JAMAICA CANE/ENERGY PROJECT

FEASIBILITY STUDY

VOLUME 1

PREPARED BY:

RONCO CONSULTING CORPORATION

BECHTEL NATIONAL INC

FUNDED BY:

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

AND

THE TRADE AND DEVELOPMENT PROGRAM

SEPTEMBER 1986

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ABSTRACT

This report evaluates the feasibility of a proposed steam-electric, cogeneration facility to be juxtaposed to Monymusk Factory, a major sugar cane processing facility in the Clarendon Parish, Jamaica. This power station improvement is to be integrated with a planned rehabilitation project to be undertaken during the next five years (Fiscal Years 1987 to 1991) for production equipment and facilities. The cogeneration facility would be constructed, begining in mid-1988 and commissioned in mid-1990.

The Base Case of this evaluation has the cogeneration facility producing 330,000 pounds of steam per hour at 900 degrees F. and 900 psig (150,000 kg/hr, 480 degrees C. and 63.4 kg/square cm) from two steam generators for 323 days per year of scheduled operations. Annual production in the Base Case is for 785.9 million pounds [356.4 million kg.] of process steam supplied to the factory. Electricity to be generated, net of plant, is estimated at 171.1 million kWh with 145.241 million KWh available for sale to the national electrical utility. Fueling of the facility is mainly dependent on sugar cane derived biofuels, bagasse and barbojo (sun dried, cane trash) with No. 6 Fuel Oil used as an augmenting source to provide about 25 percent of the fueling on a heat input basis. Additionally, the Base Case predicts significant revenues from sugar and molasses sales (68,700 tons of 96 degree sugar and 29,682 tons of molasses).

The report concludes that an investment of US$47.7 million for the proposed power station would be financially feasible (Internal Rate of Return of 16 percent). The financial return was further enhanced (an IRR of 20 percent and an overall Economic Rate of Return or EER of 17 percent), when an added agricultural investment of US$9 million is provided to assure the target level of sugar cane production each year. The Base Case electrical pricing for sale to JPS in 1990 was estimated to be cost-competitive with future coal-steam units at levelized 75 mills per kWh (1986 US Dollars).

The most important requirement for the achievement of the investment returns shown above is that annual cane production must be more than doubled from current levels to the target levels set by the Base Case.

ACKNOWLEDGEMENTS

This project's management must attempt the difficult task of gratefully acknowledging, without serious omission, the numerous persons both here in Jamaica and overseas, that materially contributed towards whatever success this feasibility evaluation can rightfully claim as its own.

Certainly, the initiating and sustaining efforts of certain USAID officers need to be singled out for clear recognition: Alan Jacobs, Paul Weatherly, Joe Sconce, Charles Mathews, Louis Reade, William McCluskey and Julius Schlotthauer.

Contractual or inter-agency transfer employees of USAID that have been contributors included: Frank Tugwell, Al Binger, Frank Ahimaz, Alex Alexander, George Samuels, Henry Steingass and John Kadyszewski. These names begin an extended series of agency personnel and others that have become involved in the project's complex technical/financial/economic proposal and its careful review. The early report entitled: "Jamaica Cane Production for Sugar and Electric Power," September, 1984, focussed a large number of contributors, both Jamaican and foreign, on the Jamaica cane/energy prospect at the Monymusk Factory, and that contribution is again acknowledged.

The following technical team has been formed, over the past seventeen months, to detail the project's description and evaluate its technical, economic and financial feasibility. The team members were organized by Ronco Consulting Corporation and Bechtel National

Inc., for USAID/Kingston, for the preparation of a "bankable document". Dr. G. S. C. Wang, formerly with Bechtel,had much to do with the project's formative stages. Wayne Richardson, Jr. must be acknowledged as the man who made the initial Hawaiian connection with the project for USAID.

Technical Contributors

Ronco Consulting Corporation

Name	Speciality
Dr. John C. Warner	Sugar Cane Genetics and Agronomy
Dr. Allan L. Phillips, P.E.	Barbojo Recovery Systems, Agricultural Engineer
Earl S. P. Smith, P.E.	Sugar Cane Processing and Cogeneration Engineering
Mead A. Kirkpatrick	Sugar Cane Production and Irrigation Specialist
John Denyes	Production Cost Engineer and Financial Analyst
Russell Sowers	Agriculturist, Industrial Engineer and Irrigation Specialist (Resident)
John P. Keppeler	General Manager (Resident)
Robert H. Hughes	Senior Executive, Sugar Technologists and Peer Reviewer

Not named, but quietly acknowledged, is a very wide circle of many colleagues in Hawaii, Louisiana, Florida, Puerto Rico, Dominican Republic and Washington D.C. that have been consulted about cane/energy issues.

Bechtel National Inc.

Name	Speciality or Title
Duane E Deonigi	Manager, International Planning, Research and Engineering
Adrian Schaefler	Agricultural and Resource Economist, Research and Engineering
Wayne G. Mikutowicz	Energy Planning, Research and Engineering
Gregory B. Kruse	Financial Analyst, Research and Engineering
C. Frederick Wall, P.E.	Supervisor, Engineering Geology, Geotechnical Services
Daniel Eisinger	Project Engineer, Bechtel Power Corporation
Richard R. Buta	Senior Business Development Representative
A. Menendez	Project Manager, International Operations
Michael H. Kappaz	Vice President and Manager, International Operations

The project's resident staff and visiting consultants were able to gain the cooperation of a wide circle of highly expertised contributors in Jamaica. Listing all of the names would be impractical, but certain names must be recognized: Frank G. Downie, Maurice W. Facey and the Board of JSH, David Walder, Robert C. Campbell, Peter Rubner, Ed Brown, Weldon Maddan, Robert Jump, J.S. Archbell and the staff at Clarendon Sugar Company (Monymusk Estate), Michael E. A. Shaw, Ian Sangster, John Holmes, Robert F. Clarke, Trevor Donaldson, David C. Henriques, Robert L. C. Henriques, Orville Cox,

Owen Clarke, Peter D. McConnell, Ralph Thompson, Winston Boyne, Clarence Franklin, T. G. Mignott, Hon. Dr. Percival Broderick, Senator Hugh Hart, Stanley Rampair, Tom Easterling, Ralph Robinson and Horace Tame.

Last but not least, the support personnel that physically produced some part of this work product need to be gratefully recognized:

Elaine E. Smith	Agribusiness Analyst
Vanica Cranston	Administrative Assistant
Neville Spike	Business Analyst
Tanya Veira	Typist
Dainty R. Burnett	Secretary
Larson Lennon	Staff Assistant

Recognition must also be included of the staff of AGRO-21, Jamaica Conference Centre, SIA, SIRI and USAID/Kingston who kindly assisted us in a hundred ways.

Finally, Ron Boyd, Steve Edelmann, Jodee Solomon, and Carolyn Boone of Ronco Consulting Corporation must be thanked for keeping the technical team on the "straight and narrow" and "within the Regs", on-time and within budget.

Mahalo Nui Loa (thank you, plenty big)

1.0 EXECUTIVE SUMMARY

This report evaluates the technical, economic, and financial feasibility of installing and operating a steam-electric power, cogeneration facility which maximizes the use of sugar cane derived biofuel (i.e., bagasse and cane trash or barbojo). The proposed facility in the study will be located adjacent to the Monymusk Factory, and will be financed and organized as a private enterprise. In addition, this report evaluates the benefits that can be achieved by the sugar company through the maximization of sugar cane production and processing.

The foci of the evaluations are as follows:

- Financial analyses of the proposed cogeneration facility, its capital costs, annual operation and maintenance costs and the pricing of electricity generated for intercompany exchange and external sale to the national utility, Jamaica Public Service Company (JPS).

- Financial analyses of the sugar company's operations at three levels of output in the production and processing of sugar cane, their capital costs beyond the currently planned rehabilitation project, and annual operating and maintenance costs.

- Economic analyses of the sugar cane production and processing operations, plus the cogeneration facility's operations and their joint impact on the overall Jamaican economy.

This cogeneration facility will supply electricity and process steam to the rehabilitated Monymusk Factory and the sugar company. Electricity generated beyond the needs of the factory and its field operations will be sold to the JPS to supply the national electric demand. During operation of the sugar cane crushing plant and boiling house, the cogeneration facility will have a peak gross capacity of 21 MW.(1) Peak gross capacity when the sugar factory is not in operation will be approximately 35 MW.

The envisioned facility would have two steam generators to produce 330,000 pounds of steam per hour [150,000 kg/hour] at 900 degrees F and 900 psig [480 degrees C and 63.4 kg per square cm]. In the Base Case of the evaluation, an annual production of 785.9 million pounds [356.4 million kilograms] of steam is planned and 171.1 million kWh of electricity is to be generated. After satisfying the electrical requirements of the sugar operations, the amount of power that would be available for sale to JPS is 145.241 million KWh per year.

The major fuels contemplated for the cogeneration power plant are cane-derived biofuels; namely, bagasse and barbojo (i.e., solar-dried cane tops and leaf trash). The augmenting and back-up fuel is residual fuel oil, which will be consumed when bagasse and/or barbojo are insufficient or not available. At the target projection or Base Case, with an annual sugar cane cropping of 742,050 tons, the fueling composition, on a percentage of

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Footnote:

(1) MW is megawatt or one million watts ($1x10^6$ watts)

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heat input basis, will be made-up of 75 percent biofuels, 51 percent bagasse and 24 percent cane trash (barbojo) as augmented by 134,900 barrels of No. 6 Fuel Oil. In the Best Case, with an annual sugar cane production of 850,000 tons, biofuels are anticipated to displace most of the augmenting fuel oil, leaving a requirement for only 23,460 barrels, or less than five percent on a heat input basis.

The cogeneration facility has been evaluated as a separate, privately owned company operating under a joint venture agreement with the Jamaica Sugar Holdings Limited (JSH). The agreement will provide for the joint management of the sugar cane production and processing, the cogeneration operations, and for the exchange or sale of biofuels, process steam and electricity between both companies and externally to JPS.

The development, construction, and operation of the proposed facility has been carefully evaluated for integration and compatibility with the currently planned factory and field rehabilitation project to be financed by the World Bank. This evaluation concluded that the improvements to sugar cane production facilities, as presently funded, will not be sufficient to allow the crop to reach the target cane production level of 742,050 tons per year as contemplated under the rehabilitation project. Therefore, the report identifies certain additional investments required to reach the targeted level of production. In addition, the report identifies further investment to the field and factory facilities which could result in an eventual cane prduction and milling through-put at a maximum level of 850,000 tons per year. The higher cane production and processing

capacity will result in substantial profitability to the JSH operations and lower electricity costs.

This report proposes an innovative biofuel recovery system for production practice development by mid-1990, the recovery of sugar cane trash (i.e., solar dried cane tops and leaves or barbojo) from selected company administered cane fields that have not been burned before manual harvesting, in order to save the cane trash for deferred use as a boiler fuel. The proposed, mechanized barbojo recovery system is to be designed and production proven, based on hay raking, baling, transport and handling experience, as has been adapted for sugar cane in other production areas. The recovery system designed must provide cost-effective biofuel production at the 74,000 ton level by the first year of the project's operations (Fiscal Year 1991), in order to contribute about 24 percent of the annual fueling on a heat input basis.

The enormous agricultural production management requirements to dramatically increase the cost-effective, sugar cane outputs, by more than 225 percent of current levels, in just five years, from the same land and water resources, has been recognized by this report. Concurrently, the agricultural managers are to develop the barbojo recovery system into a profitable production operation that provides 24 percent or 74,000 tons of fueling for the cogeneration facility. The agricultural division of the proposed operation will have a critical influence on the success and profitability of both the sugar and power companies.

The earliest date for the start of operations for the cogeneration facility is estimated to be during July of 1990. Construction activites would begin 24 months earlier in mid-1988. Total capital cost of the proposed cogeneration facilities is estimated at US$47.7 million (in 1986 US Dollars) of which approximately 78 percent is in foreign currency.

The report identifies a financing plan which features the participation of foreign and Jamaican investors. Equity financing for the cogeneration plant will be provided by the owners in proportion to their ownership interests. It is anticipated that the cogeneration company will support up to 67 percent debt financing and the equity participants will fund 33 percent of the cogeneration plant's capital cost. A break down of equity and debt financing by potential participants is as follows:

	EQUITY	DEBT
Jamaican	10%	11%
Foreign	23%	56%

The sources of debt financing assumed in the financial plan for the cogeneration facility will not require sovereign guarantees from the Government of Jamaica (GOJ).

The most important factor, which will affect the economic/financial feasibility of the project, is the quantity of sugar cane produced annually, and the derived supply of bagasse and barbojo biofuel. In order to identify the impact of variable production levels, the report evaluates three scenarios or cases for the production of sugar cane, bagasse and barbojo:

CASE 1: This case assumes that the total production of sugar cane will not exceed 600,000 tons after the completion of the planned rehabilitation project. The case assumes that only modest investments will be made to the sugar factory and sugar cane production facilites beyond what is contemplated in the rehabilitation project. The case also assumes that no investment will be made for the collection and processing of cane trash (barbojo).

CASE 2: This case assumes that the total production of sugar cane will reach the target of 742,050 tons that is set under the planned rehabilitation project. Case 2 includes the added capital expenditures, beyond the funding of the World Bank project, which will be required to reach 742,050 tons. These added capital expenditures are for improvements to the irrigation system for the administration area. The case also includes the capital expenditures required for supplying up to 74,000 tons of cane trash (barbojo) each year, at 35 percent moisture, to the cogeneration facility for deferred combustion.

CASE 3: This case assumes that the total production of sugar cane will be 850,000 tons. Case 3 includes the added capital expenditures that will be required to reach that production level. Those expenditures involve further improvements to company irrigation systems. In addition, some added improvements to the factory have been included to allow it to process the larger cane

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harvest. Case 3 also includes the capital expenditure required for supplying up to 127,500 tons of barbojo each year, at 35 percent moisture, to the cogeneration facility for deferred combustion.

Table 1-1 summarizes the economic benefits of each of the cases, expressed in terms of overall rate of return and foreign exchange savings, for a combined operation of the sugar factory, the sugar cane production facilities and, the cogeneration facility.

Based upon these results it is concluded that there are obvious economic benefits of increasing the sugar cane production, maximizing the supply of biomass fuel, even with the additional investments required to reach those higher levels of annual production.

The national and regional effects of this project are:

- Further bolstering of the existing, significant agro-industrial employment base, provided by a revitalized JSH and its planned rehabilitation project.
- Net foreign exchange savings, estimated at US$7 million per year, for the life of the project.
- Increased governmental receipts of an estimated average of US$2 million per year over the life of the project.
- Satisfying needed electrical generation capacity in 1990 and thereafter, without incurring foreign indebtedness, which represents an annual benefit of US$5 million, over a ten (10) year repayment period.
- Added new employment during the project's construction phase, and during the installation of

the irrigation system improvements, of 840 man-years, plus the establishment of additional 220 production jobs, or about 120 man-years for each year of the project life.

Implementation of the project will also have a positive financial effect on JSH for all of the cases. These benefits are derived from increased sales of sugar and molasses, cost-effective supply of process steam and electricity, and from the sale of cane trash (barbojo) to the cogeneration faciltity. In addition, if the best production case is achieved, a substantial portion of the savings resulting from fuel oil substitution will be passed on to JPS in the form of lower electricity costs.

In the financial evaluation of the cogeneration facility, the target level of production (742,050 tons of cane per year) of the rehabilitation project was selected as the Base Case, for the estimating of the price of eletricity to be sold to JPS. The Best Case production (850,000 tons of cane per year) was also analysed, with the assumption that the potential fuel oil savings would be equally divided between the parties at interest.

During the pricing calculations at the two forecasted levels of sugar cane production, Base Case and Best Case, the cost of electricity from the cogeneration facility was compared to the cost of electricity from future coal-fired expansion units, under contemplation by JPS for the early 1990's. The results of that comparison indicate that the price would be lower from this cogeneration plant than from coal-fired units.

The production risk of a significant biofuel shortfall to the cogeneration plant, and the impact of changing the fueling composition on the pricing of electricity, and/or the return on the investor's equity, will be a central topic of discussions with the Government of Jamaica. These negotiations will establish the allocation of the risks and benefits between the parties at interest.

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TABLE 1-1

OVERALL ECONOMIC BENEFITS
ESTATE/FACTORY/COGENERATION PLANT

SUGAR CANE PRODUCTION: (TONS PER YEAR)	600,000	742,050	850,000
Overall Economic Rate of Return	8%	17%	21%
Net Present Value (US DLRS Millions) @ 10%	-5.8	28.4	51.6
Foreign Exchange Savings (US DLRS Millions)(1)	-1.2	4.0	7.6

Footnote:

(1) These are the average annual savings over the lifetime of the project (30 years) expressed in constant 1986 US dollars.

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2.0 BACKGROUND

The Government of Jamaica (GOJ) has sought means to increase the nation's energy independence. Increasing its energy self-sufficiency would assist in stabilizing the important cost of energy to the country and in helping to conserve the foreign exchange now required to buy the needed fossil fuels that are produced overseas and will eventually be depleted. Virtually all Jamaican energy is based on imported petroleum resources; mainly by importing Venezuelan and Mexican crude oil. Several strategies were started to conserve the use of essential energy, to explore for possible petroleum resources on the island, and to expand the use of or newly develop indigenous and renewable sources of energy (i.e., solar, biomass, hydro, etc.)

The United States Government through its Agency for International Development (USAID) sought to be of assistance to GOJ in the energy planning and development area through the establishment of the Energy Sector Assistance Loan Program in 1981. The purpose of that program was to study and implement encouraging governmental actions to conserve energy and to develop alternate energy resources. The Jamaica Energy Cane Project, that has supported this technical, financial and economic feasibility evaluation of the better use of a major biomass resource, is part of that GOJ/USAID initiative.

Concurrent with the initiative in the energy sector, GOJ sought to restructure the Jamaican sugar cane industry to make it profitable and sized to meet current market demand. The European Economic Community (EEC) market for

sugar through sales to the United Kingdom and the domestic sugar requirements provide most of the assured annual market demand for Jamaica's sugar cane. A very small and uncertain sugar quota in the United States completes the makeup of a protected market for Jamaican sugar. A ready market is domestically available for all the molasses produced.

In the sugar cane industry rationalization process, GOJ designated for closure and re-direction certain of its factories and canelands, and these facilities and lands are in the process of being redeployed at the present time. The two keystone production and processing facilities of the Jamaican sugar cane industry, that are owned and formerly were directly operated by GOJ - Monymusk and Frome - were recently corporately reorganized and are now managed by Jamaica Sugar Holdings Limited (JSH). As the agent for GOJ, JSH is to manage an extensive rehabilitation program financed by the World Bank (International Bank for Reconstruction and Development - IBRD) to be implemented during the next five years, as well as running the day-to-day affairs of the company. The Bank's second rehabilitation program (the first rehabilitation program begun in 1978 was not fully successful) will complete long deferred equipment and facility maintenance and replacement at Monymusk and Frome, to restore their productivity. These rehabilitative actions are considered essential to keeping Jamaica in the sugar producing business as an extension of its long history as a major sugar producer in the Commonwealth.

Early in the GOJ/USAID Energy Sector Assistance Program, the interest in enhancing the use of sugar cane as a renewable and indigenous energy resource was pursued.

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Sugar cane had long been the major cropping activity in Jamaica with over 2.2 million tons(1) of millable canes being produced each year from about 90,000 acres [36,450 hectares] and processed through nine sugar factories. This major island agro-industry offers a potentially attractive focal point for new or expanded indigenous energy development.

Certain natural energy research subjects, such as: intensive production of higher performance and high fiber sugar cane varieties, utilization of solar-dried sugar cane tops and leaves (cane trash or barbojo) as a biofuel, production and use of related tropical grasses for supplemental biofuels, etc. were evaluated for application in Jamaica. In that review the established success of using high performance steam/electric generating equipment at Hawaiian sugar cane processing facilities for cogeneration of process steam and electricity with the sale of surplus electricity to the electrical utility was of keen interest to GOJ. As a result in 1984, a GOJ/USAID sponsored pre-feasibility report proposed the enhanced use of sugar cane as an expanded alternative energy resource at Monymusk. This Cane/Energy proposal recommended the generation of steam and electricity in high performance equipment from firing bagasse (i.e., the fibrous residue of sugar cane processing) and introduced the idea of new sugar cane

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Footnote:

(1) References to tons in this report are to long tons of 2240 pounds unless specifically called tonnes or metric tons at 2205 pounds or short tons at 2000 pounds.

varieties with higher fiber composition, thereby increasing their calorific value. The 1984 study discussed the possibility of using cane trash (barbojo) as a supplemental biofuel for combustion during the "off-crop" period, as well as other tropical grass and wood species to increase the biomass in the fuel mix and reduce the use of imported No. 6 Fuel Oil (Bunker C Oil).

Following the 1984 pre-feasibility evaluation of the Jamaica Energy Cane Project, this feasibility study was enabled in May, 1985. The objective of this evaluation was to prepare a "bankable" document to become the centerpiece for discussions leading to the formation of a joint enterprise to organize, finance, finally design and construct the proposed power generating facility. The proposed cogeneration improvement is to be a fully integrated development with the long planned rehabilitation of the factory and facilities as financed by the World Bank and administered by JSH.

3.0 PROJECT RATIONALE AND SCOPE

Imported fuel oil has had and will continue to have a major command on the use of Jamaican foreign exchange resources. One of the largest consumers of fuel oil is the Jamaica Public Service Company (JPS) for the generation of electricity dispatched through-out the island-wide power grid. Demand for electricity will continue to increase with development and the growth of the population on the island. Meanwhile, an indigenous, renewable resource, biofuel for electric power, has been under-utilized, as the island's sugar cane processing equipment has not been allowed to progress with technological developments. As a consequence, the full fuel potential of Jamaican sugar cane bagasse is being wasted because higher efficiency, bagasse-fired boiler/turbogenerators, that can generate more electricity than the current equipment, have not been employed. This project proposes to apply this available power generating technology on an initial site in Jamaica to begin to significantly reduce the requirements for imported fuel oil.

The island of Jamaica does not have oil or coal reserves and must depend on the importation of most of its energy from abroad. The purchase of petroleum dominates Jamaica's oversea's purchases, paid for in dear foreign exchange and essential to run the national economy. In 1985 that oil requirement amounted to 8.2 million barrels at an annual cost of US$228 million(1) (The Hon. Hugh

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Footnote:

(1) All references made to US Dollars at a Jamaican Dollar exchange rate of 5.5 to one US Dollar.

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Hart, Minister of Mining, Energy and Tourism, The Sunday Gleaner, March 2, 1986, pg 1). This energy expenditure represents a significant external burden on the national economy. Although recent oil prices have been suddenly reduced by half, it is anticipated that this energy dependence will become more and more costly in the long-run without some development of home-grown alternatives

Better use of sugar cane as an alternative energy resource could be a productive development amongst several conservation and developmental paths to increased island energy self-sufficiency. Jamaica has long produced sugar cane -- Christopher Columbus is credited with introducing sugar cane into this region in the 15th century. Commercial sugar cane plantations and processing facilities (factories or ingenios) have waxed and waned here for more than 350 years.

The current contraction by 60 percent of sugar cane production from the "high water mark" of record production in Jamaica in the mid-1970's could be just another point in the cyclical movement of Jamaica's long production history. Even at present production levels with its reduced sugar cane outputs, Jamaica grew and harvested 2.234 million tons in the last crop year (1984/85) and is estimating a slightly expanded production for the current crop of 2.270 million tons to be reaped and processed in 1985/86.

The near-term plan for this country is to further expand that production, to meet the current export and domestic sugar demand of about 242,000 tons by encouraging the production of over 2.5 million tons of millable cane per year, which will still represent the largest cropping

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effort on the island. This total does not include the cane production that might be continued in support of proposed fuel ethanol distillation operations at Duckenfield or Bernard Lodge sugar factories. About two-thirds of the national cane tonnage (1.7 million tons each year) will be focussed on the production flows through two milling facilities controlled by Jamaica Sugar Holdings Limited (JSH) -- Frome and Monymusk. In Jamaica, as elsewhere in the tropical band embracing the Equator, sugar cane continues to be an important traditional commercial crop with an opportunity to provide some more home-grown energy as well.

In addition to producing a sizeable income for this country (about US$70 million in annual turnover [revenues] from the sales of sugar and molasses with approximately 70 percent of that total or US$50 million in hard currency earnings), sugar cane will concurrently produce substantial amounts of biomass that would be a source of continuing energy. As an example on an island-wide basis, the croppings at the projected level would produce 750,000 tons of bagasse (i.e., the fibrous residue of the processing of sugar cane) at an average moisture of 50 percent. Bagasse at this moisture content has the equivalency of a barrel of fuel oil to a ton; the annual energy value of this amount of biomass resource could then be equivalent to 0.75 million barrels of oil.

Unfortunately, very little of the considerable bagasse now produced in Jamaica and used to generate process steam and electricity is in excess of the direct needs of the producing facilities. In fact, expensive quantities of fuel oil and electricity are now imported to most of these Estates and their factories to meet their

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requirements. This is mainly due to the design and age of the power generating equipment in current use in the nine Jamaican sugar factories, and the way the production facilities are operated.

Theoretically, sugar cane croppings could provide substantially more useful biofuel than they do now, and become a more important generating source for the nation's electrical needs. The cane trash (barbojo) in a mature stand of sugar cane, that is now burned before harvest or left as a mulch in the fields, might annually provide 0.625 million tons of added and practically recoverable biofuel on a wet-weight basis in Jamaica from a sugar cane crop of 2.5 million tons of millable canes. Although solar-dried barbojo has a calorific value that is similar to or greater than bagasse, the practical recovery of a substantial portion of this renewable energy resource will require considerable development to realize its potential. There is a trash recovery system under consideration by this project (i.e., following manual cutting and mechanical loading of unburned sugar cane, the cane trash [barbojo] is solar dried and baled for deferred combustion in the non-grinding period).

As part of the long-range strategy for sugar cane variety development in the Caribbean, directed at a net revenue maximizing balance between its sucrose and calorific values, the selection criteria will require some adjustment to more readily identify and promote those new clones created with a high-performance/higher-fiber (also lower juice and lower sucrose) character than was previously the case. The identification of high performance (i.e., accelerated accumulation of tons

of sugar cane per unit of space [acre] and time exposure [month] with optimal levels of inputs) but poorer juice quality varieties for rapid propagation to commercial-sized plantations may take some time to accomplish. It will take even more time to make an impact of several hundred thousands of tons of more fibrous sugar cane annually available for processing in this country. The objective of this genetic strategy is to increase, over time, the amount of biofuel (bagasse and barbojo) that would be available from a crop of sugar cane, without reducing the amount of sugar and molasses per acre-month that would be concurrently recovered. The concept of trading increased calorific value for a reduction in the sweetener value is not economic at current prices for oil/electricity and sugar/molasses.

The current priority interest in Jamaica is, and should be, to increase the production performance of field yields by 50 percent or more as measured in tons of sugar cane per acre for a crop (i.e., at the rate of 2.75 versus 1.83 tons of sugar cane per acre-month or TCAM [6.68 versus 4.48 tonnes per hectare-month]) to regain the output and profitability levels of the past. Much of the increased outcome is to be attributed to yield-maximizing cultural inputs and handling, such as: better drainage, improved tillage to increase the rooting zone and water-holding capacity of soils, effective and timely irrigation with good quality water, adequate and timely crop nutrition, a growth environment free of weeds, pests and diseases, a properly aged and ripened, promptly reaped and transported sugar cane crop for efficient processing into saleable products. Some of the production gains may be credited to improved sugar cane varieties, but most of the gains will be brought about by

improved farming in Jamaica. The increased cane tonnage will provide more calorific resources as well as more of the financially attractive sweetener component of sugar cane under the favored market conditions enjoyed by Jamaica.

The major purpose of this project is to evaluate the technical and financial/economic feasibility of installing a privately funded, new power cogeneration facility at Monymusk, which is the second largest sugar cane processing facility on the island. Monymusk shares the manufacturing of sugar/molasses and the distillation of potable alcohol, for the productive agricultural area of Clarendon in south-central Jamaica, with the privately-owned facility at New Yarmouth. Monymusk has had a modest power generating capability installed four decades ago that this proposal plans to replace. The Clarendon sugar cane production area requires virtually year-round irrigation for its cropping, so the electricity requirements to pump the needed water resources for the cane fields causes this operation to have a greater demand for power than other sugar properties in Jamaica that rely on rain-fed production.

The installation of a "current-state-of-the-art", high performance boiler/turbogenerator complex for Monymusk would be an important step to greatly improve the amount of steam and electricity that could be produced from bagasse and barbojo supplies on an annual basis. It is anticipated that there will be sufficient and regular biofuel supplies to warrant a 35 MW power generator, so as to allow Clarendon Sugar Company (Monymusk Factory) to be steam and electrical energy self-sufficient, and that a substantial block of power could be made available to

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the national electrical utility, Jamaica Public Service Company (JPS) for their island-wide dispatch.

The crushing plant and boiling-house facilites of Monymusk are in the process of being extensively rehabilitated during the next five years under financing provided by the World Bank. It is envisioned that the efficency and productivity of the factory and the sugar cane fields operated or influenced by the sugar company (Clarendon Sugar Company, Limited -- CSCo.) will be so improved as to allow CSCo. to produce and purchase sufficient sugar cane to more profitably utilize its effective factory capacity. The proposed power generation facility will be sized to match that level of sugar cane through-put to be grown, harvested and processed in an extended campaign of 35 weeks or 206 operating days. The operation of the proposed power generating facility for the 100 days during weekends, holidays and the "off-crop" period to allow for a year-around generating scheme, allows for 42 days for scheduled maintenance and 30 days for forced outages. Primarily fueled by biofuels (i.e., directly-fed bagasse during the campaign and stored bagasse and barbojo during the "off-crop" period) it will require that innovative recovery and storage techniques be developed and employed in the next few years at CSCo.

The principal benefits which are anticipated to be derived from the project include:

- <u>Elimination of The Current Government Subsidies to the Clarendon Sugar Company</u>.

  The installation of the new cogeneration facility to supply low cost electricity and steam, together with

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the complementary factory and field rehabilitation project being carried out by the World Bank, will return the mill and estate to higher profitability.

- Reduction of Foreign Exchange Expenditures for Imported Fuel Oil.

  The increased utilization of cane derived biofuels will replace substantial amounts of imported fuel oil for generation of steam and electricity and thereby reduce Jamaica's dependence on that commodity.

- Private Ownership

  The private ownership of the cogeneration facility will attract debt and equity funding from private sources which will alleviate the need to draw upon the government's limited borrowing capacity to finance future electrical generation capacity. Private ownership and management will also reduce costs and improve productivity.

- Increasing Employment

  The increased volume of sugar cane for harvest, and utilization of the barbojo as a fuel will provide for a significant increase in new jobs in the Clarendon area.

- Reducing Electricity Costs

  The cogeneration plant will produce electricity at a lower cost than some of the units currently included in JPS' least-cost capacity expansion plan.

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- Introducing New Technology

  The project will introduce advanced production techniques and systems and will provide the training to use them, thus providing technological progress for Jamaica.

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4.0 MARKETING

4.1 SUGAR

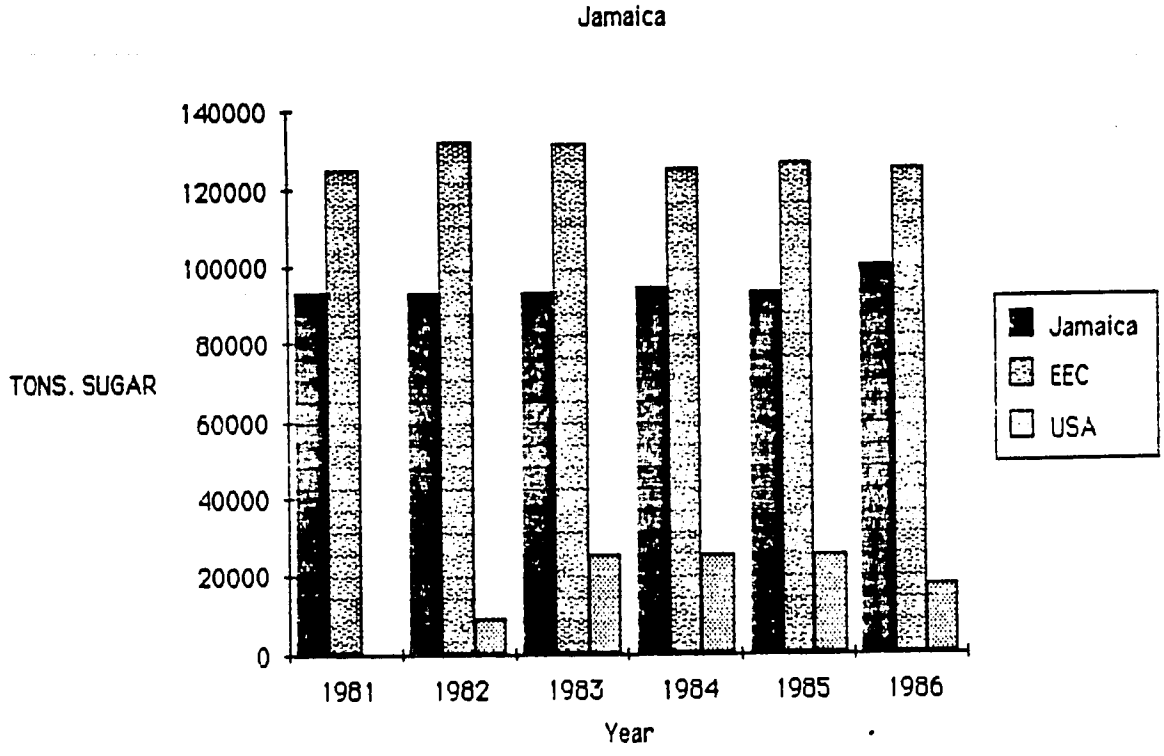
Clarendon Sugar Company Limited (CSCo.) as a part of Jamaica Sugar Holdings Limited (JSH), will market its raw or 96 degree sugar through the newly established Sugar Cane Products Association (SCPA). SCPA has been set-up as the successor to the Sugar Industry Authority's (SIA) current and long-standing function of being the exclusive national marketeer of both raw and refined sugar in and for Jamaica. The Authority is to remain the only wholesaler of refined sugar to domestic markets and that demand is now about 35,000 tons each year. The sugar refinery at the Monymusk Factory is scheduled to resume production upon completion of Rehabilitation Project Year 3 (1989) and increase its refined output to the plant's capacity of 40,000 tons over three years or by 1991.

The current market demand for raw sugar at favorable prices, supported by encouraging governmental action, is estimated to total about 207,000 tons per year, as follows:

TABLE 4-1

Market	96 Degree Sugar	Refined Sugar
	Tons/Yr.	Tons/Yr.
Domestic	65,000	35,000
Export		
UK (EEC)	125,000	
USA	17,000	
Export Total	142,000	
Raw Total	207,000	

FIGURE 4-1



Raw sugar demand at a favorable price may be anticipated to fall with a phased reduction or sudden loss of the USA Quota. Similar quota adjustments may also be made by the EEC as Jamaica has been importing its refined sugar requirements for three years now in contravention of the Lome Accord. Domestic raw sugar demand is anticipated to rise at a modest rate in response to the population growth without a change in the consumption pattern in Jamaica. The growth of the Jamaican population, as shown below, is forecasted at a lesser rate of growth than was experienced during the past decade (1976-1985) or at 1.12 percent versus 1.46 percent

in net population change per year. The domestic raw and refined sugar consumption rate, on a raw sugar equivalent basis, is high at 96.3 pounds per person per year and is expected to stabilize in the future at about that level.

The estimated domestic consumption, on a raw sugar equivalent basis, for the project period is shown below and displays a very modest expansion (averaging 12,000 tons in growth per decade) of the long term demand for sugar in Jamaica. With carefully controlled production in balance with expected demand, at favorable prices, the sugar produced by this project should be readily sold.

