

(10) Provide ongoing technical support to the JPS solar demonstration program.

JPS is beginning an island-wide solar demonstration program for the residential sector. The program would provide a low interest, three year loan for installing water heating systems in single-family and small multi-family residential structures. This program could provide a great impetus to the retrofitting of houses that already have conventional hot water systems (30,000 homes island-wide), as well as to the provision of solar hot water for as many as 1500 new housing units a year.

However, in order for the program to be effective, some ongoing technical assistance is required. This includes both engineering advice on solar hot water systems and their installation, and financial advice to maximize the use of JPS's limited funding (only $142,857 has been appropriated for the demonstration program). It is estimated that the cost of this technical support would be $25,000 annually.

(11) Establish tax incentives for cost effective commercial and industrial solar applications.

A study of the proper incentives and their effects needs to be undertaken by the Ministry of Finance, the Ministry of Mining and Natural Resources or some other appropriate agency of the Government of Jamaica before this recommendation can be implemented. The cost of such a study is probably about $5,000, and it should be funded out of ordinary budgetary allocations.

(12) Establish tax incentives for solar hot water systems installed in new housing.

Again, a small study must be undertaken by the Ministry of Finance, Ministry of Mining and Natural Resources or JPS before this recommendation can be carried out. The cost is about $5,000, to be provided from ordinary agency funds.

(13) Start a solar hot water demonstration program at Bustamante Hospital for Children.

It was suggested that this demonstration is a highly visible way to educate the public on solar water heating technology. The feasibility study for Bustamante Hospital* has already been completed, and a design prepared. Installation could be finished in a year at a cost of $40,000. All figures are included in the complete hospital program outlined in program element (h) of Table 2-6.

Table 2-6 summarizes the costs of the Solar Energy (Industrial Application) Program. The costs are relatively modest -- U.S. $2,156,000 over three years (mostly in scarce foreign exchange) for initial costs, and $75,000 annually in operating expenses. However, this total figure is misleading because most of the thirteen program elements require only modest funding. In addition, the program elements are likely to be undertaken by at least four or five different Jamaican government agencies, so the burden of finding funds will not be too great for any one office. Finally, two recommendations -- those for the purchase of ten climatic stations (a) and for a complete program to provide heated solar water for <u>all</u> hostals in Jamaica (h) -- account for a very large proportion of total funds. The former (a) accounts for $150,000 in initial costs and $25,000/year in operating costs, while the latter accounts for $1,624,000 in initial costs. In addition, if the Jamaican government were to purchase all the climatic stations, but to approve a hospital program that initially would only convert the Bustamante Hospital ($40,000 initial costs) and conduct feasibility studies for the rest ($50,000 initial costs), the total Solar Energy (Industrial Application) Program would be <u>very</u> modest indeed. Total initial costs would be reduced to $632,500, while annual operating costs would remain the same ($75,000).

The Jamaican Ministry of Mines and Natural Resources has given priority to installing a solar system in the Bustamante Hospital.

TABLE 2-6

Solar Energy (Industrial Application)

PROGRAM

ALL COSTS (1979 US DOLLARS

PROGRAM ELEMENT	Capital and Other Initial Costs (financed with foreign exchange) 1st Year	2nd Year	3rd Year	Capital and Other Initial Costs (financed with Jamaican currency) 1st Year	2nd Year	3rd Year	Operating Costs (financed with Jamaican currency) 2nd Year and after
a. Climatic stations	$150,000	$ -	$ -	$ -	$ -	$ -	$25,000
b. Collector testing	50,000	-	-	-	-	-	5,000
c. Eliminate tax	-	-	-	-	-	-	-
d. Consumer office	10,000	-	-	15,000	-	-	20,000
e. Train installers	50,000	-	-	25,000	-	-	-
f. Train archs. & engineers	25,000	-	-	12,000	-	-	-
g. Feasibility studies							
- Industry	75,000	-	-	-	-	-	-
- Commerce	75,000	-	-	-	-	-	-
h. Hospital program							
- Feasibility	50,000	-	-	-	-	-	-
- Design	37,000	37,000	-	-	-	-	-
- Installation	-	750,000	750,000	-	-	-	-
i. Export study	-	-	-	10,000	-	-	-
j. Technical support to JPS Co.	25,000	-	-	-	-	-	25,000
k. Tax incentives for Commerce & Industry	-	-	-	5,000	-	-	-
l. Tax incentives for New Housing	-	-	-	5,000	-	-	-
m. Solar hot water demonstration program for hospitals	Included in the complete hospital program (h) above.					-	$75,000
Sub Totals	$547,000	$787,000	$750,000	$72,000			

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2.7.1.4.2 Costs and Benefits Summary: Clearly, two million U.S. dollars is a very reasonable investment to attempt to reduce net oil consumption in Jamaica by 2%. The annual savings (at U.S. $20 per barrel) would be $3,785,900. Of course, it would take some time for this level of savings to be reached. The JPS program is critical, as the residential sector accounts for most of the potential savings. However, if after two years, only a few tenths of one percent of oil imports were saved each succeeding year (a very conservative assumption), by the end of the fifth year this program would already have paid for itself including cost of operation. This is summarized in Table 2-7.

Table 2-7
Solar Energy (Industrial Application)
Costs and Benefits Summary

COSTS

Using 1979 U.S. dollars, the program costs appear as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Costs					
Foreign Exchange	$547,000	$787,000	$750,000	$ -	$ -
Jamaican currency	72,000	-	-	-	-
Operating Costs *					
Jamaican Currency	-	75,000	75,000	75,000	75,000
Total Costs by Year	$619,000	$862,000	$825,000	$ 75,000	75,000
Grand Total for Program	U.S. $2,456,000				

However, in order to compare costs which occur early in the program to benefits which occur later, it is necessary to compute the present value of all costs and benefits. This is done by using a discount rate (in this case 8%) and the formula

$$V_{(i)} = \frac{P_t}{(1+i)^t}$$

Where:
- i = interest rate;
- $V_{(i)}$ = present value of cost or benefit at interest rate i;
- t = year; and
- P = undiscounted value of cost or benefit in year incurred.

* Operating costs for the first year are included in initial costs.

Table 2-7A
COSTS (Discounted)

	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Costs					
Foreign Exchange	$547,000	$674,726	$595,380	$ -	$ -
Jamaican Currency	72,000	-	-	-	-
Operating Costs					
Jamaican Currency	-	64,300	59,537	55,127	51,045
Total Costs by Year	$619,000	$739,026	$654,917	$ 55,127	$51,045
Grand Total for Program	U.S. $2,119,115				

BENEFITS

For benefits, no discounting was performed as it was assumed that the yearly rise in the price of oil (U.S. $20 in Year 1 - 1979 dollars) would be equal to the 8% discount rate. (This is a rather conservative assumption about oil prices.) In any case, the two cancel each other. Benefits were computed on the assumption that during the second year of the program, two-tenths of one percent (.2%) of net oil imports were saved, while in Year 3, three-tenths of one percent (.3%), in Year 4, four-tenths of one percent (.4%), and in Year 5, five-tenths of one percent (.5%) were saved. These are also rather conservative assumptions.

BENEFITS (U.S. Dollars)
ANNUAL BENEFITS

YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
	$355,488	$533,232	$710,976	$888,720

TOTAL BENEFITS

U.S. ($2,488,416)

BENEFIT - COST RATIO

$$\frac{\text{Benefits}}{\text{Costs}} = \frac{2,488,416}{2,119,115} = 1.17$$

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Based on the above assumptions and a five year time frame, the benefit-cost ratio of 1.17 indicates that the program should be adopted.

2.7.2 Solar Energy - Agricultural

2.7.2.1 Summary of Recommendations

The recommendations resulting from the assessment of Solar Energy - Agricultural Application are as follows:

(1) Establish climatic stations which include the measurement of solar radiation data (see Chapter 3, Section 3.8 of this Study Report for details).

(2) Establish research and development programs for drying of agricultural products in order to develop technically sound methods of solar-heated, forced-air drying.

(3) Develop air-type solar collector technology suitable for use in tropical climates.

(4) Encourage sun drying of agricultural products to the maximum possible extent consistent with product quality maintenance.

(5) Immediately begin design and installation of collectors for solar-heated, forced-air drying of agricultural products in order to develop solar heated air drying systems for agricultural products wherever sufficient quantities of products are brought together, or where production on individual farms is sufficient to merit solar-heated air drying.

(6) Construct solar collector systems to preheat air for commercial dryers.

(7) Provide the training necessary to support research development, design, installation and operation of solar dryers and solar air heaters.

2.7.2.2 Compatibility of the Recommendations with Objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan

The recommendations are compatible with the objectives of the Energy Sector Plan.

The solar agricultural program will contribute to the diversification of Jamaica's energy supplies away from imported petroleum, help develop an economically feasible, non-conventional energy source adapted to local needs through technology transfer, accelerate the development of an indigenous energy source, and contribute to Jamaica's energy self-sufficiency.

The data used to illustrate the technical and economic feasibility of solar-heated air dryers for specific uses are shown in Table 2-8. The results show that solar energy would provide essentially all of the necessary heat for the small grain dryer as well as supplement fossil fuel for the commercial dryers. An exception might be the tumeric dryer and the lumber kiln. In these two cases, the R&D program and engineering development should be utilized to assess the best method of drying various products before proceeding to production design.

2.7.2.3 Consumer and Economic Benefits

The development of food and agricultural product drying technology should benefit everyone in Jamaica by providing a better supply of food products throughout the year. A wide fluctuation in the price of a product is an indication that more of that product should be preserved for use after the peak harvest season. The drying of products with solar energy, either directly in the sun or by using air from solar collectors, is a relatively simple technology in Jamaica due to high temperatures during the day and high solar radiation, particularly near the coast. Maximum use should be made of these factors.

Supplemental heat supplied by solar air heaters for commercial dryers should benefit Jamaica through some decrease in foreign exchange expenditures, as well as through the overall savings due to the use of a more economical system. Detailed engineering design based on solar air heater performance in Jamaica should provide improved projections of these economic benefits for each system before its construction.

2.7.2.4 Economic Assessment

The recommended program includes the following elements:

(1) Establishment of climatic stations;

(2) Development of air-type solar collectors;

(3) Research and development on drying of agricultural products;

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(4) Sun drying of agricultural products;

(5) Construction of solar-heated, forced-air dryers for agricultural products; and

(6) Construction of supplemental solar heaters for commercial dryers.

The program as summarized in Table 2-9 captures most of the foreseeable potential in agricultural crop drying. The possible exception is in grain drying. It is conceivable that after the five years covered by this program, Jamaica may have significantly more potential in grain production, and consequently, more need for grain dryers.

Installing air-type solar collectors as a supplementary source of heat for the existing large-scale commercial drying of brewer's grain, coffee, cocoa, cassava and tumeric would save 2,902 barrels of #2 diesel oil annually. In addition, the construction of wholly new 2 ton grain and legume dryer would save an additional 210 barrels annually for a total of 3,112 barrels in annual fuel savings of #2 diesel oil from all these units.

Clearly, the impact of this program on Jamaica's energy situation is negligible. A bit over three thousand barrels of diesel fuel is a very tiny fraction of one percent of Jamaica's annual energy imports. However, non-fuel related economic benefits may be more substantial.

