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Washington, D.C.

FEASIBILITY STUDY OF DENDRO-THERMAL POWER GENERATION ON THE ISLAND OF PANAY, PHILIPPINES

JUNE 1980

MAIN

MAIN
Engineers

CHAS. T. MAIN INTERNATIONAL, INC.
SOUTHEAST TOWER, PRUDENTIAL CENTER, BOSTON, MASSACHUSETTS, U.S.A. 02199
TELEPHONE 617-262-3200 • TELEX 94-0009 OR 94-0598 • CABLE CHASMAIN

June 12, 1980

SUBJECT: Contract No. AID/OTR-C-1646
Study of Dendro-Thermal Plant
Philippines - Final Report

Mr. L. E. Stanfield, Contracting Officer
Chief, OTR Branch
Central Operations Division
Office of Contract Management
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Mr. Stanfield:

Chas. T. Main International, Inc. is pleased to submit the final report for the subject project. Responses to comments and questions by AID regarding the draft report for the subject project and transmitted in AID's letter of May 13, 1980, have been included in Appendix E of the report.

It has been a pleasure to assist you in this project. We hope that the results of this study will be useful in assisting the Philippine Government in its program for development of alternative energy sources.

Sincerely,

CHAS. T. MAIN INTERNATIONAL, INC.

Frank M. Tenore
Project Manager

EXECUTIVE SUMMARY

Based on the evaluation of the engineering and biological requirements for establishing a dendro-thermal generating plant on the Island of Panay, MAIN has estimated that the capital investment required to construct the generating plant and associated transmission facilities is P 48,000,000 (U.S. $6,490,000). The capital investment to establish the fuelwood plantation is P 77,000,000 (U.S.$10,400,000). Plant costs equate to P28,770 (U.S. $3,888) per net installed kilowatt. The operating costs for the proposed dendro-thermal plant are P 0.308 (U.S. $0.042) per kWh. The study shows that the "operating" costs of raising and burning wood for electric generation in the Philippines is more economical than oil-fired diesel generation.

The Nabas area (northwest coast of Panay) is the recommended area for the installation of the plant. A 2 MW cell-firing generation system is recommended, based on the fuel production potential of the Nabas Reforestation Area. If the plant is to be "on line" at the earliest possible date (December 1983), flow monitoring studies in the Gibon River must be initiated by June 1980. A site selection study to identify a specific plant site in the Nabas area must also be undertaken very early in the project.

The establishment of the fuelwood plantation presents a complex organizational and logistical problem. To meet the "on line" date, reforestation must begin in May 1981. This necessitates establishment of adequate nursery facilities, construction of several kilometers of road, and the employment, organization and training of approximately 275 forestry workers.