TABLE 4-2

Period	Mean Population	Local Consumption (96 Deg. Tons/Year)
1985	2,325,500	100,000
1985/90	2,386,700	102,610
1990/95	2,550,300	109,640
1995/00	2,692,900	115,770
2000/05	2,825,400	121,470
2005/10	2,965,300	127,480
2010/15	3,105,400	133,500

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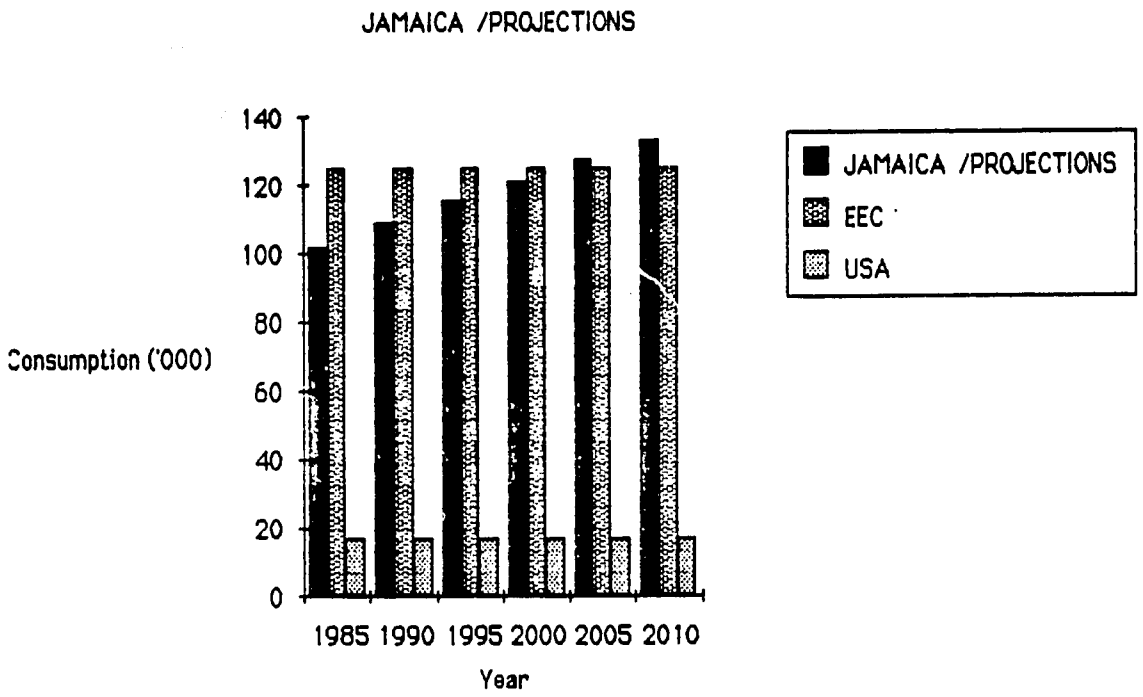
FIGURE 4-2



The current 96 degree sugar production capability was estimated at 207,000 tons at the start of this crop (1985-86 Harvest Campaign). This year's estimated total is up slightly from last year's results. The very heavy rains and extensive flooding during early June 1986, as 27.5 percent of the crop remained to be reaped and processed into sugar, has caused the estimate for the current year's production to be adjusted downward. The reduction is yet to be fully quantified.

The following table shows the current and future Jamaican production capability per year:

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TABLE 4-3

Factory	1984-85 Actual	1985-86 Estimate	1990-91 Estimate	
Frome	57,048	58,530	91,000	
Monymusk	26,652	32,000	68,700	
JSH	83,700	90,530	159,700	(1)
Long Pond	15,336	15,430	-	(2)
Bernard Lodge	23,654	19,510	-	(3)
Duckenfield	7,534	7,110	-	(3)
NSCo.	46,524	42,050	-	
New Yarmouth	25,842	24,500	24,500	
Appleton	13,995	12,390	12,390	
Worthy Park	22,242	22,100	22,100	
Hampden	14,404	15,430	15,430	
Private	76,483	74,420	74,420	(4)
Totals	206,707	207,000	234,120	

Footnotes:

(1) Upon rehabilitation, JSH will have about 68,170 tons more output at profitable levels.

(2) Long Pond may be closed as excess capacity and its production not being cost-effective; this closure may be reversed with any continuation of the USA Quota at about the 15,000 ton level.

(3) Bernard Lodge and Duckenfield are now scheduled for closure or redeployment as ethanol producing facilities.

(4) This total assumes that all private factories keep their costs in line although certain smaller operations may become increasingly marginal as they approach the 1990's.

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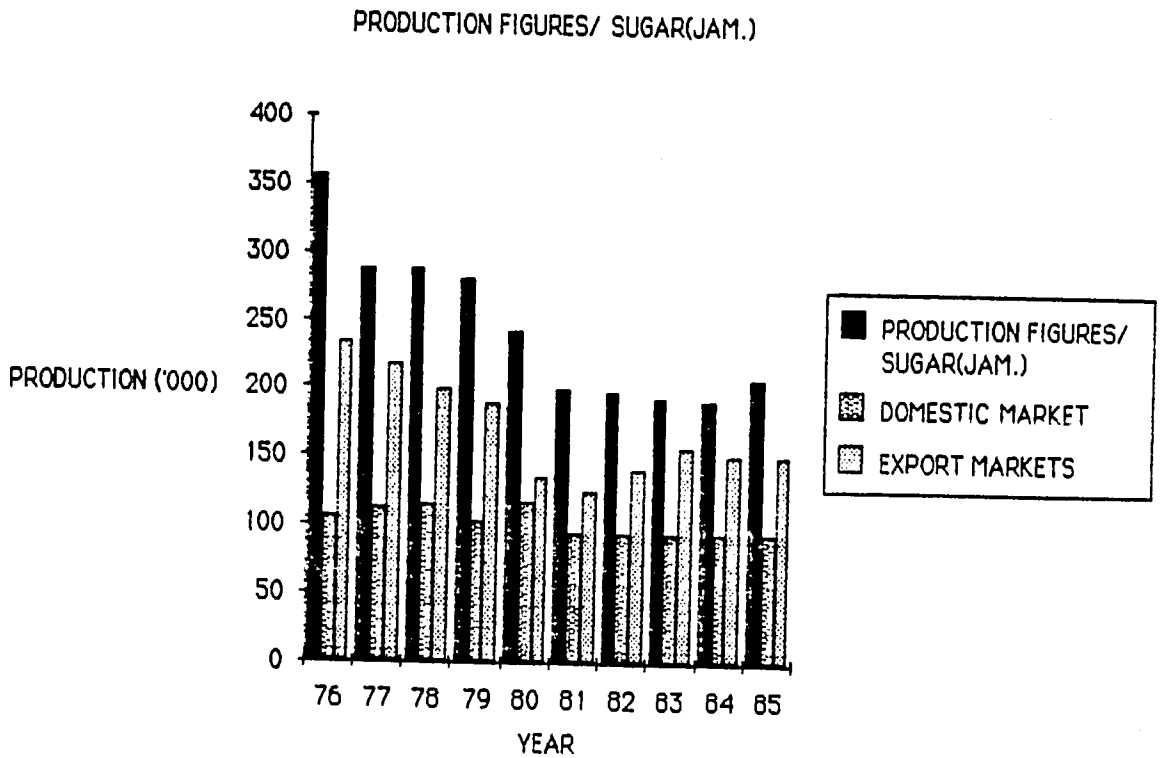
The current under-supply of 35,000 tons of 96° sugar per year in Jamaica should balance out with adjustment in the early 1990's provided that only the USA Quota is removed and Lond Pond or the equivalent production (about 15,000 tons) is reduced. Production in excess of the protected market will be only able to command the less favorable World Sugar Prices. Favorably priced Jamaican domestic and export demand for certain levels of raw and refined sugar should exceed the adjusted local production during the project period (1990-2010).

FIGURE 4-3



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The world price for raw sugar is expected to remain depressed below the production costs of the most efficient producers during the first decade of the project period. The World Bank projections indicate that for the next three years (1986, 1987 & 1988) an average price below 9 U.S. cents per pound [19.8 U.S. cents per kilogram] in constant 1985 dollars can be expected. Currently, sugar prices on this market have risen then fallen to under 5 U.S. cents per pound and this sudden change after a deep drop in price to 2.74 U.S. cents [6.04 U.S. cents per kg] in 1985 may be temporary. The long-term forecast by the World Bank is that raw sugar will average 10.3 U.S. cents per pound [22.71 U.S. cents per kg] in the next decade, 1986-1995, and that will nearly match the price average of the previous decade, 1976-1985, of 10.6 U.S. cents per pound [23.37 U.S. cents per kg].

The surplus pricing of bountiful raw sugar stocks (an oversupply of about 9.75 million tonnes, or ten percent of the annual world-wide consumption, held in addition to the routine level of stocks, set at about 30% of the consumption or 29.25 million tonnes), will restrain the project's sugar revenues. This impact on the sugar price the project receives will be in spite of the fact that its output is to be entirely sold on protected domestic and export markets.

The raw sugar price forecast of the 1985-86 year of operations now in progress in Jamaica aggregates the

returns per ton at about US$300(1) (US13.4¢/lb) from the United Kingdom (EEC), just over US$400(2) (US17.8¢/lb) from the USA and US$333(3) (US14.9¢/lb) from domestic sales of raws. The composite return after domestic handling expenses is about US$ 301 per ton(4) (US13.4¢/lb).

This return is further reduced by industry assessments for shared expenses (Sugar Industry Authority, Sugar Industry Research Institute, etc.) of US$13.89 per ton (6.2 mills/lb) leaving an ex-plant return of about US$286 per ton (US12.7¢/lb). The sugar return per ton used in this evaluation is JA$1,724 (US$313.50)(5).

The aggregate return for raw sugar is disbursed by SIA in three or four payments during the production year and the "off-crop" period. The disbursements are allocated on a split of 1/3 : 2/3 between cane millers and cane growers. This "Guaranteed Sugar Price" is augmented by a "Cane Grant" to growers, a "Milling Grant" to millers and an "Additional Cane Subsidy" to growers. The estimated factory and farmer split for the current year is as follows:

Footnotes:

	U.S.$/Tonne	U.S.¢/kg
(1)	295	29.5
(2)	394	39.4
(3)	328	32.8
(4)	296	29.6

(5) 5.5 to $1.00 Exchange Ratio

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Factory		Farmer	
JA$652.93	37.87%	JA$1071.32	62.13%

The return for raw sugar during the project period is not expected to change much, in real terms, nor is the factory/farmer split expected to change either.

The domestic market for refined sugar is controlled by SIA as to the amount allowed into the market and tne pricing is set by the government. The refinery at Monymusk will be restarted in 1989 to displace the current importation of white sugar. The level of production has been established, and the estimated refining price allowance for the refined product is US$21.43 per ton (9.6 mills/lb) for total return of US$334.93 per ton of refined sugar.

4.2 MOLASSES

The six rum distilleries in Jamaica utilize nearly all of the annual molasses output of the nine sugar cane factories currently in operation. A very small amount of molasses is sold for other local uses. The distillery requirements in the future will exceed local production by 30,000 tons annually and this year the Spirits Pool Association is importing 9,000 tons of molasses to assure adequate feed stocks. The domestic market demand for molasses during the project period should be strong as derived from the growing demand for Jamaican rum.

The distillery at the Monymusk Factory requires about 20,000 tons of molasses per year to operate in its maximum efficiency range. This operating requirement is matched to the level of molasses output of the sugar cane processing operation at its optimizing range.

The ex-plant price for molasses is set on the New Orleans market, less the cost of local transport to the port and ocean transport to the market including insurance. The price currently returns roughly one-half the New Orleans price as transport costs amount to U.S $28 per ton and the price in the market is U.S.$55.94.

4.3 ELECTRICITY

Introduction

In addition to sugar and molasses, electric power will be a product of this cogeneration project at the rehabilitated Monymusk Factory. As envisioned, the surplus electric power(1) would be sold to Jamaica Public Service Co. (JPS). After adjusting for plant auxiliary loads, this would amount to approximately 19 MW of net power available during the harvesting season and 32 MW during the off-season. (2) It is important therefore to establish the market prospects for electricity in Jamaica in the 1990's, when power from this project would be commercially available. In this section the outlook for electricity is reviewed based on recently developed projections by others. In particular, a recent study completed by Montreal Engineering Company, Ltd. (MONENCO) entitled Least-Cost Expansion Study - August, 1985 prepared for JPS, provides the basis for much of this section. The study, which was completed in 1985, included a detailed market survey and forecast. In addition to this study, more recent information concerning the economic outlook in general, and the use of electricity in particular, were developed

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Footnotes:

(1) Power available for sale after satisfying the needs of sugar cane production and processing.

(2) Gross capacity - 21 MW during the process season and 35 MW during non-grinding period.

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through interviews with JPS as well as other key institutions.

The power grid in Jamaica is interconnected; hence the market for electric power is essentially a national one. Accordingly, this project will be analyzed within that context. The current structure of the power market and the historic trends in electricity use are presented in the following section. The next section sets out the various forecasts for electricity use and the impact this project would have on the supply of electric power. Lastly, estimates of the avoided cost of electricity for future units in JPS are presented.

Current Use of Electricity

The production and distribution of electricity is presently the responsibility of JPS, which was granted an exclusive, all-island license in 1978. The license gives JPS authority to supply power to all areas of the island for a thirty-nine year period. The license stipulates that JPS is subject to the Ministry of Public Utilities, which has power to regulate its rates and insure performance under the terms of the license.

JPS owns approximately 65 percent of the total generating capacity in Jamaica, which amounted to approximately 449 MW of available capacity in 1984. The JPS system is largely dependent on fuel oil with the exception of 21 MW of hydro-electric capacity. The balance is owned primarily by industrial users for on-site power needs. The distribution among these users is as follows:

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Bauxite/Alumina	168	MW
Sugar	30	MW
Cement	14	MW
Total	212	MW

In 1984, total sales on the JPS system totaled 1,156 GWh (million kilowatt hours). Table 4-4 sets out the distribution of these sales among the various classes and customers, as follows:

TABLE 4-4

1984 SALES OF ELECTRICITY
(GWh)

Customer Class	Sales	Sales (%) Distribution	Customers
Residential	368	32%	222,895
Commercial & Small Industrial	515	45%	24,112
Large Commercial & Industrial	142	12%	22
Others	131	11%	2,160
Total	1,156	100%	249,189

Commercial and small industrial users comprise the largest consuming group in terms of sales, followed by residential. Large commercial and industrial users, while in third place of total sales, typically have on-site power generation capability,

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which reduces their power requirements significantly. In terms of average use per customer, the industrial sector ranks first, as might be expected, followed by others, commercial and small industrial, and lastly residential.

Total net generation amounted to 1,440 GWh in 1984. Sales accounted for 80 percent, while company use accounted for 1 percent, and accounted-for losses comprised 19 percent. Gross peak demand was approximately 255 MW in 1984.

Historic Trend in Electicity Use.

Figure 4-4 sets out the sales of electricity for the major customer classes from 1965 to 1983. Over the entire period total sales have grown at an average annual rate of 5.72 percent, however, this rate of growth has not been continuous. Four overlapping periods can be identified:

- 1965-1972 - This was a period of relatively rapid growth with total sales increasing at an average rate of 12 percent, due to new system expansion and low prices.

- 1972-1978 - This period was characterized by moderate growth, with total sales increasing at an average annual rate of 3 percent, due to a reduced rate of additions and slower economic growth.

- 1978-1981 - A period characterized by a decline in sales, averaging -3.6 percent per year, due

to a rapid rise in prices and declines in economic activity.

- 1981-1983 - A period characterized by increases in sales at an average annual rate of 7 percent, due to the economic growth rebound.

As indicated above, the influence of the level of economic activity on electricity sales has been an important one. Another indicator of this relationship is the ratio of per capita electricity use to per capita gross domestic product (GDP), which is set out in Figure 4-5. The trend portrayed is one of increasing intensity of use up through 1976 and a levelling off in subsequent years. The trends described above are reflected in the sales trends for each of the major customer classes, as shown in Figure 4-4. Key factors influencing each class of customer are summarized below:

- Residential - From 1965 to 1972 the number of customers increased by 75 percent. Increases of 56 percent, 17 percent and 6 percent were experienced over the periods 1972-1978, 1978-1981, and 1981-1983 respectively. Average use per customer grew by 7 percent during the 1965-1972 period, then declined by 5 percent per year between 1972-1978, and grew moderately thereafter. GDP per capita increased from the sixties to the early seventies at an average annual rate of approximately 6 percent and has declined thereafter at an average rate of 2 percent.

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- Commercial and Industrial - Sales to these sectors are influenced by customer growth, intensity of use, and the overall level of economic activity. The number of customers increased by 44 percent from 1965 to 1972 while smaller increases of 20 percent and 2 percent were experienced during the periods 1972-1981, and 1981-1983 respectively. Average use per customer increased at an average annual rate of 6 percent from 1965-1972, then declined at a rate of 2 percent per year thereafter. The level of economic activity for these two sectors exhibited moderate growth through the early seventies and declined over most of the period through 1980. From 1980 to 1983 a resumption of growth occured in both sectors.

Another factor which has affected the sales of electricity has been the level of rates established by JPS. Figure 4-6 sets out the trend in average revenue per kWh for the major customer classes on a constant dollar basis for the period 1970 to 1983. With the exception of the early part of the period prices have increased in real terms until 1983 when prices did not keep pace with inflation and consequently declined in real terms. More recently there have been significant increases in prices both in 1984 and 1985 according to discussions with JPS.

A comparison of price changes with changes in average sales per residential customer is set out in Table 4-5. In the early portion of the period sales increased while prices did not increase in real terms. In contrast the period 1973 to 1981 was

characterized by significant increases in real prices and significant declines in the average per customer sales. Sales again rose in 1981-1983 while prices again declined in real terms. More recently, although data is unavailable, sales per customer have exhibited some declines in response to the price increases in 1984 and 1985, based on discussions with JPS.

TABLE 4-5

COMPARISON OF AVERAGE SALES AND REVENUE PER CUSTOMER FOR RESIDENTIAL CUSTOMERS

PERIOD	PERCENT CHANGE IN SALES	PERCENT CHANGE IN REVENUE
1970-1973	14.8%	0
1973-1981	-37.1%	97.8%
1981-1983	9.6%	-3.4%

Source: MONENCO Report to JPS

Electric Market Outlook

This section reviews the potential market for electricity in Jamaica to the year 2000, based upon existing forecasts. These are evaluated in light of more recent information and conclusions are drawn with respect to the most likely prospects for market growth.

Figures 4-7 and 4-8 summarize three separate forecasts prepared by JPS, the Ministry of Mining, Energy and Tourism (MMET) and MONENCO showing net generation and peak demand respectively. The first two were prepared in 1983 and are provided as

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reference points while the latter was completed in 1985 and therefore provides a more current assessment.

JPS and Ministry Forecasts - The JPS forecast was prepared based upon historical relationships over the period 1964 to 1978. As shown on Figure 4-8, gross peak demand was projected to grow at an average annual rate of approximately 5 percent, reaching 318 MW in 1990 and 557 MW in 2000, compared to an actual peak of 256 MW in 1983.

The MMET forecast was presented as part of a study the purpose of which was to present national energy policies and programs. The forecast was based on a planning model. The MMET forecasted peak demand to grow at an average rate of approximately 6 percent per year reaching 373 MW in 1990 and 711 MW in 2000. A key assumption underlying this forecast was the rate of growth in constant dollar GDP, which was assumed to grow at 5 percent per year.

MONENCO Forecasts - A more recent assessment of the electric power market outlook was prepared by MONENCO as part of its least cost expansion study for JPS. This study has two advantages over the previous studies described. First, it is based on a comprehensive survey of power users in the country, coupled with an analysis of both economic and demographic factors which will influence future power use. Second, it is a more recent projection and therefore reflects the latest policies and general economic conditions. Accordingly, this projection is perhaps a better indicator of the future power market.

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As shown on Figure 4-8, a range of forecasts was prepared by MONENCO consisting of a best estimate of JPS sales and net peak demand (i.e., excluding station service requirements). In addition, a high and low estimate of net peak demand was prepared. The best estimate was developed primarily on a judgemental basis concerning the future rate of customer connections, the growth of average sales per customer and the total sales for each customer class. The forecast of net peak demand was developed by applying the expected values of future load factor to the projection of JPS net generation. The low and high forecasts were judgementally estimated variations from the best estimate forecast. The major assumptions underlying the MONENCO forecast are set out in Table 4-6, as follows:

TABLE 4-6

MONENCO FORECAST ASSUMPTIONS

PARAMETER	LOW ESTIMATE	BEST ESTIMATE	HIGH ESTIMATE
GDP GROWTH(1)			
1983-1993	1.3%	2.5%	3.3%
1993-2003	2.0%	3.0%	4.0%
POPULATION GROWTH			
1983-1993	1.0%	1.3%	1.7%
1993-2003	1.0%	1.3%	1.7%
CUSTOMER GROWTH			
1983-1993	N/A(2)	2.0%	N/A
1993-2003	N/A	1.9%	N/A

Footnotes:

(1) Constant dollar growth rate
(2) N/A - not available

Source: MONENCO, Least-Cost Expansion Study, Table 9-15

When the above information is evaluated in light of more recent information obtained through interviews with key agencies, it is believed that the low and best estimate forecasts, as shown on Figure 4-8, bracket the probable market size, while the high estimate is unlikely to be attained. This conclusion is based on the following observations:

- Historically the economic evidence as reviewed above does not support the rate of development implied in the high estimate.

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- The austerity measures proposed by the International Monetary Fund (IMF) and agreed-to by the GOJ may restrict growth, at least in the short term.

- The two major sectors of the economy that have provided the impetus for growth - sugar and mining - are not likely to rebound over the next several years. The development of a light manufacturing sector will probably take longer to emerge than envisioned by government planners.

A countervailing factor will be lower oil prices which will have an impact on all consuming sectors through increases in disposable income as well as lower energy costs. This will to some degree increase the demand for electricity. This impact can be illustrated by considering JPS's rate structure. Based on the fuel adjustment clause, and assuming a 50 percent decline in oil prices, the average savings per residential customer would be approximately J$22 per month (US$4 per month) based on average residential consumption.

The extent of the increase in electricity demand is unlikely to be large in the short run, as demand tends to be inelastic. The longer run effects could be larger, depending on expectations of future oil prices. Given the outlook for oil prices developed in this report, the impact will be to increase electricity use. Taking the combined effects of these factors under consideration would result in demand tending to the "best estimate" forecast.

Given the above, the prospective market for electricity in terms of sales, as projected by MONENCO, will range from 1432 GWh to 1586 GWh in 1993, and 1672 GWh to 2045 GWh in 2003. The 1993 market represents an increase of 24 to 37 percent over the 1984 sales level, while the market in 2003 will be 45 to 77 percent larger than 1984. In terms of peak demand, the relevant forecast range is 284 MW to 314 MW in 1993, and 332 MW to 405 MW in 2003. Compared to the 1984 peak demand of approximately 255 MW this represents an increase of 11 to 23 percent for 1993 and 30 to 59 percent for 2003.

In order to meet the projected growth in demand through 1993, a total of 110 MW of new capacity would be required, according to the MONENCO report. The following specific recommendations, with respect to generating capacity, were made by MONENCO based upon their least-cost expansion analysis:

- Rehabilitate two gas turbine units in 1985 - 1986;
- Convert two oil-fired units to burn pitch in 1986;
- Install a 22 MW gas turbine for commercial operation in 1991;
- Install a 22 MW gas turbine for commercial operation in 1992;
- Install two 66 MW coal units for commercial operation in 1993;
- Install feasible hydro-electric stations over the period 1985-1993;
- Start construction of new base-load plant required for installation in 1994 and beyond.

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Avoided-Cost Assessment

Given the above, it is assumed that both coal and oil will be viable options for future capacity expansion. Accordingly, the potential for selling surplus power to JPS would depend on the avoided costs of these new units. If surplus power is available at a price equal to or below this level then, other issues aside, a definitive market should exist.

This section assesses the avoided cost of power to JPS based on the incremental unit concept; e.g., the costs avoided by JPS by not having to add a particular unit of capacity. In this analysis three specific units are evaluated - a base-load coal unit, a base-load oil unit and a peaking gas turbine - in order to provide a range of estimates.

The following procedure was used to estimate the avoided unit cost:

- The basic cost data for each unit was taken from the MONENCO report for the following units:

  -66 MW Coal unit
  -66 MW Oil unit
  -22 MW Peaking gas turbine

- The cost data for the units, as presented in Tables 8-2, 8-3, and 8-6 of the MONENCO report, was adjusted as follows:

- Capital costs were escalated by 2 percent per year to adjust to a 1986 basis.
- Operating Costs were escalated by 10 percent per year to adjust to a 1986 basis.
- The local currency component of costs was adjusted for the exchange rate difference between 1984 and 1986.

- An additional cost of 12 million US Dollars was allocated to the coal unit to reflect the cost of a coal port. The total cost of the coal port was estimated at US$61 million, reflecting a 1984 estimate of $58 million which was escalated at 2 percent per year. The original estimate is presented in Table IV-2, pg. IV-13, USAID report No. 598-0606. Non-Utility Generation of Electricity in Jamaica: Opportunities, Needs, and Impediments, December 1984.

- The resultant costs were then used in a revenue requirement model to estimate the levelized cost of power in 1986 US Dollars. Average financing terms are similar to those assumed for the project analyzed in this report in order to provide a consistent estimate. A 15 percent return on equity (ROE) is assured; no tax holiday was assumed, since JPS typically would not qualify for one.

A final adjustment was made for fuel prices. The MONENCO assumptions are shown as follows:

TABLE 4-7

MONENCO FUEL PRICE ASSUMPTIONS

Fuel	Base Price (1986 US$)	Real Escalation Rate 1987 - 2000
Bunker C	$25 - $30/barrel	3.0% - 5.0%
Diesel Oil	$35/barrel	3.0% - 5.0%
Coal	$50.26/Ton	0.4% - 0.9%

The MONENCO study relied on World Bank projections of fuel prices developed in 1984. Given the current world oil situation, a more realistic estimate, assuming OPEC is unable to effectively regroup, would place oil prices in the realm of $20-32 per barrel by 2000, at 1986 prices (see Section 4.4) The coal price projections appear reasonable given the continued and expected worldwide surplus of coal. This fuel's price will continue to be determined by supply-related factors as discussed in Section 4.4.

The results of the avoided cost estimate are presented in Table 4-8.

TABLE 4-8

ESTIMATED AVOIDED COST FOR JPS
FOR FUTURE CAPACITY EXPANSION
(1986 U.S.$)

Unit Type	1986 U.S.$ Levelized Cost (cents/kWh)
Coal - Steam Electric(1)	8.3
Oil - Steam Electric(2)	6.6
Oil Fired Gas Turbine(3)	8.7

Footnotes:

(1) Includes coal infrastructure
(2) Assumes "likely" oil price case - see Section 4.4
(3) Peaking unit

Conclusions

Based upon the above information the following conclusions can be drawn with respect to the electric power market in Jamaica and the opportunities for this project:

- Jamaica's electricity needs will continue to grow although this growth will be at a low to moderate rate.

- Given this growth present generating capacity will be insufficient to meet future needs by 1993.

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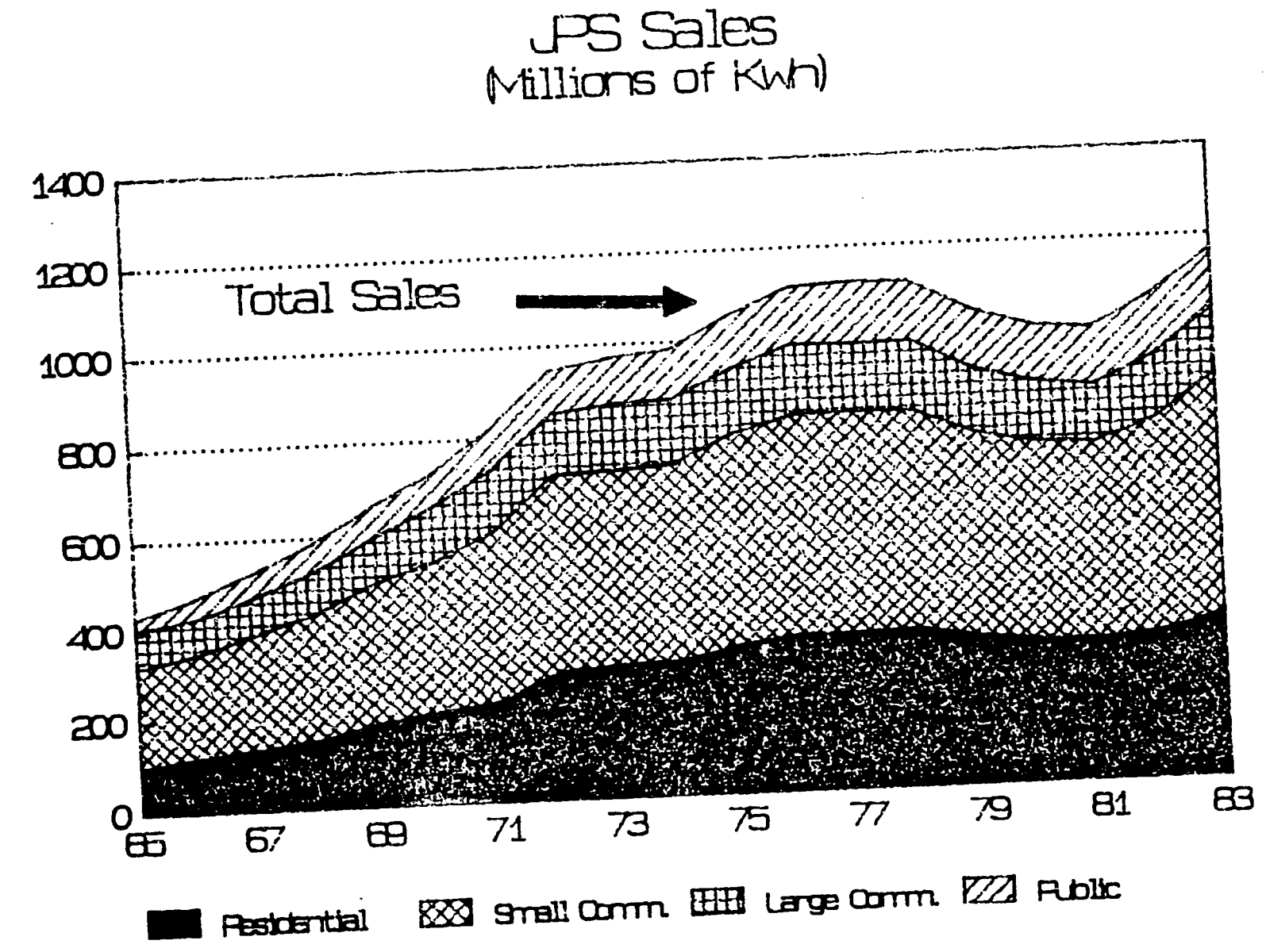
- Approximately 110 MW of new capacity has been recommended to meet these needs by 1993.

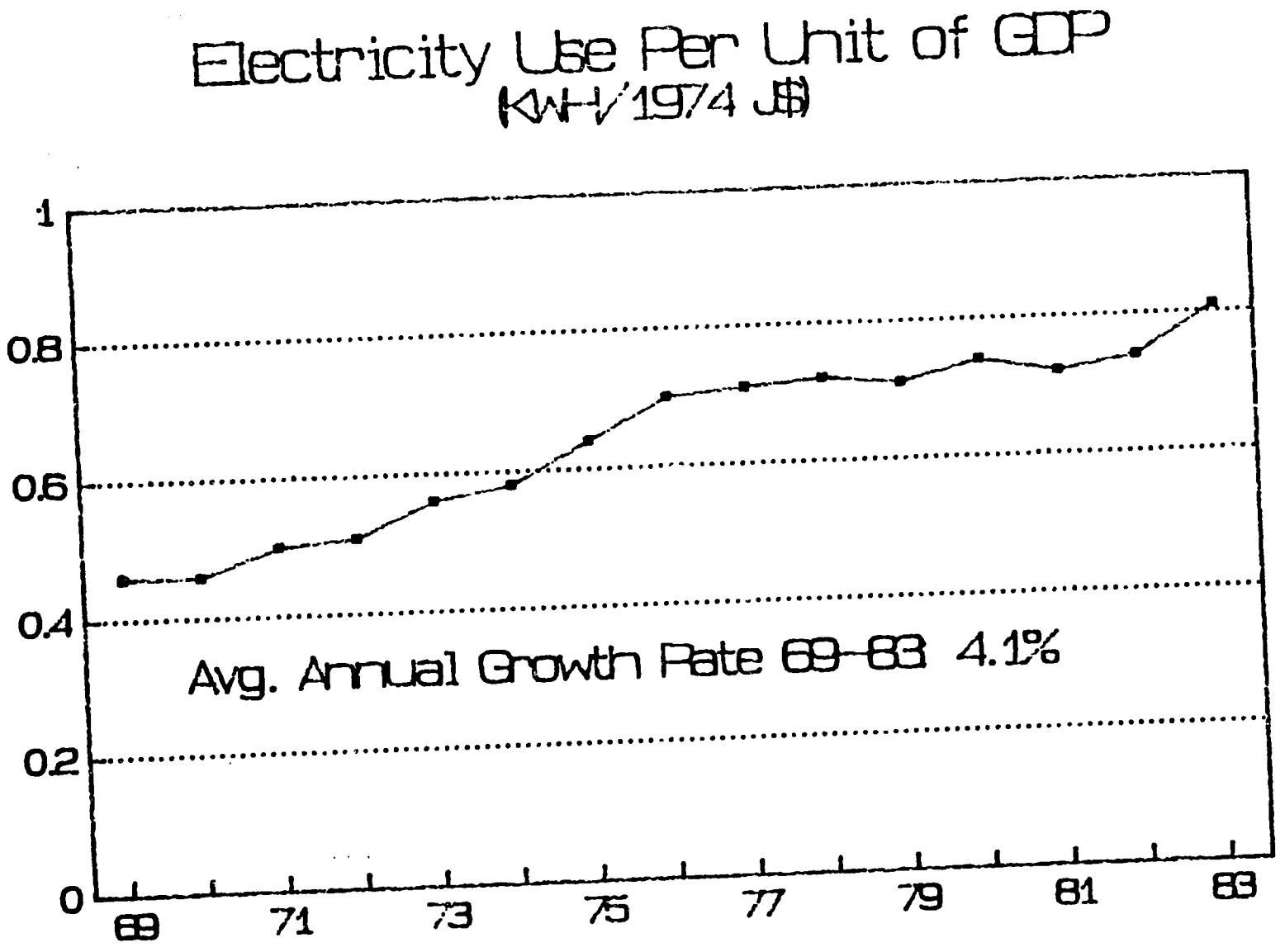
- The estimated avoided cost of power for JPS for future capacity expansion is estimated to range from 6.6 to 8.7 US cents per kWh based on the incremental unit concept.