2.7.2.4.1 Effects of the Recommended Actions on Jamaica's Economy: The program recommended by the Solar Agricultural Report shows that the agricultural sector obviously stands to gain the most by the use of renewable energy technologies in agriculture. Spoilage of agricultural produce during drying will be reduced, and the drying periods for various crops will become shorter. This means an effective rise in agricultural production. Economic growth could, therefore, be generated through the greater contribution of the agricultural sector to GDP. Agricultural exports could also rise, thereby improving the country's balance of payments and foreign exchange situation. Additionally, Jamaican consumers would profit by having a wider choice available throughout the year, possibly at lower prices.

2.7.2.4.2 Costs and Benefits Summary: Annual fuel savings of the program were estimated in the last section

TABLE 2-8

DATA USED IN ASSESSMENT OF SOLAR-HEATED AIR DRYING

Project	Dryer Units	Total Collector Construction Area Sq. Ft.	Energy Production Btu Per Year	No 2 Diesel Equivalent US Gallons	Saving Per Year US Dollars	Payback Period In Years	Total Capital Thousands US Dollars
2 Ton Grain Dryer	13	9,100	0.8×10^9	8,840	8,224	1	125
Brewer's Grain Dryer	1	16,500	2.8×10^9	30,700	28,600	6.2	158
Coffee Dryers	14	24,000	2.45×10^9	26,900	25,000	11.6	230
Cocoa Dryers	10	18,000	1.84×10^9	20,190	18,780	11.3	173
Cassava Dryer	1	16,000	3.2×10^9	35,100	32,700	5.2	154
Tumeric Dryer	1	6,000	0.82×10^9	8,970	8,300	8.2	58
Lumber Dryer	1	8,000	0.68×10^9	7,470	6,950	19	98

TABLE 2-9

RECOMMENDED PROGRAM SCHEDULE AND COSTS FOR
SOLAR-HEATED AIR DRYING
(US $)

PROJECT	1980	1981	1982	1983	1984
Climatic Data	See Solar Industrial and Commercial Report				
Collector Development	$120,000	$ 90,000	$ 90,000	$ 90,000	$ 50,000
Encourage Sun Drying	12,000	12,000	12,000	12,000	12,000
Product Drying R&D	120,000	90,000	75,000	60,000	50,000
Grain and Legume (2000)* Dryers	8,900	38,000	57,000	19,000	
Cassava		(16,000)	154,000		
Brewer's Grain			(16,000)	158,000	
Tumeric			(6,000)	58,000	
Coffee		(8,000)	33,000	100,000	100,000
Cocoa			(8,000)	30,000	130,000
TOTAL	$260,900	$254,000	$451,000	$527,000	$342,000

*Parentheses indicate initial design cost; planning for additional units is included with construction cost.

to be 3,112 barrels (130,700 gallons). At the 1979 commercial price of U.S. $0.93 per gallon of #2 diesel oil, annual foreign exchange savings for fuel would amount to U.S. $121,552. Table 2-10 summarizes the costs and benefits for the solar-heated air drying program.

Table 2-10
Solar-Heated Air Drying
Costs and Benefits Summary

COSTS

Using 1979 U.S. dollars, the costs of this program are as follows:

	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Costs					
Foreign Exchange	$ 99,506	$ 96,444	$176,251	$203,315	$130,000
Jamaican Currency	161,260	144,532	258,034	304,635	195,600
Operating Costs					
Jamaican Currency	134	13,024	16,715	19,050	16,800
Total Costs by Year	$260,900	$254,000	$451,000	$527,000	$342,000
Grand Total for Program	U.S. $1,834,900				

To compare costs and benefits that occur over a number of years, however, it is customary to compute the present value of all the costs and benefits. This is accomplished by using a discount rate (here, it is 8%) and the following formula:

$$V_{(i)} = \frac{P_t}{(1 + i)t}$$

Where:
- i = interest rate;
- $V_{(i)}$ = present value of cost or benefit at interest rate i;
- t = year; and
- P = undiscounted value of cost or benefit in year incurred.

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Table 210A

COSTS (Discounted)

		Year 1	Year 2	Year 3	Year 4	Year 5
Initial Costs	Foreign Exchange	$ 99,506	$ 82,686	$139,914	$149,943	$ 88,476
	Jamaican Currency	161,260	123,913	204,836	223,916	133,122
Operating Costs	Jamaican Currency	134	11,166	13,269	14,003	11,162
Total Costs By Year		$260,900	$217,765	$358,019	$387,362	$232,760

Grand Total for Program U.S. $1,456,806

BENEFITS

For benefits, discounting was not necessary because the assumed annual rise in the price of oil (U.S. $20 in Year 1 - 1979 dollars) was equal to the assumed discount rate (8%). Considering the trend of oil prices over the last five years, this is a relatively conservative assumption about future oil prices. Using 1979 U.S. dollars, the program benefits expressed in both the imported fuel savings and in foreign exchange appear below.

BENEFITS

Year	Savings in gallons #2 Diesel	X $ .93/gal. =	Savings in Foreign Exchange (U.S. $)
1	680		$ 632
2	3,400		3,162
3	46,423		43,173
4	102,420		95,251
5	130,704		121,555
Total Benefits	283,627		$ 263,773

BENEFIT - COST RATIO

$$\frac{\text{Benefits}}{\text{Costs}} = \frac{263,773}{1,456,806} = .18$$

This is, of course, an unfavorable ratio. However, the fifth year of the program is the first year that all annual benefits are received. After 11 years of full operation (16 years total), without the construction of new units, and without additional benefits from technological advances that might result from the collector development and product drying R&D parts of the program, the entire program will pay for itself. This includes all the R&D elements and all operating expenses. After the fifth year, additional annual operating costs amount to only J. $28,700 (or U.S. $16,400), while benefits amount to U.S. $121,555 a year (or 103,704 gallons of #2 diesel). The 16 year comparison of program costs and benefits is summarized below in 1979 U.S. dollars.

16 YEAR BENEFITS

Year	Savings in gal.#2 diesel	Savings in Foreign Exchange
1	680	U.S. $ 632
2	3,400	3,162
3	46,423	43,173
4	102,420	95,251
5	130,704	121,555
6	130,704	121,555
7	130,704	121,555
8	130,704	121,555
9	130,704	121,555
10	130,704	121,555
11	130,704	121,555
12	130,704	121,555
13	130,704	121,555
14	130,704	121,555
15	130,704	121,555
16	130,704	121,555
Total Benefits	1,694,371	$ 1,600,878

BENEFIT - COST RATIO

$$\frac{\text{Benefits}}{\text{Costs}} = \frac{1,600,878}{1,536,503} = 1.04$$

This favorable ratio means the program pays off some time before the end of the twelfth year of operation of the entire program.

2.7.3. Biogas Application

2.7.3.1 Summary of Recommendations

This study made the following recommendations:

(1) Finalize one of the Scientific Research Council (SRC) family size and medium size biogas plant designs for use in a large-scale implementation program. Select the specific design based on available development, qualifications and prototype test results, and commercialization considerations.

(2) Postpone any consideration to install a biogas collector for use at the UWI-Mona Campus sewage treatment plant. In the event that the plant were to be expanded at a future date, the addition of biogas collection should be reconsidered at that time.

(3) Implement Option A, the baseline five year program, immediately. Develop, demonstrate and deploy 2,700 family size and 41 medium size biogas plants in Jamaica at the earliest possible time.

(4) Initiate a detailed marketing study to assess the commercialization potential of the selected Jamaican biogas plant designs in Jamaica, as well as in other countries of the Caribbean region.

(5) Study the feasibility of developing and demonstrating a large size biogas demonstration unit to generate electricity at a remote site.

(6) Re-examine the feasibility of implementing Option B, the accelerated five year program after the detailed marketing study has been completed. This should be done within the first year of the baseline program.

(7) Explore the interest of other government agencies, international organizations and international financial institutions to fund the additional 112 medium size biogas plants defined in the Option C program.

(8) Establish a Jamaican Government program management organization to implement the recommended five year biogas program.

(9) Establish a comprehensive training program and a broad rural public information program to support the implementation of all facets of the recommended five year program.

2.7.3.2 Compatibility of Recommendations with Objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan

The recommendations of the Biogas Study are very compatible with the objectives of the Energy Sector Plan. The recommendations, if adopted, will help diversify the present energy supply mix away from imported petroleum, develop an economically feasible non-conventional energy source adaptable to local needs, accelerate the development of an indigenous energy source (biomass), and contribute to Jamaica's energy self-sufficiency. Moreover, it would reduce the cost of energy to low-income groups by replacing purchased butane, kerosene and diesel fuel with free waste material; reduce the intensity of commercial and conventional energy in the economy without retarding economic growth; and enhance energy conservation.

2.7.3.3 Economic Factors Derived from the Recommendations

Surveys of both small and large farms indicated that there is considerable potential for biogas as an energy source throughout Jamaica. In the rural areas, there are a surprisingly large number of families who use butane and kerosene for cooking purposes, even though there are varying quantities of other forms of energy, such as wood, available. The amount of butane used for cooking was found to vary significantly, depending on family size and cooking habits. The range is 200 to 600 pounds per family per year. The prices of butane and kerosene, approximately J. $38 per 100 pounds and J. $1.60 per U.S. gallon respectively in December 1979, have increased steadily over the past five years, and there is no end in sight to price increases.

The energy required for cooking with butane would cost in the range of J. $76 (U.S. $43.33) to J. $228 (U.S. $130.29) per year, based on the above quantities of fuel use and a butane cost of J. $38 (U.S. $21.71) per 100 pounds. These figures represent a considerable fraction of the family budget in rural areas.

There are two methods to evaluate the economics of biogas plants. In one, the actual value of butane or kerosene now being used which would be replaced by biogas is emphasized. As stated previously, the range of butane consumption per family is large, but a conservative cost estimate based on 250 pounds per year at J. $40 (U.S. $22.86) per 100 pounds, would be J. $100 (U.S. $57.14) per year. The capital cost of a family biogas plant (J $400 or U.S. $228.57) would then be repaid in four years.

Another method of economic analysis is to calculate the actual Btu energy value of the biogas produced. Here, the value of any excess biogas beyond that needed for cooking is included. Assuming 500 Btu per cu ft and biogas production of 100 cu ft per day, approximately 18 million Btu would be produced per year. per family biogas plant. This would have a butane value of nearly 1000 pounds and a potential economic benefit of approximately J. $400 (U.S. $228.57). The pay back period for a household plant costing J. $400 (U.S.$228.57) is about one year. By either method of evaluation, then, the economics of individual biogas plants are quite favorable, and will be even more so as the price of imported oil continues to increase.

The above economic considerations are based on energy production only. But there are several other benefits from biogas plants which should be considered in an economic analysis. One of these is the value of the nutrients held in the digested residue for fertilizer. Another is the potential of the digested residue as feed for plants and animals. Fish farms using waste residues are well-known in the United States, the Philippines and other countries. The digested residue is also sometimes processed and re-fed to animals. In these cases, the value of the residue is three to five times the value of the biogas produced in the digestion process. Pollution control is another potential benefit from biogas plants. In summary, there are many benefits beyond favorable energy prices alone which improve the cost effectiveness of biogas facilities.