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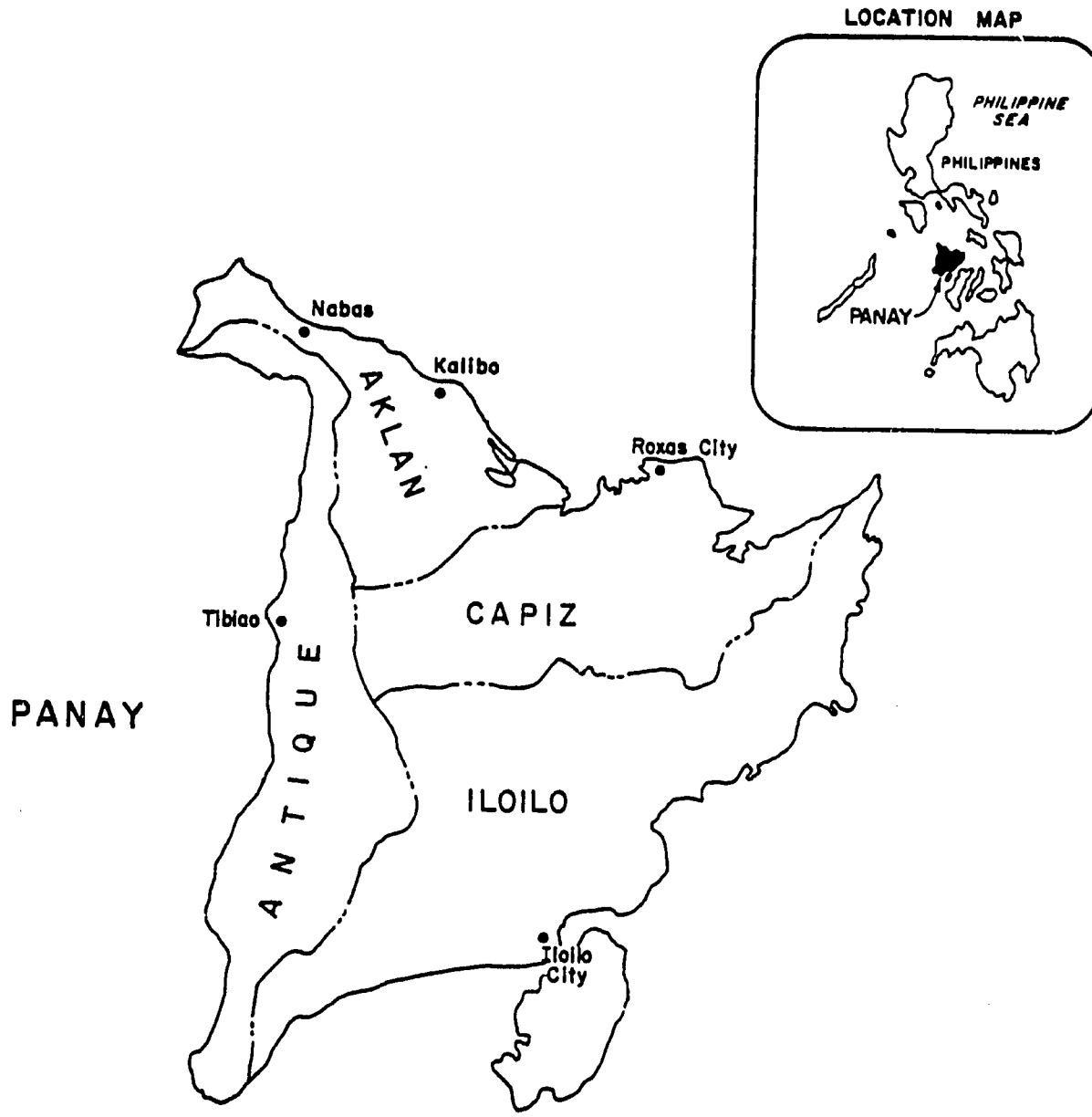
1 INTRODUCTION

The increases in prices of petroleum-based products has had its greatest impact on developing countries. In response to this, the Philippine Ministry of Energy, Center for Nonconventional Energy Development, is exploring various means of generating electrical energy by means other than petroleum fuels. Among these is a program to evaluate the use of wood fuel for power generation. Dendro-thermal generation (a term apparently coined in the Philippines meaning wood-fueled thermal generation) can utilize various wood products as raw material. However, the present study explores the use of forest plantations raised specifically as fuel for power generation.

This study addresses the feasibility of dendro-thermal generation on the Island of Panay, the Philippines (see Figure 1-1). Panay is approximately 400 km south of Manila. The island is roughly 1.2 million hectares in size, with approximately 50 percent of this classified as open land. Open lands were once forested but were cleared of vegetation for agriculture. Few native forests of commercial importance have remained after agricultural clearing, but the Philippine Bureau of Forest Development is reforesting and managing approximately 45,000 ha. of land designated as Reforestation Areas.

The Island of Panay is relatively poor in energy resources. No local coal sources have been confirmed, no sites of potentially exploitable geothermal energy have been identified, and hydroelectric potential is limited. Therefore, the BFD's Reforestation Area represents a potential source of energy via dendro-thermal generation. This study addresses the feasibility of dendro-thermal generation at Nabas in northwestern Panay.