FIGURE 4-4



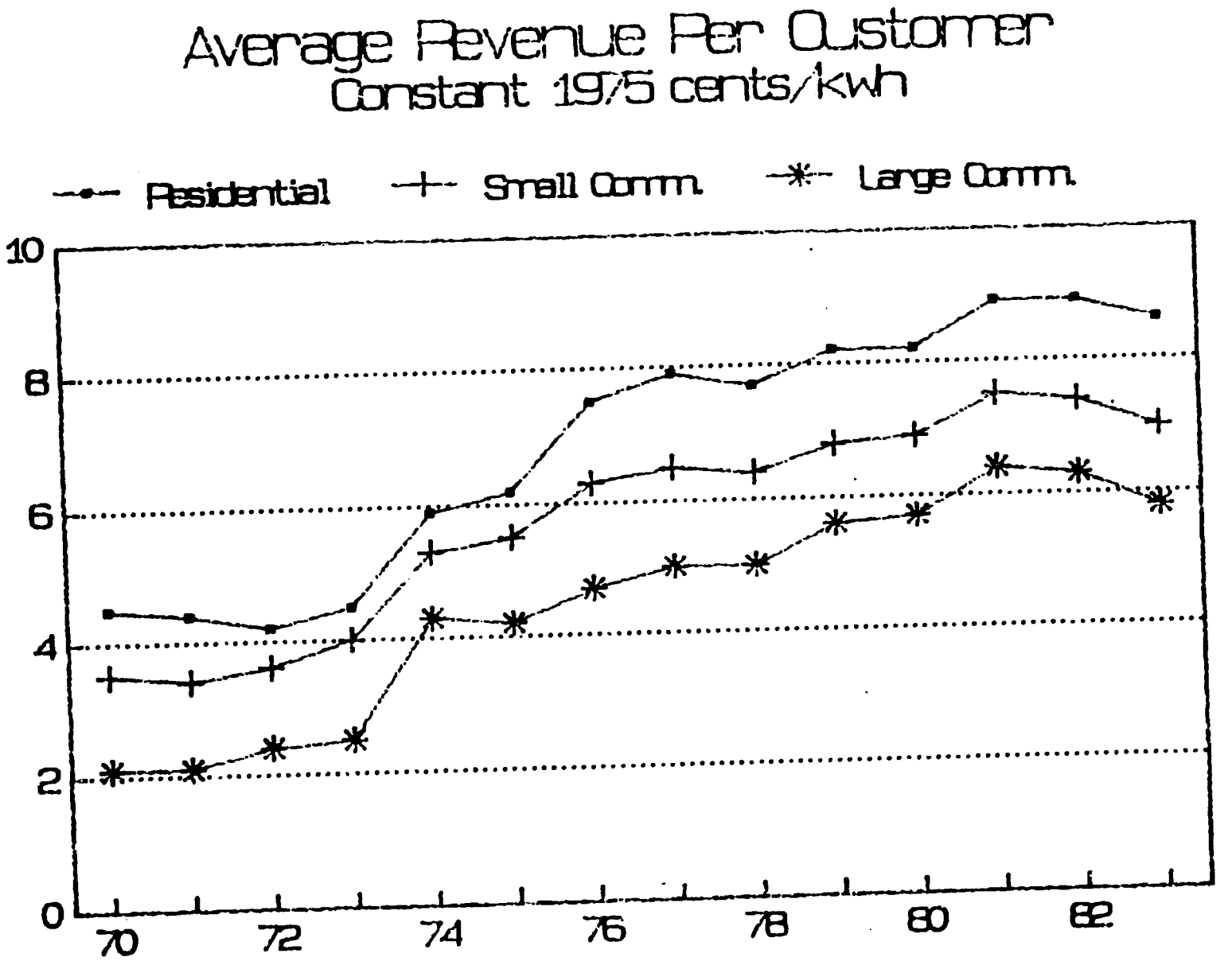
Source: JPS Annual Reports

FIGURE 4-5



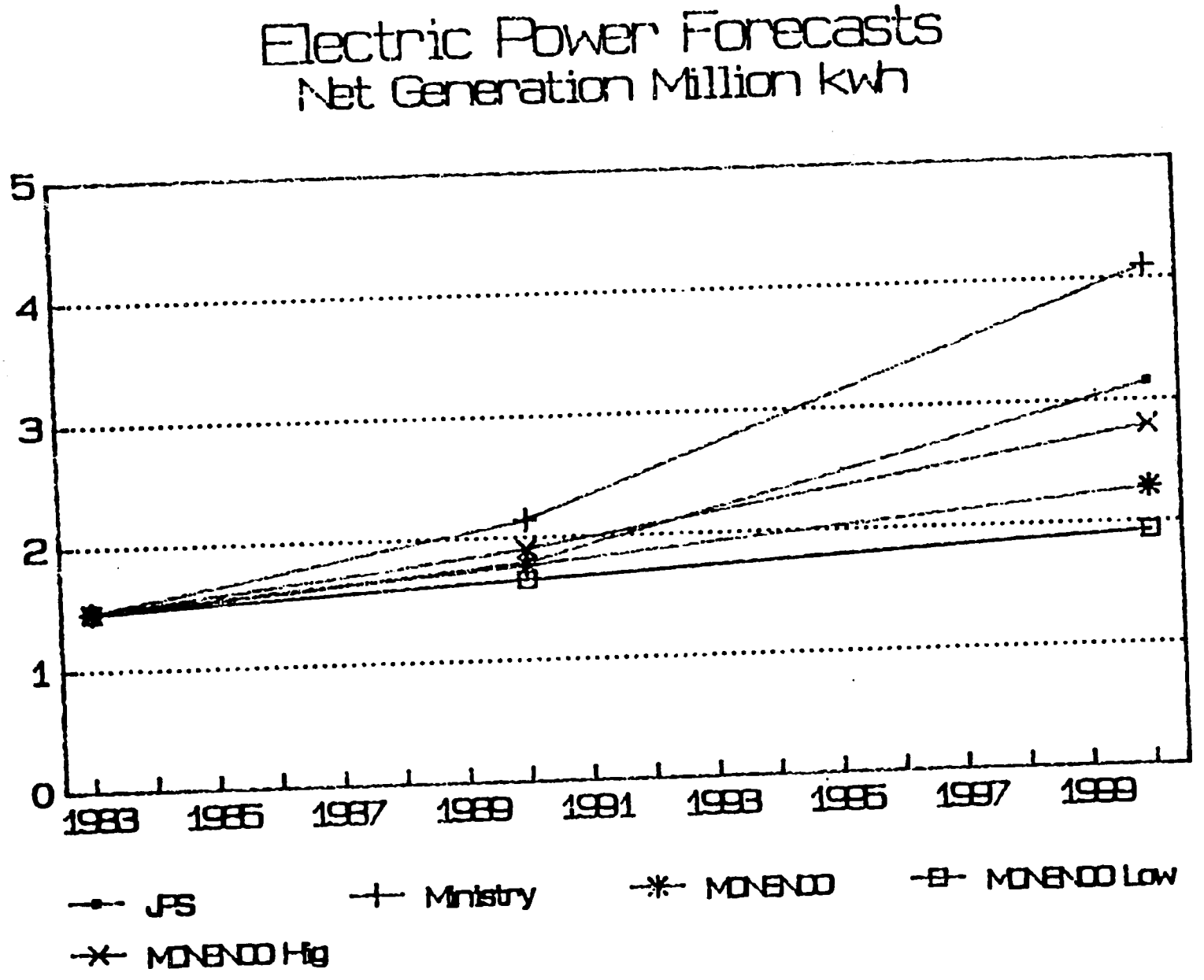
Source: MONENCO Report

FIGURE 4-6



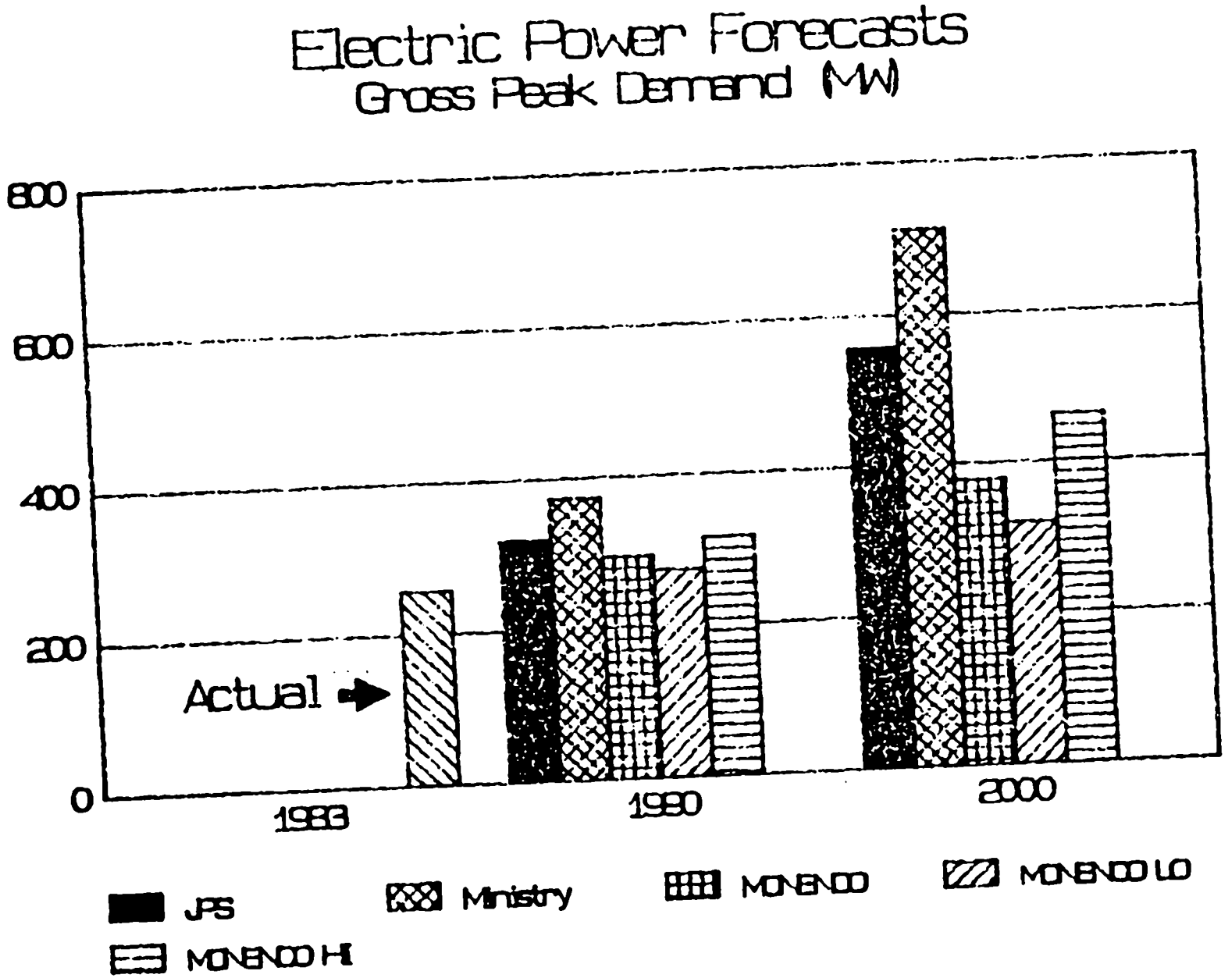
Source: MONBNDD Report

FIGURE 4-7



Source: MONENDO Report

FIGURE 4-8



Source: MONENDO Report

4.4 ENERGY PRICES

Introduction

This section sets out the projected prices for oil and coal and the associated rationale underlying those projections. The project evaluated in this report will rely on residual fuel oil as an augmenting fuel. Coal is considered only in that it presents an alternative fuel source for new power generation under consideration by JPS and thus plays a role in the avoided cost analysis presented in Section 4.3.

Oil Prices

The residual oil price projections set out herein are based on a projection of crude oil prices. Typically residual fuel oil is priced below the price of crude oil. For this analysis it is assumed that residual will be priced at 85 percent of the price of crude oil. In mid-1986 the average price of crude was approximately US$15 per barrel. Residual fuel oil in the US Gulf Coast area, the pricing basis for Jamaican residual fuel oil, had a price of approximately US$12.25 per barrel at this time, which was approximately 82 percent of the price of crude. If US60¢ per barrel is added for transportation to Jamaica the ratio of residual to crude is approximately 86 percent. Accordingly the 85 percent residual to crude relationship appears appropriate.

Recently, world oil prices have declined by over 50 percent from their peak in 1981. A number of factors have contributed to this decline:

- Demand for oil has languished since 1979.
- The Organization of Petroleum Exporting Countries (OPEC) has effectively lost control of the market while its members exceed their production quotas.
- Oil pricing has become more like a traditional commodity.

Barring a crisis of worldwide proportions, it seem highly likely that traditional market forces will act to firm the oil market in the near future. Given this situation three crude oil price scenarios were developed to capture the range of uncertainty attending oil markets. The forecasts are set out in Table 4-9 as follows:

TABLE 4-9

CRUDE OIL PRICE SCENARIOS
(1986 US$/BARREL)

	1986	1990	1995	2000	Growth Rate 1986-2000
Lower Case	$15	$16	$18	$20	2%
Likely Case	$15	$18	$22	$26	4%
Upper Case	$15	$20	$29	$32	6%

The lower case represents essentially a continuation of the current market situation coupled with slower long run economic growth, which includes a major

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recession in the 1986 to 1995 period. Furthermore it assumes OPEC remains in disarray, unable to achieve any unity whatsoever. Alternative fuels such as natural gas and coal are expected to remain in oversupply during the 1986 to 1995 period and then come into balance.

The upper case represents a market situation where economic growth is high, three to four percent in the developed countries and 6 to 8 percent in developing countries. The case assumes that OPEC is unified and that non-OPEC supply lags in responding to increases in oil demand due to reductions in exploration and development. Accordingly OPEC capacity utilization increases substantially, thereby setting the stage for significant increases by 1995.

The likely case, which is used in the evalution of this project, probably represents the most stable of the three scenarios. In this case, slow to moderate economic growth prevails with minor cyclical downturns. Oil demand is expected to continue to exhibit slow growth. With respect to crude oil supply, the Saudi Arabians are expected to establish their position as the major world source of crude oil, and price crude in accordance with their position as low cost supplier. OPEC in this situation will become a loosely knit organization. Alternative sources of crude oil supply will lag in development due to price suppression between 1985 and 1990.

Translating the above crude oil projection for the likely case to a residual fuel oil projection is

shown in Table 4-10, along with a distillate price projection. The distillate price is computed based on the relationship with crude in 1986, approximately 30 percent above the price of crude.

TABLE 4-10

PROJECTED PRODUCT PRICES - LIKELY CASE
(1986 US$/BARREL)

	1986	1990	1995	2000
Residual	12.75	15.30	18.70	22.10
Distillate	19.50	23.40	28.60	33.80

Coal Prices

The coal market is subject to less uncertainty than the world oil market. Consequently a directional forecast is used which assumes stable prices throughout the period using a base price of US$53 per ton found in the Montreal Engineering Company Limited's (MONENCO) Least-Cost-Expansion Study - August, 1985 for JPS.

Currently, the coal market is characterized by oversupply. Prices have been stable since the mid-seventies. It is important to recognize however that coal is very much affected by regional factors. In other words, there is less opportunity for any group of countries to control output and/or price. This is demonstrated in Table 4-11 which shows the distribution of the non-communist world coal reserves.

TABLE 4-11

WORLD COAL RESERVES

Total = 377 BILLION TONS(1)

North America	34%
Western Europe	11%
Far East	39%
Africa	16%
	100%

Footnote:

(1) Excludes lignite and sub-bituminous

Not reflected in Table 4-11 above are the relatively new reserves being developed in South America which will add an important new dimension to the regional supply of coal in the Southern Hemisphere and act to further increase competition and constrain price increases.

The rationale for assuming stable prices reflects three considerations. First, the coal industry will continue to face overcapacity into the 1990's. This will be exacerbated by lower oil prices, which will impact coal conversion schemes worldwide. Secondly, coal more than any other fuel is a commodity-driven business where the low cost producer has the strategic advantage. Given this situation coal supply-demand patterns in any particular regional market will gravitate to the producer who can supply the lowest cost product. Finally, the procurement

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of coal is predominantly performed under long term contracts rather than on a spot market basis. This factor adds another element of stability to the market.

Given all of the above, the projected price of steam coal is set out in Table 4-12, a showing real escalation of 0.5 percent per year.

TABLE 4-12

PROJECTED STEAM COAL PRICES
(1986 US$/TON)

	1986	1990	1995	2000
Steam Coal	$53.00	$54.00	$55.43	$56.83

5.0 FACILITY DESCRIPTIONS

5.1 CANE PRODUCTION

Geographical Location

Monymusk is in the Clarendon Plains of Jamaica on the southern extremity of the central Parish of Clarendon. As seen in Figure 5-1, it is located 45 miles west of Kingston via roads through Spanish Town and Old Harbour. The sugar cane producing area is bounded by the Caribbean Sea along the southern coast, then inland along the Milk River as the western boundary. The northern edge of the plain runs through May Pen to Old Harbour Bay, on the eastern boundary, which runs along the coastline past the Salt River to the Rio Minho. In addition, the Monymusk factory receives cane hauled 25 miles west from the Innswood estate in St. Catherine Parish, which was formerly milled at Bernard Lodge.

Climate

Jamaica's climate is generally warm and humid. Insolation is ample for growing crops year-round on the coastal plains of the Clarendon and St. Catherine Parishes. Thunderstorms produce the most significant rainfall in the early summer and autumn seasons. Almost 60 percent of the annual rainfall occurs in two periods, May - June and September - October, with precipitation occurring during only 14 days of heavy rains each year. The frequency of hurricanes hitting Jamaica is very low; the probability of an occurrence is only once in ten years.

Soils and Drainage

The Clarendon plains form the largest single agricultural area in Jamaica, with 67,000 acres [27,135 ha.] of potential crop land. Full development of the agricultural resources of the Clarendon plains is severely hampered, however, by constraints in water resource availability, adequacy of irrigation facilities, and low performance production practices. The major sugarcane supply area for the Monymusk and New Yarmouth sugar factories is the 24,000 acres [9,720 ha.] of canefields currently in production, of that total, 9,500 acres [3,850 ha.] are harvested for delivery to New Yarmouth and 14,500 acres [5,870 ha.] are committed to Monymusk. Monymusk also receives cane from 4,500 acres [1,820 ha.] of Innswood estate land in St. Catherine Parish.

Soil salinity has become a major problem in Clarendon due to continued use of saline well water for irrigation. Large expanses of soils have become salinized, particularly in the Agualta soil classification. The problem is of such magnitude that an area of 3,363 acres [1,362 ha.] in the Monymusk sugar factory vicinity has been taken out of sugar cane production in the last several years. Most of the unproductive saline areas fall within the southern section of the estate, in the Agualta soils. Sugar cane is grown almost exclusively on the heavier, imperfectly drained and moderately well-drained soils.

The major land and soil factors are: drainage, salinity/irrigation, acidity/alkalinity, and crop nutrition. Although water quality and irrigation problems are important, drainage is the most critical soil problem in the area. Efficient soil drainage is a necessity for economic crop production. The high water table is not as much the result of actual rainfall on the plains, but results from seepage from higher ground and canals at a higher elevation, poor irrigation practices and impervious layers in the soil profile. Soil sampling surveys have ascertained that the soils are mainly calcium clays that can be freed of their salts by proper drainage and irrigation practices, and thus be changed into more productive soils.

Water Resources and Irrigation

Underground aquifers supply more than 60 percent of the total water required for irrigation of the Clarendon Sugar Company and Waterwell estate, and the remaining 40 percent is supplied by surface water flows. The Cockpit Springs are the major water source, producing over half of the surface water supply, or 22 percent of the total water for the plantations. The balance is made up by relift pumps from the Rio Minho and Milk Rivers as they traverse the sugar cane lands. The underground aquifers in both limestone and alluvium are pumped from more than 40 deepwells and 50 relift pump sites that serve the various farms of the Clarendon Sugar Company, plus 17 sand wells and 7 limestone wells of the Waterwell estate. The Innswood estate lands are served by surface waters from the Rio Cobre system in addition to deep-well pumps.

To develop cane production by farmers in the Monymusk factory area, the World Bank's Jamaican Second Sugar Rehabilitation Project is to improve sections of three irrigation systems: the Mid-Clarendon, St. Dorothy and Rio Cobre canal systems. The Mid-Clarendon system distributes water to cane farmers in the Mid-Clarendon plains as well as the New Yarmouth Estate; it irrigates about 40,000 acres [16,200 ha.], of which less than half the area is under cane. The Mid-Clarendon system derives its supply from deep wells and the Milk River. The St. Dorothy system, supplied from deep wells, irrigates about 5,000 acres [2,025 ha.] with 2,000 acres [810 ha.] in sugar cane grown by cane farmers. The Rio Cobre system irrigates the Innswood estate and farmers' cane lands supplying the Monymusk factory, from deepwells and the Rio Cobre river.

Conveyance of irrigation water from sources to the infield distribution systems is via lined channels and pipelines. Rehabilitation of conveyance systems is scheduled for the first three Rehabilitation Project years, to be completed in 1989.

Distribution of water infield is done by means of furrow irrigation. The system installed is a form of basin irrigation known as the "twig and branch" system. It needs to be highly labor-intensive in its operation for water to be applied efficiently. Although application efficiency is considered to be less than 40 percent at present, it is not possible to determine the exact amounts of water applied by each irrigation round or "wetting".

Analyses of water supplies and crop demands show that efficiencies of 62 percent overall are necessary to meet peak demands without excessive depletion of underground aquifers. With conveyance or delivery efficiency of 95 percent, infield water application efficiencies must exceed 65 percent in order to achieve overall efficiencies above 62 percent. This requires considerable investments to improve existing infield irrigation systems. The Rehabilitation Project does not plan to make those capital improvements to field irrigation systems.

Cane Growers

Of the land currently committed to sugar cane production in Clarendon, about sixty (60) percent has been producing cane for processing by the Monymusk factory. In addition, Monymusk is currently receiving sugar cane from 4,760 acres [1,928 ha.] of the Innswood estate canelands for a total of 19,045 acres [7,713 ha.] of lands involved in the cane supplies for this factory.

Sugar cane production by independent cane farmeres is important to the processing enterprises in Clarendon, as forty-one (41) percent of the lands in sugar cane are controlled by cane growers. Cane farmers of 3,980 acres [1,612 ha.] or about forty (40) percent of the farmers' area deliver sugar cane to the Monymusk factory. The major portion, or sixty (60) percent of the area, is going to New Yarmouth.

The production of cane farmers is stabilized at current levels, but can be expected to respond to incentives to deliver their cane at the factory paying the better price. Production in 1990 is expected to come from 22,500 acres [9,112.5 ha.], as shown in Table 5-1.

TABLE 5-1

SUMMARY OF SUGAR CANE LANDS PRODUCING CANE AVAILABLE FOR PROCESSING AT MONYMUSK FACTORY

Canelands	Acres	Hectares	Ac./ Field	Ha./ Field
(No. of fields)				
Farm #1 (188 fields)	2,367	958.6	12.6	5.10
2 (143 ")	1,993	807.2	13.9	5.64
3 (174 ")	2,485	1,006.4	14.3	5.78
4 (145 ")	1,766	715.2	12.2	4.93
5 (138 ")	1,990	806.0	14.4	5.84
6 (138 ")	1,925	779.6	13.9	5.65
(926 ")	12,526	5,073.0	13.5	5.48
Waterwell	1,214	491.7		
Innswood	4,760	1,927.8		
Administration Total	18,500	7,492.5		
Cane Farmers	4,000	1,620.0		
Grand Total	22,500	9,112.5		

Monymusk is now purchasing close to 38 percent of the tonnage produced by farmers, which accounts for almost 31 percent of the tonnage processed through the Monymusk factory. As the central administration production is increased in the future, dependence on the individual farmers may fall to 20 percent or less.

Large growers, delivering more than 500 tons each year, deliver 65 percent of all the farmers' cane received, but number only 2 percent of all the cane farmers. At the opposite extreme, 75 percent of the farmers deliver less than 50 tons each year, amounting to less than 15 percent of the total cane tonnage. In between, those farmers delivering between 50 and 500 tons each year total 23 percent of the farmers and 20 percent of the cane tonnage.

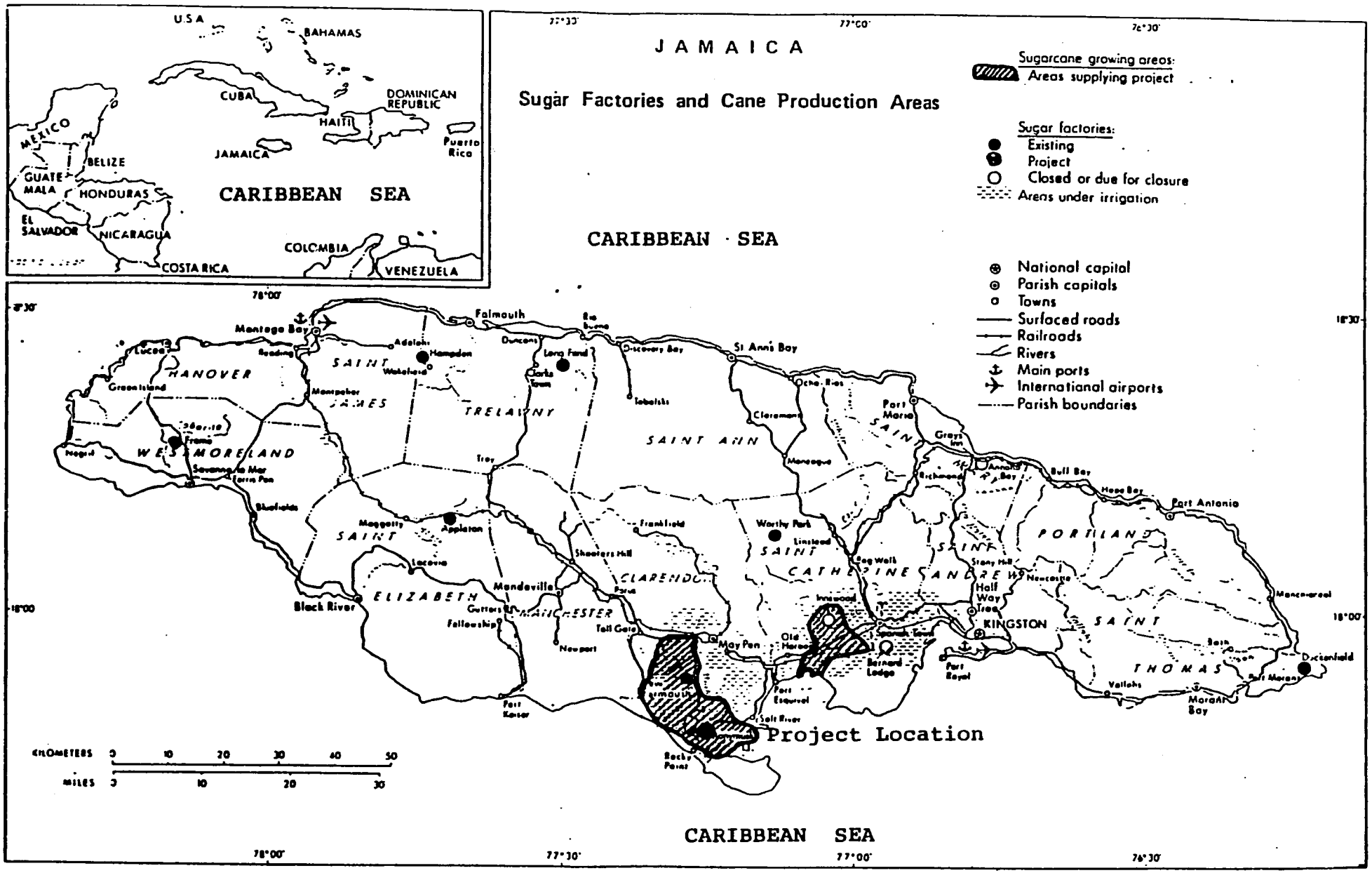
Independent cane farming has declined to less than half the production of a decade ago, when three sugar mills operated in Clarendon. Rising costs narrowed profit margins, and decreasing cash flows led to tighter credit as it became more difficult for cane planters to pay off their debt. As a result, only the most hardy and persistent farmers remain, and they are more likely to take advantage of opportunities to expand their production as economic conditions improve. The expansion of cane farmers' plantings should benefit Monymusk with increased production, as the competing private sugar mill at New Yarmouth is limited in its capacity.

The farmers' cane department of Monymusk was reduced from a staff of 13 to 10, due to reduced availability of farmers' cane. The department manager, reporting to the Agricultural Manager, has two liaison officers, two "scrutineers", two scale clerks, a typist and two office clerks.

As more resources are allocated to develop the cane farmers program, services, supplies and lines of credit for their committment to deliver cane to

Monymusk (and it is recommended that this program be carefully reviewed), additional staffing will be needed for closer coordination and liaison. Scheduling of cane deliveries must be monitored on a daily basis to ensure a dependable and quality supply of cane to mill, and minimize the stops for "no cane" at the factory, as well as juice problems.

FIGURE 5-1


JAMAICA
Sugar Factories and Cane Production Areas
Sugarcane growing areas:
Areas supplying project
Sugar factories:
Existing
Project
Closed or due for closure
Areas under irrigation
National capital
Parish capitals
Towns
Surfaced roads
Railroads
Rivers
Main ports
International airports
Parish boundaries
CARIBBEAN SEA
U.S.A.
BAHAMAS
CUBA
DOMINICAN REPUBLIC
HAITI
JAMAICA
Puerto Rico
MEXICO
BELIZE
GUATEMALA
HONDURAS
EL SALVADOR
NICARAGUA
COSTA RICA
COLOMBIA
VENEZUELA
HANOVER
SAINT JAMES
TRELAWNY
SAINT ANN
WESTMORELAND
SAINT ELIZABETH
MANCHESTER
CLARENDON
SAINT CATHERINE
SAINT ANDREW
PORTLAND
SAINT THOMAS
Montego Bay
Falmouth
Duncans
Long Pond
Clarks Town
Discovery Bay
St Ann's Bay
Ocho Rios
Port Maria
Lucea
Green Island
Savanna-la-Mar
Black River
Mandeville
Appleton
Frankfield
Shooters Hill
Worthy Park
Linstead
Innswood
Old Harbour
May Pen
Bernard Lodge
Port Royal
KINGSTON
Port Antonio
Buff Bay
Hope Bay
Bull Bay
Morant Bay
Port Morant
Dixonfield
Newport
Toll Gate
Fellowship
Gutters
Port Kaiser
Salt River
Rocky Point
Port Esquivel
Project Location
KILOMETERS 0 10 20 30 40 50
MILES 0 10 20 30
78°00'
77°30'
77°00'
76°30'
18°30'
18°00'

5.2 SUGAR CANE PROCESSING FACILITY

Introduction

The Monymusk Factory was constructed following World War Two and put into service nearly four decades ago (1948) to replace other older sugar cane processing facilities in the area. The out-put of sugar and the processing efficiency at Monymusk have been in serious decline over the past ten years. This deterioration was caused by severe financial shortages and the absence of an effective senior management over the past decade. And despite an attempt at a previous rehabilitation effort funded by the World Bank in 1978, which was not fully effective, a major plant rehabilitation is urgently needed and is planned to begin during the up-coming Fiscal Year (1 October 1986 - 30 September 1987). The Second Sugar Rehabilitation Project of the World Bank is to restore the profoundly deferred maintenance on this facility with US$14.7 million for restorative repair and replacement over a five year period (1987-1991). This World Bank Project will also provide for the effective and professional management of the rehabilitation and the corporation's "turn-around".

The Jamaica Sugar Holdings, Limited (JSH) Corporate Plan (see Volume III, Monymusk Factory and Estate Technical Report, Tate and Lyle Technical Services, December, 1984)(1) considered three production cases

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Footnote:

(1) The description of the sugar cane processing facility and its rehabilitation are taken from this cited plan.

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or alternatives in establishing the likely factory production and efficiency out-comes of the rehabilitation project. The production and efficiency forecasts predict rapid recovery of the Grinding Rate, Overall Time Efficiency and Standard Factory Efficiency to accepted norms in the third year (1989) of the Rehabilitation Project. These measures of effectiveness in the final year of the project (1991) are: 200 tons cane per hour, 75% Overall Time Efficiency and 90% Standard Factory Efficiency.

Although Monymusk has demonstrated the capability in the past to process sufficient cane to produce in excess of 80,000 tons of sugar in a crop, the Base Case predicts 742,050 tons of cane - 68,700 tons of sugar - 29,682 tons of molasses in 206 days. The Best Case that JSH considered was 770,800 tons of cane processed in 214 days and the Cane/Energy Project will analyze its top case at 850,000 tons of cane processed.

The JSH Corporate Plan calls for the resumption of refinery operations in Rehabilitation Project Year 3 (1989), provided domestic market conditions are right.

Cane Weighing, Handling and Preparation

The flow of incoming cane is a source of serious concern as millyard traffic is complex and dangerous under existing conditions according to the JSH Corporate Plan. Security in the cane yard is also poor. The three Avery weigh scales, two units with

40 tons capacity and one of 60 ton capacity, are located too far from the factory for good supervision and security, making their important function suspect. There are too many cane unloading points and handling systems (nine) that are too costly to maintain and operate. Cane unloading and storage facilities will provide more capacity than is required after rehabilitation. The cane handling and preparation operations require abnormally large work crews that are costly. A major rearrangement of the entire cane yard, that is to be accomplished in two phases during Rehabilitation Project Year 2 and 3 (1988 & 1989), is planned as part of the rehabilitation to improve efficiency in this process area.

During the millyard rearrangement, the relocated scales are to be modified in Rehabilitation Project Year 3 (1989) to a load cell type with electronic reading and controls to facilitate frequent transport unit taring and to allow automated remote recording of cane weights by computer. The new layout being proposed by JSH will make significant changes to the handling and preparation facilities in this area concurrently with important repairs.

Milling

There are six mill tandems of three 78 inch [198 cm] wide rolls each that have a maximum roll diameter of 37 inches [94 cm]. Many of the mill bearings are in need of replacement, or new liners are required for bearing housings. During Rehabilitation Project Year 1 (1987), eleven rollers should be reshelled.

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Mill bed beams are badly worn and the broken bed beam on the gear side of the No. 1 Mill will require replacement. The input pinion of the No. 2 set of gearing for Mills No. 5 & 6 is badly worn and must be replaced. Several other problems in this area will require repair or replacement (i.e., bed beams for No. 2 set of gearing, oil coolers for reduction gearboxes, multistage turbine overhaul, drive sprockets for the intermediate carriers, juice handling pumps, maceration water pumps, etc.) during the Rehabilitation Project.

With rehabilitation, the JSH Corporate Plan predicts the milling plant should be capable of a daily throughput of 5,000 tons of cane per day.

Bagasse Storage and Handling

This facility is in reasonable condition and the Bodinson bagasse reclaimer is functional, although the JSH Corporate Plan identifies its operation as a personnel safety problem. A modest amount is budgeted under the rehabilitation program in the first year for a spare electric motor for the main bagasse conveyor, but most of the US$0.732 million (JA$4,023,850 at JA$5.50 : US$1.00) was budgeted for the Rehabilitation Project Year 5. The JSH Corporate Plan programmed a significant modernization of these facilities with an automated handling system in mind to be accomplished in the final year of the project (Rehabilitation Project Year 5 - 1991)

We foresee a need to construct an enlarged (e.g. 2,000 ton capacity of bagasse and cane trash/ barbojo) and automated biofuel storage facility at a future time to fully support the proposed cogeneration facility. Biofuel storage needs to be carefully studied as to sizing, layout and cost in this operational setting before a capital improvement proposal is developed. The expanded power generation capacity and dispatch commitment to the national utility justifies the added capital investment in biofuel supply facilities. With the addition of baled cane trash (barbojo) to the fueling of the boiler, special provisions are to be planned into this improvement for receiving, shredding and conveying the dried and prepared cane trash (barbojo) into the bagasse house for mixing with the bagasse before reclaim or by direct, unmixed feeding to the furnace.

Juice Processing

The mixed juice heat exchangers, juice tank stirrer, pH control equipment and juice heater doors are slated for rehabilitation or component replacement in Rehabilitation Project Years 1 & 2 (1987 & 1988). The two modified Howe scales are to be replaced in Rehabilitation Project Year 3 (1989) with modern load cell equipment. The juice heater station with its 7,550 square feet [701 square meters] of heating surface is thought to be adequate for the targeted throughputs of the Base Case.

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The two 26-foot [7.9 meter] diameter Dorr clarifiers with a total 19,500 cubic feet [552 cubic meters] are thought to be capable of meeting the requirements of the targeted throughputs.

The mud filter station at present consists of two 8 foot [2.44 meter] by 16 foot [4.88 meter] filters which have a filtering capacity of 800 square feet [74.3 square meters] and that capacity is adequate for current operations. With expanded throughputs and the resumed operations of the refinery, the already purchased filter (First World Bank Rehabilitation Project - 1978) that is on site will be installed to increase the filtering area to 1,100 square feet [102 square meters] which will be adequate for grinding rates to 220 tons cane per hour and give a filter area ratio of 5 square feet [0.46 square meter] per ton of cane per hour.

The major rehabilitation or replacement in the juice processing station will be concentrated on the pumps in Rehabilitation Project Years 1 & 2 (1987 & 1988).

Evaporation & Talodura Clarification

This station currently has 51,800 square feet [4,812 square meters] of heating surface in eight vessels, and that is adequate at the lower grinding rate of 170 tons of cane per hour. Replacement of the two existing 4th effect vessels with new 9,000 square foot [836 square meter] vessels, one in Rehabilitation Project Year 1 (1987) and one in Rehabilitation Project Year 2 (1988), is called for in the Rehabilitation Program. With that

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replacement, the better of the existing 4th effect vessels will be refurbished and installed to increase the capacity of the 1st effect in Rehabilitation Project Year 2, that will result in a total heating surface of 60,800 square feet [5,648 square meters] for the station, which is considered to be adequate for the targeted throughputs of the Base Case.

The rehabilitation or replacement of insulation, instrumentation, pumps and valves, and rehabilitation of the talodura clarification installation are budgeted for in the rehabilitation project.

Raw Sugar Crystallization

The boiling system in use is a conventional three massecuite system. Seven raw pans are installed, but one 1,000-cubic foot [28.3 cubic meter] pan is not in use and is to be replaced; upon replacement in Rehabilitation Project Year 3 (1989) all units will be of 1,250-cubic foot [35.4 cubic meter] capacity, giving a total capacity of 8,750-cubic feet [247.6 cubic meters] for raw sugar production. This capacity will be adequate to cover the resumption of Golden Crystal production when sugar refining has also been resumed.

The rehabilitation program plans to modify the two new seed/magma vessels for use as a vacuum receiver to increase seed storage and pan floor flexibility and to replace the existing magma receiver in Rehabilitation Project Years 2 & 3 (1988 & 1989).

The "A" Centrifugal Station, with five ASEA 48-inch [122 cm] by 30-inch [76 cm] batch machines, has ample capacity. A personnel safety problem has been identified at this station with the machines' rotational stability, that requires remedial dynamic balancing under the supervision of the manufacturer's engineer. Additionally, significant funding has been provided by the World Bank project to rehabilitate the "A" centrifugals in Rehabilitation Project Years 1 & 2 (1987 & 1988).

A similar rehabilitation program is envisaged for the "B" Centrifugal Station, with two ASEA 48-inch [122 cm] batch machines, as is planned for the "A" Centrifugals. This station's capacity is in balance, provided juice quality is improved as targeted throughputs are regained.

The first-year plan for the rehabilitation calls for the repair of the molasses dilution solenoid control valves and extensive repair or replacement of all the pumps at this station.

Molasses Exhaustion (Crystallizers)

The crystallizer system consists of six Blanchard water-cooled units followed by a rotating-element Werkspoor unit with a closed-circuit cooling water system. There are six new water drums and paddle arms for the Blanchards already on the site to be installed during Rehabilitation Project Years 1 & 2 (1987 & 1988). The No. 6 Blanchard's drive is to be rehabilitated and the Werkspoor is to be repaired during the first Rehabilitation Project Year (1987).

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The Greensmith reheater is in need of immediate rehabilitation. Priority rehabilitation is also called for four of the six "C" Centrifugals in the first Rehabilitation Project Year (1987) followed by the set being replaced in the second Rehabilitation Project Year (1988) by four modern machines of a matched capacity. Extensive repair and some replacement of all of the pumps at this station is planned in Rehabilitation Project Year 1 (1987).

Sugar Conveying and Packing

This section covers the A and B sugar screw conveyors, raw sugar belt conveyor and the raw sugar storage bin; all units only require routine maintenance. The four production lines for Golden Crystal packing, made-up of four Auto-Pak weighers and packing machines are to be fully replaced, according to the Corporate Plan, in Rehabilitation Project Years 1 & 2 (1987 & 1988).