2.7.3.4 Economic Assessment

The study recommends a five year program (Option A) of demonstrating and commercializing biogas plants. The first two years would be entirely demonstration. This program will provide for the funding of one hundred household size plants and six medium or community size plants throughout Jamaica. The commercialization phase of the program would be its last three years. It is envisaged that during this period, 2,600 household size and 35 medium

size plants would be constructed. The costs of a training program for constructing, operating and maintaining biogas plants, along with management costs, are included in the five year budget.

Two options to the program were also addressed in this report. Option B is a much larger program designed to expand the effort in years 2 through 5 in order to install a total of 11,450 family size units and 79 medium size plants. Option C is somewhat larger, but emphasizes medium size plants. At the end of five years, only 2,700 family size units would be in place, but 153 medium size plants would also be installed. For a complete analysis of these two options, see Sections 5.7.3.2 and 5.7.3.3 in Chapter 5 (Biogas).

Table 2-11 summarizes the fuel oil equivalent (f.o.e.) of imported fossil fuels that the suggested program (Option A) would save.

Table 2-11
Energy Savings (bbl. f.o.e.)
of the Biogas Program

Year	SECTOR			TOTAL
	Residential	Industrial	Agricultural	
1	152	165	17	334
2	304	324	40	668
3	912	600	69	1581
4	2128	800	478	3406
5	8208	1694	800	10,702
TOTAL	11,704	3,583	1,404	16,691

The impact of this program on the country's energy situation is very small. With 8,887,200 barrels (net) f.o.e. imported in 1978, the 10,702 barrels saved in year 5 of the program account for a small fraction of one percent of Jamaica's oil imports. However, it should be noted that this program is only a beginning. Only 2,700 households, for instance, will have biogas plants at the end of the program. In a country of over 2 million, this leaves tens of thousands of homes to be fitted with plants in a follow-up program.

Assuming four hundred thousand households in Jamaica, and assuming further that only 5% of them could reasonably be outfitted with biogas plants, the potential annual savings of

imported energy could be as much as 61 thousand barrels of f.o.e. imported. These annual savings would represent .7% of net fuel imports.

2.7.3.4.1 Effects of Recommended Actions on Jamaica's Economy: At a price of U.S. $20 (1979 dollars) a barrel of oil in Jamaica, a .7 percent annual savings in energy imports (61,000 barrels) is equivalent to U.S. $1,220,000 This is a small, but significant savings in foreign exchange. Therefore, this program has a good deal of potential. If it is not exceptionally costly, it should be adopted as a first step in approaching that potential. Table 2-12 outlines the construction schedule.

TABLE 2-12

BIOGAS PROGRAM - CONSTRUCTION SCHEDULE

Year	Demonstration 1	Demonstration 2	Commercialization 3	Commercialization 4	Commercialization 5
Household size					
new units	50	50	200	400	2000
total units in place	50	100	300	700	2700
Medium size					
new units	3	3	5	10	20
total units in place	3	6	11	21	41

2.7.3.4.2 Costs and Benefits Summary: Table 2-13 summarizes the costs and benefits of this program.

TABLE 2-13

BIOGAS COSTS AND BENEFITS SUMMARY

Using 1979 U.S. dollars, the program costs appear as follows:

	Year 1	Year 2	Costs Year 3	Year 4	Year 5
Initial Costs					
- Foreign exchange	$ 45,943	$ 45,029	$ 69,486	$101,486	$315,200
- Jamaican currency	68,914	67,543	104,228	152,229	472,800
Operating Costs					
- Jamaican currency	4,000	8,571	17,143	25,714	57,143
Total Costs by Year	$118,857	$121,143	$190,857	$279,429	$845,143

Grand Total for Program U.S. $ 1,555,429

However, in order to compare costs and benefits that occur over a number of years, it is customary to compute the present value of all the costs and benefits. This is accomplished by using a discount rate (in this case 8%) and the following formula:

$$V_{(i)} = \frac{P_t}{(1+i)^t}$$

Where:

i = interest rate;
$V_{(i)}$ = present value of cost or benefit at interest rate i;
t = year; and
P = undiscounted value of cost or benefit in year incurred.

Costs (discounted)

	Year 1	Year 2	Year 3	Year 4	Year 5
Initial Costs					
-Foreign exchange	$ 45,943	$ 38,605	$ 55,160	$ 74,595	$214,520
-Jamaican curreny	68,914	57,907	82,740	111,893	321,780
Operating Costs					
-Jamaican currency	4,000	7,348	13,609	18,900	38,891
Total Costs by Year	$118,857	$103,860	$151,509	$205,388	$575,191
Grand Total for Biogas Program	U.S. $1,154,805				

Benefits

For benefits, no discounting was performed as it was assumed that the annual rise in the price of oil (U.S. $20 in Year 1 - 1979 dollars) would be equal to the 8% discount rate. In light of the price rises over the last five years, this is a rather conservative assumption about future oil prices. In any case, the two cancel each other. Using 1979 U.S. dollars, the program benefits expressed in both savings of fuel oil equivalent and in foreign exchange appear below.

Benefits

YEAR	SAVINGS IN BARRELS (f.o.e.)	SAVINGS IN FOREIGN EXCHANGE (U.S.$)
1	334	$ 6,680
2	668	13,360
3	1,614	32,280
4	3,406	68,120
5	10,702	214,040
Total Benefits	16,724	$ 334,480

Benefit - Cost Ratio

$$\frac{\text{Benefits}}{\text{Costs}} = \frac{334,480}{1,154,805} = .29$$

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This is an unfavorable ratio. Of course, the benefits of the program are just beginning. Only at the end of the fifth year are all the biogas plants in place and in full operation. After only five additional years (10 years total), and without the construction of additional units, the entire program will pay for itself including all operating expenses. Additional annual costs amount to only J. $168,000 (or U.S. $57,143 in foreign currency terms), while benefits amount to U.S. $214,040 a year (or 10,702 barrels f.o.e. saved). The ten year comparison of program costs and benefits is summarized on the next page in 1979 U.S. dollars.

Benefit - Cost Ratio

$$\frac{\text{Benefits}}{\text{Costs}} = \frac{1,404,680}{1,310,177} = 1.07$$

Based on the above assumptions and an ten year time frame, the benefit-cost ratio of 1.07 indicates that the program should be adopted even if no further expansion is undertaken in a follow-on program.

8 Year Costs (discounted)

Initial Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
- Foreign exchange	$ 45,943	$ 38,605	$ 55,160	$ 74,595	$ 214,520	$ -	$ -	$ -		
- Jamaican currency	68,914	57,907	82,740	111,893	321,780	-	-	-		
Operating Costs Jamaican currency	4,000	7,348	13,609	18,900	38,981	36,011	33,343	30,873	$ 28,586	$ 26,469
Total Costs by Year	$118,857	$103,860	$151,509	$205,388	$ 575.281	$36,011	$33,343	$30,873	$ 28,586	$ 26,469
Grand Total for Program	US $1,310,177									

8 Year Benefits

Year	Savings in barrels (f.o.e.)	Savings in foreign exchange (US$)
1	334	$ 6,680
2	668	13,360
3	1,614	32,280
4	3,406	68,120
5	10,702	214,040
6	10,702	214,040
7	10,702	214,040
8	10,702	214,040
9	10,702	214,040
10	10,702	214,040
Total Benefits	70,234	US 1,404,680

2.7.4 Energy Conversion from Waste

2.7.4.1 Summary of Recommendations

Urban Solid Wastes - Kingston

It is concluded that the only alternative worthy of consideration for energy recovery from urban solid wastes in Kingston is waterwall incineration with steam generation. This application appears to be cost effective. The major problem is inefficient and unreliable refuse collection, making it impossible to recover energy from the waste.

It is recommended that a detailed study of the physical, managerial, and sociological aspects of the collection problem in Kingston be considered.

University of the West Indies - Mona Campus

The results of this study lead to the conclusion that the UWI-Mona Campus should not get involved in a field-scale demonstration of the anaerobic digestion of campus refuse for methane generation.

It is recommended that the UWI-Mona Campus develop an "Alternative Energies Laboratory" and that the University be assisted financially in the amount of U.S. $182,500 over the next three years.

2.7.4.2 Compatibility of Recommendations with Objectives of the Five Year Plan (1978-1983) and its Energy Sector Plan

The recommendations of the Assessment of Energy Conversion from Waste are to do nothing in this area. Certainly, inaction does nothing to further (or conflict with) national goals; but the urban waste report points out that scarce financial resources could best be spent on other, more productive energy projects.

2.7.4.3 Economic Assessment

Energy Recovery from Urban Waste in Kingston

The study pointed out that the 1,000 tons per day of urban waste generated in the Kingston Metropolitan Region are equivalent to 370,000 barrels of fuel oil per year, or 4.2 percent of all Jamaica's energy imports. At a price of U.S. $20 per barrel, this represents a foreign exchange savings of U.S. $7.4 million a year.

While the annual costs (capital, operating and maintenance) of recovering this energy through a waterwall furnace would be U.S. $7,724,000 ($4,074,000 = annual capital costs and $3,650,000 = annual O&M), the costs of collecting the refuse are estimated at U.S. $9,788,000 annually. Therefore, with annual costs for both refuse collection and actual energy recovery in a waterwall furnace of U.S. $17,512,000 (U.S. $10,112,000 in excess of the energy import savings from the process), the project is economically infeasible. Consequently, it is recommended that it not be undertaken. However, a detailed socio-economic analysis of the project (at a cost of about U.S. $150,000) would point out benefits other than energy savings which would make the project a reasonable one. For example, there would be substantial health benefits from increased sanitation, and a large number of jobs could be generated by the refuse collection process, etc. However, it must be emphasized that without the regular, efficient and expensive collection of urban refuse, the project could not succeed.

Demonstration Unit at the University of the West Indies - Mona Campus

An assessment of the value and feasibility of an energy recovery demonstration project at the Mona Campus was conducted. A field scale demonstration project would be one way to help educate students about alternative energy technologies and to promote "energy awareness" in Jamaican society. The assessment showed that the only energy recovery alternative that is reasonably well-suited to a moderate size field-scale demonstration would be an anaerobic conversion (biogas) unit. The thermal process, incineration and pyrolysis are not suited to small-scale applications. It was concluded that the proposed demonstration at the Mona Campus would not be a very meaningful or helpful exercise in providing a technology or in educating students. It was felt that financial resources would be best used in the development of a laboratory that could be devoted to research and demonstration or a wide range of energy conversion alternatives, rather than to justify a single technology as would be the case with the field activity. The establishment of such an "Alternative Energy Laboratory" would cost approximately U.S. $182,500.

2.7.5 Coal Prefeasibility Study

2.7.5.1 Summary of Conclusions and Recommendations

The coal technology study provided the following information:

Conclusions

The following conclusions have been reached:

(1) JPS installed system capacity is approximately 455 MW which is greatly in excess of the present 210 MW peak. Thus, a new unit is not needed to meet the expected system load at the present time. However, unit outages cause frequent rolling blackouts. A major program is needed to improve unit availability, particularly of the newer, more efficient units. If the four newest units, having a total capacity of 250 MW, could have improved availability and operate at a high capacity factor, there would be a large fuel savings without any capital expenditure.

(2) Existing boilers for JPS or the aluminum companies can not be retrofitted to burn coal directly. In the future they may be able to burn coal-oil mixture (COM) or a coal gasification product.

(3) The possibility of obtaining a favorable long-term coal contract is very good at the present time. However, a detailed coal contract study is required to determine the actual coal price delivered in Jamaica.