FIGURE 1-1



US AID - PHILIPPINES DENDRO THERMAL PLANT	
ISLAND OF PANAY	
MAIN	DATE MARCH 1980
	SCALE NONE / JOB NO. 2785-10

2 PROJECT SCOPE

The present study examines the feasibility of establishing a dendro-thermal (wood fueled) electric power generation plant on the Island of Panay in the Philippines. The studies performed cover six general areas.

1. Preliminary Siting Study
2. Transmission Facility Requirements
3. Generation System Requirements
4. General Management Plan for Fuelwood Plantation
5. Environmental Evaluation
6. Economic Evaluation

The scope of each of these areas is discussed below.

Preliminary Siting Study

Two reforestation areas on Panay were previously identified as being potentially capable of supporting a dendro-thermal plant. These two areas are evaluated to determine which would represent the better area for the proposed plant. Factors evaluated in making this determination include water availability, total area available for fuel production, differential cost parameters, and project objectives. Once the "preferred area" is selected, a representative plant site is identified.

Transmission Facility Requirements

The existing power generation resources on the Island of Panay are identified and scheduled modifications are discussed. Existing and proposed transmission facilities are addressed. System loads on the existing system are estimated and a projection of future loads is presented. Considerations for, and costs of interconnecting the proposed dendro-thermal plant to the Panay power grid are presented.

Generation System Requirements

A preliminary design concept is developed. Plot plan and general arrangement drawings are presented. Based on this concept, an order of magnitude cost estimate is developed.

General Plantation Management Plan

The framework for a plantation management plan is presented. Species and rotation lengths are recommended. Plantation establishment and maintenance procedures are developed. A general harvesting and handling system is designed. Areas recommended for further study are identified.

Environmental Evaluation

The environmental evaluation is limited to potentially significant environmental impacts, both positive and negative, associated with project establishment and operation. Few data are available for the local area. Site specific environmental studies will need to be undertaken if the project is to proceed.

Economic Evaluation

This evaluation estimates the annual operating costs and cost per net kilowatt hour produced. A sensitivity analysis is performed to evaluate the effect of fluctuating wood (fuel) prices on the feasibility of the project. This includes alternative uses and markets under both present and possible future market conditions.

The contractual scope of work is included for reference.

I. TITLE

Nonconventional Energy Development Project

II. OBJECTIVE

The specific objective is to conduct a preliminary engineering study of the dendro-thermal plant proposed under the Nonconventional Energy Development Project.

III. STATEMENT OF WORK

A. The Contractor shall provide an engineering team to determine the feasibility of constructing a dendro-thermal generating plant in Northern Antique on the Island of Panay, Philippines. This preliminary study is a part of the Nonconventional Energy Development Project. The Contractor's team will be briefed on this project by AID/W Engineering Office in the Asia Bureau, ASIA/PD/ENGR; USAID/Manila, Office of Capital Development; and, the Philippine Bureau of Energy Development. Basic additional background for this study is contained in a report prepared by Drs. Murphy, Massey, Blankenhorn and Bowersox. A copy of this report will be given to the Contractor's team by AID/W engineering office, ASIA/PD/ENGR.

B. Specific Tasks

The Contractor shall perform the following preliminary engineering work to determine the feasibility of a dendro-thermal generating plant in Northern Antique on the Island of Panay. The major tasks will be:

1. Evaluate the proposed plant site to determine: costs for site development, availability of water, waste handling and disposal, access to fuel supply and the means of delivering the plant output into the existing transmission and distribution system.