Refining Operations

The Monymusk refinery is designed for a continous carbonatation and sulphitation process followed by recrystallization of the white sugar. The refinery has not been operated for the past five years and centrifugals, pumps and motors have been removed or cannibalized, and now the refinery requires considerable rehabilitation. The Corporate Plan calls for the resumption of refinery operations in Rehabilitation Project Year 3 (1989) with the following production targets being set for the first three years of operation:

Project Year 3	1989	15,000 Tons
Project Year 4	1990	30,000 Tons
Project Year 5	1991	40,000 Tons

Factory Services

- Steam Generation - There are seven WIF type B & W boilers, Nos. 1 through 5 each having 30,000 pounds [13,600 kilograms] per hour capacity and Nos. 6 & 7 each having 35,000 pounds [15,900 kilograms] per hour capacity for a total of 220,000 pounds [100,000 kilograms] per hour. These boilers have hearth-type furnaces with separate combustion chambers. The eighth boiler, No. 8A, is a B & W bi-drum, waterwall boiler with dumping grates and a capacity of 110,000 pounds [50,000 kilograms] per hour. All of the boilers produce steam at 200 psig [14 kilograms per square centimeter] and 488 degrees F [253 degrees C] although No. 8A boiler was designed for 300 psig [21 kilograms per square centimeter] and 520 degrees F [271 degree C]. The drums of Boilers 1 through 7 require replacement and the World Bank's First Rehabilitation Project (1978) has provided the replacements drums to be installed. Thorough maintenance is required for the refractory of all boilers. Air heaters are on-site for five of the seven WIF type boilers as provided sometime ago by the First Rehabilitation Project (1978). Significant repair and improvements are planned for No. 8A boiler in Rehabilitation Project Year 2 (1988).

- Instrumentation and Controls - There are plans for significant upgrading during the rehabilitation project.

- Ash Handling - A thorough overhaul of all drives and some replacement of chain and slats are planned during the rehabilitation process.

- Pumps - Phased partial replacement is planned.

- Additional Fuel - The rehabilitation plan calls for dramatic reduction in the consumption of auxiliary fuel (Bunker "C" Oil) over the five year program.

- Steam Requirements - The Corporate Plan projects steam requirements for the five-year period from 210,000 pounds [95,000 kilograms] per hour to 238,000 pounds [108,000 kilograms] per hour beginning in Rehabilitation Project Year 3 (1989). The refinery requirement in the third project year and thereafter is an additional 25,000 to 30,000 pounds [11,000 to 14,000 kilograms] per hour.

- Power Generation - There are three Allen turboalternators that are designed to generate a total of 8.0 MW. These units require some rehabilitation. A 1.0 MW Nugata Diesel Alternator has been installed as an auxiliary and was supplied by the First Rehabilitation Project (1978).

- External Power - The facility exists to purchase up to 1.7 MW from Jamaica Public Service Company.

- Power Demand - The Corporate Plan projects loading of 3.0 to 3.6 MW in Rehabilitation Project Year 3 (1989) for the raw sugar factory and the distillery operations. Refinery and packaging operations are forecasted to require 500-600 KW in addition at that time (1989) for a total of 4.2 MW. The power available to displace purchased power for irrigation at this point will be about 800 KW according to the Plan.

- Electrical Power Distribution - Power is distributed at 440V. Replacing three transformers is recommended by the Plan in Rehabilitation Project Year 1 (1987) and a phased replacement of some cabling and switchgear is planned as is the upgrading of lighting at some factory and refinery stations.

- Air Services - The Plan calls for replacement of two air compressors for general duty and two new oil free compressors are required for the instrument and control functions.

- Water Services - Factory water supplies and pumps, ponds, rotary screens, nozzles and piping are slated for repair/replacement over Rehabilitation Project Years 1, 2 & 3 (1987, 1988 & 1989). A closed circuit cooling tower is to be installed to reduce heavy scaling in Project Year 2 (1988).

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- Piping and Valves - Phased replacement of piping and valves and the rehabilitation of pipe insulation is to be programmed in Rehabilitation Project Year 1 (1987) for the balance of the project term.

- Factory Buildings - Some repairs to flooring, siding and roofing is planned. Cleaning and painting of the facilities are planned as well. The clearing of brush and grass from the security fence lines and the re-establishment of that security is also budgeted for in the rehabilitation project.

- Workshop Equipment - The replacement of certain machine and hand tools, the electrification of overhead cranes and the overhaul machine tools has been budgeted in the rehabilitation project.

- Factory Stores - A detailed survey is planned in Rehabilitation Project Year 1 (1987) to thoroughly review inventories of replacement parts and their restocking levels. An allowance has been set-up for rationalization and clean-up of the warehouse, but not for the write-down of obsolete stock.

- Laboratory - Moderate amounts of repair and painting are planned. Replacement or repair of testing equipment and restocking of chemicals are budgeted in the rehabilitation project.

5.3 COGENERATION FACILITY

General

The cogeneration plant will be a major addition to an existing facility and will consist of: (1) two fifty (50) percent capacity, bagasse fired, spreader stoker type, steam generators and (2) a single, one hundred (100) percent capacity, tandem compound, condensing type turbine generator with automatic extraction at 200 psig [14 kg/sq cm].

During the cogeneration mode of operation the unit will provide 190,000 pounds [86,200 kilograms] per hour of process steam from the turbine cycle and produce 21,067 kW of electric power for internal use or for sale. During other times, when process steam is not required, the unit can be operated as a power producer only and will produce 34,250 kW (gross) of electric power for internal use or sale.

The two boilers will be equipped to burn cane trash (barbojo), cane trash (barbojo)/bagasse mixtures, and No. 6 Fuel Oil as alternatives to the primary fuel, bagasse.

Additional equipment to support the steam generators and turbine generator will be provided as required to complete the cogeneration unit. Some of this equipment will include a condenser, deaerator, closed feedwater heater, condensate and feedwater pumps, water treatment equipment, air compressors, cooling tower, circulating water

pumps, closed cooling water system and other required equipment.

Engineering details provided by Bechtel, are included, as follows:

Plant Rating

The proposed cogeneration plant will have two (2) bagasse fired, spreader stoker type boilers each rated as follows:

Steam Output	165,000 lb/hr [75,000 kg/hr] maximum continuous rating.
Pressure	900 psig [63.4 kg/sq cm]
Temperature	900°F [480 degree C]

The boilers will be connected in parallel to deliver superheated steam to a tandem compound steam turbine generator rated as follows:

Turbine Rating	35,000 kW
Steam Supply	329,500 lb/hr [150,000 kg/hr] - 850 psig [60 kg/sq cm], 900°F [480 degree C]
Speed	3000 rpm
Exhaust	3.5 in HgA [88.9 mm HgA]
Generator Rating	13,800 volt, 40,000 KVA, .85 power factor

The plant, when operated as a cogeneration unit, will provide process steam for the crushing plant and boiling house operations and electric power for use in the factory, its supporting shops, the field administration's irrigation pumps and other company facilities, and for sale, in the following amounts:

Process Steam	
200 psig steam [14 kg/sq cm]	146,000 lb/hr [66,400 kg/hr]
20 psig Steam [1.4 kg/sq cm]	44,000 lb/hr [20,000 kg/hr]

Power Output 21,067 kW

When the plant is operated as an electric power producer with no process steam, it will produce the following:

Process Steam	0
Power Output	34,250 kW (gross)

Heat balance diagrams M70-AX01 and M70-AX02 (Appendix Exhibits 5-1 & 5-2) depict the cycle conditions when operating with and without process steam. Diagram M70-AX01, the process steam case corresponding to an annual cane production of 742,050 ton/yr, shows process steam supply of 146,000 lb/hr [66,400 kg/hr] from the 200 psig [14 kg/sq cm] controlled extraction steam header, and 44,000 lb/hr [20,000 kg/hr] of steam to process from the 20 psig [1.4 kg sq cm] uncontrolled extraction header. The generator

output for this mode of operation will be 21,067 kW. Makeup to the cycle of 9,900 lb/hr [4,500 kg/hr] is required to compensate for condensate lost in boiler blowdown. All process steam condensate is returned to the cogeneration plant.

Diagram M70-AX02 (Appendix Exhibit 5-2) shows cycle conditions with zero process steam. Predicted power output will be 34,250 kW. Since water is not lost to the sugar cane processing, makeup of only 9900 lb/hr [4,500 kg/hr] is required to compensate for boiler blowdown.

Fuels

The new cogeneration steam generators will be designed to fire three different fuels (i.e., bagasse, cane trash [barbojo] and Bunker Oil) with bagasse being the primary fuel. Bagasse will be burned primarily during sugar cane harvesting and processing operation. Bagasse will contribute approximately 51 percent of the total yearly heat input to the steam generators.

Barbojo (cane trash) accummulated following sugar cane harvesting, will be collected and stored for burning during the "off-crop" period, when bagasse is not available. This fuel will contribute approximately 24 percent of the total yearly heat input to the steam generators. The third fuel, No. 6 Fuel Oil, will be burned to supplement bagasse and cane trash (barbojo) firing or when no other fuel is available. This

fuel will contribute approximately 25 percent of the total yearly heat input to the steam generators, for the Base Case under consideration.

Bagasse is characterized as a biofuel that is low in heating value, low in ash content, and high in moisture. Barbojo (cane trash) has somewhat higher heat content than bagasse, when lower in moisture and is estimated to be higher in ash content. Analysis of the three fuels is as follows:

- Bagasse: As Fired

Heating Value, Btu/lb	4,000 kcal/kg
Moisture, percent	50
Ash, percent	2.1

- Cane Trash (Barbojo): As Fired

Heating Value, Btu/lb	5,400 kcal/kg
Moisture, percent	25
Ash, percent	8.9

- No. 6 Fuel Oil:

Heating Value, Btu/lb, minimum	18,300 kcal/kg
Sulfur, percent maximum	3.0
Ash, percent maximum	0.12
API (American Petroleum Institute), degrees minimum	10

PLANT DESCRIPTION

Site Features

Drawing COA-001 (Appendix Exhibit 5-3), Site Plan, shows the overall site plan arrangement of the sugar factory and the plot plan arrangement of the new cogeneration plant. The site plan view shows the

existing plant features and locates the proposed new cogeneration plant and the proposed routing of the 69 kV transmission line. Proposed locations of three new wells, Nos. 1, 2, and 3, for cooling tower makeup are shown to the west and north along the west boundary of the factory. These wells along with a softening and filtering system will provide makeup water to the cooling tower and circulating water system. Existing features shown on the site plan will remain as shown when the cogeneration plant is added to the facility.

The plot plan view shows the arrangement of the new cogeneration plant. The new boiler No. 9 will be located to the west of the existing bagasse storage house. A new bagasse conveyor will be provided to convey bagasse from the existing bagasse storage house supply conveyor. The turbine generator building will be located to the west of Boiler No. 10. The 69 kV switchyard will be located north of the turbine generator building.

The outdoor features shown on the plot plan include the condensate storage tank, the demineralized water storage tank, and well water treatment equipment for system cycle or cooling tower makeup. A separate package type demineralizer will be provided to treat well water from the existing Raymond Wells for makeup to the condensate/steam cycle.

Location of the cooling tower and circulating water pumps to the northwest of the turbine generator building will minimize the effect of cooling-tower water spray drift on to plant equipment since the predominant prevailing wind is from the southeast.

The fuel oil tank for No. 6 Fuel Oil storage will be conveniently located next to an access road for ease of tank truck unloading of fuel oil. Excess bagasse and/or shredded barbojo (cane trash) will be stored in the existing bagasse storage. Baled barbojo (cane trash) will be stored in the secure millyard, under portable roofing, for "off-crop" reclaim and furnace preparation.

Boiler Area

The boiler structure is of outdoor type construction with weather roof for protection against tropical rainstorms. The boiler equipment will be arranged as shown on general arrangement drawings POA-001(Appendix Exhibit 5-4) and POA-002(Appendix Exhibit 5-5). Drawing POA-002 shows sections of the boiler and the location of major boiler equipment on various levels. The air fan which supplies air to the pneumatic distributer for distributing bagasse to the furnace will be located above the ground floor, elevation 37 feet [11.3 m]. The forced draft (F.D.) and induced draft (I.D.) fans will also be located above this level. These fans will be centrifugal units, one per boiler, each rated to deliver 100 percent of the required flow.

The ash hoppers for collecting furnace ash will be also located above the ground floor elevation. Ash from these hoppers will be conveyed in a suitable container for trucking to the plant ash disposal area. Ash (cinders) from the dust collector hoppers, also located above the ground floor elevation, will be reinjected into the furnace.

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On floor elevation of 51 feet [15.6 m], equivalent to the turbine building mezzanine floor elevation 53 feet [16.2 m], will be located the pneumatic distributors, fuel oil burners (above elevation 64 feet [19.5 m]), cinder return and miscellaneous ductwork. The pneumatic distributors feed bagasse to the furnace using high pressure air. The fuel oil burners will be conventional units designed to burn No. 6 Fuel Oil.

On the rear of the boiler, at an elevation of 60 feet [18.3 m] will be located the flue gas dust collector. This unit will be a cyclone type, mechanical dust collector with a dust collection efficiency of up to 80 percent. Dust collected in this unit will be reinjected into the furnace.

In front of the boiler, on floor elevations 73'-9" [22.5 m] and 82 feet [25.0 m] the bagasse/cane trash (barbojo) feed conveyor, shutoff slide gates and rotary feeders will be located. The rotary feeders below the slide gates have a rotating drum which feeds the fuel to the pneumatic distributor.

On the rear of the furnace soot blowers will be provided above elevations 73'-9" [22.5 m] and 82 feet [25.0 m]. The blowers will utilize steam for soot blowing. Further back and above elevation 73'-9" [22.5 m] will be located the economizer and airheater. The economizer will be separated from the furnace and will be a conventional horizontal tube heat exchanger. The air heater will be a vertical tubular type unit.

The top floor of the boiler structure, at elevation 94 feet [28.7 m], will contain the steam drum and miscellaneous valving and hardware, including the steam outlet valve at elevation 106 feet [32.3 m].

A 120 foot [36.6 m] tall free standing metal stack will be shared by both boilers and will be located approximately 36 feet [11.0 m] behind the boilers.

Turbine Area

The turbine building will be an enclosed metal sided and roofed area consisting of three levels, the ground floor, mezzanine floor and operating floor. The plan arrangement of each level is shown on Drawing POA-001(Appendix Exhibit 5-4)

The ground floor, elevation 37 feet [11.3 m] will contain much of the support equipment for the new cogeneration plant such as the lube oil conditioner and oil tanks, water pumps, and air compressors. The two pass, divided water box condenser will be arranged so that tubes can be pulled to the west by removing a portion of the west wall. The vertical can type condensate pumps will be located east of the condenser. The boiler feedwater pumps will be conveniently located beneath the deaerator storage tank which is on the operating floor. Other equipment will be arranged as indicated on the plan, with the 4160 volt and 440 volt switchgear and load centers in the northeast corner of the building. The generator bus will be oriented towards the switchyard outside the north wall of the turbine building. The equipment laydown area will be beneath equipment hatches located in the mezzanine and operating floors and will be easily accessible by trucks at the roll up door.

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The turbine building will not include space for a shop or locker/washroom since the existing factory facilities will be available. A toilet will be located adjacent to the control room.

The mezzanine floor at an elevation of 53 feet [16.2 m] will contain additional equipment and features necessary for operation of the cogeneration plant. The cable spreading room will be located to service the control room on the operating floor directly above. The lube oil reservoir and electrohydraulic control (EHC) units for the turbine are located as recommended by the equipment supplier. The EHC unit will provide a pressurized source of hydraulic fluid for turbine controls. Also located on the mezzanine floor will be the high pressure feedwater heater, the closed cooling water heat exchangers and the steam jet air ejectors (SJAE). Tube pulling space has been provided in the arrangement for this equipment as well as the steam jet air ejector inter-condensers and after-condensers.

The turbine generator located on the operating floor at elevation 67 feet [20.4 m] of the turbine building will consist of a condensing type turbine with one controlled and one uncontrolled extraction, and an air cooled generator. The deaerator located in the southeast corner of the bay will be a spray type unit with a 7,000 gallon [26,500 liter] condensate storage tank. The control room containing controls and monitoring equipment necessary for operation of the cogeneration plant will be located in the northeast corner of the building. A 25 long-ton bridge crane

will be provided above the operating floor to service the turbine generator unit and any other equipment which is accessible by crane hook. The crane will be operated by pendant control from the operating floor and will have a 5 long-ton auxiliary hook for use in lifting light loads. The crane is sized to lift the heaviest turbine generator component that is normally required to be lifted and handled for maintenance.

Cooling Tower Area

The cooling tower area is shown on Site Plan drawing No. COA-001 (Appendix Exhibit 5-3) and includes the two cell cooling tower and circulating water pump area. The cooling tower includes the basin, and wood structure containing fill material, fans and motors, and discharge stacks. The basin will be constructed of reinforced concrete with the floor of the basin at grade elevation. The circulating water pump area will include the two half capacity horizontal split case circulating water pumps which will take suction directly from the cooling tower basin. This area will also contain chemical injection equipment for injecting chlorine, acid and scale inhibitor into the circulating water system. This equipment will be located on a concrete slab and weather protected by a rainroof.

Water Treatment Area

The water treatment area will be located west of the turbine generator building as shown on the plot plan view of site plan drawing COA-001(Appendix Exhibit 5-3). The area includes the following equipment:

- Demineralized water storage tank with a capacity of 75,000 gallons [284,000 liters] and constructed of stainless steel.

- Water treatment system for turbine cycle makeup water including parallel trains of cation and anion ion exchangers, a degasifier, neutralizing tank, demineralizer feed pumps, degasifier booster pumps, and chemical storage and feed systems necessary for operation of the water treatment system.

- Soft water storage tank constructed of carbon steel material with a capacity of 200,000 gallons [757,000 liters].

- Water softening equipment for the cooling tower make-up water including pressure filters, clearwell pumps, clearwell, clarifier and lime feed equipment.

All equipment will be specified for outdoor use. Equipment will be located on reinforced concrete slabs and will be purchased as skid mounted units where practicable.

Miscellaneous Facilities

The following miscellaneous facilities will be extended from the existing plant, for use in the cogeneration plant:

- Fire protection mains will be extended for cooling tower fire protection, cogeneration plant hose stations, lube oil tank sprinkler sytems, and other miscellaneous fire services.

- Potable water supply.

- Sanitary sewer service.

MAIN, EXTRACTION AND AUXILIARY STEAM, SYSTEMS

Function

The steam systems as shown on the Flow Diagram M73-AB01 [Appendix Exhibit 5-6] carry steam from the two steam generators to the steam turbine or to other users as shown on the diagram. The system is made up of three subsystems with the following functions:

- Main Steam - This subsystem carries steam from the superheater outlet header on each of the two steam generators to the single steam turbine generator.

- Extraction Steam - this subsystem carries steam from the steam turbine to the high pressure feedwater heater and the deaerating feedwater heater.

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- Auxiliary Steam - the auxiliary steam system consists of steam piping to the boiler feed pump turbines and to the existing 200 psig [14 kg/sq cm] and 15 psig [1.0 kg/sq cm] process steam headers.

Design Basis

The main steam subsystem is designed to the steam temperature limitations set by the turbine and steam generator suppliers. Each steam generator delivers main steam at a temperature up to 900 degrees F [480 degrees C] and 900 psig [63.4 kg/sq cm] at the steam generator outlet connection. Main steam piping is sized on an evaluated basis by comparing cost of piping installation with cost of energy due to pressure loss in the system. The extraction steam system is designed to limit the pressure drop to each feedwater heater. Bleeder trip valves (BTV) are installed in each extraction line to prevent backflow of steam to the steam turbine in case of a turbine trip.

Each steam system is designed for the most severe conditions of pressure and temperature expected in the system during operation.

System Description

- Main Steam System - The main steam system originates at the superheater outlet header connection of each steam generator. The

individual steam line from each steam generator joins to form a single lead which is routed to the steam turbine. Each lead at the steam generator outlet is equipped with a combination stop-check valve. All low points in the common and branch main steam lines are provided with drains routed to the condenser. One branch main steam line carries steam to the steam jet air ejector (SJAE). Safety relief valves mounted on the superheater outlet headers and boiler drums are provided in accordance with the ASME (American Society of Mechanical Engineers) Boiler Code to protect against overpressurizing piping or equipment.

- Extraction Steam System - The extraction steam system extends from the main turbine extraction points to the inlet nozzles on the feedwater heaters and the feed pump turbine, and to the inlet connection of the pressure reducing valves suppling steam to the existing process plant.

  The extraction lines to all heaters have bleeder trip valve(s) and motor-operated shutoff gate valves. The bleeder trip valves provide turbine overspeed protection, and the motor-operated shutoff gate valves prevent turbine water induction damage. Automatic drains to the condenser are installed in the low points of the extraction piping. The drain valves can be operated from the control room and will open automatically on a turbine trip.

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The high pressure heater normally drains to the deaerating heater, but during off-normal conditions drains directly to the condenser.

- Auxiliary Steam System - The auxiliary steam system consists of piping which carries turbine extraction steam to the existing plant 200 psig [14 kg/sq cm] and 15 psig [1.0 kg/sq cm] steam headers. The auxiliary steam system also provides soot blowing steam to the two steam generators.

  Exhaust steam from the two boiler feed pump turbines is routed directly to the deaerator to supplement feedwater heating. The extraction steam header is provided with a pressure reducing station for use in supplying extraction steam to the 15 psig [1.0 kg/sq cm] process steam header (existing) at the correct pressure. Process steam for the existing 200 psig [14 kg/sq cm] process steam header is supplied directly from the steam turbine high pressure extraction line after passing through a desuperheater.

CONDENSATE AND FEEDWATER

Function

The condensate and feedwater system as shown on the Flow Diagram M73-AD01 (Appendix Exhibit 5-7) serves to supply clean, heated feedwater to the steam generators. The condensate system pumps

condensate from the condenser hotwell through the steam jet air ejector (SJAE) condenser to the deaerator. This system also maintains a stable level in the deaerator over the entire range of plant operation and supplies condensate for other miscellaneous services.

The feedwater system pumps boiler feedwater from the deaerator storage tank through the high-pressure feedwater heater (via the main feed pumps), to the inlet of the steam generators. The system controls feedwater flow in response to main steam flow and drum level in the two steam generators.

Design Bases

The condensate/feedwater system design is based on the heat balance for the maximum calculated load with turbine valves wide open including additional requirements for boiler blowdown, sootblowing, the steam jet air ejector, and condensate for desuperheating.

Pumps

The condensate pumps are sized in excess of maximum expected operating condition with a four (4) percent margin to account for system surge and a four (4) percent margin in flow to account for pump wear. The pump net positive suction head (NPSH) is based on runout conditions (empty condenser hotwell) and includes a pressure drop allowance for losses across the suction

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strainer. Two nominal 100 percent capacity vertical can type condensate pumps are provided.

The feedwater pumps are sized in excess of maximum expected operating condition with a four (4) percent margin to account for system surge and a four (4) percent margin in flow to account for pump wear. The horizontally mounted, split case pumps are positioned sufficiently below the deaerator storage tank to ensure positive suction head at the pump suction under all operating conditions.

Storage

The condenser hotwell storage capacity is selected to provide condensate at the system design flow for five (5) minutes after the hotwell level falls below the low-alarm water level.

The deaerator storage tank is sized to provide ten (10) minutes of feedwater at the system design flow after the tank falls below the low water alarm level.

Feedwater Heating

The feedwater heater and deaerator are specified to perform satisfactorily during system load transients as well as during abnormal modes of operation when various items of equipment are taken out of service for repair and maintenance. The feedwater heater and deaerator will be

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specified to comply with applicable sections of the Heat Exchange Institute (HEI) recommendations for Closed Feedwater Heaters and Deaerators.

Design Pressures

Design pressure for the condensate/feedwater system is based upon pump shutoff pressure produced by the condensate or feedwater pump and extraction steam pressure in the deaerator or high pressure heater.

The condensate system design pressure is based upon shutoff pressure of the condensate pumps. Components between the deaerator and the feedwater pump suction, including the deaerator, are designed for maximum pressure occurring in the deaerator. Equipment downstream of the feedwater pumps is designed for the maximum (shutoff) pressure produced by the feedwater pumps.

Design Temperatures

Design temperature of the condensate/feedwater system equipment, piping, valves, and feedwater heater channel is the maximum expected temperature of feedwater leaving the condenser, deaerator, or feedwater heater tubes. This temperature is reached when an increase in extraction steam pressure raises the steam temperature in the vessel. The increased pressure is based on valves wide open, heat balance pressures, plus a 15 percent margin for mis-staging and fouling of the steam turbine.

System Description

The condensate system extends from the condenser hotwell to the condensate inlet on the deaerator and includes a separate condensate storage tank.

The system also supplies condensate for the following services:

- Steam jet air ejector condenser
- Main and feed pump turbine gland steam desuperheaters
- Main feed pump seal water
- Closed cooling system head tank
- Chemical feed tanks
- Caustic dilution water heater
- Process steam desuperheating

The two condensate pumps are centrifugal, vertical-can type; each pump is rated at 100 percent capacity. The pump casings will be carbon steel and the impellers will be stainless steel.

The steam jet air ejector condenser is installed in the condensate system and consists of an inter-cooler and after-cooler in one shell. A condensate system control valve with manual

bypass is installed in the condensate piping to control flow to and level in the deaerator.

The condensate storage tank will have a capacity of 75,000 gallons [284,000 liters] and will be fabricated from stainless steel.

The feedwater system includes the deaerator and extends from it to the inlet connection on the boiler.

The system also includes the following equipment:

- Three 50 percent capacity feed pumps (2 turbine driven, 1 motor driven)
- The channel side of the high pressure feedwater heater.
- Feedwater and pump recirculation piping, valves, control and instrumentation
- Piping and valves for the pump sealing water

The horizontal high pressure feedwater heater will have No. 304 L stainless steel tubes and will have an internal drain cooling section.

System Operation

Condensate Pumps - One condensate pump will normally operate at full load with the other on automatic standby. The deaerator has sufficient storage to provide uninterrupted feedwater flow while the standby pump starts.

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During start-up, the condensate pump is locally started against a partially open discharge valve to fill and pressurize the system and minimize waterhammer. During complete pump shutdown, the discharge valves will be manually closed to prevent system leakdown and the minimum flow recirculation valve will automatically close.

Minimum flow through the condensate pumps is maintained by recirculating condensate back to the condenser through the recirculation check valve installed in the piping at the discharge of each pump. This valve modulates recirculation flow according to the minimum flow requirements of the pump.

Condensate Control - Condensate flow to the deaerator is regulated by a control valve located in the condensate piping upstream of the deaerator. The valve is controlled by a three-element deaerator level control system which monitors deaerator level, condensate flow to the deaerator, and feedwater flow from the deaerator. A manual bypass control valve is provided in case the automatic control valve is out of service.

If during normal operation the condensate reaches too high a level in the hotwell, the excess is transferred to the condensate storage tank through the condensate reject control valve.

Feedwater Pumps - The feed pumps take suction from the deaerator outlet through a permanent, quick removal strainer and discharge through the high pressure feedwater heater to the boiler inlet. A vortex breaker and an additional coarse strainer are provided in the outlet from the deaerator storage tank.

Two of the feed pumps are constant speed steam turbine driven. The third feed pump is motor driven and is normally shutdown. This pump serves as a standby and is normally used for startup when steam is not available for the turbine driven pumps.

Minimum flow through the feed pumps is maintained by recirculating feedwater back to the deaerator though the recirculation check valve installed in the piping at the discharge of each pump. This valve modulates recirculation flow according to the minimum flow requirements of the pump.

Feedwater Control - Each boiler is provided with a three-element boiler feedwater flow control system. A control valve located at each boiler inlet modulates to control flow to the boiler according to the boiler and system demands. A manual bypass control valve is provided for each boiler automatic control valve.

Feedwater Heating - Feedwater heating is accomplished by the deaerator and the high pressure heater. The deaerator is a spray type

unit which simultaneously removes non-condensibles (deaerates) and heats feedwater by direct contact with steam. The deaerator also provides a reserve of feedwater sufficient for 10 minutes of operation at full load.

The high pressure heater is a shell and U-tube closed heat exchanger which heats feedwater using extraction steam from the steam turbine. The unit has stainless steel tubes and can be isolated from the feedwater system and bypassed in case heater repairs are required.

PLANT COOLING WATER SYSTEM

Function

The plant cooling water system, as shown on Flow Diagram M73-DA01 (Appendix Exhibit 5-8), provides cooling water for the condenser and the plant cooling water heat exchangers. The plant cooling water heat exchangers provide cooling for plant auxiliary equipment coolers such as the turbine lube oil coolers, the generator coolers, air compressor coolers and other heat exchangers located in the closed cooling system.

Design Basis

The major equipment for this system consists of the following:

- Two 50 percent capacity, horizontal, centrifugal circulating water pumps;

- A two cell mechanical draft wood cooling tower with plastic fill;

- Two full capacity horizontal service water pumps;

- Two full capacity horizontal plant cooling water heat exchangers;

- Two full capacity, horizontal, centrifugal closed cooling system pumps;

- Associated piping, valves, controls, and instrumentation.

The circulating water pumps and piping are sized to supply the flow requirements of the condenser when the turbine generator is carrying maximum load and the cold circulating water temperature is 90 degrees F [32 degrees C]. The system sizing also includes an additional flow allowance for the plant cooling water heat exchangers. The circulating water pump head is based on friction and static losses in the piping between the cooling tower and condenser. The service water pumps are provided to overcome the additional friction loss associated with the plant cooling water heat exchangers, piping and valves.

The cooling tower is sized based on maximum heat rejected to the circulating water system and a selected high ambient wet bulb temperature based on evaluation of weather data.

Butterfly valves and expansion joints are located at the condenser supply and outlet connections.

The system design and pump controls are such that pressure surges from hydraulic transients during start-up, shutdown, or pump trip will be limited and not cause damage to system components.

The design pressure of the system is the maximum pressure due to either the hydraulic transients or the maximum shutoff head of the pumps, whichever pressure is greater.

Circulating water system piping below ground will be reinforced concrete pressure piping while the above ground piping will be carbon steel with an allowance for corrosion.

The service water pumps are each sized to provide the maximum flow required to dissipate the heat load produced by various heat exchangers located in the closed loop cooling system.

The closed loop cooling system picks up heat rejected by various plant equipment and rejects this heat to the circulating water system via the plant cooling water heat exchangers. The system is designed to reject the maximum heat load with one closed cooling system pump and one plant cooling water heat exchanger in service.

Component Description

- Circulating Water Pumps - The circulating water pumps are 50 percent capacity, horizontal, centrifugal, split case pumps installed adjacent to the cooling tower basin. The pumps will be installed so that the pump suction is flooded when water is in the cooling tower basin. The pumps will be driven by electric motors which are operated from the control room.

- Condenser - The condenser will be a single shell, two pass type, with divided waterboxes. Water boxes will be lined with provisions for attachment of sacrificial anodes for corrosion protection.

- Plant Cooling Water Heat Exchangers - Two 100 percent capacity heat exchangers will be provided to pickup heat rejected from the miscellaneous equipment coolers. Heat exchanger material will be selected to resist corrosion when exposed to circulating water. The closed cooling system will use a corrosion inhibiting chemical to reduce corrosion in the system.

- Pumps - The closed cooling system and service water pumps will each be 100 percent capacity pumps with horizontal split cases and materials selected as suitable for the service.

- Piping - Circulating water piping will be reinforced concrete pressure piping for below ground installation and extra heavy carbon steel for above ground. Closed cooling system piping will be carbon steel.

- Head Tank - A small head tank will be provided in the closed cooling water system to maintain a completely flooded system and provide a convenient means of providing condensate makeup to the system.

System Operation

During normal operation, the circulating water requirements are supplied by two pumps operating continuously in parallel. The pumps take suction from the cooling tower basin and discharge water into the underground supply pipe leading to the inlet connections on the condenser waterbox. Before start-up, the circulating water system is partially filled by gravity. During start-up the first circulating water pump is manually started from the control room with its discharage valve closed and the pump vented. After a short delay the automatic controls partially open the pump discharge valve. The sequence is controlled by a timer. The second pump is started from the control room and automatically put into operation. Normally, when there is a pump shutdown, the motor operated butterfly valve in the pump discharge line is automatically closed to prevent backflow through the idle pump. The pump discharge valves may be operated by manual override of the

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automatic controls. If one pump is not operating, the remaining pump will supply runout flow which, depending on ambient temperature conditions, may be adequate for full plant capacity.

Normally, one service water pump operates continuously to provide cooling for the closed cooling system. Similarly, one of two closed cooling system pumps operates continuously to supply cooling water to the equipment heat exchangers.

WATER TREATMENT

Function

The water treatment systems, shown as Flow Diagram M73-AM01 (Appendix Exhibit 5-9), serve to treat well water for use as cycle makeup water or makeup to the circulating water system. Well water from the existing Raymonds well will be demineralized for use as cycle makeup water. Well water from new wells at Monymusk will be clarified (lime softened) and filtered for use as makeup to the circulating water system. The equipment selections described in this section are based on preliminary well water analysis and may require modification when additional water analysis are available.

Design Bases

The makeup water demineralizer system has two trains of demineralizers. The system capacity is based on each train of equipment providing the average daily plant requirement for demineralized water. However,

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both trains can be operated in parallel simultaneously to provide additional treated water. The demineralized water storage tank provides approximately one full day of storage based on expected water usage. Cogeneration plant demineralized water usage is based on the following:

Boiler blowdown	20 gpm [1.26 liter/sec]
Allowance for loss of process condensate	35 gpm [2.21 liter/sec]
Total net usage	55 gpm [3.47 liter/sec] or 79,200 gal/day [300,000 liters/day]

Since the demineralizer ion exchange units must be regenerated periodically using some of the demineralized water produced by the unit, a demineralizer capacity of approximately 100 gpm [6.31 liters/sec] is provided.

Makeup of 800 gpm [50.5 liters/sec] to the circulating water system is based on the expected maximum makeup flow requirements which will occur when the plant is generating at full electrical output capability. The soft water storage tank provides approximately four hours of storage capacity at the system design flow rate. Makeup to the circulating water system is based on the following flows:

System blowdown	255 gpm [16.1 liters/sec]
Evaporation and drift losses	510 gpm [32.2 liters/sec]
Total net usage	765 gpm [48.3 liters/sec]

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System Components

The makeup demineralizer will be a skid mounted package unit consisting of two parallel trains of cation and anion exchange units, a degasifier and regeneration equipment. The demineralizer will be designed specifically for treating Raymonds well water. The system will consist of the following equipment:

- The existing Raymonds Well water pumps and raw water storage tank will be utilized to supply raw water to the water treatment system;
- Two full capacity, horizontal centrifugal demineralizer feed pumps;
- Two full capacity cation exchangers;
- One full capacity degasifier;
- Two full capacity horizontal centrifugal degasifier booster pumps;
- Two full capacity anion exchangers;
- One 75,000 gallon [284,000 liter] capacity stainless steel demineralized water storage tank;
- Acid and caustic regeneration equipment.
- Waste neutralization equipment.

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A separate demineralized water storage tank is provided to prevent contamination of the cogeneration plant condensate system due to possible malfunction of the water treatment system.

The cooling tower makeup water treatment system will consist of a clarifier, clearwell and clearwell pumps and pressure filters. A single train of equipment will be provided except for two pressure filters and two clearwell pumps in parallel. The following equipment will be supplied:

- Three half capacity well water pumps;
- One full capacity clarifier;
- One clearwell;
- Two full capacity, horizontal, centrifugal, clearwell pumps;
- Two full capacity pressure filters; and
- One 200,000 gallon [757,000 liter] capacity carbon steel soft water storage tank.

System Operation

During normal cogeneration plant operation with average demineralized water makeup demand, the makeup demineralizer will operate with one train in service and one train on standby or being regenerated.

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Therefore, one demineralizer feed pump and one degasifier booster pump will be operating, and one cation and anion exchanger will be in service, along with the degasifier.

The existing well water pumps will be operated as required to maintain water in the raw water storage tank. The demineralizer can produce 100 gpm [6.31 liters/sec] of demineralized water for a period of 12 hours with this arrangement. A four hour regeneration period will be required before the demineralizer can be put back into service. Should additional demineralized water be required, the second parallel group of ion exchangers and pumps can be placed in service to produce an additional 100 gpm [6.31 liters/sec] of demineralized water for 12 hours, followed by a four hour regeneration period.

The circulating water makeup, water treatment system will operate on a continuous basis to supply makeup water to the circulating water system. The system will produce up to 800 gpm [50.5 lps] of soft water. The Monymusk well water pumps will be operated as required to maintained desired flow to the clarifier. A soft water storage tank will be provided to minimize surges in the system and provide some reserve storage of makeup water.

FUEL SYSTEM

Function

The fuel system shown on Flow Diagram M73-JX01 (Appendix Exhibit 5-10) maintains sufficient quantities of fuel at the plant site and delivers it

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to the cogeneration steam generators in quantities required to maintain the required steam output. The cogeneration plant will utilize the following types of fuels:

- Bagasse, Cane Trash (Barbojo), Bagasse/Barbojo (Cane Trash) Mixture
- No. 6 Fuel Oil
- No. 2 Fuel Oil for Start-Up Only

Bagasse will be the primary fuel with cane trash (barbojo) and No. 6 Fuel Oil as secondary fuels.