(4) The schedules of the bauxite and aluminum ships are tight, but the transportation of coal from the U.S. Gulf Coast on the backhaul is a distinct possibility. Large enough quantities of coal may be required in the event COM firing becomes feasible to permit one of the companies to add a new ship to free up the schedule. This can only be determined by detailed discussion with the aluminum companies at that time. There is a good possibility coal can also be transported by non-U.S. ships at a cost approximating that of the bauxite ships.

(5) The installation of a coal-fired unit may look attractive if a conservative differential oil-coal escalation rate of only 1 percent exists, and if joint use of harbor facilities and site can be made at Port Esquivel, or at the new proposed Jamaica Bauxite Mining (JBM) South Manchester site at Cuckold Point. This can only be determined by

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conducting detailed discussions with Alcan and JBM, preparing more detailed cost estimates, and obtaining accurate coal prices.

(6) The decision to build a coal-fired unit at this time with new harbor and extensive coal unloading and storage facilities would be a judgment decision, as a large differential coal-oil escalation rate of 3 to 4 percent would probably be required to justify the construction. This would also assume that the large differential escalation rate would continue for 25 years.

(7) The use of a combined cycle gas turbine does not close the door to the eventual use of coal. If one of the low-Btu coal gasification processes proves commercially feasible, it can supply coal gas to the gas turbines and reap the benefits of a very low station heat rate of approximately 8,750 Btu/kWh, as compared with about 10,500 Btu/kWh for a coal-fired unit.

Specific Recommendations

The specific recommendations of this report are as follows:

(1) It is recommended that the Jamaican Government and JPS provide sufficient funds to maintain and upgrade the newer, more efficient existing units to obtain the potential fuel savings available in these units.

(2) It is recommended that exploratory negotiations be initiated with Alcan and JBM regarding joint use of their harbor facilities and site at Port Esquivel and Cuckold Point, respectively. If these negotiations prove positive, it is recommended that a more detailed estimate for installing a coal-fired unit be prepared and compared with the expected costs and benefit of burning coal. It is estimated that the cost of arriving at a mutually agreeable plant layout and cost estimate is U.S. $100,000.

(3) It is recommended that a coal supply and shipping study be authorized to confirm the delivered price of coal in Jamaica. This will provide the necessary back-up to determine more accurately the expected cost savings for burning coal, and will provide the basis for future coal contract negotiations.

(4) It is recommended that COM progress be monitored, and if JPS can devise an effective reliability program and if oil prices continue to rise at 1 or 2 percent greater than coal, a full-scale coal feasibility study should be authorized.

(5) Technology advances in coal gasification should be followed closely, and as systems are proven feasible, they should be examined for applicability in Jamaica.

2.7.5.2 Compatibility of Recommendations with Objectives of the Five Year Development Plan (1978-1983) and its Energy Sector Plan

The recommendations of the coal assessment team are compatible with one of the crucial objectives of the Energy Sector Plan listed in Section 2.5.1.3. That is, if either the coal-fired plant or the coal-oil mixture facility is found to be economically feasible, it would diversify the present energy supply mix away from imported petroleum. However, since Jamaica has no coal of its own, it would still remain dependent on fuel imports. Even though the costs would be much lower, this would do nothing to alleviate Jamaica's energy dependency and it would still leave the country at the mercy of foreign producers.

2.7.5.3 Economic Factors

Several important factors would affect the feasibility of converting from oil to coal for electricity generation:

- Additional electric generation capacity is not needed presently in Jamaica, and is not projected to be needed before 1985-1990.
- Jamaica's newer, more efficient units could be repaired to realize additional conservation of fuel oil.
- The price at which coal could be purchased and transported would have a significant impact on the economic feasibility of coal conversion.
- The off-loading, port facilities and plant location are of primary importance in determining the economics of coal use in Jamaica.

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- Future developments in the use of coal-oil mixture (COM) or coal gasification may cause coal use to become more attractive since existing boilers cannot be retrofitted to use coal. The fuel cost differential escalation rates for oil and coal will be a significant factor.

- Based on the above factors, coal use does not appear justified, especially in light of the excess generating capacity already available. More detailed analysis and feasibility studies are needed to determine the economic feasibility of a new coal-fired unit.

An economic analysis was conducted based on some of the assumptions listed below. Any variance in these assumptions could have a drastic effect on the results; for that reason, they must be quantified before any decisions are made.

Assumptions

(1) Current coal price of J. $82.25 (U.S. $47) per ton escalated at 8 percent over the 25 year life of the plant.

(2) Current oil price of J. $31.50 (U.S. $18) per barrel escalated at 9 percent over the 25 year life of the plant.

(3) Coal-fired plant capital cost is based upon use of existing port facilities with minimum coal unloading facility costs.

(4) Present worth capacity factor of 65 percent.

(5) Average heat rate of existing units will remain at 13,500 Btu/kWh which compares with the 1978 system heat rate of 13,134 and the 1977 system heat rate of 14,101. (If the four most effective existing units can be base loaded to reduce the system heat rate to approximately 12,000 Btu/kWh, this will greatly affect the evaluation compared to existing units. It will not affect the evaluation compared to a new oil-fired unit.)

2.7.5.4 Economic Assessment

2.7.5.4.1 Effects of Recommended Actions on Jamaica's Energy Situation: If a coal-fired plant were built, the new facility could be expected

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to save 923,917 barrels of oil annually. With consumption of imported fossil fuel at 8,887,200 (net) barrels of fuel oil equivalent (f.o.e.) in 1978, this represents a potential annual imported fuel savings of 10.4 percent. However, imported coal would be used each year. This is equivalent to approximately 652,500 barrels f.o.e. Net annual fuel savings then would be reduced to 271,367 barrels f.o.e., or 3.1 percent of imported fuel (based on 1978 comsumption). While this is a more modest savings, over the 25 year life of an electrical generating facility, the net levelized savings in foreign exchange remain quite significant. These and other important economic considerations are presented in the following section.

2.7.5.4.2 Potential Effects of Recommended Actions on Jamaica's Economy: At a price of U.S. $20 (1979) per barrel of oil in Jamaica, but taking into effect the different heating values of coal and oil, a 3.1 percent annual savings of petroleum imports (271,367 barrels) is equal to U.S. $7,867,000. This is a reasonably important annual savings in foreign exchange.

The coal study, moreover, has demonstrated that there are other substantial savings to be acquired by building a new coal-fired plant rather than any other type of plant. These are summarized in Table 2-14.

Over the 25 year life of an electrical generating plant, a coal-fired plant would save about U.S. $24 million more than a new low-speed diesel plant.

In addition, it would save about U.S. $4.4 million more than the combined-cycle gas turbine plant. Actually, this is a rather insignificant amount. However, the fuel savings for the coal-fired plant (see Table 2-14) are much greater than those for the combined-cycle plant. The savings for the latter plant are due primarily to its much lower capital costs.

TABLE 2-14

COMPARISON OF NEW ELECTRICAL GENERATING PLANTS IN JAMAICA

Plant Type	Plant Cost (1979)	1985 Capital Cost of Plant	Annual Oil Savings (1979)* over Existing Plants barrels oil	US$	Capitalized Fuel Savings (levelized 1985) Over Existing Plants	Net Savings Over Existing Plants	Power Generation Costs (US¢/kWh) levelized 1979	levelized 1985
Coal	76,700,000	102,577,000	923,917 -652,550 ← *coal required 271,367	18,478,340 in f.o.e. 7,867,000+	207,062,000	104,485,000	7.24	11.08
Oil	55,965,000	73,970,000	273,968	5,479,360	84,748,000	10,778,000	7.85	12.24
Combined Cycle	31,720,000	41,210,000	388,311	7,766,220	141,125,000	99,915,000	7.32	12.05
Diesel	62,172,000	76,578,000	412,383	8,247,660	156,941,000	80,183,000	8.64	14.00

* 179,272 tons of coal x 3.64 (f.o.e. conversion factor) = 652,550 barrels f.o.e.

\+ Although the US$ savings of 271,367 barrels (at US$ 20/barrel) are $5,427,340, the savings actually realized are $7,867,000. This is because of the difference in cost for the equivalent number of barrels of f.o.e. as compared with the costs of the equivalent heating value of coal vs. oil.

2.7.6 Electric Utility Rate Analysis

2.7.6.1 Summary of Options

Specific recommendations were not made as to which tariffs should be adopted; instead, a group of options based on marginal cost principles were developed for JPS. These options were derived based on a number of general conditions summarized below:

(1) Total revenue requirements will not be changed.
(2) Total revenue allocations among customer categories will not be altered.
(3) Declining block pricing will be eliminated.
(4) Ratchet provisions will be eliminated.
(5) Expander tariffs will be eliminated.
(6) Flat (both all-energy and two-part) demand and energy tariffs will be considered.
(7) When metering and customer acceptance seem reasonable, time of use pricing will be considered.
(8) The very progressive (from an efficiency standpoint) fuel adjustment clause will be continued.
(9) The innovative Cost of Service adjustment will be retained.
(10) Continuing the residential customer flat rate with the first 10 kWh included free, will be presented.

The table provided (Table 2-15) is an overview of some of the options provided to JPS for their decision-making process on electric tariff structures.

2.7.6.2 Compatibility of Recommendations with Objectives of the Five Year Plan (1978-1983 and the Energy Sector Plan

The overall objectives of the study were to establish a system that:

(1) Promotes a more economic use of electricity in Jamaican society;
(2) Maintains the financial viability of the electric utility corporation;
(3) Optimizes the use of fuel and foreign exchange; and
(4) Meets the income distribution objectives (e.g., subsidizing poorer consumers) which the electricity tariff is required to serve.

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TABLE 2-15

A SUMMARY OF OPTIONS BASED ON MARGINAL COST PRINCIPLES

CUSTOMER	TARIFF OPTION	DISCUSSION	EXAMPLE TARIFF STRUCTURE*			REFERENCED TABLES
Residential (Rate 10)	o Flat Tariff	o The same rate regardless of usage	All Usage		11.66¢/kWh	8-19A
	o Inverted Block	o Costs increase with usage	0-10 kWh	0¢	10.60¢	8-19B
			11-100 kWh	12.19¢	10.60¢	8-20A
			over 100 kWh	12.60¢	12.60¢	8-20B
Small Commercial (Rate 20)	o Flat Tariff (Low)	o The same rate regardless of usage	All Usage	12.42¢	12.77¢/kWh	8-21A
	o Inverted Block	o Costs increase with usage	0-1000	11.274¢		8-21B
			over 1000	13.274¢		8-22
Large Commercial (Rate 40)	o Flat Tariff with Demand Charge	o The same rate regardless of usage - Two factors determine Rate: (1) Maximum power requirement (kW) above established level; (2) Total energy demand over a period of time (kWh)	2.15¢/kW/mo. + 6.11¢/kWh			8-23 8-24
	o Peak - Off-Peak with Demand Charge	o Less is charged during periods of low demand - Same two factors above (kW and kWh) determine charge	2.15¢/kW/mo. + 7.11¢ during peak or 4.11¢ during off-peak			8-25
	o Increased Revenue	o Declining Block (more usage - less cost) -- not as steep as existing blocks	First 100 hrs		6.38¢ + 2.15¢/kWh	
			Next 200 hrs		5.38¢ + 2.15¢/kWh	
			Over 300 hrs		4.50¢ + 2.15¢/kWh	
	o Flat Tariff - No Demand Charge	o Flat rate with no two-part charge as above	All Usage		6.11¢/kWh	
	o Peak - Off-Peak No Demand Charge	o Flat rate for peak time usage -- another less expensive flat rate for off-peak usage	Peak Usage		7.89¢/kWh	
			Off-Peak Usage		4.89¢/kWh	