2. Determine the most appropriate type of firing method to be employed and provide schematic drawings of and describe the major plant processes.
3. Provide a general plan of the proposed generating plant and describe the general arrangement.
4. Identify and provide pertinent data sheets for all major equipment including fuel handling and transport system.
5. Provide a preliminary schedule for the final engineering design, civil construction and the supply and installation of the equipment through operation. This will include an estimate of the effort required to prepare performance type specifications suitable for soliciting bids for a turn-key supply and erect contract for the plant.
6. Provide an order of magnitude estimate of the capital costs for civil construction, supply and installation of the equipment and the detailed engineering design.
7. Provide an estimate of the annual operating costs.
8. Assess the electrical power and energy demand in the area that will be served from the plant and determine what must be done to the existing transmission or distribution system to utilize the plant output. Determine optimal plant size and required transmission/distribution facilities considering demand assessment, plant economics and analysis of National Electrification Administration/National Power Corporation NEA/NPC plans for the island.
9. Derive the cost per net KWH produced.
10. Perform a sensitivity analysis to establish the maximum wood fuel price which can be paid so that the electric energy rates will cover the operating costs and compare this with the price of alternative uses of the wood.

11. Identify and discuss likely adverse and positive impacts on the human and physical environment and indicate measures which can be taken to mitigate adverse effect. Identify and recommend planning and design actions for positive impact such as employment generation and for mitigating negative impacts.

12. After review of the report prepared by Dr. W. K. Murphy and others and site visits, prepare a basic energy plantation plan for the generating plant life-cycle fuel supply. The plan should, if possible, provide details regarding recommended species or genetic strains, optimal spacing, fertilization and irrigation requirements and recommended plantation management systems. If information gaps preclude this level of detail, identify those areas requiring further investigation which could be carried out during project implementation.

IV. REPORTS

The Contractor shall submit reports as follows:

1. Five (5) copies of a draft report covering the tasks as stated in Article III above, for AID/Washington, USAID/Manila and BED review.
2. Ten (10) copies of a final report within thirty (30) days after receipt of AID approval to print the report in final form.

V. RELATIONSHIPS AND RESPONSIBILITIES

Performance of the work hereunder shall be subject to the technical directions of the cognizant A.I.D. Project Office indicated on the cover page. While in the Philippines, the contract team will be responsible to the Philippine Bureau of Energy Development, Dr. Ernesto N. Terrado; with liaison through the USAID/Manila, Office of Capital Development.

3 PRELIMINARY SITE SELECTION

The report prepared by Murphy et al[8/] was "to site a power plant on the basis of biological potential to fuel such a plant". The Island of Panay was chosen because the island has less opportunity than other areas in the Philippines to exploit geothermal and coal sources and the island has active reforestation programs. Six Bureau of Forest Development (BFD) reforestation projects were identified as potential production areas for a dendro-thermal plant. Of these areas, only the Nabas Reforestation Project (Aklan Province) and the Tibiao Reforestation Project (Antique Province) are adjacent to rivers with sufficient flow to provide cooling and boiler make-up water for a dendro-thermal plant.

In order to evaluate "the proposed plant site" (Task 1, Scope of Work), a plant site had to be identified in greater detail than that provided by Murphy et al. This required: (1) a selection of either the Nabas or Tibiao area as a "preferred" area; and (2) the identification of a representative site within that area where the dendro-thermal plant could be constructed.

A detailed siting study would evaluate numerous factors in the selection of an optimum site for the proposed plant. However, due to budgetary and time constraints, only a preliminary siting effort was carried out.

Three parameters were evaluated to identify the preferred area. These included: (1) water supply; (2) transmission requirements; and (3) fuel supply.

3.1 AREA SELECTION

3.1.1 Water Supply

For siting purposes (before actual design requirements were established), the volume of water required for boiler makeup and cooling was initially estimated as 500 gallons/minute (gpm), or 31.54 liters/second (CMS).

Typically, design criteria for water-using facilities assume that the minimum flow of the water source will be provided except for one seven-day period each ten years. The calculation of this seven-day ten-year flow can be made with reasonable certainty if fifty or more years of stream flow data are available. An alternative is if ten or more years of flow data and fifty or more years of rainfall data are available.