Bagasse and/or barbojo (cane trash) will be delivered from the existing storage area to the two boilers by a conveyor.

No. 2 Fuel Oil will be unloaded and stored using existing equipment and facilities. A new piping and pumping system will be provided to supply No. 2 Fuel Oil to the new boilers. No. 6 Fuel Oil will be unloaded using a new unloading pump. A new 570,000 gallon [2,160,000 liter] storage tank will be provided for storage of No. 6 Fuel Oil. A new piping and pumping system will be provided to supply No. 6 Fuel Oil to the new boilers.

Design Basis

The bagasse, cane trash (barbojo), and fuel oil systems will be designed to deliver fuel based on both boilers operating at maximum load. The bagasse/barbojo (cane trash) conveyor will be sized to deliver the maximum quantity required without any redundancy in conveyor equipment. The fuel oil systems will be

designed with some redundancy in the form of a standby one-half capacity burner fuel oil pump and a standby full capacity startup fuel oil pump.

System design flows are based on the maximum fuel requirements with both boilers operating at maximum continuous rating.

The 570,000 gallon [2,160,000 liter] No. 6 Fuel Oil storage tank will supply the fuel requirements of both boilers operating at maximum continuous rating for 8 days.

System Components

- Bagasse/Barbojo (Cane Trash) Conveyors - A drag chain slat type conveyor will be supplied to convey bagasse, trash, or a mixture of the two fuels from the storage area to the two new cogeneration boilers. Fuel will be conveyed to the five fuel feeder hoppers on each boiler. Slide gates above each hopper will be open to allow fuel to drop into each hopper. A variable speed rotary feeder will be located below each hopper to meter fuel from the conveyor to each of five boiler pneumatic distributors. The distributor is a unit mounted on the furnace wall which operates on pressurized air to evenly distribute fuel to the spreader stoker traveling grate.

Excess fuel remaining on the conveyor will be transferred to existing bagasse storage house by means of a hopper and chute arrangement located east of the new Boiler No. 9.

- Fuel Oil Storage - The No. 6 Fuel Oil storage tank will have a capacity of 570,000 gallons [2,160,000 liters] and will be a field erected type with conical fixed roof. The tank will be fitted with nozzles for connecting the tank to the tank truck unloading station, fuel oil pumps suction header, and fuel oil pumps recirculation line. The tank will also be fitted with a breather and flame arrestor. A diked area around the tank will be sized to contain the full capacity of the tank. No. 2 Fuel Oil used for boiler startup will be stored in one of the existing horizontal fuel oil storage tanks.

- Fuel Oil Unloading - A new fuel oil unloading pump will be provided to unload No. 6 Fuel Oil. The pump will take suction from the tank truck unloading station and discharge No. 6 Fuel Oil to the fuel oil tank.

  No. 2 Fuel Oil for startup will be unloaded from tank trucks using the existing unloading facilities.

- Fuel Oil Pumps - New fuel oil pumps will be provided for the burner and startup fuel oil systems. The pumps will be positive displacement

type with motor drives. Relief valves, recirculation lines, and pressure control valves will be provided as required for each system. The fuel oil pumps will be sized as follows: Three half capacity burner fuel oil pumps will be provided. Each pump will be sized to deliver one-half the maximum No. 6 Fuel Oil requirement for both boilers plus an allowance for recirculation flow. Two full capacity startup fuel oil pumps will be provided. Each pump will be sized to deliver the maximum No. 2 Fuel Oil requirement for both boilers plus an allowance for recirculation flow.

- Miscellaneous - The fuel oil piping for both systems will be carbon steel cleaned (pickled) prior to installation. Fuel oil strainers and heaters will be provided as required for satisfactory system operation.

System Operation

- Bagasse and Cane Trash (Barbojo) - Bagasse, cane trash (barbojo), or a mixture of the two fuels will be stored and handled in the existing bagasse storage house. The bagasse can be fed directly on to the conveyor feeding the two boilers from the bagasse storage house supply conveyor. Excess fuel will be stored. Bagasse and barbojo (cane trash) will be prepared in the storage area when it is desired to burn the two fuels as a mixture.

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Cane trash (barbojo) will be handled in a manner similar to bagasse. The conveyor supplying bagasse or cane trash (barbojo) to the boilers will be controlled locally by personnel handling the fuel in the storage area. A manually operated slide gate will be located above each boiler fuel feeder to isolate the feeder.

- Fuel Oil Unloading Pumps - The No. 6 Fuel Oil tank will be filled by a fuel oil unloading pump located near the tank. A local tank level gauge will be provided on the tank to monitor tank fuel oil level.

  The fuel oil unloading pump will take suction from the tank truck unloading station and discharge to the fuel oil tank. The pump will be controlled by local on/off switch. Oil from the tank truck will be metered.

- Fuel Oil Pumps - The No. 6 Fuel Oil pumps will take suction from the suction header and discharge to the fuel oil header feeding the boilers. The pumps will be controlled by On/Off/Auto switches in the main control room. In the Auto mode, the standby pump will start automatically when loss of pressure is detected in the pump discharge header. A pressure controller and pressure control valve downstream of the fuel oil pumps limits pressure in the fuel oil header by passing excess oil back to the storage tank.

BOILER AIR AND FLUE GAS

Function

The steam generator air-side system, shown on Flow Diagram M73-BA01 (Appendix Exhibit 5-11), consists of the following:

- The forced draft air system which directs combustion air from the forced draft (FD) fan through the air heaters and into the furnace through the windbox, the stoker grate, and overfire air ports.

- The fuel distribution system for solid fuel which directs air from the pneumatic distributor air fan to the pneumatic distributor.

The steam generator gas-side system also shown on Flow Diagram M73-BA01 (Appendix Exhibit 5-11), moves the gaseous products of combustion from the furnace through the convection sections, the air heater, the dust collector, and the gas ducts between the boiler and the stack.

Design Bases

The system is designed to convey combustion air and gaseous products produced in the boiler as required for proper operation of the boiler.

System Components

The system consists of the following:

- One motor driven full capacity forced draft (FD) fan with all accessories, including inlet air silencer. The fan will be a centrifugal, constant speed type machine.

- One motor driven full capacity pneumatic distributor air fan with all accessories. The fan will be a centrifugal, constant speed type machine.

- One motor driven full capacity induced draft (ID) fan with all accessories. The fan will be a centrifugal, constant speed type machine.

- One economizer.

- One tubular air heater.

- One mechanical "Multiclone" dust collector with collection hopper.

- One lot of dampers and duct work.

- Stack

System Operation

The forced draft fan draws in ambient air and discharges the air through the air heater to the undergrate combustion air supply heater, the windbox, and the overfire air ports. One full capacity FD fan is provided for each boiler and must be available to operate the boiler.

The combustion products are drawn out of the furnace and through the boiler convection sections, economizer, and then through the tubular air heater and dust collector. The inlet of the ID fan receives the flue gas from the dust collector and discharges directly to the stack common to the two boilers. One full capacity ID fan is provided for each boiler and must be available to operate the boiler.

ASH REMOVAL

Function

The function of the ash removal system will be to collect ash generated by the cogeneration plant steam generators. Fly ash collected in the furnace convection pass hoppers, the economizer hoppers, and the dust collector hoppers will be reinjected into the furnaces and will therefore not be collected external to the boiler. All ash generated by the boiler and collected for disposal will be collected in the two bottom hoppers of each furnace. It is planned that ash from these hoppers will be collected in containers and trucked to the ash disposal collection area.

Design Basis

The system will be designed to collect bottom ash for a convenient period of time before hauling is required to reduce the frequency of hauling ash containers.

System Description

Ash collected in the furnace bottom hoppers will

periodically conveyed to containers located near each hopper. The system will consist of mechanical or pneumatic conveyor systems, ash gates, and other hardware required to convey ash from each hopper to the collection container. The containers will be designed so that they can easily be removed and trucked to the ash disposal collection area with a minimum of handling. A number of containers will be provided so that when one container is removed for disposing of ash an empty replacement container is available.

System Components

The ash removal system will consist of the following equipment to collect and dispose of ash:

- Pneumatic or mechanical ash conveyors
- Suitable portable ash collection containers for collecting ash from the furnace hoppers
- System hardware, such as hopper ash gates, as required to complete the ash removal system.

System Operation

Ash collected in the furnace hoppers will be conveyed by a mechanical or pneumatic conveying system. The conveying system will be manually actuated when required to reduce the level of ash in each hopper. The system will be shutdown manually when the desired quantity of ash has been conveyed to the ash container. Ash containers will be removed and emptied as required.

MATERIAL BALANCES

Material balances have been prepared for plant water and fuel. These balances show the source and quantity of raw commodity and its disposition within the system.

Plant Water Balances

Drawing M71-AN01, Plant Water Balance (Appendix Exhibit 5-12), shows the source of makeup water for the circulating water system and the condensate/feedwater/steam cycle. The drawing also indicates the quantity and source of waste water. In addition, some internal flow quantities have been indicated.

Makeup water for the circulating water system is supplied from the new Monymusk wells. Because of high hardness of this water, clarification followed by filtration is required. The treatment system is sized for 800 gpm [50.5 lps] based on makeup requirements of 765 gpm [48.3 lps] (evaporation and drift losses 510 gpm [32.2 lps] - blowdown 255 gpm [16.1 lps]).

Makeup water for the power plant cycle is obtained from the existing Raymonds Well and demineralized by a new package demineralizer described elsewhere. The design flow rate of 100 gpm [6.31 lps] per train is based on continuous cycle makeup requirements of 55 gpm [3.47 lps] (20 gpm [1.27 lps] blowdown and allowance for 35 gpm [2.21 lps] lost to process) and allowance for

regeneration water and time lost in regenerating the demineralizer equipment. After the demineralizer has been operated for about 12 hours it must be shutdown for approximately 4 hours to regenerate the cation and anion resin beds.

Plant Fuel Balance

Drawing number M71-JX01, Plant Fuel Balance (Appendix Exhibit 5-13) shows the quantity of fuel required to generate steam at the rated output of both boilers of 330,000 lb/m [150,000 kg/hr] . Fuel rates are indicated for bagasse, cane trash (barbojo), bagasse cane trash (barbojo) mixture and No. 6 Fuel Oil. Bagasse is the primary fuel, but is not available in sufficient quantities to supply 100 percent of the fuel requirements and is not available during the non-harvesting period. Cane trash (barbojo) accumulated during the sugar cane harvest will be burned when available. Number 6 Fuel Oil will be burned only when other fuels are not available or when required to support combustion of bagasse or cane trash (barbojo).

GEOTECHNICAL FEATURES

Geology and Foundation Conditions

The plant site is located on Quaternary (recent) alluvial deposits consisting of unconsolidated and interbedded sand, gravel, silt and clay. The alluvial sediments are of igneous and sedimentary origin, derived mostly from the highlands to the north. The thickness of these deposits varies from a few feet at the coast and thickening

inland to greater than 500 feet. The Newport Formation of Miocene Age (about 24 million years before present) occurs beneath the alluvial deposits. In the plant area, the Newport Formation is a poorly bedded to massive, fine-grained limestone. The thickness of this unit is reported to be greater than 2000 feet.

Medium stiff to stiff silty clays were encountered in the three shallow borings made at the site, west and north of the existing bagasse storage house. The clay contained some sand, and was found to be generally softer beneath the water table, which is 10 to 14 feet [3.0 to 4.3 meters] below existing grade.

Actual column loads for buildings and other facilities are not yet available. Pending this information and based on data from the three shallow borings, the following foundation conditions may be assumed:

- Shallow spread footings, mats and strip footings to support structural loads, with allowable bearing capacity of 2000 pounds per square foot [1.0 kg/sq cm] or less on natural soils.
- For heavier column loads, such as major boiler columns, piles 50 feet [15 meters] long, 12 inches [30 cm] in diameter, with a design load of 45 tons, may be required.

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- Site grading is minimal due to the flat topography; however, any compacted fills for road subgrades and parking lots should be compacted to 95 percent of Standard Proctor.

- Existing drainage ditch north of the cogeneration plant will be rerouted.

- Plant grade and yard grading require consideration for drainage from local rainfall and protection against frequent stream flooding to minimize plant outage.

- Settlements could be induced by drawdown of the ground water level beneath the structure.

A geotechnical investigation will be performed early during the design phase of the project to determine the safest and most economical foundation type, the associated bearing capacities on the natural soils, and to further consider the potential settlement of the foundation soils. Once actual structural loads are available and the detailed subsurface investigation has been completed, mat foundations may be proven to be more econmical than piles for the support of heavy structures.

Hydrology

Surface water sources in the area of the plant includes Rio Minho River and Cockpit River. The Rio Minho River passes about 1 mile to the north

of the plant. Use of this river water for irrigation may limit the availability of water for the plant, particularly during the dry seasons.

The Cockpit River in currently being used to provide water to the sugar factory at Monymusk by pumping into a canal from the river outlet at Salt River. Excess water supply from this river for use by the plant was not assessed since exact data on yield and demand are not available.

The availability of water from these sources for the plant use to provide approximately 800 US gpm [50.5 lps] will be investigated, considering the variability of flow in these streams, the existing water uses, and the quality of water.

For the conceptual development presented in this report, the cooling tower makeup water supply is assumed to be from new wells near the power plant, as discussed in the following section.

Ground-water supply for the plant area is primarily withdrawn from the alluvial deposits. Saltwater intrusion, resulting from frontal intrusion and upconing, has contaminated large areas of the aquifer adjacent to the coastline. Freshwater is obtained from the upper position of the zone of flow. The data are not available to determine the depth to the saltwater/freshwater interface.

The cogeneration plant will use two different sources of makeup well water for plant operations. Demineralizer makeup will be obtained from the existing Raymonds Well which is approximately six (6) miles further inland from the plant site. This water has much lower total dissolved solids (TDS) than well water in the vicinity of the plant site and is therefore better suited for treatment as condensate system makeup. the TDS of this water is expected to be in the range of 600-650 ppm [mg/liter]..

Circulating water system makeup of approximately 800 gpm [50.5 lps] will be obtained from new wells drilled near the power plant. The TDS of this water is expected to be in the range of 2000-2200 ppm [mg/liter]. The availability of this water has been determined using data from a study of yields from wells completed in alluvial deposits in an area about 22 miles (35 km) east of the plant site. Alluvial deposits in the study area are from the same source and were deposited in relatively the same environment as those in the plant site area. It is, therefore, assumed that the hydraulic characteristics are similar. From the available data, it appears that a yield of 425 gpm [27 lps] from a single well is possible. Results of estimates using a constant flow of 425 gpm [27 lps] over a 30-day time period show about 35 feet [10.7 m] of drawdown at the well with a radius of influence of 1300 feet [400 m]. Without additional knowledge of the hydraulic characteristics of the

sediments beneath the plant site a reasonably conservative estimate is for a well 200 feet [60 m] deep spaced 1500 feet [460 m] from the next nearest production well.

CIVIL AND STRUCTURAL

Foundations

The turbine building and boiler columns and the turbine pedestal will be supported on reinforced concrete spread footings which rest on undisturbed soil and are designed to a bearing capacity of 2000 pounds per square foot [1.0 kg/sq cm] and the heavier loads will be supported on 45-ton capacity piles. The remaining plant equipment and plant features requiring foundations or support, will be supported by a reinforced concrete continuous slab which rests on undisturbed soil.

Buildings

The turbine building and boiler structure will be constructed of steel and will be designed in accordance with AISC specifications for the design, fabrication, and erection of structural steel for buildings. Major field connections will be made with high strength bolts, unless welding provides a more suitable connection. Secondary connections will be made with common bolts.

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The boiler structure will be completely open except for the roof. The turbine building will be completely enclosed by metal siding and roofing.

The ground, mezzanine, and operating floors of the turbine building will primarily be of reinforced concrete construction, except for open hatch areas and grating-covered areas provided for ventilation or access. The boiler area floors will be constructed of checker plate and grating.

Building design will be in accordance with the requirements of the Uniform Building Code for Seismic Zone 3. Structures will be designed to withstand wind loadings of up to 130 miles per hour [200 km/hr].

ELECTRICAL AND CONTROLS

Power Distribution System

A main single line diagram is shown on Drawing No. E-73001 (Appendix Exhibit 5-14). The electric power is generated at 13.8 kV and stepped up through the main transformer to feed into the JPS 69 kV system via a 69 kV oil circuit breaker and 69 kV tie line. The point of interface between the facility and JPS is the 69 kV structure at the JPS switchyard.

Electrical power for plant station services will be supplied by distributing part of the generated

power to the 4.16 kV switchgear via the 13.8/4.16 kV auxiliary transformer. A feeder from this switchgear will also supply the existing sugar factory loads.

Startup power will be supplied by JPS's network by using the generator breaker for isolation of the generator from the system. The generator breaker will also be utilized for synchronization of the generator with the JPS system during startup. The 69 kV breaker will be used for resynchronizing the generator after a tie-line trip and reclosure, and/or feeding the auxiliary transformer during generator outages. The major electrical equipment will consist of the:

- Generator;
- Main step-up transformer;
- Auxiliary transformer;
- Non-segregated phase bus;
- 4.16 kV main switchgear;
- Generator breaker assembly;
- 440 volt load centers;
- Motor control centers;
- Distribution panels;
- 125 V DC system;
- Metering relay panel;
- Generator neutral grounding cubicle;
- Neutral grounding resistor;
- AC and DC distribution panels;
- Power, control, and instrumentation cables and raceways;
- Grounding system;
- Motors;

- Lighting system;
- Raceways; and
- Communications system.

The following is a detailed description of the major electrical equipment that will be furnished for operation of the plant:

- Main Step-Up Transformer - The main step-up transformer will be installed adjacent to the switchyard. The transformers will be rated 38 MVA FOA at 65 degree C rise, 3 phase 50 hertz, 69/13.8 kV, minimum calculated impedance at 55 degree C base MVA. The high-voltage winding will be connected in wye upper case with solidly grounded neutral. The transformer will be equipped with lightning arrestors, a no-load 5-position tap changer, on the high-voltage (HV) side, standard accessories and protective devices. The low-voltage winding will be connected in delta. The transformers will be oil filled; polychlorobiphenols (PCB's) will not be used. The connection between generator breaker and main transformer will be by non-segregated phase bus.

- Auxiliary Transformers (Station Service) - The auxiliary transformer (station service) will be installed adjacent to the main transformer and will be connected to the generator breaker through a tap on the non-segregated phase bus. The transformers will be rated 8/10 MVA, OA/FA, 65 degree C rise, 3 phase, 50 hertz, 13.8-4.16

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kV, 110 kV BIL. Transformer will be oil filled; PCB's will not be used. The high voltage winding will be connected in delta. This winding will be equipped with a hand-operated, no-load, 5-position tap changer. The low voltage winding will be connected in wye and neutral will be grounded through a resistor. The low voltage side will be connected by cables to the 4,160 volt switchgear. Transformer impedance will be calculated to permit starting the largest motor without affecting the operation of other equipment, with the transformer carrying all remaining loads. The transformer impedance, however, will be sufficient to limit the short circuit duty on the 4,160 volt switchgear. The transformer will be equipped with standard accessories and protective devices, such as temperature gauge, sudden pressure relay, control cabinet and local annunciator.

- Non-Segregated Phase Bus - The generator will be connected to the generator breaker and main transformers by a metal enclosed non-segregated phase bus. The non-segregated bus will consist of aluminum conductors supported on insulators. The bus will be rated for carrying the generator full load amperes and braced for the expected short circuit currents it has to withstand in case of a fault. A tap from this bus connects the auxiliary transformer to the main transformer.

- 4,160 Volt Switchgear - The 4,160 volt switchgear assembly will be an indoor, metal clad, horizontal drawout type. The switchgear line-up

will include one incoming line breaker, two feeder breakers, seven fused contactor starters for motors, instrument transformers and protective devices for motor and other equipment feeders. All circuit breakers will be oilless, electrically operated and stored energy type. In general, large motors (those over 200 hp [150 kW]) and the 440 volt load center transformers will be supplied from this switchgear.

- Generator Breaker Assembly - The generator breaker assembly will consist of a 13.8 kV, 2,000 A, 750 MVA class circuit breakers, surge arrestors, and current and potential transformers. The circuit breakers will be an oil-less, stored energy and horizontal drawout type.

- Generator Neutral Grounding Assembly - The generator neutral grounding assembly will consist of a metal enclosed generator neutral assembly consisting of a 13,800-220 volt, single phase, 25 kVA dry type transformer and a grounding resistor rated 0.5 ohm, 300 A, 1 minute.

- Neutral Grounding Resistor - The neutral grounding resistor will be a metal enclosed, outdoor type, comprised of a 2,400 volt, 1,000 A, 6 ohm, 10-second rated resistor. The resistor is intended for high resistance grounding of the 4.16 kV system.

- 440 Volt Load Centers - The 440 volt load centers will consist of two indoor type 440 volt, single

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ended load centers, consisting of 600 volt switchgear containing drawout circuit breakers, high-voltage entrance cubicles and transformers to supply motors and 440 volt motor control centers.

- Low Voltage Transformers - The low voltage transformers will be three phase, 50 hertz, 4,160-440 volt, air-cooled dry type. The high-voltage winding of these transformers will be equipped with a hand-operated tap changer and will be connected in delta. Transformer impedance will limit the short circuit duty on the switchgear to lower than rated value. The low voltage winding will be connected in wye and solidly grounded.

- Circuit Breakers - Transformer secondary breaker, tie breakers, and motor control center feeder breakers will be protected by adjustable short-time and long-time overcurrent trips. All circuit breakers will be manually or electrically operated as required, provided with static trips and will have stored- energy type operators.

- 440 Volt Motor Control Centers - The 440 volt motor control centers will consist of six 440 volt motor control centers, NEMA Class 1, Type B, with plug-in, combination, across-the- line starters with molded case breakers. The motor control centers will supply and control the 440 volt motors, generally 220 hp [165 kW] and smaller, lighting and power panel transformers, and small 440 volt loads. Each combination motor

starter will be equipped with a 120 volt control transformer. The feeder circuit breakers will be 600 volt class and will be equipped with thermal magnetic series trip devices. Motor control centers will be located throughout the plant, indoor motor control centers will have NEMA enclosure Type 1, motor control centers located outdoors will have NEMA enclosure Type 3R.

- Distribution Panels - The distribution panels will consist of miscellaneous 220 volt AC loads supplied from 440/220 volt single phase, 4-wire panel boards supplied from the 440 volt motor control centers through step down transformers. Associated loads will include 1/2 hp [0.4 kW] and smaller motors, space heaters, solenoid valves, control panels and lighting fixtures. 220 volt receptacles will be provided. AC power panels, rated 440/220 volt, three phase, supplied from the 440 volt motor control centers, will be provided to feed lighting fixtures, space heaters and miscellaneous three-phase loads.

- 125 Volt DC System - The 125 volt DC system will provide control power for protective relays, 4,160 volt switchgear, 440 volt load centers, miscellaneous devices of the process control and instrumentation, and power for emergency motors and other emergency services. The system will consist of a 600 ampere-hour, lead calcium, 60-cell storage battery, a 100 A static battery charger and one DC control center. The battery size will be dictated by the normal and emergency plant requirements and will have enough capacity

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to permit a safe shutdown of the generating unit. The battery charger will be sized to bring the battery from full discharge to full charge in less than 24 hours while simultaneously carrying the normal continuous load. The charger will be supplied from a 440 volt motor control center. The 125 volt DC control center will be connected to the battery and charger will be comprised of DC motor controllers, feeder breakers, protective relays, meters and one DC distribution panel with twenty 2-pole breakers. Local DC starters will be provided for the DC emergency oil pump motor.

- Metering Relay Panel - The metering relay panels will be located in the switchgear room. This panel will contain protective relays for the generator and the main and auxiliary transformers and 69 kV tie line. Generator controls and indicators will be incorporated in the turbine generator control boards located in the control room. The generator will be provided with underfrequency, loss of field, reverse power negative sequence, ground, differential, voltage balance and phase distance relays. The transformers will be protected with overcurrent, differential, ground and fault pressure relays.

  Metering will be provided to measure the generator gross output and in plant power use. Metering will consist of kilowatthour meter, hourly recording meter and totalizing relays.

- Cables and Wires - Cables and wires of the following types will be provided -

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- 13,800 Volt and 4,160 Volt System - Either single or 3-conductor triplxed, fully insulated, 15 kV or 5 kV stranded, soft drawn copper, XLPE insulated and encased in a PVC jacket.

- 440 Volt System - Multiconductor, 600 volt class, stranded soft drawn copper cable, with XHHW insulation, type TC.

- DC Power - Single conductor, 600 volt class, stranded soft drawn copper cable, XHHW insulation.

- Control Systems (except instrumentation) - Multiconductor 600 volt class stranded, soft drawn tinned or alloy coated soft drawn copper, No. 14 or larger, with XHHW insulation, type TC.

- Instrumentation - Cable for instrumentation and low level signal circuits will be rated at 300 volts, PLTC, #16 AWG stranded copper, PVC insulated, twisted, aluminum mylar shield, copper drawn wire and PVC jacket.

- RTD & T/C - Shielded multiconductor with PVC insulation and PVC jacket. High temperature insulation will be used in high temperature areas.

- Lighting circuits - No. 12 or larger, copper conductors, type THWN in conduits or ALS (aluminum sheathed cable) as appropriate.

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- Motors - Motors in general will be squirrel cage induction type, designed for full voltage starting, except where the application dictates otherwise. Motors larger than 200 horsepower [150 kW], in general, will be rated 4,000 volt for use on a 4,160 volt, 3-phase, 50 hertz, resistance grounded system. Integral horsepower motors rated 3/4 through 200 horsepower [0.56-150 kW], and reversing motors in general, will be rated 420 volt for use on a 440 volt, 3-phase 50 hertz solidly grounded system. Smaller motors will be single phase, 220 V AC or DC, as required by the function of the motor. Motors will have Class B or other insulation as required by the application. To prevent damage by moisture condensation, motors for outdoor service that are rated larger than 25 hp [19 kW] will have space heaters, which will be automatically activated when the motor is idle, except for specially designed motors for which it would not be practical to install space heaters. Weather protected, NEMA Type II enclosures will be provided for 4,000 volt motors installed outdoors. Motors installed indoors will have drip-proof enclosures unless the location or application requires a different type of enclosure. Motors will have the manufacturer's standard service factor.

- Lighting - Lighting will consist of a 440/220 volt distribution system. The lighting system will be fed from dry type, 440/220 volt, single phase transformers supplied from the 440 volt

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motor control centers. Normal lighting in boiler, cooling tower, water treatment, and turbine- generator areas will be provided by high pressure sodium and incandescent fixtures. Switchgear and control room will be by fluorescent fixtures. Illumination level for all areas will be based on recommendations of the Illuminating Engineering Society (IES). Stack lights, if required, will be provided in accordance with Aviation Safety regulations. Emergency lighting will be provided by battery packs for special locations such as access, egress and critical operating areas.

- Grounding Grid - A grounding system will be furnished in accordance with the requirements of the appropriate Electrical Code to ensure proper grounding of the system, structure and equipment facilities, as well as for personnel safety. The conductor will be annealed, concentric-stranded, bare copper cable of sufficient size to carry the maximum expected ground-fault current. All underground joints in the ground grid will be made by exothermic weld-type joints. Steel-to-copper connections for grounding of the columns will be made above ground. Exposed connections will be made with bolted or compression-type connectors or by the Cadweld process.

- Raceways for Power, Control and Instrumentation Cables - The raceways for power, control and instrumentation cables will be run in duct bank cable trench, tray and conduit, as required by

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site and plant layout conditions. Aluminum sheathed or metal clad cable may be used in lieu of conduit wherever possible. Lighting and nonessential power cables may be direct burial. The tray system will be protected by covers in areas when cables may be subject to physical damage.

Aluminum trays will be provided. Indoor exposed runs between trays and motors, push-button stations and other local devices will use steel conduits or metal clad cable. Flexible conduits will be used at the connection to equipment and devices subject to removal, vibrations, or uneven settlement. Separate raceways will be provided for the medium voltage and low voltage power cables. Separate raceways or tray barriers in the general control trays will be provided for isolating low-power, low-voltage signal cables if necessary.

- Communications System - A plant communication system consisting of handsets and speakers will be provided at key locations within the cogeneration plant. The system will have paging and party line conversation capability.

- Revenue Metering - Revenue metering on the 69 kV side and 4.16 kV connection to the sugar factory will be provided for power flowing in and out of the generating facility. The 69 kV tie line metering will be provided and installed by JPS.

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69 kV Transmission and Switchyard

Transmission System - The cogeneration plant will be connected to the JPS system by a transmission tie line. The 69 kV tie line, approximately 1300 feet [400 m] long, will be a single circuit overhead transmission line, routed from the switchyard terminal structure over wooden poles to the existing JPS Monymusk substation, as shown on the plant layout drawing. The Monymusk substation terminal structure for the tie line and the Monymusk substation modification will be provided and installed by JPS.

Switchyard - The 69/13.8 kV main, generating plant unit, step-up transformer will be connected to the 69 kV tie line via the cogeneration plant switchyard. This switchyard will be an air insulated type, with one 69 kV power circuit breaker, two disconnecting switches with grounding switches, lightning arresters, buses, hardware, associated foundations and support structures. The 69 kV switchyard ratings shall be as indicated in the single line diagram, Drawing #E-73001 (Appendix Exhibit 5-14) and in the electrical equipment list.

The 69 kV tie line protective relaying will consist of a pilot wire relay system over pilot wire cable to the Monymusk substation, and a directional overcurrent relay system for backup protection. Pilot wire relay system includes the supply of the relay package for the tie line remote end at Monymusk substation.

Switchyard and tie line protective relaying will be located in the cogeneration plant building and will be power supplied from the dc and ac plant station service systems.

The 69 kV breaker and disconnecting switches will be manually controlled from control devices located at the breakers and switches. The 69 kV breaker will also be controlled remotely from the cogeneration plant control room.

Instrumentation and Control System

General - The instrumentation and control systems will be designed to achieve safe, reliable and economic operation and generation of power and production of process steam for the sugar processing equipment. Utility power station quality equipment of proven design will be utilized and arranged so that the boilers, turbine generator, and auxiliary equipment are operated in an efficient manner from a central control room.

Control Room - The control room will be designed so that essential information required for operation is displayed continuously on conventional edgewise indicators, recorders and status lights, grouped in control action sequence.

Equipment requiring frequent or timely actuation while the unit is in normal operation will be located and controlled either from the main control room or automatically. Examples of automatic control loops

include: boiler combustion controls (air and fuel), boiler drum level control, and steam temperature control. The turbine generator will be furnished with a panel insert located in the main control room which contains all essential operating and monitoring controls for the unit. Additionally wattmeters, varmeters, voltmeters, ammeters, etc., will be provided to monitor the status of the unit generator and electrical distribution systems. Process variables such as temperatures, pressures, flows, and levels for equipment that must operate continuously will be monitored in the control room on main control board indicators and recorders. Major motors, valves, fans, pumps, circuit breakers, etc., will have their control switches located on the main control boards.

Systems with local controls will have their system information or status displayed in the main control room when such displays are needed for prompt operating decisions. Local control panels will be furnished for packaged systems or where operator attention is required only to set up a system for operation or where the equipment to be operated requires only intermittent attention during plant operation. Local control panels will be provided for demineralizers, chemical injection, compressed air, sampling, and similar package type equipment systems. Compact and miniaturized control and instrument devices will generally be utilized on the control panels. Annunciator displays will provide information on equipment status and will alert the operator to abnormal plant conditions.

Type of Controls - Controls for the major control systems (combustion, feedwater, steam temperature, etc.) will be of the solid state electronic analog type with final drives and actuators pneumatically or electrically operated.

Local control systems that do not require remote status indication will employ pneumatic devices to the maximum extent possible.

Operating controls will contain interlocks or safety systems to provide pre-planned actions when unsafe conditions develop faster than an operator can be expected to respond.

Signal transmission to and from the control room for control and display will employ electric/electronic media. Any required electric-pneumatic converters will be located in close proximity to the associated final control elements.

Local Instruments - Local instruments will generally consist of:

- Pressure gauges, 4-1/2 inch [11.5 cm] diameter phenolic cases equipped with pulsation dampeners on pulsating service.

- Electronic field transmitters where control room indication or control is required.

- Orifice plates will be the preferred flow metering method. Flow nozzles will be used for feedwater and main steam metering. Rotameters will be used to measure flow in 3/4 inch [2 cm] and smaller lines.

- Liquid level measurement devices include: level gauge glasses of the reflex or transparent tube type, displacement or float type switches and pneumatic controllers, differential pressure type devices and tape type gauge boards on large tanks.

- Dial thermometers, 5-inch [12.7 cm] diameter will be the any angle type, gas or bi-metallic actuated. RTD's will be 100 ohm platinum or 10 ohm copper type; thermocouples will be type E, J, K as required by the process.

Instrument Application - Temperature and pressure measuring connections will be provided on the inlet and outlet nozzles of all heat exchangers, pumps, compressors, and similar processing equipment.

Differential pressure indicators will be permanently installed across filters, screens, strainers, and demineralizers when the process equipment is part of a major process system. Permanently installed level indication will be included on all vessels or tanks containing liquids or solids.

5.4 ENVIRONMENTAL ASSESSMENT - COGENERATION POWER PLANT

Jamaican Standards

There are no published environmental standards in Jamaica; United States standards have been used as guidelines for establishing control technologies.

Air Quality

Bagasse, a waste product of sugar cane processing has a heating value of approximately 4,000 Btu/lb [16 cal/g] (at 50 percent moisture). Barbojo, the cane tops and leaf waste from sugar cane, has a heating value of approximately 5,000 Btu/lb [20 cal/g] (at 35 percent moisture). To minimize the cost of sugar processing and power generation, sugar cane mills use bagasse as the primary fuel for on-site steam production. This cogeneration plant intends to burn bagasse, barbojo and oil.

Emissions from bagasse boilers contain particulates, nitrogen oxides and, when oil is fired, sulfur dioxide; there is no sulphur in bagasse or barbojo. Current United States regulatory requirements involve only particulates. Since the heat input from oil firing is expected to be less than 250 million Btu [one million calories] per hour, U.S. EPA New Source Performance Standards do not apply. Bagasse boilers are not subject to federal new source performance standards, but individual State particulate standards require emissions control equipment and proper combustion practises. For this project, the State of Hawaii's particulate

emissions standards of 0.4 lbs/100 lbs of fuel fired has been selected as a guideline for evaluating control technologies.

Water Quality

Federal effluent guidelines have not been established for power generating facilities which combust non-fossil fuels. In the U.S., these facilities are typically designed to comply with Steam Electric Power Generating Effluent Guidelines (40CFR423) even though these guidelines are written specifically for fossil fuel fired units.

The proposed facility will be designed to comply with the following limitations which are contained in 40CFR423:

Parameter	Maximum Concentration mg/l	Average Concentration mg/l
Total Suspended Solids	100	30
Oil & Grease	20	15
Free Available Chlorine	0.5	0.2

Solid Waste

In the United States, the disposal of non-hazardous solid waste is typically regulated by the individual States. Hazardous waste disposal is regulated by the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA) regulations.

Operation of the proposed bagasse-fired facility will result in the generation of the following solid wastes:

- Flyash
- Bottom ash
- Wastewater treatment sludge

It is currently planned to dispose of the flyash and bottom ash as fertilizer and to dispose of the wastewater treatment sludge in an environmental acceptable manner. If any of these wastes need to be landfilled, Hawaii Solid Waste Management Control Regulations (Hawaii Code of Regulations, Title II, Chapter 58) will be used as a guideline for determining procedures.

Assessment

The cogeneration facility proposal, with the appropriate control technologies being applied, should not provide a basis for concern.

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6.0 COMMERCIAL STRUCTURE

6.1 OWNERSHIP AND MANAGEMENT

For the purpose of this report, it has been assumed that the Monymusk Cogeneration Company, a limited liability, Jamaican corporation, will be established to develop and own the new cogeneration facility. The Jamaican Sugar Holdings Limited (JSH) which would be expected to continue to operate the Monymusk Factory and the field division of the Clarendon Sugar Company, would enter into a joint venture agreement with the Monymusk Cogeneration Company. That agreement might provide, amongst other things, for the integrated operation of the entire Monymusk complex, including the supply of bagasse and cane trash (barbojo) to the cogeneration facility in exchange for process steam and electricity to the factory and electricity to Clarendon Sugar Campany.

The Monymusk Cogeneration Company will be responsible for financing, construction and ownership of the proposed cogeneration facility. It is anticipated that the company might be owned by a grouping of Jamaican and foreign investors. It is further anticipated that the foreign interests will be sold to local participants once the project debt is repaid thus resulting in ultimate Jamaican control.