TABLE 2-15 CONTINUED

A SUMMARY OF OPTIONS BASED ON MARGINAL COST PRINCIPLES

CUSTOMER	TARIFF OPTION	DISCUSSION	EXAMPLE TARIFF STRUCTURE*			REFERENCED TABLES
Residential (Rate 10)	o Flat Tariff	o The same rate regardless of usage	All Usage		11.66¢/kWh	8-19A
	o Inverted Block	o Costs increase with usage	0-10 kWh	0¢	10.60¢	8-19B
			11-100 kWh	12.19¢	10.60¢	8-20A
			over 100 kWh	12.60¢	12.60¢	8-20B
Small Commercial (Rate 20)	o Flat Tariff (Low)	o The same rate regardless of usage	All Usage	12.42¢	12.77¢/kWh	8-21A
	o Inverted Block	o Costs increase with usage	0-1000	11.274¢		8-21B
			over 1000	13.274¢		8-22
Large Commercial (Rate 40)	o Flat Tariff with Demand Charge	o The same rate regardless of usage - Two factors determine Rate: (1) Maximum power requirement (kW) above established level; (2) Total energy demand over a period of time (kWh)	2.15¢/kW/mo. + 6.11¢/kWh			8-23 8-24
	o Peak - Off-Peak with Demand Charge	o Less is charged during periods of low demand - Same two factors above (kW and kWh) determine charge	2.15¢/kW/mo. + 7.11¢ during peak or 4.11¢ during off-peak			8-25
	o Increased Revenue	o Declining Block (more usage - less cost) -- not as steep as existing blocks	First 100 hrs		6.38¢ + 2.15¢/kWh	
			Next 200 hrs		5.38¢ + 2.15¢/kWh	
			Over 300 hrs		4.50¢ + 2.15¢/kWh	
	o Flat Tariff - No Demand Charge	o Flat rate with no two-part charge as above	All Usage		6.11¢/kWh	
	o Peak - Off-Peak No Demand Charge	o Flat rate for peak time usage -- another less expensive flat rate for off-peak usage	Peak Usage		7.89¢/kWh	
			Off-Peak Usage		4.89¢/kWh	

Any tariff structure with the above four effects is very compatible with several important objectives of the Energy Sector Plan enumerated in Section IV.A.3. Specifically, energy would be conserved through its more efficient use, and electricity prices would be rationalized to achieve economic allocation of energy resources while cushioning the cost of energy to low income groups.

2.7.6.3 Economic Assessment

Any new tariff structure adopted is expected to change the pattern of electricity consumption. The fuels used to generate electricity would be used more efficiently. More electricity would be generated and consumed from the same quantities of fuels because a smoother electrical load pattern would exist. However, the precise amount of fuel savings due to increased efficiency or redistribution of usage is dependent upon the nature of the exact measures that JPS adopts. Consequently, evaluation of these savings must await JPS's decisions. Once a new rate structure is established, fuel savings and potential foreign exchange savings to the economy can be estimated.

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2.8 RECOMMENDED COMBINED ENERGY PROGRAM

Before discussing the actual program, it should be noted that the Combined Energy Program is thought of as an initial effort that will encourage other larger and even more comprehensive undertakings. The Terms of Reference detailed only the 6 specialized studies; other renewable resources such as wind and mini-hydro power were not reviewed. Conservation measures were also excluded from analysis. Other Jamaican Government efforts, however, are already in progress to deal with these issues.

2.8.1 Compatibility of the Recommendations of Each of the Specialized Studies with Those of the Others

The recommendations of the separate studies either have no direct relationship to each other, and therefore do not conflict, or they reinforce each other.

2.8.2 Combined Energy Program Recommendations

Recommendations are grouped according to highest, higher, and high priority; the underlying assumption being that all the recommendations are of high priority, but some merit more immediate attention than others. Within each of the three groups, however, the recommendations are not listed in any order.

2.8.2.1 Highest Priority Recommendations

These are identified for immediate action:

(1) Solar Energy - Commercial and Industrial

a. Establish five climatic stations to record solar radiation levels and ambient temperatures;

b. Establish a solar collector performance testing and certification program;

c. Eliminate the existing tax on water heater tanks utilized in solar water heater systems;

d. Establish training courses for solar system installers;

e. Start in-depth feasibility studies and evaluations of all industrial processes and commercial systems to determine the most economically justifiable solar hot water applications;

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f. Start in-depth feasibility studies and evaluations of all hospitals to determine the most economically justifiable solar hot water applications;

g. Start a solar hot water demonstration program at Bustamante Hospital for Children; and

h. Provide ongoing technical support to the JPS solar demonstration program in the residential sector.

(2) Solar Energy - Agricultural

a. Implement the solar data collection program as recommended in Solar Energy -- Commercial and Industrial Study;

b. Develop air-type solar collector technology suitable to tropical climates;

c. Encourage the development of agricultural products sun-drying technology, maintaining quality through an education program administered by the Agricultural Extension Service; and

d. Establish a product drying research and development program to institute technically sound methods of solar-heated air drying of agricultural products.

(3) Biogas Study

a. A five year demonstration and commercialization program should be initiated to install 2700 household size and 41 medium size biogas plants for the production of methane for cooking. Initiate a detailed marketing study to assess the commercialization potential of biogas applications.

(4) Coal Prefeasibility Study

a. JPS should initiate negotiations with Alcan and/or Jamaica Bauxite Mining to obtain agreement for the use of an existing or new aluminum port facility for coal handling if a 65 MW coal-fired electrical generating plant is to be considered. The repair and upgrading of existing power plant units should be separately considered by JPS and the Government of Jamaica.

(5) Energy Conversion From Waste

a. No actions are recommended.

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2.8.2.2 Higher Priority Recommendations

These are either slightly less critical than the highest priority recommendations, or in some way depend on one or more of those in the highest priority group already being approved, initiated or implemented.

(1) Solar Energy - Commercial and Industrial

a. Establish two more climatic stations to record solar radiation and ambient temperatures;

b. Investigate the possible export of solar products manufactured in Jamaica;

c. Establish tax incentives for cost effective commercial and industrial solar applications;

d. Establish tax incentives for solar hot water systems installed in new housing;

e. Establish a consumer energy information office; and

f. Develop designs for converting all remaining hospitals to solar hot water.

(2) Solar Energy - Agricultural

a. Construct thirteen solar-heated 2-ton air drying systems for grain and legumes; and

b. Construct systems for the solar preheating of air for commercial dryers of cassava (one system), brewer's grain (one system) and tumeric (one system).

(3) Biogas Study

a. None

(4) Coal Prefeasibility Study

a. If an agreement with one or both aluminum companies to use an existing or new aluminum port for coal handling is forthcoming, then a detailed feasibility estimate for a 65 MW coal-fired electrical generation plant should be undertaken.

b. If an agreement with one or both aluminum companies is not signed, a 65 MW coal-fired plant will not be economically feasible. Consequently, the progress of developments in the coal-oil mixture schemes being tested abroad should be monitored quite closely by the Government of Jamaica.

(5) Electric Utility Rate Analysis

a. None at this time.

(6) Energy Conversion from Waste
a. Establish an "Alternative Energies Laboratory" at the University of the West Indies - Mona Campus.

2.8.2.3 High Priority Recommendations

These either depend upon the initiation or implementation of the first two groups of recommendations, or should only be undertaken if funding remains after the others are financed.

(1) Solar Energy - Commercial & Industrial
a. Establish another three climatic stations to record solar radiation levels and ambient temperatures;

b. Establish a college-level energy conservation and solar application course for architects and engineers; and

c. Install solar hot water systems in all remaining hospitals in Jamaica.

(2) Solar Energy - Agricultural
a. Construct fourteen systems for the solar preheating of air for commercial dryers of coffee; and

b. Construct ten systems for the solar preheating of air for dryers of cocoa.

(3) Biogas Study
a. None.

(4) Coal Prefeasibility Study
a. If an agreement is not signed between the GOJ and one of the two aluminum companies previously mentioned to use their port for coal handling, and if, after two years of monitoring coal-oil mixture (COM) overseas, one of the COM schemes should prove commercially feasible, then a detailed feasibility study of that scheme for Jamaica should be authorized.

(5) Electric Utility Rate Analysis
a. None at this time.

(6) Energy Conversion from Waste
a. None

2.8.3 Effects of the Combined Energy Program on Jamaica's Energy Situation

A number of the recommendations of the Combined Energy Program will have very little direct, immediate effect on Jamaica's energy situation. Rather, they will create a sound base for the steady diversification of the nation's energy sources in the coming decade. In order for Jamaica's large potential resources of solar energy and biogas, identified in this report, to be exploited to any degree, and for coal to be used effectively, these first small, principal steps must be taken.

Solar energy (3.5%) and biogas (.7%) potential together, if fully exploited, amount to 4.2% of Jamaica's net energy imports. If the net fuel savings of a coal-fired electrical generating plant are included, the potential savings rise to 7.3%. If the new electrical utility tariff structure that JPS adopts results in even a 1% savings in fuel, the potential savings in imported fuel that this Combined Energy Program begins to capture will amount to 8.3%. Using the 1978 figure of 8,887,200 barrels (net) f.o.e. for Jamaica's consumption of imported fuel, this amounts to 737,632 barrels f.o.e. annually.

Immediate effects will, of course, be much lower. None of the specialists on the U.S. energy team feels that all this potential will be captured within the next few years. Nonetheless, if by 1985, thirty percent of hotels (3,155 barrels f.o.e.), all hospitals (13,700 barrels) and 4,000 additional residences (21,200 barrels) use solar hot water, if enough commercial and industrial systems use solar hot water to save .5% of fuel imports, if 2,741 biogas plants are built (10,702 barrels), if 40 solar air-type dryers are built (130,702 gallons of #2 diesel), if a 65 MW coal-fired electrical generating plant is in operation (3.1% savings in fuel imports), and if the JPS tariff structure allows for a fuel savings of .2% of energy imports, the net import bill for energy will be reduced by 4.4% annually, or by 389,582 barrels f.o.e. Of course, this figure represents a mere beginning. It assumes no technological change. However, by 1985, some form of solar energy besides water heating and agricultural applications may be feasible. Also, other non-energy developments might make additional projects possible. For example, if an efficient waste collection program were undertaken in Kingston, a project to convert this waste to energy could become both technically and economically feasible.

Moreover, an enormous amount of experience will have been gained by the Jamaican people in implementing alternative energy technology programs. With the programs that will have been completed, the studies that will have been finished, and the technical capability that will have been established, Jamaica will be in a position to obtain far greater gains over the next five years.

If the Combined Energy Program outlined here is adopted, by 1985 Jamaica could, quite possibly, have a well-functioning and professionally operated solar collector testing and certification service, all its plumbers trained to install solar hot water, and a reasonable number of new and old residences installing solar water heaters each year. It should also have a growing and increasingly export-oriented solar collector manufacturing industry, and an increasing use of solar hot water in commerce and industry. Also, there should be a public well-informed on energy matters, an excellent meteorological data base, and energy-sensitive architects and engineers. Twenty-seven hundred household size and forty-one institutional size biogas plants could also be in place, plus the country would have the capability of installing many thousands more. An efficient and modern coal-fired electrical generating plant, a sensible electrical tariff structure that helps conserve energy, and 40 solar air-type agricultural dryers might also be in place. Finally, Jamaica would have well-functioning R&D programs in air-type solar collector technology, in agricultural product drying and in other alternative energy technologies.

These are diverse and important gains. They would place Jamaica at the forefront of energy development in the Caribbean region. Certainly, in the absence of this or a similar energy program, few of these advances could be accomplished.

2.8.4 Effects of the Combined Energy Program on Jamaica's Economy

Perhaps the most surprising aspect of the Combined Energy Program is the modest cost for all these improvements in Jamaica's energy situation. The initial costs plus operating costs of the entire program as summarized in Tables 2-16 and 2-17 are only $6,228,828 (U.S. $ 1979). If only the Bustamante Hospital, rather than all those in the country, were converted to solar hot water during the program, total costs would be reduced to only $4,644,828 (U.S. $ 1979), an extremely modest amount.

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TABLE 2-16

SUMMARY OF RECOMMENDATIONS, COSTS AND BENEFITS OF COMBINED PROGRAM (1979 US$)

Priority	Recommendation	Costs (i=initial) (o=operating)	Benefit	Type of Funding	Number of years initial funding required	Program Year of Start	Program Year of 1st benefit
HIGHEST							
o Solar							
· Industrial							
	- Climatic Stations (5)	75,000(i); 50,000(o)	-improved meteorological data	External	1	1	2
	- Solar Collector testing Program	50,000(i); 20,000(o)	-better collectors	External	1	1	2
	- Eliminate solar water heater tax	0	-more solar hot water heaters in operation	No funding necessary	0	1	1
	- Training course for installers	75,000(i+o)	-better operating systems; lower maintenance costs	External	1	1	1
	- Industrial & Commercial feasibility studies	150,000 (over 2 yrs)	-will learn best potential in these sectors	External	2	1	3
	- Hospital feasibility studies	50,000	-show extent of potential for hot water in all hospitals	External	1	1	2
	- Hospital demonstration project (costs included in total hospital program)		-demonstrate and popularize solar hot water in a visable way	External	2 1/2	1	2

TABLE 2-16 (CONTINUED)

SUMMARY OF RECOMMENDATIONS, COSTS AND BENEFITS OF COMBINED PROGRAM (1979 US$)

Priority	Recommendation	Costs (i=initial) (o=operation)	Benefit	Type of Funding	Number of Years initial Funding Required	Program Year of Start	Program Year of 1st Benefit

- Technical support to JPS	25,000(o)	-provide impetus to solarize residences	External	0	1	1
• Agricultural						
- Air type solar collector development	440,000(i)	-will develop dryers for tropics	External	5	1	1
- Sun drying extension program	12,000(i); 48,000(o)	-will reduce product spoilage	Ordinary Budgetary funds	1	1	1
- Product drying R&D	395,000(i)	-will determine best way to dry various products	External	5	1	1
o Biogas						
- 5 year demonstration and commercialization program	1,457,143(i) 98,285(o)	-will install more than 2740 biogas plants in all parts of the country	External	5	1	1
o Coal						
- Negotiations with aluminum companies	0	-may make a coal plant in Jamaica economically feasible	No funding necessary	-	1	1
o Electric Utility						
- None	-	-	-	-	-	-
o Energy Conversion from waste						
- None	-	-	-	-	-	-

HIGHER

o Solar

- Industrial

- Climatic stations (2)	30,000(i); 20,000(o)	-improved meteorological data	External	1	1	2
- Investigate solar exports	10,000(i)	-knowledge of export markets	Ordinary budgetary funds	1	1	2
- Tax incentives for commerce and industry	5,000(i)	-increased use of solar hot water	Ordinary budgetary funds	1	1	2
- Consumer energy information office	25,000(i+o 1st yr.) 80,000(o)	-energy conservation larger market for alternative energy	Partially external funding and partially new line item funding	1	1	1
- Tax incentives for new housing	5,000(i)	-increased use of solar hot water	Ordinary budgetary funds	1	1	2
- Total hospital program - design	74,000(i)	-solar hot water systems designed for all nation's hospitals	External	2	1	2

Agricultural						
- Grain dryers	120,542(i); 2,358(o)	-dry grain more effectively	External	4	1	2
- Cassava, Brewer's grain and tumeric dryers	400,280(i) 7,720(o)	-dry the crops more effectively and at reduced costs	External	3	2	3
o Biogas						
- None	-	-	-	-	-	-
o Coal						
- Coal plant feasibility estimate & coal contract study	200,000(i)	-will know exact costs of plant in Jamaica	External	1	1	2
- Monitor COM testing	(2000(i+o))*	(-will know status of technology)	(Ordinary budgetary funds)	(2)	(1)	(1)
o Electric Utility						
- None	-	-	-	-	-	-
o Energy Conversion from Waste						
- Alternative energies laboratory	80,000(i); 102,500	- will create capability -to study, develop and adapt a wide variety of alternative energy technologies to Jamaica	Partially external; partially from University	3	1	3

HIGH

o Solar						
• Industrial						
- Climatic Stations (3)	45,000(i); 30,000(o)	-improved meteorological data	External	1	1	2
- Course for architects	37,000(i)	-foster solar energy awareness among design professionals	Partially external; partially from fees; partially from dept.	1	2	3
- Installation of solar hot water systems for Jamaica's hospitals	1,500,000(i)	-solarize all remaining hospital in country	External	2	2	2
• Agricultural						
- Coffee dryers	236,705(i); 4,295(o)	-dry coffee more effectively and at a reduced cost	External	4	2	4
- Cocoa dryers	165,050(i); 2,950(o)	-dry cocoa more effectively and at a reduced cost	External	3	3	5
o Biogas						
- None	-	-	-	-	-	-
o Coal						
- None	-	-	-	-	-	-

o Electric Utility					
- None	-	-	-	-	-
o Energy Conversion from Waste					
- None	-	-	-	-	-

* Optional and not included in total costs.

Even if the price of oil rises at 8% per year, in 1985, the 4.4% savings in net energy imports estimated for this program (if a new coal plant is built as a cost of 1979 U.S. $ 76 million would be worth $7,820,736 (discounted U.S. $) annually. This is somewhat more than the foreign exchange earnings of Jamaican rum, citrus and coffee in 1978.

In addition, other considerations make this Combined Energy Program attractive.

(1) Numerous agencies would be involved in the Combined Energy Program. MMNR, JPS Co., the Ministry of Finance, the Trade Administration, CAST, the SRC, the Ministry of Agriculture and others would all have roles to play. This means also that no single agency need bear the burden of seeking all financing. Thus, financing individual projects should be easier.

(2) There are multiplier effects of the Combined Energy Program on the economy. That is, other than the direct benefits planned for a particular project will be generated. Thus, for example, the biogas demonstration and commercialization program would not only produce cooking gas, but could stimulate a new industry to construct these units.

(3) Most of the projects in the Combined Energy Program are relatively small and, therefore, should be easy to finance. Several of the projects in the proposed program cost somewhere in the range between U.S. $50,000 and 150,000.

(4) As Table 2-16 indicates, most of the projects can be initiated in the first year of the Program, and begin producing benefits in the first or second year.

(5) There is a relatively low reliance on imported technology and other imported inputs in the Combined Energy Program. The biogas scheme, for example, which is one of the largest elements of the Program, requires no technological or material imports at all. Only the coal plant and the climatic stations are exceptions. Solar hot water collectors, however, may have to be imported early in the program if Jamaican industry cannot keep up with demand.

(6) Except for the coal plant it is not expected that heavy reliance on foreign technical advice will be necessary after the first few years. Additonally, in any program that may succeed this Combined Energy Program, Jamaica would most likely be able to plan, coordinate and implement all elements of that program with only minor and very specific external technical advice.

Table 2-17 summarizes the entire five year Combined Energy Program.

TABLE 2-17 Combined Energy Program Summary

Priority	Recommendation	Capital and Other Inital Costs (foreign exchange costs) 1st year	2nd year	3rd year	4th year	5th year
Highest	o Solar					
	· Industrial					
	- Climatic stations (5)	75,000	-	-	-	-
	- Solar collector testing program	50,000	-	-	-	-
	- Eliminate solar water heater tax	-	-	-	-	-
	- Training course for installers	50,000	-	-	-	-
	- Industrial & commercial feasibility studies	150,000	-	-	-	-
	- Hospital feasibility studies	50,000	-	-	-	-
	- Hospital demonstration project		(All these costs are included in the total hospital program. Therefore, they are excluded from summation here.)			
	- Technical support to JPS Co. solar demonstration (residential)	25,000	-	-	-	-
	· Agricultural					
	- Air-type solar collector development	48,000	36,000	36,000	36,000	20,000
	- Sun drying extension program	-	-	-	-	-
	- Product drying R&D	48,000	36,000	30,000	24,000	20,000
	o Biogas					
	- Five year demonstration and commercialization program	45,943	45,029	69,486	101,486	320,915
	o Coal					
	- Negotiations with aluminum companies	-	-	-	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)

(Foreign Exchange Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
Higher	o Solar					
	· Industrial					
	- Climatic stations (2)	30,000	-	-	-	-
	- Investigate solar exports	-	-	-	-	-
	- Tax incentives for commerce & industry	-	-	-	-	-
	- Consumer energy office	10,000	-	-	-	-
	- Total hospital program design	37,000	37,000	-	-	-
	· Agricultural					
	- Grain dryers	3,506	14,972	22,173	7,391	-
	- Cassava, Brewer's grain & tumeric dryers	-	6,272	71,876	85,104	-
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- Coal plant feasibility estimate & coal contract study	200,000	-	-	-	-
	- (Monitor COM study)	-	-	-	-	-
	o Electrical Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- Alternative energies laboratory	-	-	20,000	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)

(Foreign Exchange Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
High	o Solar					
	· Industrial					
	- Climatic stations (3)	45,000	-	-	-	-
	- Course for Architects & engineers	25,000	-	-	-	-
	- Installation of solar hot water systems for Jamaica's hospitals	-	750,000	750,000	-	-
	· Agricultural					
	- Coffee dryers	-	3,200	13,002	39,000	39,000
	- Cocoa dryers	-	-	3,200	11,820	51,000
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- (detailed COM feasibility study)	-	-	(1,000,000)	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-
Subtotals		$ 892,449	$928,473	1,015,737	$304,801	$450,915

TABLE 2-17 Combined Energy Program Summary (Continued)

Priority	Recommendation	Capital and Other Inital Costs (Jamaican Currency Costs) 1st year	2nd year	3rd year	4th year	5th year
Highest	o Solar					
	· Industrial					
	- Climatic stations (5)	-	-	-	-	-
	- Solar collector testing program	-	-	-	-	-
	- Eliminate solar water heater tax	-	-	-	-	-
	- Training course for installers	25,000	-	-	-	-
	- Industrial & commercial feasibility studies	-	-	-	-	-
	- Hospital feasibility studies	-	-	-	-	-
	- Hospital demonstration project	(All these costs are included in the total hospital program. Therefore, they are excluded from summation here.)				
	- Technical support to JPS Co. solar demonstration (residential)	-	-	-	-	-
	· Agricultural					
	- Air-type solar collector development	72,000	54,000	54,000	54,000	30,000
	- Sun drying extension program	12,000	-	-	-	-
	- Product drying R&D	72,000	54,000	45,000	36,000	30,000
	o Biogas					
	- Five year demonstration and commercialization program	68,914	67,543	104,228	152,228	481,371
	o Coal					
	- Negotiations with aluminum companies	-	-	-	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)