6.2 COMMERCIAL ARRANGEMENTS

Under direction of its board of directors, the Monymusk Cogeneration Company would:

- enter into a Joint Venture Agreement with the JSH providing for coordinated operation of the entire Monymusk complex and intercompany sales of bagasse, steam and electricity,
- enter into an operating agreement with the JSH, and a contract operator to operate the complex,
- lease the project site from GOJ,
- arrange debt financing for the cogeneration plant,
- contract for design and installation of the cogeneration equipment, and
- contract with JPS and others for sale of electricity

Because the sugar cane production and processing facilities and cogeneration plant are a highly interconnected enterprise which requires coordinated management and operation, it is proposed that the Monymusk Cogeneration Company and the JSH enter into a Joint Venture Agreement which would contractually provide for intercompany transfers of bagasse, steam and electricity, and would also require the JSH and the Monymusk Cogeneration Company to contract operation of the facilities to a single experienced operator with the overall responsibility for day-to-day management and operation of all aspects of the Clarendon Sugar Company including the Monymusk Factory and proposed cogeneration plant. The management would be delegated substantial operating authority with only a few key policy matters left to the directors of the respective owner companies. This authority would be defined and established through an Operating Agreement between the operator and the Joint Venture. The

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operator would subcontract certain activities to local and foreign firms as appropriate.

The intercompany bagasse, power and steam exchange arrangements, included in the Joint Venture Agreement between the JSH and the Monymusk Cogeneration Company, will be structured with a view to both administrative simplicity and economic incentives for both companies to maximize output and efficiency. For example, power might be sold to the JSH at a low wholesale rate, with steam and bagasse transferred free, provided that bagasse quantity, bagasse heat content and steam usage fall within agreed-upon ranges. However, to the extent bagasse quantity or heat content fall below the agreed-upon minimum levels, the JSH would pay a penalty sufficient to offset the increase in fuel cost of the Monymusk Cogeneration Company. Similarily, to the extent steam consumption exceeds an agreed-upon level, the JSH would pay a penalty equal to the foregone electricity revenues. Conversely, the JSH would earn bonuses for additional bagasse production, high heat-content bagasse (low average moisture in bagasse) and below average steam usage. Likewise, incentives have been included in the pricing of cane trash to encourage deliveries by JSH.

A strong power sale contract with JPS will of course be an important element in attracting both lenders and investors. Among other things, the contract will have to be structured to provide fuel cost adjustments during periods when biomass fuel is unavailable, and provide a floor price or similar mechanism sufficient to cover debt service, in the

event of forced outages of the plant. Moreover, a portion of the payment (possibly structured as a capacity payment) might be paid either in US Dollars or in exchange-rate adjusted Jamaican Dollars to help service US Dollar debt.

If JPS is unwilling to enter this type of power contract, other foreign exchange assurances will be required. Because the cogeneration project does not directly generate foreign exchange (substituting domestic biomass fuel for imported oil indirectly reduces GOJ foreign exchange expenditures), the ability to convert Jamaican Dollar revenues from the sale of steam and electricity into foreign currency, to pay foreign debt service and dividends, will be essential to attracting investors and lenders.

Figure 6-1 summarizes the ownership and contractual arrangements under the proposed business plan.

6.3 ALTERNATIVE BUSINESS STRUCTURES

If the GOJ wishes to privatize both the Monymusk Factory and Clarendon Sugar Company as well as the cogeneration plant, two alternatives to the proposed business plan described above might be considered.

Single Project Company

The simplest arrangement would involve ownership of the entire operation, including the control of the sugar production and processing facilities and the proposed cogeneration plant, by a single project company - the Monymusk Sugar and Power Company

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(MSPCo.). The new company would be responsible for improving and operating the cogeneration plant. Ownership of the new company would be generally the same as that proposed for the Monymusk Cogeneration Company, or other private sector-oriented International Financial Institutions.

The GOJ/JSH would also contribute an interest in the mill and canefields to the company in return for preferred stock, with par value equal to the estimated value of the property. The GOJ/JSH preferred dividends would be tied to profitability of the complex, but subordinated to both debt financing and a minimum return to common shareholders. Specifically, the dividends would equal an agreed-upon percentage of the excess of sugar sales revenues over the sum of the company's operating costs, debt service, taxes and an agreed-upon minimum common equity return. If the GOJ/JSH is unwilling or unable to contribute the fields and mill to the MSPCo., an alternative with essentially identical ownership arrangement would involve the GOJ leasing the fields and mill to the MSPCo. with rental payments keyed to mill profitability.

As with the Monymusk Cogeneration Company, the MSPCo. would be established with the idea of selling the foreign equity interests to the local participants after project debt is repaid.

The, MSPCo. would fund the proposed cogeneration plant costs in the same manner as the Monymusk Cogeneration Company. The equity investment would

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be provided by the sponsors in proportion to their common stock ownership.

Commercial arrangements would be somewhat simpler than under this proposed business plan, since the Joint Venture Agreement providing for coordinated operation of the entire complex, and intercompany transfers of bagasse, steam and electricity would be eliminated. On the other hand, existing arrangements for sale of sugar products would have to be transferred to the new company.

Figure 6-2 summarizes the contractual and ownership arrangements under this alternative business plan.

Separate Project Companies

To facilitate cogeneration plan financing, it may be necessary to segregate the sugar mill and field operations from the cogeneration plant. Under this approach, privatization of the mill and fields could be accommodated by formation of two new Jamaican corporations. The first corporation - the Monymusk Sugar Company - would own and operate the mill and fields while the second - the Monymusk Cogeneration Company - would own and operate the cogeneration plant.

The Monymusk Cogeneration Company would be identical with the cogeneration company described in the proposed business plan in terms of its ownership, financing and commercial arrangements.

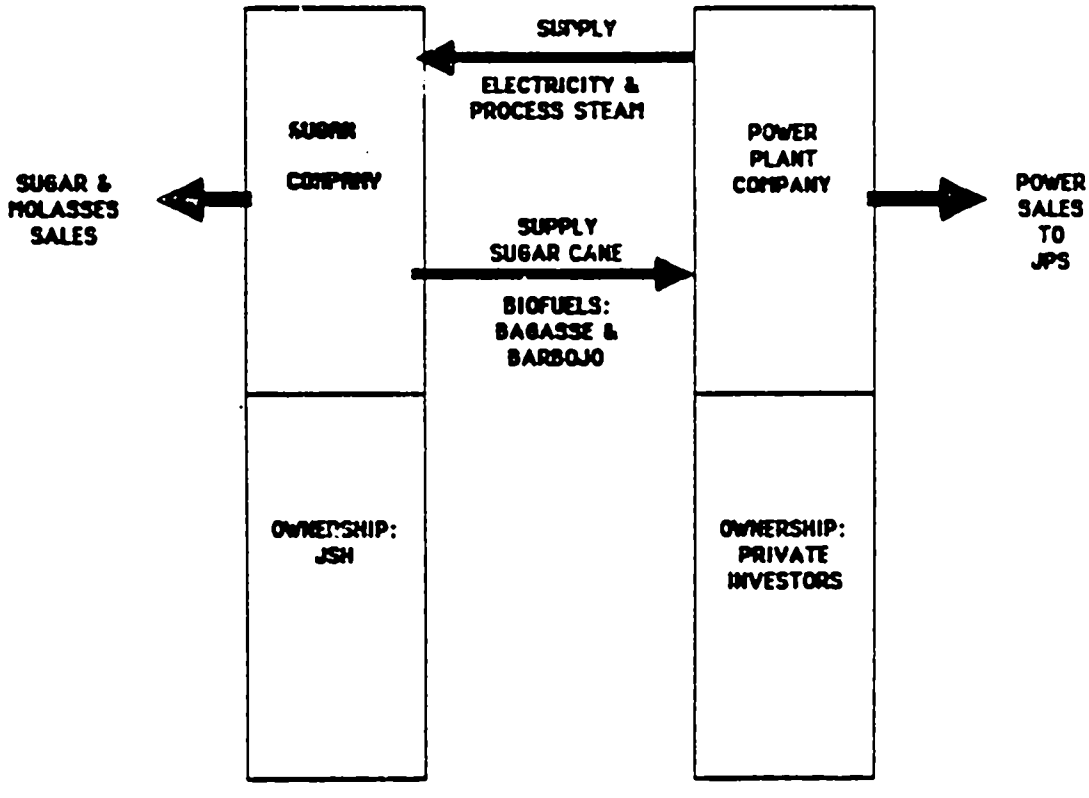
The Monymusk Sugar Company would assume all of the responsibilities of the JSH under the proposed plan, including purchasing cane from independent growers, carrying out mill and field improvements, marketing sugar products, and entering into a Joint Venture Agreement with the Monymusk Cogeneration Company to operate the complex and provide for intercompany transfers of bagasse, steam and electricity.

The sugar company might be owned at least 25 percent by the JSH/GOJ. The JSH/GOJ would either contribute the mill and estate to the new company in return for preferred stock, or lease the mill and estate to the project company as described. All other financing arrangemnts would be the same, with the exception that the JSH's current sugar product marketing arrangements would have to be transferred to the new company.

Figure 6-3 summarizes this alternative business structure.

FIGURE 6 - 1

OWNERSHIP & MANAGEMENT STRUCTURE
JAMAICA CANE/ENERGY PROJECT

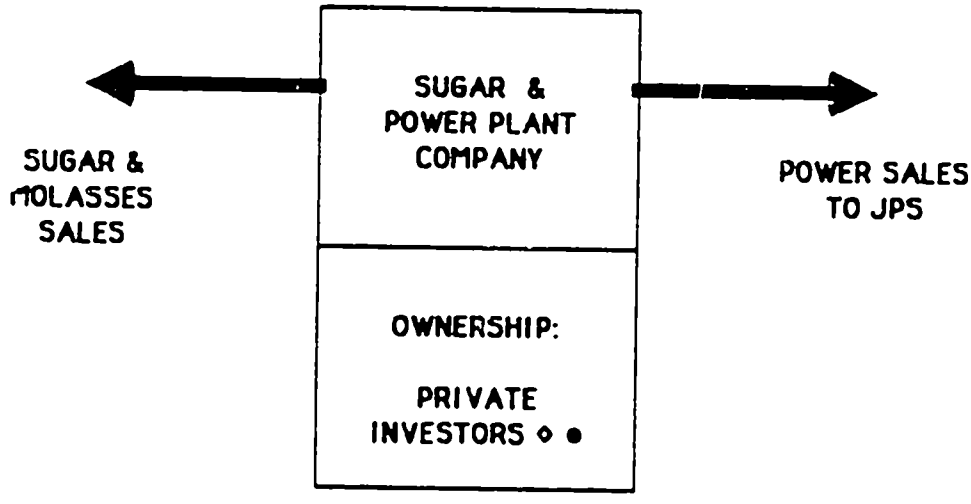


AGREEMENT TO:

- PROVIDE UNIFIED MANAGEMENT OF THE SUGAR COMPANY AND THE POWER PLANT COMPANY
- PROVIDE INTERCOMPANY EXCHANGE AND SALE AGREEMENTS FOR PROCESS STEAM, ELECTRICITY AND SUGAR CANE DERIVED BIOFUELS

FIGURE 6 -2

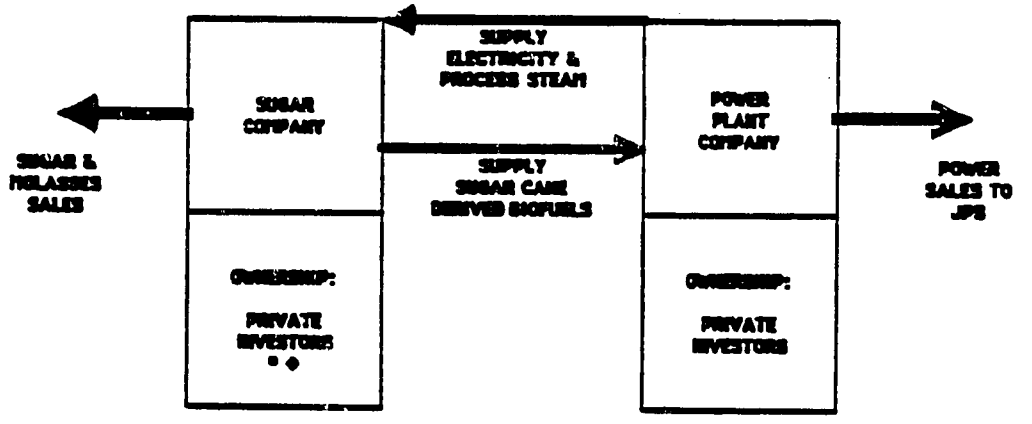
OWNERSHIP & MANAGEMENT STRUCTURE
JAMAICA CANE/ENERGY PROJECT
ALTERNATIVE 1



◇ SUGAR FACTORY AND COMPANY FIELDS LEASED FROM GOJ.
● AS ANOTHER ALTERNATIVE, GOJ MAY BE A PARTICIPANT IN THE OWNERSHIP OF THE COMPANY.

FIGURE 6 - 3

OWNERSHIP & MANAGEMENT STRUCTURE
JAMAICA CANE/ENERGY PROJECT
ALTERNATIVE 2



AGREEMENT TO:
- PROVIDE UNIFIED MANAGEMENT OF THE SUGAR AND POWER PLANT COMPANY.
- PROVIDE INTERCOMPANY AGREEMENTS FOR THE EXCHANGE AND SALE OF ELECTRICITY, PROCESS STEAM AND SUGAR CANE DERIVED BIOFUELS.

* SUGAR FACTORY AND COMPANY FIELDS LEASED FROM GOJ.
◆ AS ANOTHER ALTERNATIVE, GOJ MAY BE A PARTICIPANT IN THE OWNERSHIP OF THE SUGAR COMPANY.

7.0 PROJECT SCHEDULE

7.1 INTEGRATION WITH THE REHABILITATION PROJECT

The Cane/Energy Project needs to be fully coordinated with and integrated into the corporate strategic planning of Jamaica Sugar Holdings Limited (JSH). Steps have been taken to fully integrate the planned projects. JSH is in the process of implementing the World Bank's Second Jamaica Sugar Rehabilitation Project. Those rehabilitative and replacement expenditures are to be made over a five (5) year period beginning during this up-coming fiscal year (i.e., 1987 to 1991) and are critical to the successful outcome of this project and its profitability.

The rehabilitation expenditure schedule (see Figures 7-1, 7-2 attached) is planned to rapidly pay-out most of its funds and implement its production improvements in four (4) years or by 1990, the year the proposed power station is to be ready for commissioning. All expenditures are contributory to the overall productivity and profitability of Clarendon Sugar Company and its Monymusk Factory, but certain expenditures may be directly impacted by a decision to build a high performance boiler/ turboalternator, and those points of contact between the two projects will require further coordination (e.g., bagasse house improvements, steam economy improvements, etc.).

7.2 DEVELOPMENT AND CONSTRUCTION

The major activities for the Cane/Energy Project have been segregated into two schedules, one for project development (Figure 7-3) and one for the project implementation phase (Figure 7-4).

The project development phase would commence after this report has been reviewed and accepted as a basis to proceed. This acceptance would be shown by a Letter of Intent indicating the Government of Jamaica's agreement with the principles of the project and their interest in supporting follow-on development efforts. The following additional issues should be clarified before proceeding to the development phase:

- Type of participation by the Government of Jamaica;
- Management structure;
- Basic conditions for an Energy Sales Agreement with Jamaica Public Services;
- Convertibility of local currency revenues into foreign exchange;
- Specific modifications to the current mill and estate rehabilitation project and
- Availability of additional land, if required, to increase sugar cane production.

The first activity will be to incorporate the project investors into a Power Plant Company which will then oversee the development activities and enter into the various agreements needed to implement the project. The power sales agreement

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with JPS and the joint venture agreement with JSH along with a more detailed design will support the applications for financing the project. The financial closing will signal the completion of financial arrangements and that funds are available to draw upon for project implementation.

The overall project implementation schedule from financial close (estimated in mid-1987) to commercial operation of the plant is 33 months. This includes a 9-month period for award of supply contracts and detailed engineering, followed by a start of site work and 24 months of contruction, test and start-up activities. The start of construction activities is anticipated for mid-1988.

As shown on the implementation schedule, the operation of the power plant could start in mid-1990. Efforts should be made to have most of the factory improvements completed to coincide with the cogeneration plant completion. Field improvements, mainly irrigation system modernizations, would continue into the early 1990's.

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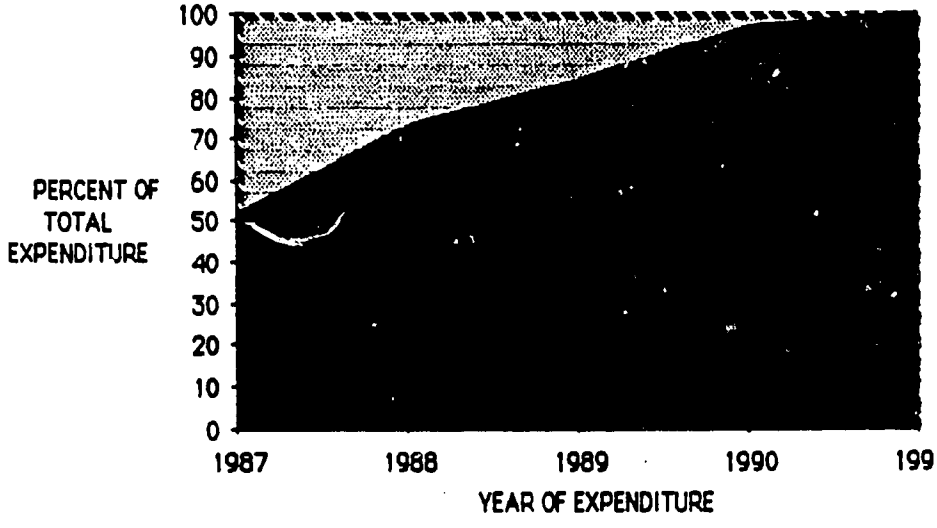
FIGURE 7 - 1

WORLD BANK
JAMAICA SECOND SUGAR REHABILITATION PROJECT
CLARENDON SUGAR (MONYMUSK FACTORY)
RATE OF EXPENDITURE



ACCUMULATIVE AMOUNTS OF EXPENDITURE

	1987	1988	1989	1990	1991
PROCESSING	4.7	6.1	6.8	8.1	8.1
AGRICULTURE	3.0	4.6	5.0	5.3	5.3
IRRIGATION	2.6	3.7	4.8	5.8	6.3
TOTALS	10.3	14.4	16.6	19.2	19.7
PERCENT OF TOTAL	52%	73%	84%	97%	100%

FIGURE 7 - 2
PROJECT DEVELOPMENT WORKPLAN
JAMAICA CANE/ENERGY PROJECT

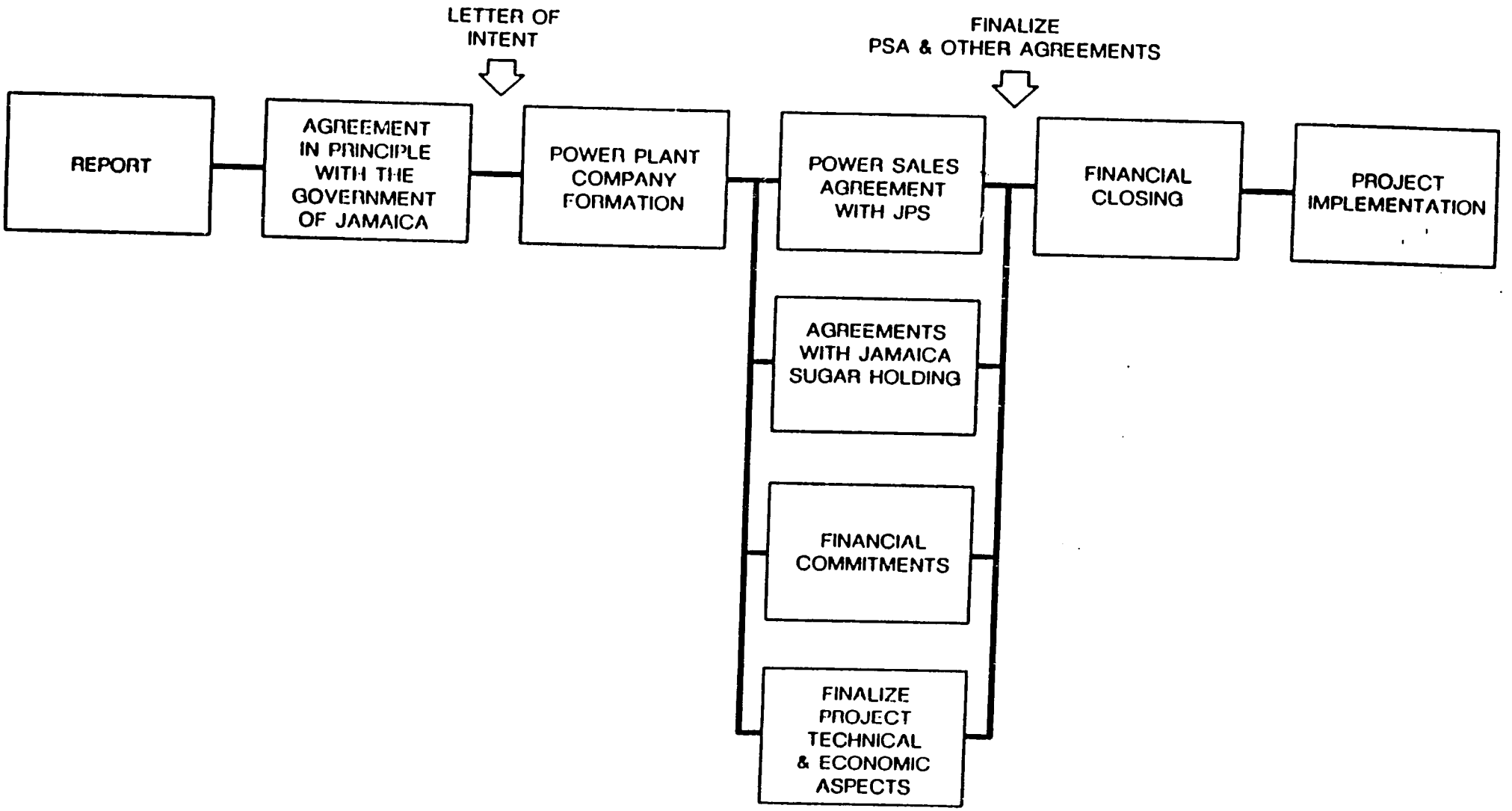
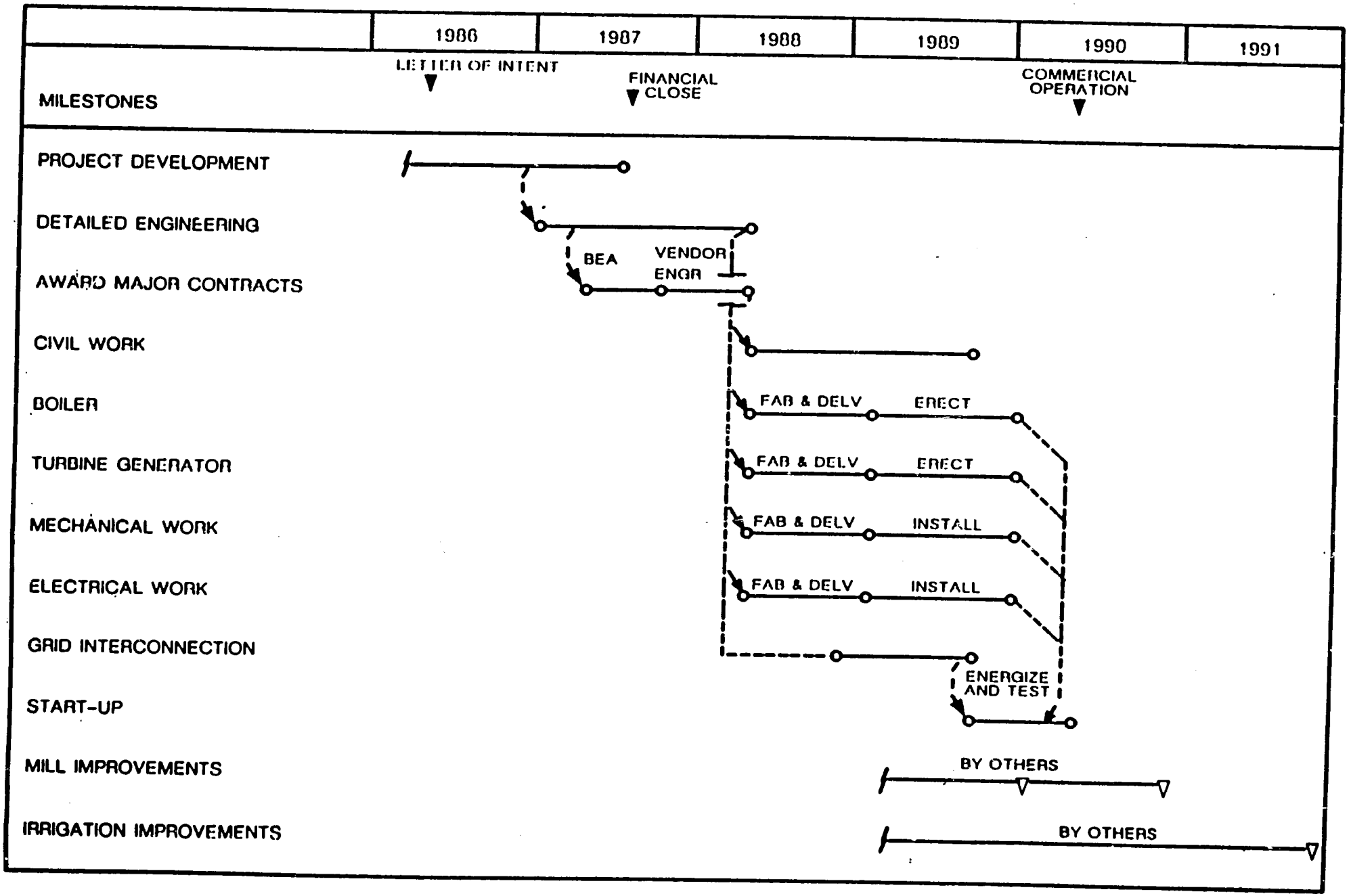


FIGURE 7 - 3
PROJECT IMPLEMENTATION SCHEDULE
JAMAICA CANE/ENERGY PROJECT



8.0 OPERATION PLAN

8.1 CANE PRODUCTION

Three levels of annual production were considered for this project. The Base Case of 742,050 tons of cane per year is the target set for completion of the Rehabilitation Project, and is considered to be the minimum production needed for economic viability of sugar operations. However, a reappraisal of this production target was necessary for consideration of the effects upon cane yields due to lack of improvements to field layouts and infield distribution of irrigation water. The target irrigation efficiency of 62 percent overall cannot be achieved with infield distribution efficiency below 40 percent. Water shortages and saline conditions will only be aggravated further by wasting over 60 percent of this resource. The effects of this artificial drought can be expected to reduce cane production by 20 percent, down to 600,000 tons per year, which is the Low Case. The capacity of the mill determined the Best Case at 850,000 tons of cane per year.

Crop Cycles and Age

Annual harvesting of plantcane and several ratoons has developed in response to varietal yields and costs per unit of production. As most varieties decline in yield after one or two ratoon crops (i.e., regrowths from existing root systems after harvesting), the costs of tillage and planting must be combined with ratooning costs to achieve the

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lowest average cost per ton of cane. This generally occurs with three or four ratoons, as the yield of cane from fifth and subsequent ratoons is often so low that the average cost per ton of cane increases, when compared with the averaged costs of plantcane and four ratoons.

Increasing age with existing varieties has not increased yields per acre-month; therefore, annual cropping has prevailed. Time lost for fall planting after reaping in the summer cannot be compensated by higher yields when the fall plantcane is harvested at extended age, especially when production from those fields is denied to the crop immediately following the fall planting.

No change from annual cropping is recommended for this project site. A crop cycle of planting after four ratoons is proposed, as is now the accepted practice, necessitating an annual renewal rate of twenty (20) percent.

Field Layout Design Criteria:

The Clarendon Sugar Company is comprised of 926 canefields that average 13.5 acres [5.5 hectares] each (Table 5-1). While this large number of small parcels was required for control of water and labor with the low productivity of early flood irrigation systems (i.e., the limited area that an irrigator could handle or cover at the required frequency of irrigation), it is nc longer necessary for modern surface irrigation systems to be so confined.

Reblocking of existing fields into larger units will have advantages for future mechanized operations as well as irrigation. Large tractors used for plowing, subsoiling and other preparation tasks need long runs with a minimum of turning for greater and justifying productivity. The recovery of cane tops and dry leaves (barbojo) will need mechanized equipment for low-cost pick-up and transport of this bulky material, and large-area field blocks can increase machine performance and lower costs.

Drip irrigation systems are more efficient in large blocks of 200 acres or more, to reduce the capital requirements per acre for water treatment and filtering. Consolidation of small field blocks will therefore be necessary in their redesign for drip irrigation.

Eventually, the harvesting of unburned cane will have to be mechanized, as the volume of material will become too great for future availability of manpower for manual cane cutting. Labor for cutting cane is already in short supply, and rates of pay favor burned cane over unburned due to productivity differentials. When rates are increased for unburned cane, mechanization will be more economical. Field layouts will need to be designed for this eventuality as well.

Land Clearing and Tillage

On twenty (20) percent of Clarendon Sugar Company lands, preparation and plowing is done each year with appropriate equipment to achieve good tilth

necessary for roots to grow down 1.5 feet [45 centimeters] below the surface of the soil. The initial breaking operation on old ratoons is done crawler tractors (200 hp) drawing disk plows and followed by ripping on heavy lands only (2 passes). Two heavy disk harrowings are done by four wheel drive tractors (225 hp), followed by levelling, final harrowing, land-planing, and creation of furrows by "mid-busted" ridging.

Ratooning

On 14,800 acres [6,000 hectares] of Clarendon Sugar Company lands each year, preparation of stubble cane left after reaping or seed-cutting is done to enable regrowth of stalks from old root systems underground. Subsoiling between cane rows to at least 12 inches [30 centimeters] of depth, with two pairs of chisel knives spaced on the toolbar so that cane stools are pared to 75 percent of their normal width, aerates the roots, improves drainage, and alleviates harvest compaction. Reforming ridges and moulding to build up cane rows creates furrows for irrigation lines of the surface system.

Varieties

Performance-selected sugar cane varieties for multi-purpose planting, to produce cane energy as well as sugar and fermentable solids, will include the following recommendations of SIRI, derived from empirical data obtained in field testing:

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- BJ7015 - Currently accounting for 22 percent of the 1986 crop, and expected to expand to even higher percentages over the next five years as an outstanding producer.

- BJ7452 - Newly recommended and expected to increase to over 30 percent of plantings over the next five years.

- BJ7132 - Multi-purpose cane that retains its dry leaf matter on the stalk, ideal for one-pass mechanized harvesting of cane/barbojo.

Other varieties currently cultivated are expected to decline in production, as they were selected for interim needs after smut and rust diseases decimated the former major varieties. Imported varieties from offshore have fallen prey to Jamaican pathogens.

Seed Cane Production -- Cutting, Treatment & Transport

On 750 acres [304 hectares] of Clarendon Sugar Company lands each year, nurseries of varieties desired for the following year of scheduled planting are set aside as Seed Farm areas for optimum growth of seed cane under controlled conditions, to ensure that the required seed supply for planting will be available. Treating the seed cane after cutting with "Benlate" or a similar fungicide will improve the percentage of germination for more complete stands of plantcane.

Drainage

After reaping of mature cane, drain ditches and facilities need cleaning out with backhoe machines, to enable excess water to drain away from the cultivated fields, and maintain the water-table depth to no less than three feet [one meter] below the surface of the soil in the fields. Deep drains surrounding the fields need to be maintained for profound drainage drawdown of the water table.

Weed Control

Spraying the general pre-emergence application of Gesapax 500, Actril'ds, and sticker combinations is the usual practice. For the drier areas of the sugar cane plantation, Gesapax 500 is reduced and Karmex added. Application with tractor or knapsack is done according to field layout, after moulding operations are finished about two weeks after planting, or immediately after knifing of ratoons.

For general post-emergence weed control, spraying is done with knapsacks after fertilization, using Karmex in combination with Gesapax 500 and Actril'ds sticker. For hybrid pangola grass (Andropogon sp.), either Daconate (MSMA 6.5) or Talent is used, or a combination of Daconate with Talent together with Actril'ds and a sticker. Mechanical weeding is done with hi-clearance tractors about six weeks after planting.

The leaf canopy is closed-in at 5 to 6 months age of the cane.

Planting

On twenty (20) percent of Clarendon Sugar Company - lands, varieties desired each year for harvest in the following year will be planted to replace lower yielding varieties in the third and fourth ratoons.

Three tons of seed per acre are to be planted on middle-busted banks spaced at 5 feet [1.5 meters] in width. Cane is to be planted in shallow furrows made by moldboards. On heavy land three main furrowers will cut irrigation and drainage inter-row furrows, while smaller furrowers between them cut the planting furrows located on top of the ridges (middle-busted banks). Cane is to be planted by dropping whole-stick seed stalks into three adjacent furrows, chopping them manually into 3-node setts, and aligning them with the correct amount of overlap (i.e., overlapping the segmented seed stalks 50 percent as asexual "seed" pieces). Planted cane will then be covered with a disk hiller towed by a wheeled tractor (45-hp) set to work the same number of rows as the planting furrower. Final molding is to be done at 12 weeks of age, using a high-clearance tractor.

Replant(1)

On 14,800 acres [6,000 hectares] of ratoon cane in company fields, gaps of 5 feet [1.5 meters] or more

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Footnote:

(1) Replanting is the practice of planting "seed" cane pieces to fill-in gaps in the cane lines where the ratoons do not regrow.

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in the stand of ratoon growth will be replanted, to enable cane growth to close-in with a minimum of blank spaces that allow sunlight to reach the ground. Checking of plantcane for germination failure problems will indicate where replanting is needed.

Fertilization

Based on soil analysis, about 800 acres [324 hectares] require a mix of NPK fertilizer. New plantings receive two applications of ammonium sulphate at 300 lb/ac. [336 kilograms per hectare] for a total of 126 lb/ac. [141 kg/ha] of nitrogen.

Ratoon fields are given a single application of ammonium sulphate at 500 lb/ac. [560 kg/ha] for a total of 105 lb/ac. [118 kg/ha] of nitrogen. Fertilizer is banded at 6 weeks of age, followed by a light molding operation.

Irrigation

Immediately after planting seed cane, and at intervals of three weeks thereafter until rainfall is adequate for soil moisture to be maintained, irrigation of each line of cane with three-inch to four-inch [7.6 to 10.2 cm] applications of water is necessary under normal conditions. Ratoon fields need to be irrigated as soon as possible after reaping, when furrows are restored, so that replanting can be performed in moist conditions.

Operation of drip irrigation systems to maintain the ideal Soil Moisture Storage levels will be controlled by pan evaporation estimates of crop demands, plus leaching factors appropriate to the salinity of the water.

Pest Control

The most serious pest is the stem borer (Diatraea saccharalis), which is controlled biologically by a parasite (Apanteles spp.); the propagation of this parasite is managed by SIRI. Periodic outbreaks of cane fly (Saccharosydne saccharivora) are readily controlled by spraying malathion or fenitrothion, by aircraft or mist sprayers. This control procedure is required on 1000 acres per year, more or less.

Some evidence of smut (Ustilago scitaminea) and rust (puccinia melanocephala) in older varieties suggests no threat to cane production of newer resistant varieties that have brought these diseases under control. Rogueing out (i.e., manually removing and destroying the root stumps) mixtures of older varieties in new plantcane stands will minimize the incidence of smut and rust diseases.

Ripening Mature Fields

Dry-Off Time--Better yields are usually obtained when there has been little or no rain or irrigation applied in the six weeks prior to reaping. Heavy rains in the mid-season of harvesting depress the sugar content of the cane for five to ten weeks subsequently.

Chemical Ripener/Dessicant--Application of glyphosate to mature fields six weeks prior to reaping will improve the quality of cane, especially in the early months of the season.

Harvest and Transport

All company cane close to the mill will be reaped green (without burning), hand cut and grab loaded. Cane tops and dry leaf trash (barbojo) left infield will be picked up a few days after the cane reaping operations. Residue left after recovery of barbojo will be left unburned as mulch for the subsequent crop.

Standardized transport units must be employed for efficiency of unloading at the millyard. Each unit must be weighed upon entry to the millyard, and the tare weight taken upon departure. Farmers' cane is to be consolidated at transfer stations, for transport to the mill in larger units of comingled small loads, after weights are recorded.

Crop Control and Research Program

Scheduling of fields for reaping at the proper age of maturity is essential for maximizing yields, and control of the actual harvesting must be done as well to ensure that the schedule is followed. Shortages of loading and transport machinery cannot be the constraining determinants for the proximity of the harvest field from the mill. The proper sequence of fields must be determined by their age, maturity, and subsequent cycle of renewal planting,

whether scheduled for spring or fall start in the following crop. Dry-off schedules and ripening chemical applications require testing of field maturity with tissue sampling and analysis for proper control of reaping. Quality control of cane arriving at the Factory requires sampling for assessment of extraneous matter (non-cane material) as well as degree of freshness or souring related to the sucrose purity of the cane juice.

Irrigation control is essential for achieving maximum efficiency in the use of limited water resources. Wastage of water by over-irrigation must be curtailed by scheduling proper intervals of wettings based upon consumptive use through evapotranspiration, effective rainfall and soil moisture storage.

Fertilization specifications should be tailored to fit soil analyses obtained at the beginning and ending of each crop, and applications correlated with growth assessment measurements taken every four weeks starting at eight weeks of age, with nutrient uptake verified by leaf tissue analyses every four weeks from twelve to twenty-eight weeks of age.

Detailed records of individual field performance are necessary to relate yields of cane and sugar with various inputs of fertilizer, irrigation, cultivation and varietal interactions for total biomasss, fiber and fermentable sugars.

Climatic data related to growth and irrigation requirements must be collected and analyzed for

changes that may need to be made with respect to inputs of fertilizer and water.

The local research program will be directed toward identifying techniques necessary to fully utilize the agricultural resources of the company and cane farmers' lands, primarily the soils, climate and water supply.

As newer varieties are introduced into cultivation, field trials initiated by and conducted with SIRI on a continuing basis are needed to evaluate cultural practices of tillage, drainage and irrigation systems, fertilization schedules, control of pests, weeds and diseases, related to the propagation and evaluation of newer varieties.

Mechanization of field operations will require trials of new cultivation systems to determine their compatibility with existing systems, or the need to adapt cultural practices with respect to the proposed mechanization, with guidance from SIRI.

Replicated variety trials should be planted in six or seven field locations each year to obtain empirical data for evaluation of newer seedlings "best fit" to ecological zones.

Mechanized Operation

Field operations have become increasingly automated and the trend is expected to increase as onerous manual tasks are mechnized, because cost-effective hand labor is not available. With the eventual

mechanization of reaping, the repair and maintenance facilities (Agricultural Workshops) of an operation can become very important to its success or lack of profitability. The Clarendon operations are, and will be, no exception to this experience.

The current equipment and facilities have been reviewed by the Rehabilitation Project for adequacy in responding to the current vehicle and equipment upkeep requirements. Future mechanization of sugar cane operations, including cane trash (barbojo) recovery, will require very careful, advance review to assure proper support for the machine systems purchased.

Installation of Irrigation Improvements

In order to assure a stable supply of cane from company lands, irrigation efficiencies should be improved for more effective application of water to meet the peak demands of the crop. Analyses of water supplies and crop demands show that efficiencies of 62 percent overall are necessary to meet peak demands without excessive depletion of underground aquifers. Infield water application efficiencies must exceed 65 percent, when averaged with delivery efficiency of 95 percent, in order to achieve overall efficiencies above 62 percent.

Surface irrigation efficiencies currently are less than 40 percent. Improvements to furrow irrigation systems can raise this average to 55 or 60 percent, but a higher order of technology is needed to meet the essential crop requirements. Drip irrigation

can satisfy 90 percent of the crop's peak requirements with efficiency of 85 percent or more. Thus, better cane growth can be maintained with less pumping of the aquifer, because the water applied is used more effectively with less wastage.

Saline soil conditions will also benefit from drip irrigation, as the water is to be applied directly into the root systems, 8 inches [20 cm.] below each row of cane. Salt accumulations will be flushed away from the root zone into the inter-row space, where evaporation will draw the salts to the surface for rainfall to wash them away to the field drains.

Base Case Production (742,050 tons/year) - Matching the water supplies to the crop demands with the desired efficiencies requires that 52 percent of the Clarendon Sugar Company land be converted to drip irrigation, (up to 7,900 acres [3,200 ha]). This area includes 4,700 acres [1,900 ha] of the former Monymusk estate, 1,200 acres [490 ha] of Waterwell estate, and 2,000 acres [810 ha] of Parnassus Estate lands currently idle. Cane yields are estimated at 36 tons [90 tonnes per hectare] per acre per year (43 TCA [108 tonnes/ha] on plantcane, 35 TCA [88 tonnes/ha] on ratoons) based on data from SIRI trials by Patel and Shaw (1978) at Monymusk and Bernard Lodge. Parnassus lands are expected to average 40 TCA [100 tonnes/ha] per year with more favorable growing conditions. (Capital requirements would total US$8,900,000. See section 9.)

TABLE 8-1

BASE CASE (742,050 TON CROP)

Systems	Hectares	Acres	TCA	Tons Cane	MT/ Ha
Drip					
- Parnassus	810	2,000	40.0	80,000	100
- Waterwell	490	1,200	36.0	43,200	90
- Clarendon Sugar	1,900	4,700	36.0	169,200	90
- Sub-total	3,200	7,900	37.0	292,400	93
Furrow					
- Clarendon Sugar	2,960	7,300	25.0	182,500	63
- Sub-total	6,160	15,200	31.2	474,900	78
- Innswood Estate	1,900	4,700	28.5	133,750	71
- Sub-total	8,060	19,900	30.6	608,650	77
Cane Farmers	1,860	4,600	29.0	133,400	73
- Grand Total	9,920	24,500	30.3	742,050	76

Best Case for Maximum Production (850,000 tons/year) - To increase annual cane production to 850,000 tons per year, additional installations of drip irrigation are necessary to increase average yields, as shown in Table 8-2 (Capital requirements would total US$22,200,000. See Section 9).)

TABLE 8-2

ALTERNATE CASE (850,000 TON CROP)

Systems	Hectares	Acres	TCA	Tons Cane	MT/ Ha.
Drip					
- Parnassus	810	2,000	40.0	80,000	100
- Waterwell	490	1,200	36.0	43,200	90
- Monymusk (highlands)	1,900	4,700	36.0	169,200	90
- Monymusk (lowlands)	2,960	7,300	34.0	248,200	85
Sub-total	6,160	15,200	35.6	540,600	89
Drip					
- Innswood Estate	1,900	4,700	36.0	169,200	90
Estate Total	8,060	19,900	35.7	709,800	89
Cane Farmers	1,860	4,600	30.5	140,200	76
Grand Total	9,920	24,500	34.7	850,000	87

8.2 CANE TRASH (BARBOJO) PRODUCTION

The Cane/Energy Project proposes to commercialize, for the first time, the use of solar dried, sugar cane tops and leaves (barbojo) as a boiler fueling source. Barbojo is to be routinely recovered from certain sugar cane fields, following their reaping, from areas nearby the Monymusk Factory that are administered by Clarendon Sugar Company (CSCo.). These certain CSCo. fields are to be selected to be manually reaped, without first burning-off the cane trash, so that barbojo can be raked into windows, further sun dried and then gathered by a custom-designed cane trash (barbojo) compactor/baler for movement to a storage area prior to furnace preparation and use as a biofuel.

Cane trash (barbojo) will require field drying to a moisture content below 35 percent to enhance its calorific value and assure its non-flammable storeability. It is anticipated that upon shredding, the furnace prepared barbojo may be about 25 percent in moisture content and represent a displacement of approximately a barrel and a half of fuel oil per ton of barbojo.

The proposed barbojo scheme is to use this supplemental biofuel during the "off-crop" period when bagasse (i.e., the fibrous residue of sugar cane processing) is not available. Both bagasse and barbojo firings are to be augmented by No. 6 Fuel Oil (Bunker Oil) throughout generating operations in this proposal.

Ultimately, substantial barbojo collection could nearly double the biofuel recovered, on a calorific basis, from a sugar cane cropping for use in a cogeneration scheme. This level of biofuel supplies, bagasse and barbojo, could reduce the requirement for No. 6 Fuel Oil to a minor augmenting role throughout the scheduled generating period.

In this initial commercial undertaking of baled cane trash (barbojo) recovery for deferred biofuel use in 1990, a conservative barbojo production estimate of ten (10) percent of the total cane tonnage produced annually is used (approximately 74,000 tons or 148,000 bales of barbojo at thirty-five percent moisture or less). At this level of recovery, forty (40) percent of the theoretical amount of cane trash (barbojo) available for recovery, leaves sufficient allowance to recover only from carefully selected fields. That selection can be made on crop cycle, field layout, varietal, surface condition and transport distance considerations. In the best case forecast at a maximum sugar cane production level of 850,000 tons per year, the barbojo recovery estimate is increased to sixty (60) percent of the theoretical amount of cane trash (barbojo) that is practically available for recovery and use; that annual production is estimated at 127,500 tons of baled cane trash (barbojo) or approximately 255,000 bales, at field moistures of less than thirty-five percent, for production beginning in the early 1990's.

The estimated capital and operating costs of the proposed cane trash (barbojo) recovery systems for the forecasted levels (i.e., Level A - 74,000 tons

and Level B - 127,500 tons) of production are as follows (see Section 9 for details)

CAPITAL REQUIREMENTS

LEVEL A - U.S.$ 1.2 MILLION
LEVEL B - U.S.$ 1.5 MILLION

ANNUAL OPERATING COSTS

	US$/Year	US$/Ton (Wet Weight)
LEVEL A	765,000	10.34
LEVEL B	1,080,000	8.47

Follow-on recovery system development is recommended during the project development phase in 1987 and 1988 to assure prompt commercialization of this biofueling process. This development is required in order to supply the target amounts projected in mid-1990, just three harvest campaigns away.

The development of an interim recovery process to direct-feed, forage chopped barbojo, as is now practised to the level of 28,000 tonnes production per year at Central Romana in the Dominican Republic, should be developed to marginally supplement (10 percent) the bagasse supplies in the immediate displacement of purchased No. 6 Fuel Oil. The chopped barbojo recovery system, without a significant storage capability, may be financially attractive up to the point that direct supplementation of bagasse supplies exceeds the biofuel requirements to produce the desired levels

of steam and electricity. At that point of bagasse production, displacement of No. 6 Fuel Oil supplies may become more cost-effective through a baled storage strategy that makes it available for off-harvesting periods.

In addition to the priority development of new machinery systems for cane trash (barbojo) recovery, the socially significant change in hand harvesting practice in Jamaica that will be brought about by saving cane trash (barbojo) rather than field burning it prior to reaping will take a number of years to carefully effect on the scale required (8,000-9,900 acres [3,240-4,010 ha.] per year). This field practice change will also require careful evaluation of the timing of the introduction of mechanical harvesting techniques to reduce the onerous and heavy field work of hand reaping.

8.3 CANE PROCESSING

The targeted production and process efficiency that was set by the Jamaica Sugar Holdings Limited (JSH) Corporate Plan 1984-89, Volume III, December, 1984 has been also adopted as the Base Case for this project. The physical connection of the two projects would be made in mid-1990 and the processing objectives as shown below for the Rehabilitation Project in its fifth and final year are expected to be accomplished in the harvest campaign of 1990-1991. (Alternative 1, Base Case, see pp. 4 JSH Corporate Plan, Volume III)

Category	Target	Unit
Overall Time Efficiency	75	%
Grinding Rate(1)	200	tph
Cane Potential	742,050	Tons
TC/TS 96 degree(2)	10.8	Ratio
Ton 96 degree Sugar	68,700	Tons
Standard Factory Efficiency	90	%
Tons Molasses	29,682	Tons
Operating Days	206	Days

Footnotes:

(1) tph - tons per hour grinding rate.
(2) TC/TS 96 degree - a cane quality ratio of the tons of cane to produce a ton of 96 degree sugar.

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Sugar cane processing operations have been carefully reviewed for the three cases (i.e., Base Case - 742,050 tons of cane per year, Low Case - 600,000 tons cane per year and a Best Case scenario of 850,000 tons cane per year). Operating and capital improvement cost estimates have been made (see Section 9.0) to reflect the impact of these production levels. Operating costs are largely fixed costs and vary only in relation to certain materials and supplies that are consumed as a function of through-put.

Capital improvements to the factory, beyond the Rehabilitation Project, in response to increasing production efficiency and through-put above 742,050 tons of cane per year, plus facilitating increased exported energy sales by steam economies in the crushing plant/boiling house and biofuel storage and handling facilities have been identified and estimated. These improvements will require further detailed engineering and justification during this project's developmental phase.

8.4 STEAM AND ELECTRICITY

General

The proposed cogeneration plant will provide process steam to the mill turbine drives and to the sugar processing facility, as well as generating electricity for use in the plant and for sale to Jamaica Public Service Co., Ltd. (JPS). This mode of operation will occur during the cane harvesting season of 206 days each year. The primary fuel burned in the new boilers will be bagasse. No. 6 Fuel Oil will be an augmenting fuel to the bagasse and be fired simultaneously to assure the maximum output of process steam and electrical generation. Cane trash (barbojo) may be used to supplement the supply of bagasse and thereby displace a portion of the fuel oil requirement. When the mill is not in operation during the harvesting season, such as on Sundays and holidays, the boiler will burn No. 6 Fuel Oil as the primary fuel, after bagasse and barbojo from the bagasse storage house have been consumed.

During the "off-crop" period or off season, the cogeneration plant will provide electricity for sale to JPS when not shut down for its annual scheduled maintenance. The primary fuel burned during the off-season will be cane trash (barbojo) which has been accumulated during the cane harvest season for deferred combustion. No. 6 Fuel Oil will be an augmenting fuel, to be burned only after the biofuels have been consumed.

Expected Availability

The North American Electric Reliability Council (NERC) data base for the period 1973-1982 for units sized in the range of 1 to 99 MW has been reviewed to determine the probable availability of the cogeneration plant. The NERC Generating Availability Data System (GADS) presents statistical information obtained from the United States electric utility industry based on historical performance of generating plants. The statistical information is arranged by the size and major types of generating units and their major component groups.

GADS data sets for fossil units are separated by type of primary fuel. The fuel contributing the greatest number of Btu's is generally reported as the primary fuel. The U.S. electric utility industry does not use bagasse as a primary fuel. For establishing the availability of this plant, the GADS data for fossil units with coal as primary fuel is presented.

The performance measures of interest for this evaluation were scheduled outage factor (SOF), forced outage rate (FOR), and equivalent forced outage rate (EFOR).

The averages for fossil units (coal primary) in the range of 1 to 99 MW are presented below:

Scheduled Outage Factor	-	9.9 percent
Forced Outage Rate	-	5.8 percent
Equivalent Forced Outage Rate	-	8.0 percent

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Over ninety percent of the units reporting to NERC in this size range have been operating for over twenty-five years. The scheduled outage rate of 9.9 percent is equivalent to 36 days and the equivalent forced outage rate of 8.0 percent is equivalent to 29 days. For this evaluation, it is assumed that the scheduled outage for maintenance will be 42 days (seven weeks) and that the equivalent forced outage will be 30 days. This cogeneration plant will operate at lower pressure and temperature than utility boilers in this size range. Burning of bagasse in a boiler may be as severe as burning coal. It is anticipated that the equivalent forced outage rate for bagasse boilers should be better than for coal fired plants.

The assumed annual operating plan for the cogeneration plant is as follows:

Plant scheduled outage	-	42 days
Plant scheduled operation	-	323 days
Plant capable of full operation	-	273 days
Plant capable of half operation	-	40 days
Plant inoperable	-	10 days
Equivalent forced outage rate	-	30 days

Operation during the 35-week cane harvesting and processing season is assumed as follows:

Days at:	Full Load	Half Load	No Load
Weekday	148	22	5
Saturday	30	4	1
Sunday	30	4	1

Bagasse is burned on weekdays and Saturdays only. The Factory does not operate on Sundays. Operation during the eleven-week off-crop period that utilizes baled cane trash (barbojo) as a primary fuel is scheduled as follows:

Days at:	Full Load	Half Load	No Load
Weekday	47	7	2
Sat & Sun	18	3	1

Plant Performance

Steam Production - Maximum annual steam produced from the two new boilers is calculated on the base operating plan discussed above. Both boilers simultaneously will be available for 273 days per year and one of the two boilers will be available an additional 40 days per year. Total annual steam production for this operation scenario is 2,321 million pounds per year. The steam is used within the sugar factory and power plant for generation of electricity. The steam generation capacity factor is 80.3 percent (of full capacity operation for 365 days per year).

Electric Power Production - The cogeneration facility will provide process steam to the mill turbines and the sugar processing whenever the mill is in operation, as well as generating electricity during the sugar cane harvesting and processing season. Based upon the 35-week harvesting campaign and no mill operation on Sundays, process steam will be provided from the new boilers 206 days per year. Two-boiler operation is forecasted for 178 days and one new boiler will be in operation for 26 days.

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Electrical generation available for sale to JPS (and to the sugar company) is 19,640 kW for two boilers and 6,860 kW for one-boiler operation during the cogeneration mode of operation.

The cogeneration plant is forecasted to operate 109 days a year as an electrical generation facility only, without any process steam supplied to the sugar factory. During this mode of operation, approximately 32,250 kW (net) are available for sale with two new boilers and 14,690 kW (net) with one new boiler in operation. Two boilers will be available for 95 days and only one new boiler available for 14 days of the year.

Annual electrical generation available for sale to JPS and the sugar company is 171.1 million kWh. This is based upon the scenario of expected availability presented above, and preliminary performance curves developed by selected turbine generator manufacturers.

Fuel Consumption - The bagasse available each week for 35 weeks for fuel is approximately 5,800 tons; based upon a total production of 742,050 tons of sugar cane during the harvesting season. Annual bagasse burned in the new boilers will be approximately 203,300 tons.

Annual barbojo available for primary off-season fuel is 74,000 tons based upon the assumption that 10 percent of the annual production of sugar cane can be recovered as baled cane trash (barbojo) from selected fields. By the time cane trash is used in

the boilers, its moisture content can be reduced to 25% and its weight may be reduced to 66,500 tons. All of the barbojo available is assumed to be burned in the two new boilers.

The third fuel used in the boilers will be No. 6 Fuel Oil, which will be fired as an augmenting fuel with the bagasse or barbojo, and as a primary fuel when the biofuels are not available. Annual consumption of No. 6 Fuel Oil in the new boilers will be approximately 134,900 barrels in the Base Case.

In summary, annual fuel consumption based upon the mode of operation for the Base Case described above will be as follows:

Fuel	Quantity per year	Percent of Heat Input
Bagasse	203,300 tons	51
Cane trash (Barbojo)	74,000 tons	24
No. 6 Fuel Oil	134,900 barrels	25

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9.0 PROJECT COSTS

The development of the capital and operating costs were based on the facility descriptions (Section 5) and operation plans (Section 8). The capital cost for the estate and factory include only the investments required in addition to the expenditures under the World Bank's Jamaica Second Sugar Rehabilitation Project. All costs are in 1986 US Dollars and include a contingency.

9.1 SUGAR COMPANY OPERATING COSTS

The projection of financial results required the use of operating and capital cost assumptions for the operation of the factory and estate with no further alterations beyond the Second Sugar Rehabilitation project (to obtain a base case scenario and to provide a context within which to observe the effects of any proposed or projected changes), and also required the development of new cost estimates to reflect the consequences of improved or expanded operations. Most operation and capital costs were derived from the Tate & Lyle Technical Services (TLTS) prepared JSH Corporate Plan (Dec. 1984) or on recent updates of that plan obtained from the Sugar Industry Authority (SIA) or Price Waterhouse (who prepared much of the financial data presented to the World Bank for the Jamaica Second Sugar Rehabilitation Project loan request). This chapter discusses the source and magnitude of those cost estimates not taken directly from that plan.

Operating Expenses

As mentioned above, most operating expenses were taken directly from the JSH Corporate Plan or subsequent revisions to that Plan, and many others were derived from information contained in the Plan and its revised worksheet. Significant changes to the basic operating expenses are discussed below.

Agricultural Operations

Irrigation Pumping Power Costs - Drip irrigation does result in more efficient application of water to the cane plant, and in situations where the total water supply is adequate to meet demand this can result in reduced pumping and lower costs. However, at Clarendon, there is an almost constant state of deficit during the period when pumping is now occurring, so increased application efficiencies will have the effect of increasing yield rather than reducing pumping costs.

The price of electrical power was, however, revised to reflect current reduced power costs resulting from lower fuel prices. The effects on power costs of both an integrally owned and operated cogeneration plant, and the price to be charged by an independent, free-standing cogeneration operation are detailed in Table 9-1.

TABLE 9-1

ELECTRIC POWER PRICES AND COSTS

Situation	Power Price USCents/KWH	Total Power Costs (US$000)
Power purchased from JPS	10.3	US$1,259
Factory-operated Cogeneration plant	9.0	1,100
Independent Cogeneration plant at production of:		
600,000 tons	6.44	787
742,050 tons	6.28	768
850,000 tons	6.28	768

Harvesting and Hauling Operations - These costs were considered to be variable with cane production; since the cost projections in this analysis considered three alternate different levels and schedules of increased production, harvesting and hauling costs varied from year to year with each scenario, depending on the amount of Clarendon Sugar Company cane produced. The Price Waterhouse data, from which these costs were projected, showed a cost of harvesting of US$1.00 per ton and a Loading & Transport cost of US$0.96 per ton; these rates were applied to the annual tons of cane in each case (after the completion of the improvements included in the Rehabilitation Project).

Cane Trash (Barbojo) Operations - Collection, transport, and storage of barbojo are described in a Section 8.2 of this report. The costs of this operation have been synthesized from the description of the proposed operation plan, and are shown in Table 9-2 for a barbojo production level of 74,000 tons on a wet-weight basis at 35% moisture.

TABLE 9-2

CANE TRASH (BARBOJO) PRODUCTION COSTS
(INITIAL LEVEL)

ITEM	COST (US$/year)
Harvest Impact	200,000
Raking	44,000
Baling	76,000
Transport	182,000
Storage	53,000
Reclaim	35,000
Shredding	75,000
Contingency 15%	100,000
TOTAL	$765,000
Estimated Cost/Ton	$ 10.34

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As mentioned, these costs were developed for a production level of 74,000 tons (wet weight) of barbojo, which is expected to be reached with cane production of 742,050 tons. At a cane production level of 850,000 tons, barbojo production is expected to increase to 127,500 tons(wet weight), the cost of production will increase proportionately to $1,080,000.

Raw Sugar Operations

Unloading Operation - These costs were considered proportionate to cane production. A rate per ton of cane was derived from the JSH Corporate Plan revised data and applied to the appropriate cane production levels. The rate applied was US$0.10 per ton.

Bagasse Boilers and Power Plant - Since these operations were to be the ones replaced by the proposed cogeneration plant, they were closely studied and a detailed set of costs were synthesized. Appendix Exhibit 11-21 shows the resulting costs for the Boiler and Power Plant; in addition, an annual operating cost of US$54,000 was calculated for the fuel storage (bagasse house) operation. The boiler and power plant cost were considered to be totally eliminated when the proposed cogeneration plant began operations, but the bagasse house costs were considered to continue unchanged.

Processing - The production cost of sugar in a given factory, once the processing capacity of the factory is fixed and operations are stable, is relatively

insensitive to variations in production volume (especially if the harvesting season remains unchanged in length). However, there is some variation in materials used; this is reflected by changes in process costs derived from the JSH Corporate Plan. After production stabilized at the anticipated rates of 600,000 tons, 742,050 tons, or 850,000 tons, process costs were assumed to be US$363,000 per year, US$460,000 per year, or US$534,000 per year, respectively. The base level of US$460,000 per year was taken from the JSH Corporate Plan, and the variation of US$0.68 per ton was derived from an analysis of the cost of materials involved.

Cane Purchases - Purchases of cane from the administation and from farmers were projected at the same level as contained in the JSH Corporate Plan (revision referred to previously). Appendix Exhibit 11-22 shows the schedule and amounts paid.

Cane trash (Barbojo) - The cost of barbojo to the cogeneration plant was assumed to be US$12 per ton, to be paid to agricultural operations. The actual cost of collecting and transporting the barbojo is derived in detail in Table 9-2. This table shows the total cost of 74,000 tons of barbojo as US$765,000, or US$10.34 per ton. The cost of 127,500 tons is US$1,080,000, or US$8.47 per ton.

TABLE 9-3

COGENERATION PLANT
OPERATING COSTS SUMMARY
(ALL COSTS IN THOUSANDS US$)

1. Fixed Costs		
a)	Supervision and Technical Payroll	$ 240
b)	Labor (Manual) Payroll(3)	120
c)	Administrative and Indirects	225
d)	Insurance (includes Business Loss and OPIC)(8)	700
	Total	$1,285
2. Variable Costs		
a)	Maintenance Materials and Tools(2), (5) (6)	$ 290
b)	Consumables(1), (4), (7)	240
	Total	$ 530
	Sub Total	$1,815
3. Contingencies, Fees, etc. (10%)		185
		$2,000

Footnotes:

(1) Consumables costs assume US source pricing.
(2) Spare Part costs are included in the Maintenance Material costs. All spares are assumed to be imported.
(3) All Maintenance Labor costs are included in the Fixed Labor costs.
(4) All lubricants are included in the Consumables Variable costs.
(5) Capital Replacement costs are included in the Variable Maintenance costs.
(6) It is assumed that vehicles used during construction will be turned over to the plant owner at completion of construction. Replacement costs of vehicles are not specifically allocated in the above numbers.
(7) Fuel Costs Are Not Included.
(8) OPIC - Overseas Private Investment Corporation.

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Cogeneration Plant - Costs of operation for the cogeneration plant were estimated in conjunction with the detailed capital estimate discussed above and were used in the more complex escalated financial and economic analyses referred to previously. The costs of operation of the plant, exclusive of escalation, financing costs, and depreciation, were estimated as shown in Table 9-3 on the preceding page. These costs do not include the cost of barbojo or fuel oil. The fuel costs are based on the utilization summarized below in Table 9-4.

TABLE 9-4

FUEL SUPPLY
CANE PRODUCTION

	(Tons/Annum)		
	600,000	742,050	850,000
Bagasse (tons)	164,100	203,300	233,200
Barbojo (tons)	0	74,000	127,500
Fuel Oil (barrels)	287,750	134,900	23,460

Bagasse is to be provided at no charge. The cost of barbojo to the cogeneration plant is estimated at US$12 per ton. The fuel oil cost increases in real terms based on forecasts of crude oil prices per barrel to be US$18 in 1990, US$22 in 1995 and US$26 in 2000 and beyond. The fuel oil cost is estimated to be 85 percent of crude oil costs.

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Fuel Oil costs varied according to the amount of bagasse and barbojo available for power production; total costs were as shown in Table 9-5:

TABLE 9-5

Cane Production Tons Per Year	Oil Consumption (barrels)	Total Cost US Dollars
600,000	287,750	$4,316,250
742,050	134,900	2,023,500
850,000	23,460	351,900

Revenues

Agricultural Operations - Income to agricultural operations is derived from a portion of sugar and molasses returns, and from sale of barbojo in certain cases. Projections of sugar and molasses revenues were based on a recent revision of the JSH Corporate Plan, and are presented in detail in Appendix Exhibit 11-16. Barbojo revenues (when a cogeneration plant is in operation) are received at a price of $12/ton (field-dried weight)(See Table 9-6)

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TABLE 9-6

Cane Production	Barbojo Production	Barbojo Revenue
600,000 Tons	0	0
742,050 Tons	74,000 Tons	US$ 798,000
850,000 Tons	127,500 Tons	US$1,369,200

Raw Sugar Operations - Sugar and molasses revenues to Raw Sugar Operations are likewise projected from recent revisions of the JSH Corporate Plan, and are also shown in Appendix Exhibit 11-22.

Cogeneration Plant - Revenues to the cogeneration plant are derived from the sale of power to JPS, and depend both on the power available for export and on the assumed price received. Based on material and energy balances at various levels of operation, the revenues were assumed for a cogeneration plant operated as a part of the overall sugar factory operations as shown in Table 9-7:

TABLE 9-7

Cane Production	Available Power (MWh)	Power Revenue
600,000 Tons	158,976	US$14,307,840
742,050 Tons	145,241	US$13,071,690
850,000 Tons	138,367	US$12,453,030

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Capital Investments for Irrigation Improvements - Drip irrigation is proposed for increased yields to be achieved. The rationale and programming for this investment are discussed in more detail in Chapter 8.1; the actual capital investment used in the cash flow analysis is presented in Table 9-8:

TABLE 9-8

DRIP IRRIGATION CAPITAL

	742,050 Tons Cane			850,000 Tons Cane		
Year	Area Installed Acs.	Ha.	Investment (US Dollars)	Areas Installed Acs.	Ha.	Investment (US Dollars)
1989	2,000	810	$2,500,000	4,000	1,620	$ 4,700,000
1990	2,000	810	2,200,000	4,000	1,620	4,400,000
1991	2,000	810	2,200,000	4,000	1,620	4,400,000
1992	1,900	770	2,090,000	4,000	1,620	4,400,000
1993				3,900	1,580	4,290,000
Total	7,900	3,200	$8,990,000	19,900	8,060	$22,190,000

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Factory Improvements Capital - Further improvements to the factory beyond the program in the JSH Rehabilitation project were felt advisable to ensure continuity of operations and quality of performance. The capital investments included are shown in Table 9-9.

TABLE 9-9

FACTORY IMPROVEMENTS CAPITAL

	For All Cases		Additional for Production at 850,000 Tons Level
Year	Mill Foundations	Lab Equipment	Bagasse House
1988/9	US$ 299,189	US$ 17,918	US$ 362,882
1989/90	598,379	161,261	1,542,245
1990/1	1,097,029		
TOTAL	US$1,994,597	US$179,179	US$1,905,127

Footnote:

(1) These costs were based on engineering estimates for similar items at US prices, plus increases for exporting costs and local expenses.

Cane trash (Barbojo) Systems Capital - The system for collecting, transporting, and processing barbojo is explained in detail in Section 8.2. For those cases in which the barbojo system was assumed to be in operation (i.e., all situations with production greater than 600,000 tons of cane per year in which a cogeneration plant was operating) capital costs were included for the necessary equipment. These costs amounted to

US$1,190,000 at a production level of 742,050 tons of cane, and US$1,547,900 when production was 850,000 tons, as detailed in Table 9-10. Periodic replacement of the equipment was also provided for.

TABLE 9-10

BARBOJO SYSTEMS EQUIPMENT REQUIREMENTS

Item	Price (US$)	Number Required		Total Cost (US$)	
Production Level(1):		A	B	A	B
Barbojo Rakes	15,000	3	4	45,000	60,000
Barbojo Tractors	15,000	3	4	45,000	60,000
Compactor/Baler	90,000	3	4	270,000	360,000
Bale Loader	20,000	3	4	60,000	80,000
Infield Tractors	15,000	3	4	45,000	60,000
Transport Tractors	15,000	3	4	45,000	60,000
Trailers	10,000	24	36	240,000	360,000
Millyard Tractor	existing	1	1	--	--
Boom Crane	existing	2	2	--	--
Crane attachm't	5,000	1	1	5,000	5,000
Roofing				30,000	51,000
Stacker	existing	2	2	--	--
Shredder	250,000	1	1	250,000	250,000
Contingency	15%			155,250	201,900
TOTAL				1,190,250	1,547,900

Footnote:

(1) Production Level A - 742,050 tons of cane/year
Production Level B - 850,000 tons of cane/year

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Cogeneration Plant Capital - Investment in the cogeneration plant is developed in detail elsewhere in this report for use in the financial and economical analyses of the cogeneration plant as an independent operation. The costs developed for those purposes include the effects of escalation of costs and prices and of debt financing. The analysis discussed in this section exclude both these considerations; total cost of the cogeneration plant under these conditions is $47.7 million, with expenditures scheduled in Table 9-11.

TABLE 9-11

COGENERATION PLANT CAPITAL

YEAR	CAPITAL EXPENDITURE (US$MILLIONS)
1986/7	1.2
1987/8	8.4
1988/9	26.2
1989/90	11.9
TOTAL	US$47.7

9.2 CAPITAL COSTS

Cogeneration Plant Capital Costs

A capital cost estimate has been prepared for the cogeneration facility to be added to the Monymusk Sugar Factory. The estimate was developed from similar facility data resident in the Bechtel Historical Data Base, and from the plant conceptual design information developed as described in Section 5.3.

The estimate is summarized in Table 9-12 (on the following page).

The estimate allows for the employment of Jamaican nationals for all craft services, and for 75 percent of the field management group. Approximately 95 percent of the craft work force and 75 percent of the field management force will be Jamaican. The total estimated cost for Jamaican labor is the equivalent of approximately four and one half million US Dollars. The foreign/local currency allocation further assumes procurement of any and all major equipment will be via the international market, with local procurement of consumable type materials.

The approximate split between foreign and local costs is 78 percent and 22 percent, respectively.

TABLE 9-12

COGENERATION PLANT
CAPITAL COST SUMMARY

(In Thousands of 1986 US Dollars)

Cost Category	Value in US$(000)
Boiler Island (excluding civil costs)(1)	$11,900
Turbine Generator	5,900
Other Mechanical Equipment	3,300
Civil/Structural/Architectural(2)	2,200
Piping(3)	3,600
Electrical and Controls(4)	5,900
Total Project Direct Costs	$32,800
Field Indirect Costs, Incl. Construction Management(5)	7,200
Total Project Field Costs	$40,000
Architect/Engineer Services	3,400
Project Insurance Allowance(6)	1,000
Total Project Cost, 1986 US Dollars(7)	$44,400
Owner/Operator Costs: Import Duties & Stamp Taxes	2,700
Initial Parts & Spares	200
Initial Fuel Supply	400
Total Capital Required (1986 US Dollars)	US$47,700

Footnotes:

(1) The Boiler Island account includes the installed costs for the project steam generation (i.e. two 1/2 size, stoker firing steam boilers) combustion air fans and fan drives, structural and miscellanous steel, boiler island piping,

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electrical wiring, and wire raceway, boiler instrumentation, flue gas particulate removal and re-injection equipment, and the plant stack. Installed costs for the turbine and generator, and associated auxiliary pumps, pump drives, reservoirs, and heat exchangers are included in the Turbine Generator account. The Other Mechanical Equipment account includes the installed costs for the main turbine steam condenser, condenser evacuation equipment, main boiler feedwater pumps and drives, other main cycle pumps and drives, main cycle heat exchangers, including the feedwater heating and deaerating vessels, and other miscellaneous equipment.

(2) Civil/Structural/Architectural accounts include those costs associated with site preparation and earthwork, concrete, siding, roofing, structural and miscellaneous steel (except in boiler area) and other miscellaneous architectural treatments and features.

(3) Bulk materials for piping, wiring, and wire raceways external to the boiler island are included in the Piping and Electrical and Controls Account.

(4) The Electrical and Control equipment, switchgear, motor control centers, control panels, and control valves and instruments are also included in the Electrical and Control account.

(5) Field Indirect costs include those costs for construction equipment rental and operation, construction utilities (water, electricity, and sewage), communications, consumables (fuels, lubricants), small tools and equipment, scaffolding, welder's qualification, surveying, support crafts, craft management and supervision, and project startup services.

(6) The project insurance allowance is an amount intended to cover the premiums associated with project efficacy and builder's all-risk insurance.

(7) The capital cost estimate represents current day (1986) project capital costs, excluding costs normally covered by the owner/operator. Those costs, however, have been included in the financial analysis and are identified in Section 11.

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10.0 ECONOMIC ANALYSIS

10.1 INTRODUCTION

This section presents the results of the economic analysis of the Jamaica Cane/Energy Project. An investment of the magnitude envisaged in this project requires analysis from two different points of view: financial and economic. The financial aspect of the analysis is concerned with the income and expenses of each of the entities associated with the project; namely, the estate, factory, cogeneration plant and the independent growers. For the project to be successful, these entities must be able to meet their financial obligations and earn a satisfactory return. The financial analysis is presented in Section 11.

The economic aspect of the analysis focuses on the effects of the proposed project on the nation as a whole. The resources used and the outputs obtained are valued in terms of their total effect on the amount of goods and services available to the nation, without regard to who pays the costs or receives the benefits. This aspect is of interest to the government and international institutions in considering the advisability of investing resources in the project.

In the economic analysis, the actual or "financial" prices used to estimate the project's costs and revenues were converted to "economic" prices. Economic prices for project costs were estimated by excluding all intra-Jamaica transfer payments, such

as import duties and stamp taxes, and interest payments, and by valuing labor at its opportunity cost. Product prices used to estimate project revenues were adjusted to reflect import or export parity prices.

The analysis was done on an incremental basis and assumes that the World Bank's Jamaica Second Sugar Rehabilitation Project will be implemented. As discussed in Section 8.1 it is assumed that the annual sugar cane output at the end of the Rehabilitation Project will be 600,000 tons of cane per annum. The analysis has been done for the 600,000 ton, 742,050 ton and the 850,000 ton cases and includes the incremental sugar company capital and operating costs necessary to achieve the higher tonnages. Therefore at the 600,000 ton case the capital and operating costs include only the cogeneration plant.

Financial capital and operating costs are summarized in Section 9.

Costs and revenues were distributed over time consistent with the implementation schedule in Section 7.

The factors taken into account in converting financial to economic prices are discussed in Section 10.2. The adjustments to the capital costs, operating costs, and revenues are discussed in Sections 10.3, 10.4, and 10.5, respectively. The results of the economic analysis and sensitivity tests are presented in Section 10.6.

10.2 CONVERSION TO ECONOMIC PRICES

Foreign Exchange

The exchange rate used in the analysis is US$1.0 = J$5.5. This rate approximates the actual rate during the analysis period as established at the Bank of Jamaica auctions. All revenues and costs are expressed in constant 1986 US Dollars.

Customs Duties and Stamp Taxes

All payments for customs duties, surcharges, and stamp taxes have been excluded from the cost of imported goods as well as from the estimated import content of local goods. Imported goods are subject to duties of 0 to 75 percent and stamp taxes of 6 to 95 percent. The import content of local goods was estimated at 35 percent, based on studies by the Planning Institute of Jamaica (PIOJ). However, a study for PIOJ estimated that the average effective import duty and stamp tax in 1985 was only 11.5 percent. It was assumed, based on the same study, that by 1990 the average effective rate will be 25 percent; thus, 9 percent was deducted from the cost of local goods (0.25 x 0.35 x 100 = 8.75%; say 9%).

Other Taxes

All company and additional profits taxes were excluded.