(Jamaican Currency Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
Higher	o Solar					
	· Industrial					
	- Climatic stations (2)	-	-	-	-	-
	- Investigate solar exports	10,000	-	-	-	-
	- Tax incentives for commerce & industry	5,000	-	-	-	-
	- Tax incentives for new housing	5,000	-	-	-	-
	- Consumer energy office	15,000	-	-	-	-
	- Total hospital program design		-	-	-	-
	· Agricultural					
	- Grain dryers	5,260	22,324	33,687	11,229	-
	- Cassava, Brewer's grain & tumeric dryers	-	9,408	101,044	126,576	-
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- Coal plant feasibility estimate & coal contract study	-	-	-	-	-
	- (Monitor COM study)	(2,000)	-	-	-	-
	o Electrical Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- Alternative energies laboratory	20,000	20,000	20,000	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)

(Jamaican Currency Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
High	o Solar					
	· Industrial					
	- Climatic stations (3)	-	-	-	-	-
	- Course for architects & engineers	12,000	-	-	-	-
	- Installation of solar hot water systems for Jamaica's hospitals	-	-	-	-	-
	· Agricultural	-	4,800	19,503	59,100	59,100
	- Coffee dryers	-	-	4,800	17,730	76,500
	- Cocoa dryers	-	-	-	-	-
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- (detailed COM feasibility study)	-	-	-	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-
Subtotals		$322,174	$232,075	$382,262	$456,863	$676,971

TABLE 2-17 Combined Energy Program Summary (Continued)

Priority	Recommendation	Operating Costs (Jamaican Currency Costs) 1st year	2nd year	3rd year	4th year	5th year
Highest	o Solar					
	· Industrial					
	- Climatic stations (5)	-	12,500	12,500	12,500	12,500
	- Solar collector testing program	-	5,000	5,000	5,000	5,000
	- Eliminate solar water heater tax	-	-	-	-	-
	- Training course for installers	-	-	-	-	-
	- Industrial & commercial feasibility studies	-	-	-	-	-
	- Hospital feasibility studies	-	-	-	-	-
	- Hospital demonstration project	(All these costs are included in the total hospital program. Therefore, they are excluded from summation here.)				
	- Technical support to JPS Co. solar demonstration (residential)	-	25,000	25,000	25,000	25,000
	· Agricultural					
	- Air-type solar collector development	-	-	-	-	-
	- Sun drying extension program	-	12,000	12,000	12,000	12,000
	- Product drying R&D	-	-	-	-	-
	o Biogas					
	- Five year demonstration and commercialization program	4,000	8,571	17,143	25,714	42,857
	o Coal					
	- Negotiations with aluminum companies	-	-	-	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)
Operating Costs
(Jamaican Currency Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
Higher	o Solar					
	· Industrial					
	- Climatic stations (2)	-	5,000	5,000	5,000	5,000
	- Investigate solar exports	-	-	-	-	-
	- Tax incentives for commerce & industry	-	-	-	-	-
	- Consumer energy office	-	20,000	20,000	20,000	20,000
	- Total hospital program design	-	-	-	-	-
	· Agricultural					
	- Grain dryers	134	704	1,140	380	
	- Cassava, Brewer's grain & tumeric dryers	-	320	3,080	4,320	
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- Coal plant feasibility estimate & coal contract study	-	-	-	-	-
	- (Monitor COM study)	-		-	-	-
	o Electrical Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- Alternative energies laboratory	34,200	34,100	34,200	-	-

TABLE 2-17 Combined Energy Program Summary (Continued)

Operating Costs
(Jamaican Currency Costs)

Priority	Recommendation	1st year	2nd year	3rd year	4th year	5th year
High	o Solar					
	· Industrial					
	- Climatic stations (3)	-	7,500	7,500	7,500	7,500
	- Course for architects & engineers	-	-	-	-	-
	- Installation of solar hot water systems for Jamaica's hospitals	-	-	-	-	-
	· Agricultural					
	- Coffee dryers	-	-	495	1,900	1,900
	- Cocoa dryers	-	-	-	450	2,500
	o Biogas					
	- None	-	-	-	-	-
	o Coal					
	- (detailed COM feasibility study)	-	-	-	-	-
	o Electric Utility					
	- None	-	-	-	-	-
	o Energy Conversion from Waste					
	- None	-	-	-	-	-
Subtotals		$38,334	$130,695	$143,058	$119,764	$134,257

2.9 RECOMMENDATIONS

(1) The main recommendation of this Economic Assessment is that the Combined Energy Program is a sensible way for Jamaica to direct its efforts in the energy sector over the next five years, and that it should be accepted. The recommendations of the special studies that have been incorporated into this program have been shown to produce benefits well in excess of their costs. The costs themselves have been found to be modest; the government should be able to find the necessary funding.

(2) It is recommended that immediate action be emphasized to implement the Combined Energy Program. The Government of Jamaica should consider this program without delay and quickly move on the recommendations it accepts. Financing should be sought as soon as possible.

(3) With so many agencies involved, there may be a problem coordinating this program with other ongoing and planned programs and projects under the Energy Sector Plan. Consequently, to ensure that Jamaica's efforts in the crucial energy sector progress as smoothly as possible, it is recommended that an Interagency Energy Coordinating Committee of all interested agencies be formed. Perhaps meeting monthly, and with the nation's Energy Director as Chairman, this group could help resolve any conflicts or problems among participants in the energy effort, and provide a forum for the easy interchange of useful information.

(4) Finally, the Energy Sector Plan should be modified in all of the ways suggested in Appendix C, as soon as the government reaches its decision regarding the Combined Energy Program.

2.10 REFERENCES

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The final reports of each of the Special Studies, as well as several working drafts of each, have been reviewed and discussed with their authors. They provide the inputs to the sections of this assessment on each of the Special Studies.

APPENDIX A

TERMS

OF

REFERENCE

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STATEMENT OF WORK

A. Objective

The objectives of this activity are:

1. To conduct, by a team of experts, a study to assist the Government of Jamaica (GOJ) in further program development under its Five-Year National Energy Plan (1978-1983).

2. To assess the feasibility of, and/or requirements for, successful implementation of particular key projects and programs.

3. To provide the baseline information necessary to identify potential opportunities for future support in the general area of Energy.

B. Scope of Work

Task 1 - Study Integration and Project Management

The scope of the first task is to develop a detailed study plan based on the information contained in this Statement of Work. The plan will contain a detailed schedule of all study activities and manpower allocations. The plan will include a Project Management Plan, an initial identification of the outline of task reports, work flow functional diagrams, preliminary identification of study tasks, and data requirements between tasks. Aslo included will be a definition of criteria, assumptions and procedures to be used in the study. Although subject to later revision as information and analysis proceed, the study plan will serve as the basic management and control procedure for the remainder of the study.

Upon approval by the USAID Mission to Jamaica and the Government of Jamaica, Energy Division, Ministry of Mining and Natural Resources, the study plan will be implemented and used to accomplish Tasks 2 through 7 specified below.

The scope of work to be implemented includes the following specific subtasks:

1. Overall management of the U.S. Study Team

2. Overall U.S. Team Coordination

3. Overall Coordination between U.S. Team and GOJ and Jamaican personnel, as well as with USAID Mission.

4. Planning and conducting periodic Study Reviews in support of GOJ.

5. Preparation, review and integration of draft and final Study Reports.

Task 2 - Economic Assessment

The Government of Jamaica Five-Year Developemnt Plan (1978-1983) Energy Sector Plan, serves as the baseline planning document establishing the requirements for the specialized studies of the energy projects defined in Tasks 3 through 7. After the specialized studies are sufficiently underway, the energy projects proposed by the individual studies will be reviewed for their general energy implication on The Five-Year Development Plan. Appropriate changes to the Energy Plan will be recommended to the GOJ Energy Division, Ministry of Mining and Natural Resources.

Based upon the above work a coordinated summary report on economic aspects of energy projects, drawing broad policy implications shall be prepared.

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Task 3A - Solar Energy - Commercial & Industrial

Task 3B - Solar Energy - Agricultural

The study shall include a technical and economic assessment of the feasibility of near-term application of solar energy with a primary focus on food processing and storage. The study shall examine the potential for solar crop drying, both on the scale of small individual farmers and on the scale of bulk marketing and food processing and storage. In addition the study shall assess the feasibility of commercial solar air-conditioning and of solar industrial applications. The assessment will include examinations of the following:

1. Corn drying at regional drying centers to be operated by the Agricultural Marketing Corp.

2. Drying of agriculutral products at the farm level including peppers, onions, corn, peanuts, and hay.

3. Drying of pimento, coffee, cocoa, bananas and timber on a commercial scale.

4. Crop drying on a commercial scale (approximately 1 ton/day).

5. Fish drying on a commercial scale.

6. Solar cooling for food storage in accordance with requirements to be specified by the Agricultural Marketing Corp.

7. The technical and economic feasibility of solar air-conditioning for a new extension to a government office building and for a regional hospital.

8. The feasibility of commercial and industrial applications of solar energy, in particular industrial process heat and hotel hot water in the tourist industry, to substitute for imported petroleum.

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Task 4 - Biogas Applications

The study shall assess the feasibility of biogas generation in rural agricultural areas. Included in the assessment shall be an examination of the following: size of livestock holdings, feasibility of collecting animal wastes, the possible use of biogas to provide cooking, and lighting in rural areas that are without access to electricity.

Particular attention should be paid to medium-scale installations (approximately 100 cattle or equivalent in animal waste) and installations appropriate for agricultural research stations, agricultural schools and other schools and rural communities to be specified by the Government of Jamaica.

The study should also address the feasibility of the generation of biogas as an integral part of the sewage treatment facilities of the Jamaican campus of the University of the West Indies.

Pertinent projects already initiated by the Ministry of Mining Energy Division, the Scientific Research Council and others should be reviewed in detail. The report should include recommendations for follow-on projects that might be undertaken. In such projects, adaptive programs should be emphasized, rather than basic research.

Task 5 - Coal Prefeasibility Study

The objective of this task is to prepare a prefeasibility study on the potential of substituting imports of steam coal (particularly 3% sulphur coal) for some imported 3% sulphur #6 fuel oil. The study will include a recommendation to the GOJ as to the desirability of conducting a full pre-investment feasibility study of this subject. If the recommendation is positive, a scope of work for a full feasibility study should be prepared. Particular attention should be given to the economics of coal imports for satisfying a large part of the primary energy needs of the steam rising plants of the Jamaica Public Service Company (JPS) System. Discussions should be held with the operators of the alumina plants (Alcan, Alcoa and Alpart) in Jamaica to ascertain what studies/analyses they have performed or intend to perform regarding the use of imported coal to raise steam in

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their power plants. The results of any studies performed by these companies should be commented on.

The study should also assess the technical, economic and environmental feasibility of diversification into coal. In particular, the study should address the following:

1. The possibility and terms of obtaining long-term supply contracts for steam coal (particularly 3% sulphur coal). Price projections for such coal for up to ten years should be made.