Income taxes of 33 percent incorporated into the wages paid were subtracted from the cost of skilled

labor. The income tax was based on the current proposed tax system. Other taxes also excluded were National Housing Trust Contributions, education taxes, and HEART (Human Employment and Resource Training) contributions totaling 10 percent of the wage bill.

Government taxes of 38 percent and 55 percent of diesel fuel and gasoline sales prices, respectively, were excluded. The taxes were estimated based on the forecast crude oil price and the assumption that the GOJ intends to maintain constant retail prices and constant margins for marketing, transport, and dealers with the tax as the difference. Estimates of the various margins were obtained from the Petroleum Corporation of Jamaica (PCJ) and the average crude oil cost component of ex-refinery price from PIOJ's input-output model data.

Interest Payments

All interest payments including interest during construction, and interest payments on operating and long-term loans were excluded.

Wages

Wages after income taxes for skilled labor were valued at 100 percent of market rates. Wages for unskilled labor were valued at 50 percent of market rates. This illustrates the opportunity cost of unskilled labor indicating the ready lack of alternative sources of employment in the project area. These estimates are within the range of estimates used in other recent analyses as summarized in Table 10-1.

TABLE 10-1

ECONOMIC WAGE AS PERCENTAGE OF MARKET WAGE

	Administrative Staff College (1)	MONENCO (2)	World Bank (3)	USAID (4)	Tate & Lyle (5)
Unskilled labor	50	100	50	25	75
Skilled labor	80	100	100	100	75

Footnotes:

(1) National Economic Parameters for Jamaica, Oct. 1984
(2) Jamaica Public Service Corp. Least Cost Expansion Study, August 1985.
(3) Jamaica Second Sugar Rehabilitation Project, Staff Appraisal Report, Dec. 1985
(4) Cane Production for Sugar and Electric Power in Jamaica, Oct. 1984
(5) Jamaica Sugar Holdings Ltd., Corporate Plan 1984-89, Dec. 1984

10.3 CAPITAL COSTS

Conversion factors were estimated to convert financial capital costs to economic costs, based on the proportions of foreign and local content, and skilled and unskilled labor. These conversion factors are provided below. Their derivation is presented in Table 10-2.

The foreign component of the cogeneration capital cost were estimated without duties and taxes; thus, no adjustment was required. For the local capital component, estimated import duties and stamp taxes of 25 percent on the local component's import content were subtracted (see Subsection 10.2).

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TABLE 10-2

CAPITAL COST CONVERSION FACTORS

	Proportion	Adjustment	Conversion Factor
Cogeneration Plant:			
FEC(1)	.78	1.0 (2)	.780
Local Materials	.14	.7 (3)	.098
Skilled labor	.06	.57(4)	.034
Unskilled labor	.02	.45(5)	.009
			.92
Factory Improvements:			
FEC(1)	.62	1.0	.620
Local labor	.26	.7	.182
Skilled labor	.04	.57	.023
Unskilled labor	.08	.45	.036
			.86
Irrigation Improvements:			
FEC(1)	.40	.85 (6)	.340
Local Materials	.40	.70	.280
Skilled labor	.05	.57	.029
Unskilled labor	.15	.45	.068
			.72

Footnotes:

(1) Foreign exchange component
(2) Import duties and stamp taxes not included in cost
(3) Deduct 9% for Import content and 21% for general taxation
(4) Deduct 33% for income tax and 10% for other taxes
(5) Deduct 10% for other taxes then value at 50%
(6) Import duties and stamp taxes included in cost

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The costs for irrigation infrastructure and factory improvements are investments required beyond the 600,000 tons of cane per annum level.

The conversion factors for the capital costs are:

- o Cogeneration plant .92
- o Irrigation infrastructure .72
- o Factory improvements .86

10.4 OPERATING COSTS

Incremental economic operating costs were estimated for cane production and processing above the 600,000 ton level and for the cogeneration plant. For cane production these include primarily higher harvesting and transport costs. The estimated import duties and stamp taxes on the import component of local products, as discussed in Subsection 10.2 were excluded. The non-import component of operating cost was adjusted to reflect the general level of taxation in Jamaica as it is incorporated in financial prices. This was estimated to be 21 percent for the National Economic Parameters study. Adjustments were made to wages incorporated into operating costs, as discussed in Section 10.2.

Harvesting and transport costs were adjusted to eliminate taxes on diesel fuel as well as import duties and stamp taxes maintenance materials and spare parts.

The conversion factors are presented in Table 10-3.

TABLE 10-3

OPERATING COST CONVERSION FACTORS

	Proportion	Adjustment	Conversion Factor
Cogeneration Plant: (1)			
FEC (2)	.46	1.0	.46
Local Non-labor	.44 (3)	.8 (4)	.35
Skilled labor	.13	.57	.07
Unskilled labor	.07	.45	.03
			.91
Harvesting:			
Diesel Fuel	.04	.62	.02
Local Materials	.15	.70	.11
Skilled labor	.11	.57	.06
Unskilled labor	.70	.45	.32
			.51
Cane Transport:			
Diesel Fuel	.50	.62	.31
Local Materials	.40	.70	.28
Skilled labor	.01	.57	.01
Unskilled labor	.09	.45	.04
			.64
Sugar Processing:			
FEC (2)	.30	1.00	.30
Local Materials	.40	.70	.28
Skilled labor	.20	.57	.11
Unskilled Labor	.10	.45	.05
			.74
Barbojo Production:			
Diesel Fuel	.35	.62	.22
Local Materials	.10	.70	.07
Skilled labor	.02	.57	.01
Unskilled labor	.08	.45	.04
Equipment Charge	.5	1.00	.50
			.83

Footnotes:

(1) Excluding fuel costs
(2) Foreign exchange component
(3) Including insurance
(4) Average conversion factor, National Economic Parameters

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10.5 REVENUES

Economic Prices

Prices for incremental production of raw sugar and molasses were set at export (sugar) parity levels in 1986 US Dollars. Export parity prices measure the economic value of an internationally traded product at the project boundary (i.e., at Monymusk). The prices were derived by using an f.o.b. (free-on-board) price for potential exports.

The f.o.b. prices were adjusted to reflect economic costs. That is, the transport cost in Jamaica used to estimate f.o.b prices excluded taxes on diesel and other noneconomic costs.

Sugar - The economic price of raw sugar was set at an export parity level with the 1995 World Bank projection of U.S.$265 per metric ton f.o.b. Caribbean port. The price f.o.b. Ocho Rios was converted to long tons (U.S.$269 per ton). Deductions for the economic cost of internal transport (see Subsection 10.2 for an estimate of fuel taxes) reduce the ex-Monymusk price by U.S.$12 per ton to U.S.$257 per ton.

Molasses - The molasses price was set to be equivalent to the c.i.f (cost, insurance and freight) New Orleans price. The New Orleans price is influenced by demands for molasses as livestock feed, rum, and industrial use. The price used is U.S.$60 per ton. The estimate is consistent with that used in the Petroleum Corporation of Jamaica (PCJ) study on ethanol production at Bernard Lodge.

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Electricity - Because, under most circumstances, electricity is neither priced at market clearing prices nor traded internationally, the conventional economic pricing mechanisms are not applicable. The pricing mechanism used in this analysis is an avoided-unit cost, whereby the cost of production of the best alternative generation method is used to value electricity. The market analysis (see Subsection 4.3) has identified the most likely alternatives: coal-steam unit, oil-steam unit, and oil-fired gas turbine. The economic costs of generation are 0.075, 0.062, and 0.079 U.S.$ per kWh, respectively. For the analysis, the average cost of power generated by a coal or oil-steam unit was used; that is U.S.$0.068 per kWh in 1990.

Barbojo - Barbojo is priced at 17 percent above the estimated production cost of U.S.$10.30 per ton, or U.S.$12 per ton.

Summary of Economic Prices - Economic prices for the products ex-plant Monymusk are summarized below:

Product	Economic Price
Raw sugar - US$ per ton	257
Molasses - US$ per ton	60
Electricity - US mills per kWh	68

10.6 RESULTS

Economic Return

After making the adjustments to capital costs, operating costs, and revenues, measures of economic

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worth were calculated over a period of 30 years. There is no allowance for residual value at the end of the period. The results for the entire project (i.e. estate, factory and cogeneration plant) are presented below for the three cases. The economic cashflows for the total project are presented in Appendix Exhibits 10-4, 10-5 and 10-6.

ECONOMIC RESULTS

Cane Production (tons)	600,000	742,050	850,000
ERR(1) (percent)	8	17	21
NPV(2) @ 10% (US$ million)	-5,839	28,372	51,560

Footnotes:

(1) ERR - economic rate of return
(2) NPV - net present value

Sensitivity

The effects on the economic results for the 742,050 ton case of changes in key assumptions of ±20 percent are presented in Table 10-7. The results are most sensitive to changes in revenues. A decrease in revenues of 20 percent results in a decrease in economic rate of return (ERR) to 12 percent.

The results are not sensitive to any other independent changes of 20 percent in assumptions.

However, a 20 percent increase in capital and operating costs would result in an ERR of 13 percent.

TABLE 10-7

SENSITIVITY TESTS

Parameter	Change (%)	ERR (%)	NPV @ 10% (US$ Million)
Base case(1)	-	17	28.3
Revenues	+20	22	49.3
	-20	12	7.5
Cogeneration plant's capital costs	+20	16	24.3
	-20	19	32.4
Total operating costs	+20	16	21.2
	-20	19	35.5
Total capital and operating costs	+20	13	13.2
	-20	23	43.6

Footnote:

(1) 742,050 tons cane per year.

10.7 NATIONAL AND REGIONAL EFFECTS

The effects of the project that can be measured in terms of project cash flows are incorporated in the financial and economic return calculations. There are additional significant effects that must be estimated in order to evaluate the project. The section discusses the project's effects on foreign exchange flows, GOJ revenues, public sector debt and employment.

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Foreign Exchange Flows

Given the incremental nature of the project to the World Bank's Second Sugar Rehabilitation Project, the principal foreign exchange savings will be the substitution of bagasse and barbojo for fuel oil offset by the foreign exchange requirements in the debt service and dividends and operating costs. The foreign exchange component of debt service and dividends is estimated in the financing plan (Section 11).

All flows are presented in constant 1986 US Dollars. Also included in the estimate of foreign exchange cash flow are incremental sugar exports and molasses import savings generated by production above 600,000 tons of cane per annum.

The foreign exchange debt service costs for the irrigation improvements were estimated by assuming a 15 year repayment schedule at 10 percent per year on the imported component.

After making these adjustments the average annual net foreign exchange savings at 742,050 tons was estimated to be US$7 million.

The net annual foreign exchange cashflow for the 742,050 ton case is shown in Appendix Exhibits 10-8. The annual net foreign exchange savings at 600,000 tons and 850,000 tons are -1.2 million and 7.6 million respectively.

GOJ Revenues

The Government of Jamaica (GOJ) would enjoy receipts resulting from import duties, stamp taxes, company taxes, dividend withholding taxes, and dividends. These receipts less GOJ equity outlays are shown on an annual basis in constant 1986 US Dollars in Appendix Exhibit 10-9. Receipts average US$2 million per year over the life of the project.

Public Sector Debt

A particularly significant aspect of the project is that it allows the GOJ to expand electric power generation without incurring or guaranteeing the foreign debt of US$31 million associated with the project. Given the constraints on public sector debt being required by the International Monetary Fund (IMF) this allows the GOJ to incur debt for other purposes. Assuming that this ability to borrow is valued at a discount rate of 10 percent, this represents an annual benefit of US$5 million over the 10 year debt repayment period.

Employment

During the construction of the cogeneration plant a local work force of about 200 people will be required in the first year and about 240 people in the second year. The irrigation improvements will employ about 100 people per year over the 4 year construction period. When fully operational, the project will employ an additional 20 people on a full-time basis and 200 people on a seasonal basis primarily for green cutting and barbojo collection at a production level of 742,050 tons.

11.0 FINANCIAL ANALYSES

This section presents the results of the financial analyses done on the sugar company and cogeneration facility operations. Each of these operations was analyzed separately and in a consolidated manner.

11.1 SUGAR COMPANY OPERATIONS

Projections of Profit and Loss and Cash Flow for the combined Estate and Factory operations were made for three assumed production levels and three different operating alternatives. The sugarcane production levels used were 600,000 tons, 742,050 tons, and 850,000 tons. For each of these situations, costs and revenues were projected for:

Operating Case 1 - An operation essentially unchanged from the present situation, with the exception of whatever investments and improvements were needed to produce the requisite increases in cane production (i.e., no cogeneration plant was considered);

Operating Case 2 - Incorporation of a cogeneration plant whose financial results and physical operation was an integral part of the overall operation;

Operating Case 3 - Operation of the factory and estate as a venture independent of a new cogeneration plant, but whose costs and revenues are affected by interaction with the plant.

Cogeneration Plant Operations

Financial analysis of this project was carried out from two perspectives. The first excluded all considerations of financing methods and merely considered the effects of the cogeneration project itself. This portion of the analysis also excluded consideration of cost escalation over time. The purpose of those simplifications was to permit evaluation of the project on the basis of its own financial merit. The inclusion of an advantageous financing structure or optimistic combinations of cost and revenue inflation rates could have the effect of enchancing the return on equity investment in the project beyond its average level, and the basis of a well-informed decision should include knowledge of the project's total intrinsic return. The second portion of the financial analysis introduced the consideration of financing methods and the ownership structure of the proposed commercial entity. Also included were estimates of likely escalation rates in capital and operating costs and power revenues.

Summary of Results

Cash Flows and Profits for the various production level/plant configuration scenarios are summarized in Exhibits 11-1 and 11-2, and more detail for each situation can be found in Appendix Exhibits 11-3 through 11-20. Several conclusions can be drawn from analysis of these results.

First, at a production level of 600,000 tons of cane, without major changes in the operations beyond those envisioned in the JSH Corporate Plan, the Monymusk Factory and Estate operations can be expected to show a moderate operating profit in the years subsequent to successful implementation of the Plan, but this profit will be entirely devoted to repaying the heavy debt service resulting from financing the needed improvements. Consistently positive cash flows will not be achieved until twelve years after the implementation of the Plan begins, if cane production indeed rises only to the 600,000-ton level (as discussed in Section 8.1 of this report).

Incorporation of the operations and financial results of the proposed cogeneration plant has the effect (at the 600,000-ton production level) of raising the expected operating profit to an annual level of approximately US$9,300,000 with a corresponding increase in cash flows. This represents a return of 16 percent on the plant investment of almost 48 million US Dollars.

If the operations and financial results of the cogeneration plant are divorced from the factory and estate operations, and the plant's usage of bagasse is treated basically as an even exchange for the factory's use of steam, then there is only a minimal change in the profits and cash flow of the sugar company from the results experienced without a cogeneration plant.

Due to the dubious viability of sugar operations at a production level of 600,000 tons, the Base Case production level of 742,050 tons was analyzed, and an approximation of the capital investment necessary to raise production to that point was included as a necessary cash outflow. Exclusive of any effects of a cogeneration plant, this raised annual profits to approximately US$5 million to US$6 million, and cash flow (after servicing of the debt incurred to finance the Rehabilition Program) would be approximately US$3 million to US$4 million (and rising even higher in later years of the Plan). This represents a 47 percent return on the $9 million investment for field improvements. With these profits and cash flows, the desirability of continuing the sugar operations becomes more apparent, and the risks of basing cogeneration investment on a financially shaky supplier of raw materials is correspondingly reduced. Results for the integral operation of the plant at the 742,050 ton level, and for treatment of the plant as an independent supplier of electrical power and steam (and purchaser of barbojo) are also shown in the exhibits. At this increased production level, the cogeneration plant can use more biofuel and less fuel oil; however, the biomass is burned less efficiently in the boiler, and consequently the power available for sale is reduced; the return on investment for the plant remains at 16 percent. The combined return on an investment for the cogeneration plant and the agricultural improvements is 20 percent on the US$57 million total capital investment.

Finally, to evaluate the effects of extending the factory's throughput to its maximum capability, an examination of the results at a production level of 850,000 tons of cane was made. This examination included the assessment of a capital investment of US$22.2 million for irrigation and field improvements intended to lead to increased yields; this investment would have a return of 25 percent, and result in total profits of approximately US8.6 million per year, after year 12. The cogeneration plant would be able to make a significant reduction in fuel oil consumption as more bagasse and barbojo would become available; at 850,000 tons of cane production, the cogeneration plant would return 17 percent. On the combined investment of US$70 million for the irrigation improvements and the cogeneration plant, the return would be 19 percent.

11.2 FINANCIAL PLAN

This section sets out the financing plan, assumptions and results of the financial analysis for the privately funded cogeneration plant. The capital and operating costs identified in Section 9.2 were used in this analysis.

The hypothetical financing plan for the cogeneration plant is summarized in Table 11-1, Sources and Uses of Funds and is based on discussions with representative institutions both in Jamaica and offshore. Conservative terms have been assumed for the purpose of this analysis. Primary considerations in the design of the plan were the avoidance of sovereign assurance for foreign

indebtedness, and local tender providing local debt. However, a need may exist for exchange rate guarantees to attract equity investors. As shown in Table 11-1 approximately 67 percent of capital would be debt and 33 percent equity.

Debt Funding

The potential sources of debt funding are shown in Table 11-2. The major sources of debt financing would include the following:

- International Finance Corporation (IFC) - It is assumed that the IFC would carry approximately one-fourth of project debt, along with other International Financial Institutions (IFI). Their funds would be provided without guarantees.

- International Financial Institutions (IFI) - It is assumed that other IFI's would provide debt financing to the non-power aspects of the project if required.

- U.S. Commercial Banks - These banks would provide the balance of debt requirements for hard currency. Overseas Private Investment Corporation (OPIC) guarantees would be required for this portion of the debt.

- Jamaican Development Banks - These banks are assumed to fund the bulk of local debt related to project investment at concessionary terms.

- Jamaican Commercial Banks - These institutions are assumed to provide credit lines for working capital.

- Export Credits - For this analysis no export credit financing is assumed because of the requirement of sovereign guarantees. It is possible that up to 85 percent of export value could be financed from their sources.

Equity

It will be desirable to have a mix of technical, institutional, and local partners involved in the project with appropriate incentives to insure the commercial success of the project. It is assumed that an equity contribution of 33 percent of the total capital requirement of the project will be required to attract debt financing.

A nominal after tax rate of return of 20 percent is assumed, which should be attractive to equity investors.

The equity participants would consist of the following groups:

- Major plant equipment and construction contractors.
- IFC/IFI's
- Jamaican Development Banks
- Jamaican Private Investors

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11.3 METHODOLOGY AND ASSUMPTIONS

The financial analysis evaluates the required price for power sold to JPS in order for the project to provide adequate returns to investors and cover debt service. The price of power required is presented on a real, levelized basis for comparison with other alternatives. The method of analysis is described in detail in the section below. Assumptions and results are presented in following sections. Results of sensitivity analysis for variations in biomass availability and plant operating capacity are presented after Results of the Base Case and Alternative Case.

Method of Analysis

A computer model estimates the revenue requirements of the project on an annual basis. Nominal dollars are used for expenses and revenues in each year, which reflects the advantage to investors of repayment of debt with dollars of declining real value, and tax advantages calculated from a constant dollar base. The objective of the calculation is to determine the smallest annual revenue which will allow the plant to meet all expenses and debt service, and generate a payment to equity which will recover investment at the target rate of return over the thirty-year life of the plant. Given the power available for exchange with JSH and sale to JPS, this revenue requirement implies a minimum price of power for an acceptable project.

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Based on the Material Balance figures (see Table 11-3), which are tied directly to the level of biomass production, power available for sale and operating expenses are estimated. Operating expenses are derived from engineering analysis of plant operating characteristics and nominal prices for inputs, primarily fuel oil and biomass. Interest and principal payment obligations are calculated based upon the hypothetical financing plan and terms of debt. The payment to equity is essentially an annual dividend in after tax dollars. Working capital is estimated as the cost of fuel inventory. One-half of working capital funds are assumed to come from equity, and one-half from a revolving line of credit.

The estimated revenue requirement is presented in the income statement in two components. The capacity charge represents capital recovery (debt repayment and return to equity) and fixed operating and maintenance charges. The power payment represents variable operating expenses, including fuel, and interest expense.

The power available for sale is distributed according to the material balance data between the sugar company and Jamaica Public Service. Power is sold to the sugar company at a fixed price, which escalates with inflation, based on an estimate of the sugar company's own cost of providing power. The balance of funds required, as calculated by the revenue requirements model, implies a price for the power sold to JPS in each year.

This price of power to JPS is first estimated in nominal terms for each year of the project life. The nominal price of power is then discounted for inflation to yield a 1986 dollar price of power for each year. The present value of this power price stream is calculated, using the real weighted cost of capital (debt and equity) as the discount rate. This present value of the power price stream is then transformed, using a capital recovery factor for the real weighted cost of capital over 30 years, to yield an equal annual payment over the life of the project. This is the real levelized price of power.

The revenue stream generated by the revenue requirements model, the operating costs estimated from engineering analysis, and debt service obligations based on assumed terms of debt are used to develop a pro-forma income statement for the first twenty years of project operations. Both book and tax depreciation are shown, to show Net Income and Taxable Income in accordance with current Jamaican law and accounting practice. Net Income from the bottom of this statement is adjusted for depreciation, loan fund inflow, capital investment outlay, principal repayment, and equity contributions to working capital to generate a net equity cashflow estimate for the project beginning with the first year of construction. This cashflow stream is reduced by withholding taxes to estimate the after-tax cashflow available to investors, and the return on equity is verified from this cashflow stream to equity after taxes (See Appendix Table 11-4).

Assumptions: Costs, Prices, and Inflation

All costs and prices are based on July, 1986 US Dollar estimates, inflated at a general inflation rate of 5 percent to time of expenditure, except for construction costs. Inflation on construction costs is estimated at 2 percent per annum. Five percent is taken to be a representative long-term inflation rate, for the purpose of a thirty-year analysis. Current rates of inflation in the United States are closer to two percent, which was used as the inflation rate for construction costs, since all such expenditures will occur within four years.

Fuel costs - For the purposes of this analysis, the value of bagasse delivered from the factory to the cogeneration plant was assumed to be equivalent to the value of the steam delivered to the factory from the cogeneration plant. The cost of cane trash (solar-dried sugar cane tops and leaves) was estimated at US$12.00 per ton delivered to the power plant. This price escalates at the general inflation rate over the course of the analysis period.

The residual fuel oil price is US$12.75 per barrel in 1986 and escalates in real (constant dollar) terms over the life of the analysis, as discussed in subsection 4.4.

Power sales - Power is sold to the Clarendon Sugar Company for a price which represents the cost which the factory would incur to produce that power from existing facilities. This price escalates at the

general inflation rate over the analysis period. Power is sold to JPS at a price which is calculated to make up the differential between revenue available from power sales to the sugar company and the total revenue requirement.

Fiscal Year - The plant fiscal year runs from mid-year to mid-year. Construction is assumed to begin on July 1, 1987. Operations begin at the beginning of fiscal year 1991, or on July 1, 1990.

Economic Life - Economic life of Plant is assumed to be 30 years, which results in a total project life of 33 years, allowing three years lead time for all project planning, design, and construction. No salvage value is assumed at the end of plant life.

Capital Costs - Broken out by foreign currency and local currency components, 50 percent of foreign currency costs are assumed to represent dutiable items, such as turbines, boilers, and other machinery and equipment. Import Duties and Stamp Taxes are levied only on this portion of capital costs. Import duties are assumed to be 5 percent on 50 percent of all foreign currency capital costs, and a Stamp Tax of 10 percent is added to the c.i.f. cost plus duty. These taxes are capitalized for purposes of debt financing and calculation of allowances.

Tax Holiday - Assumed for 6 years, which is the primary period of debt service, this is to nullify the effect of any Investment Allowances which might have been claimed. Annual allowances are calculated

at a rate of 2.5 percent for concrete structures (assumed to represent 25 percent of base capital costs) and 10 percent for machinery and equipment (assumed to represent 75 percent of base capital costs) on a declining balance basis, with the written down value calculated from time of project start-up.

Jamaican corporate taxes - At 35 percent, plus Additional Corporate Profits Tax of 10 percent, calculated on earnings in all years in which the project has a tax liability, the 10 percent Additional Profits Tax is treated as a downpayment on Dividend Withholding Taxes. The Tax Holiday applies to both corporate and dividend withholding taxes. Individual shareholders are treated according to their respective tax liability. Multilateral institutions are assumed to have no dividend withholding liability. Foreign investors are subject to US income tax on dividends during the Jamaican Tax Holiday at an assumed rate of 45 percent; the applicable dividend withholding rate for foreign investors with significant positions is 10 percent after the Tax Holiday, which is covered by the Additional Profits Tax. Their US income tax liability is offset by the overall 45 percent corporate tax paid in Jamaica. All Jamaican investors, including the Government, are subject to 37.5 percent dividend withholding tax.

Earnings - All cashflow is distributed to shareholders in every year of operations in order to achieve the required return on equity with the least possible price of power.

11.4 FINANCIAL STATEMENTS

Base Case Results

The base case assumes cane production reaches 742,050 tons by the third year of power plant operations, providing 203,300 tons of bagasse and 74,000 tons (wet weight) of cane trash (barbojo) for process steam and electric power generation. This results in a fuel oil requirement of 134,900 barrels per year. The mill and factory requirement of 785.9 million pounds of steam results in electricity production of 171.1 million kilowatt hours, net of plant. Monymusk Factory requires 25.859 million kilowatt hours of electricity, leaving 145.241 million kilowatt hours for sale to JPS. This results in an estimated price of power to JPS of 7.5 cents per kilowatt hour in 1986 US Dollars. A minimum debt service ratio of 1.2 is maintained during the period of debt service (Operating Income before Interest and Taxes divided by Principal and Interest Payments). The Income to Cashflow Statement with corresponding annual material balance figures is presented in Table 11-4.

Alternative Case Results

A more favorable scenario assumes that cane production reaches 850,000 tons by the fifth year of power plant operations, providing 233,200 tons of bagasse and 127,500 tons (wet weight) of cane trash (barbojo) to the cogeneration plant, reducing fuel oil requirement to 23,460 barrels per year. Monymusk Factory process steam requirement increases

to 899.2 million pounds, while electric power requirement at the sugar company remains relatively constant at 25.633 million kilowatt hours, due to improved operating efficiencies at this higher level of throughput. Power available for sale to JPS becomes 138.367 million kilowatt hours, resulting in an estimated price of power of 6.8 US cents per kilowatt hour. The minimum debt service ratio is maintained.

If the net savings due to higher biomass production are distributed equally among the power plant, Clarendon Sugar Company, and JPS, the price of electricity to JPS becomes 7.0 US cents per kwh, and to the sugar company, 6.0 US cents per kwh.

11.5 SENSITIVITY ANALYSIS RESULTS

In order to evaluate the sensitivity of the analysis to possible variations in the base case assumptions, three alternative scenarios were analyzed. These were:

- Zero biomass availability
- 50% increase in barbojo cost
- 10% reduction in power available for sale to JPS

These alternatives represent the major areas of uncertainty for plant operations, which center upon the ability of the factory/sugar company to provide biomass to the plant in the expected quantity, and at the expected cost, and on the plant to perform to design standards.

If no biomass is available, all power will be generated by burning No. 6 Fuel Oil. Two variations on this scenario were examined:

- price of power to JPS is the same as that estimated in the Base Case.

- Price of power is estimated to return 20 percent after tax to equity when burning 100 percent fuel oil.

In the first variation, the levelized real price of power estimated in the Base Case is inflated at the general inflation rate over the life of plant, and the consequences for debt service and return on equity examined. After tax cashflow is sufficient to cover all debt service obligations, however, return to equity over the life of plant falls to 12 percent.

In the second variation, the revenue requirements model is used to estimate the price of power required to achieve the required return on equity, which is 8.2 US cents per kilowatt hour.

If the cost of providing barbojo to the power plant is 50 percent greater than anticipated, the price of power to JPS becomes 7.7 US cents per kilowatt hour, an increase of only 2.5 percent.

If the plant operates below capacity, and power available for sale to JPS falls by 10 percent, the price of power estimated by the revenue requirements calculation become 8.35 US cents per kilowatt hour, an increase of 11 percent.

Availability of biomass and plant performance are more critical to project success than the cost of barbojo.

11.6 PROJECT RISKS

In addition to the risk elements analyzed in the sensitivity analysis, any project of this nature has certain other risks which may confront the project.

An appropriate assessment of risk requires identifying the key risk parameters and the measures which would mitigate these risks. For the purpose of this report an identification of the other risk parameters is presented below.

The key risk parameters are as follows:

- Capital cost overruns
- Change in the rate of escalation
- Changes in fuel prices
- Delays in construction
- Reduction in bagasse and barbojo supply
- Changes in the political environment
- Force Majeure events (natural disaster, civil strife, etc.)

The allocation and quantification of risks would be the subject of discussion with the Government of Jamaica if the project moves forward.

TABLE 11-1

SOURCES & USES OF FUNDS DURING CONSTRUCTION

Sources	1987	1988	1989	Total	Share
Equity - 33%					
Foreign Investors	1.32	3.19	3.60	8.10	15%
IFI	0.73	1.77	2.00	4.50	8%
Local Investors	0.44	1.06	1.20	2.70	5%
Gov't of Jamaica	0.44	1.06	1.20	2.70	5%
Debt - 67%					
IFI	1.34	3.51	4.49	9.34	17%
Jamaican Development Banks	0.86	2.26	2.90	6.02	11%
U.S. Commercial Banks	3.13	8.29	10.37	21.80	39%
Total Sources	8.26	21.15	26.75	55.16	100%
Uses					
Construction	7.34	19.98	22.79	50.11	91%
Committment Fees	0.23	0.17	0.03	0.44	1%
Other Fees	0.48			0.48	1%
Interest During Construction:					
IFI	0.05	0.26	0.79	1.10	2%
Jamaica Development Banks	0.03	0.17	0.51	0.71	1%
U.S. Commercial Banks	0.12	0.56	1.64	2.32	4%
Total Uses	8.26	21.15	25.75	55.16	100%

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TABLE 11-2

DEBT FINANCING ASSUMPTIONS

	Private Sector IFI's	US Commercial Banks	Jamaican Dev. Banks	Local Commercial Banks
Loan Coverage	25% of total project debt	Remaining foreign currency debt	Local Currency debt	Working capital credit line
Typical Interest Rate	10.5% fixed	7.25% floating	10.5%	15%
Typical Guarantee Fee	-	2% (OPIC)(1)	-	-
Typical Commitment Fee	1%	0.5%	1%	-
Typical Management Fee	1%	1.5%	1%	-
Grace Period	36 mos.	36 mos.	36 mos.	-
Repayment	20 equal semi-annual principal payments	12 equal semi-annual principal payments	14 equal semi-annual principal payments	Revolving

Footnote:

(1) OPIC - Overseas Private Investment Corporation

TABLE 11-3

MATERIAL BALANCE SCENARIOS

	Base Case	Best Case
Sugar Cane Production (tons per year)	742,050	850,000
Barbojo Percent of sugar cane	10%	15%
Electricity, Net of Plant (million kWh)	171.1	164
Process Steam Supplied (million lbs)	785.9	899.2
Quantities of fuel required:		
Bagasse (tons)	203,300	233,200
Cane trash (Barbojo) (tons at 25% moisture)	66,500(1)	114,100(1)
No. 6 Fuel Oil (barrels)	134,900	23,460
Power Price to Monymusk (US¢ per kWh)	6.28	6.28
Power Supplied to Factory Estate (million kWhs)	25.859	25.633

Footnote

(1) Barbojo on a field-weight basis of about 35% moisture would weigh 74,000 tons for the Base Case and 127,500 tons for the Best Case, and might dry to weights shown in this table prior to firing.

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EXHIBIT 11-1 : SUMMARY OF PROFITS AND (-LOSSES)

PROFITS / (-LOSSES) YEAR	PRODUCTION : 600,000 TONS			PRODUCTION : 742,050 TONS			PRODUCTION : 850,000 TONS		
	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.
1986	-1629	-1629	-1629	-1629	-1629	-1629	-1629	-1629	-1629
1987	-896	-896	-896	-896	-896	-896	-896	-896	-896
1988	1387	1387	1387	1900	1900	1900	1156	1156	1156
1989	2150	2310	2151	2914	622	3384	1310	1310	1310
1990	2120	9311	2161	3235	10345	2973	1553	7912	1559
1991	2120	9311	2161	4004	11114	3761	2058	8417	2064
1992	2120	9311	2161	4765	12291	4702	2450	9452	2479
1993	2123	9314	2163	4781	12307	4718	4609	11511	4638
1994	2136	9327	2176	4851	12323	4734	5523	14310	5680
1995	2160	9351	2200	4981	12454	4865	6516	15302	6672
1996	2180	9371	2220	5091	12564	4975	7681	16467	7837
1997	2180	9371	2220	5341	12814	5225	8649	17435	8804
1998	2180	9371	2220	5561	13034	5445	8649	17435	8804
1999	2180	9371	2220	5781	13254	5665	8649	17435	8804
2000	2180	9371	2220	5990	13463	5874	8649	17435	8804
2001	2180	9371	2220	5990	13463	5874	8649	17435	8804
2002	2180	9371	2220	5990	13463	5874	8649	17435	8804
2003	2180	9371	2220	5990	13463	5874	8649	17435	8804
2004	2180	9371	2220	5990	13463	5874	8649	17435	8804
2005	2180	9371	2220	5990	13463	5927	8719	17506	8876

EXHIBIT 11-2 : SUMMARY OF CASH FLOWS

CASH FLOWS	PRODUCTION = 600,000 TONS			PRODUCTION = 742,050 TONS			PRODUCTION = 850,000 TONS		
YEAR	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.	NO COGEN. PLANT	W/ COGEN. PLANT	SEPARATE COGEN.
1986	-1657	-1776	-1657	-1657	-1776	-1657	-1657	-1776	-1657
1987	2389	-5956	2389	2389	-5956	2389	2389	-5956	2389
1988	2721	-23499	2721	984	-25236	984	-1579	-27799	-1579
1989	1703	-10053	1703	736	-11141	1206	-2975	-14890	-2975
1990	-1300	8220	-1260	-1696	6673	-3029	-4370	3424	-4669
1991	20	9540	60	712	10271	588	-456	8267	-416
1992	748	10269	788	4292	14267	4348	1633	10999	1696
1993	627	10148	667	4170	14145	4226	7020	16386	7083
1994	-302	9219	-262	3254	13229	3310	6104	17255	6295
1995	741	10262	781	4354	13794	3875	6499	17642	6682
1996	-901	8620	-861	2819	12794	2875	5669	16820	5860
1997	660	10181	700	4470	14445	4526	7320	18471	7510
1998	88	9609	128	3899	13874	3955	6749	17899	6939
1999	1366	10886	1406	5176	15151	5232	8026	19177	8216
2000	2356	11877	2396	6166	14951	5032	7807	18619	7658
2001	1702	11223	1742	5512	15487	5568	8362	19513	8553
2002	1647	11168	1687	5458	15433	5514	8308	19458	8498
2003	2610	12130	2650	6420	16395	6476	9270	20421	9460
2004	945	10466	985	4755	14730	4811	7605	18756	7795
2005	3028	12549	3069	6839	16814	6895	9689	20839	9879

ACRONYMS & ABBREVIATIONS

bbl	Barrel (of Oil)
Btu	British thermal unit
c.i.f.	Cost, Insurance & Freight
CSCo.	Clarendon Sugar Company
EEC	European Economic Community
EFOR	Equivalent Forced Outage Rate
ERR	Economic Rate of Return
FEC	Foreign Exchange Component
f.o.b.	Free on Board
FOR	Forced Outage Rate
FX	Foreign Exchange
GADS	Generating Availability Data Systems
GDP	Gross Domestic Product
GNP	Gross National Product
GOJ	Government of Jamaica
GWh	Gigawatt-hours (million kilowatt-hours)
HEART	Human Employment and Resource Training
HST	Hawaiian Sugar Technologists
IBRD	International Bank for Reconstruction and Development (The World Bank)
IFC	International Finance Corporation
IFI	International Financial Institutions
IMF	International Monetary Fund
ISSCT	International Society of Sugar Cane Technologists
JAST	Jamaican Association of Sugar Technologists

JNEC	Jamaica National Export Corporation
JNIP	Jamaica National Investment Promotion
JPS	Jamaica Public Service Company Limited
JSH	Jamaica Sugar Holdings Limited
kWh	Kilowatt-hours
MinAg	Ministry of Agriculture
MMET	Ministry of Mining, Energy & Tourism
MSPCo.	Monymusk Sugar and Power Company
MWh	Megawatt-hours
NERC	North American Electric Reliability Council
NHT	National Housing Trust
NPV	Net Present Value
OPEC	Organization of Petroleum Exporting Countries
OPIC	Overseas Private Investment Corporation
PCJ	Petroleum Corporation of Jamaica (PetroJam)
PIOJ	Planning Institute of Jamaica
PSOJ	Private Sector Organization of Jamaica
ROE	Return On Equity
SIA	Sugar Industry Authority
SIRI	Sugar Industry Research Institute
SMA	Sugar Manufacturers Association
SCPA	Sugar Cane Products Association
SOF	Scheduled Outage Factor
TCAM	Tons of Cane per Acre per Month
UK	United Kingdom (Great Britain)
USAID	United States Agency for International Development