2. Feasibility of transporting coal to Jamaica from U.S. Eastern Seaboard ports in bauxite ships returning on the backhaul, or by other appropriate modes.

3. The location of port handling facilities and storage facilities at port and plant sites. In particular, two schemes are to be assessed: unloading at Old Harbour for use at the JPS Old Harbour Plant and unloading at Montego Bay with overland rail transport to Old Harbour. The latter scheme is to be considered in relation to proposals to use port facilities in Montego Bay for trans-shipment and distribution of metallurgical coal in the Caribbean.

4. The possibility of retro-fitting existing units on the JPS system to burn either steam coal or a mixture of coal and oil and the possibility of using either of these fuels in projected new plants on the JPS system.

5. The possibility of carrying out similar retro-fitting in alumina plants, bearing in mind any proposals of the companies themselves, and the possibility of burning coal or coal-oil mixtures in any new alumina plants.

6. The potential environmental impact of diversification into coal and possible methods and anticipated costs of ameliorating adverse impacts.

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Task 6 - Electric Utility Rate Analysis

The purpose of this study is to derive a practical tariff structure which:

1. Promotes a more economic use of electricity in the Jamaican society.

2. Maintains the financial viability of the electric utility.

3. Optimizes the use of fuel and foreign exchange.

4. Meets any income distribution objectives (e.g., subsidizing poorer consumers) which the electricity tariff may be required to serve.

The study should include the following elements:

1. The determination of the long-run marginal cost of supply by analyzing the marginal costs of generating, transmitting and distributing electricity to consumers at different places, times and voltage levels. This will require due attention to the daily and seasonal variations in actual and, to the extent possible, in forecast demands of various consumer classes. Much of the required information may have to be specially collected, e.g., by taking substation readings, by enquiring about shift-working and seasonal work patterns and by statisitcal analysis of available load curves. Particular attention should be given to identification of consuming sectors responsible for unusually high demands during peak load periods.

2. An examination of the present customer classification to determine if each class exhibits appropriate characteristics (e.g., cost/consumption). Based on this examination, a recommendation for modifications to the customer classifications would be developed.

3. An analysis of price elasticities and associated response times for each customer classification (using available historical data). This analysis would include the effect of changes in the prices of electricity, appliances and equipment on consumer demand.

4. An investigation of the social benefits to be derived from subsidizing poorer consumers and the development of a quantitative index of the benefits derived (or the identification of such an index developed in other studies).

5. A determination of the revenue requirements to maintain the financial viability of the electric utility.

6. A determination of the foreign exchange required to operate the utility.

7. A new tariff structure should be developed based on consideration of the factors outlined above, along with considerations of practicality such as metering and administration.

8. A determination should be made of the sensitivity of the foreign exchange requirement to changes in the tariff structure, in particular a structure that promotes shift to selected loads from peak to off-peak.

9. The new tariff structure should be compared with the existing tariff structure, and the implications of a change to the new tariff investigated. Of particular concern would be the effect of price elasticity (for each consumer classification), the effect on present or potential industrial growth and probable consumer reaction.

10. A formula permitting automatic adjustment of the new tariff to allow for changes in the cost of fuel should be developed.

11. Recommendations for the expedient implementation of the new tariff structure (as proposed after any required revisions) should be developed.

12. A load forecast study involving the development of a computer based model to be used by the JPS for electric load forecasting, including projections of the requirements for additional generating capacity, transmission lines and major substations and geographic distribution of the electric load.

The study should be conducted in such a way that the maximum amount of training is imparted to the Jamaican counterparts in order that they may undertake on their own future updating of the tariff structure.

Task 7 - Energy Conversion from Waste

An assessment shall be made of the feasibility of constructing a prototype unit to produce energy, fertilizer and other by-products from the waste and refuse of the Mona Campus of the UWI which has its own sewage treatment plant (50,000 gallons of water per day), refuse dumps and incinerator.

The assessment will include a determination of the amount and type of waste and type of waste available on campus, a technical evaluation of alternative approaches to energy conversion from the waste, a determination of the quality of the water to be expected to be produced from the various approaches, a determination of the availability of applying the approaches to sewage and dry refuse handling in rural and urban areas of Jamaica, a recommendation as to preferred approach and a detailed estimate of the costs of the recommended system. Personnel of the UWI should be involved in all the required activities to the maximum extent possible. The assessment will be conducted in coordination with the study of biogas described above.

APPENDIX B - INTERVIEWS AND DISCUSSIONS

(1) Dr. Philip Palmedo, October 4 - Energy Development International, Consultant of Energy Division MMNR - Offered opinions on the data required by Task 2 and the scope of a study that could be completed in the time allocated.

(2) Ms. Ann Moser, October 5 - Energy Division MMNR - Reviewed the proposed outline for the final report of Task 2.

(3) Mr. Roddy Ashby, October 5 - Deputy Director, Energy Division MMNR - Discussed the possibility of treating incentives and tax breaks for users of solar systems as part of the Economic Assessment or the Solar Study. Also talked about looking at the feasibility of setting up a soft-loan facility for biogas system purchasers as part of the Economic Assessment or the Biogas Study.

(4) Mr. David Barnwell, October 5 - Energy Division MMNR - Reviewed the proposed outline for the final report of Task 2, and discussed what should be done to accomplish the study. He indicated data sources and further contacts.

(5) Mr. Michael Ranglin, October 8 - Energy Division MMNR - Reviewed data acquired in the industrial process heat survey conducted by Mr. Ranglin for the Ministry. Most of the information concerned drying processes and/or hot water and steam processes. The electric bills of the companies were included.

(6) Mr. Ahmad Zia Mian, October 8 & 11 - UNDP Consultant, Energy Division MMNR - Discussed scope of work of the Coal Study with Walt Williams and Herb Yim (October 8). Then reviewed the work to be done under the Economic Assessment (October 11). Mr. Mian pointed out that energy inputs to each project must also be considered, since it is the net energy gained by these projects that is important. Also, he suggested that the cash flow problem, that may result from interest payments during construction, be carefully considered.

(7) Mr. William Saunders - Managing Director, Petrojamaica; Dr. Henry Lowe - Director, Energy Division MMNR; Mr. Ahmad Zia Mian - UNDP Consultant, Energy Division MMNR; (October 8) - Meeting also attended by Walt Williams and Herbert Yim. The scope of work for the Coal Study was reviewed in detail and approved.

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(8) Ms. Jacqueline Mayers, October 10 - Director, Development Division, Ministry of Finance - Discussed the work of the Energy Team in general, and the scope of the Energy Assessment in particular. She suggested a variety of people that might have valuable inputs for the work of a number of the individual studies.

(9) Mr. William Saunders, October 11 - Managing Director, Petrojamaica - Discussed the approach to be followed in the Energy Assessment. Mr. Saunders indicated the necessity of prioritizing the final recommendations of this task and of showing where and how the Energy Sector Plan should be updated to accommodate them.

(10) Mr. Ambrose DaCosta - Deputy Director, Sectorial Division, National Planning Agency (NPA); Mrs. J. Glean-Walker - Energy Specialist, NPA (October 12) - After reviewing the Economic Assessment, Mr. DaCosta and Mrs. Glean-Walker made a number of important observations. A consideration of unit costs vs. total costs of energy in the projects would be useful because slightly more expensive energy that would require less foreign exchange might be desirable. The managerial and technical aspects of any project should be stated and the training component for Jamaican staff and management should be identified.

(11) Dr. Henry Lowe, October 17 - Director, Energy Division MMNR - The proposed outline for the Economic Assessment was discussed with Dr. Lowe. Mr. Yim and Mr. Roberts also attended this Preliminary Review for Task 2. Dr. Lowe felt that the scope of the Task as presented at the meeting was suitable for the time allocated to it, and that it was in agreement with the Terms of Reference.

(12) Numerous sessions were also held between October 17 and November 13 with the Technical Specialists. Individuals who provided significant inputs from their studies to this Task 2 Report were Thomas Lewis (Solar-Industrial), Blaine Parker (Solar-Agriculture), Rolf Skrinde (Biogas), Richard Dague (Energy Conversion from Waste); Walter Williams (Coal Prefeasibility); and Charles Cicchetti (Electric Utility).

APPENDIX C - MODIFICATIONS REQUIRED IN ENERGY SECTOR PLAN TO ACCOMMODATE THE COMBINED ENERGY PROGRAM

The Combined Energy Program was established through the integration of study recommendations of the U.S. Energy Team specialists. The findings of the study require minor modifications in the Energy Sector Plan to accomodate the Combined Energy Program. The following changes are recommended:

(1) As was noted earlier in this report, a review of the objectives of the Energy Sector Plan (Section 3.2 of the Plan), in relation to the proposed Combined Energy Program shows no conflict and no need to change either the objectives or the program. However, a one word change in the Plan is suggested above in Section 2.6.2. While the second objective now reads, "To reduce the energy intensity of the economy while sustaining economic growth", it is proposed that this be changed to read, "To reduce the commercial energy intensity of the economy while sustaining economic growth". After all, a program that would solarize the production of hot water for all the hotels or hospitals in Jamaica would still use a lot of energy. However, it would be free energy.

(2) A review of the procedures section of the Energy Sector Plan (Section 3.3) indicates one possible change. In Section 3.3 B. (i.)(b.) is the recommendation for coal studies. It calls for, "economic and technical studies on coal-retrofitting programme." It is suggested that this be changed to, "economic and technical studies on coal-retrofitting and on the construction of a new coal or coal-oil mixture electrical generating plant".

(3) Again, in the procedures part of the Energy Sector Plan, it is suggested that a change might be made in Section 3.3 B. (ii.)(a.)(g.). This now calls for, "tax incentives for energy-efficient investments in industrial processes and plants". It is recommended that this be rewritten to read, "tax incentives for commercial energy efficiency investments in industrial processes and plants, in commercial establishments and in new housing".

(4) If any or all of the recommendations of the Combined Energy Program are adopted by Jamaica, a number of changes will have to be made in the implementation section of the

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Energy Sector Plan (Section 4). This is the chapter where the various projects to be undertaken during the five year period of the Plan are briefly outlined. Precise recommendations for changes are not offered at this time because the Government of Jamaica has not decided which elements of the Combined Energy Program it will implement. However, the sections that should be reviewed and might be modified after a decision is made include: Energy Demand Management (Conservation) - Fiscal Incentives (Section 4.2 vi.) and Reducing Energy Intensity (4.2 ii.); Energy Supply Management - Diversification of the Energy Mix - Substitution of Coal for Fuel Oil (4.3 B. i.); Role of Non-Conventional Energy (4.4); and Major Projects within the Energy Plan(8.).

(5) Changes in the Role of Non-Conventional Energy (Section 4.4) should include the modification of one phrase in the introduction. Where it now reads, "Although during the current Plan period non-conventional Energy Sources would not play a significant role,...," the following phrase should be substituted, "Although during the current Plan period non-conventional energy sources would play a small, but signigicant role,...".

(6) Other sections under the Role of Non-Conventional Energy (Section 4) will require updating if some or all of the recommendations of the Combined Energy Plan are adopted. These include Solar Water Heating (4 i.), Solar Crop Drying (4.ii.), and Biomass (4.iv.). In addition, the section on Solar Air Conditioning (4. iii.) should be rewritten to accommodate the finding of the Solar Energy (Industrial Application) Study that, "A solar cooling demonstration program should not be considered at his time".

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