However, no flow data are available for either the Gibon River, which passes near the Nabas area, or for the Tibiao River, which passes near the Tibiao area. In an effort to provide a rudimentary estimate of the order of magnitude low flow, the following procedure was followed. A point on each river was initially selected as a possible point of plant water intake. At this point, average river depth, width, and velocity were estimated to calculate approximate flows. Assuming this is a mean flow for the month of December, this flow was reduced by a ratio equal to the lowest mean monthly flow divided by the mean December flow of nearby rivers for which data existed. This admittedly crude approximation of the mean lowest monthly flow was interpreted as a rough indication of possible low flows. The data

used for this approximation were mean monthly discharges as liters per second on a daily basis. Therefore, daily lows can be expected to be below the monthly means and below the computed low flows for the Gibon and Tibiao Rivers.

Mean lowest monthly flows for the Gibon and Tibiao Rivers were approximated as 72 liters per second and 12 liters per second, respectively. It was, therefore, deemed improbable that the Tibiao River could sustain the proposed plant during low flow periods. The approximations indicate that the Gibon River in the Nabas area may have a greater probability of meeting the demand during low flow periods.

Therefore, relative to water supply, the Nabas area was judged preferable.

3.1.2 Transmission Requirements

To optimize the utility of the proposed dendro-thermal plant, it must be linked to the existing transmission "grid" on Panay (see Section 4). Approximately 6 kilometers of transmission line would be required to link the Nabas dendro-thermal plant to a 69 kV line presently being constructed in the Nabas area. A 69 kV transmission line is scheduled to be constructed to the general area of Tibiao by 1983 (see Section 4). If this line were constructed as scheduled, approximately 6 kilometers of 69 kV line would be required to link a dendro-thermal plant at Tibiao to the Panay grid via that newly constructed line. If that line is not constructed as scheduled, up to 53 kilometers of new, plant-related 69 kV transmission could be required to link the Tibiao plant to the 69 kV line presently being constructed in Nabas. Based on these factors, the Nabas area was judged preferrable.

3.1.3 Fuel Supply

Murphy et al estimated the generation potential of the Nabas and Tibiao reforestation areas as 4.0 MW and 15.5 MW, respectively. The most efficient exploitation of these resources in terms of project design would be to design a generation plant to utilize the maximum potential generation

capacity of the resource rather than to design a project that utilizes only a portion of the resource and which would require the addition of other generation units at a later date for full resource utilization. The smaller dendro-thermal unit of three to four megawatt generating capacity was considered preferable to a unit of fifteen megawatts for a number of reasons. The design of both 3 MW and 15 MW wood-fired units is well established. However, no such units are presently operational in the Philippines which are fueled from fuelwood plantations. As such, the potential organizational and logistical problems of operating such a generation plant have not been identified or solved. Construction and operation of a smaller unit initially would serve as a "learning tool" with a smaller initial investment. If the project is considered successful, the experience may be applied to larger project areas such as Tibiao.

Based on these criteria, the Nabas area was selected as being preferable to Tibiao for the proposed dendro-thermal generating unit.

3.2 SITE SELECTION

Within the Nabas area, a representative plant site was identified (see Figure 3-1). The criteria for the selection of this representative site were: (1) suitable topography (to minimize site preparation); (2) proximity to the water source; i.e., the Gibon River; (3) existing land use in the area (to minimize conflict); and (4) a judicious balance between distances of fuel transport and required transmission line construction.

3.3 RECOMMENDATIONS

Before the initiation of the proposed dendro-thermal project, a detailed siting study should be carried out. Unless characteristics are identified during the siting study indicating the contrary, it is assumed that the general area near the Nabas Reforestation Area is suitable for a dendro-thermal generation unit of four megawatts or less. If one parameter is found to be limiting; e.g., low flows in the Gibon River, the siting

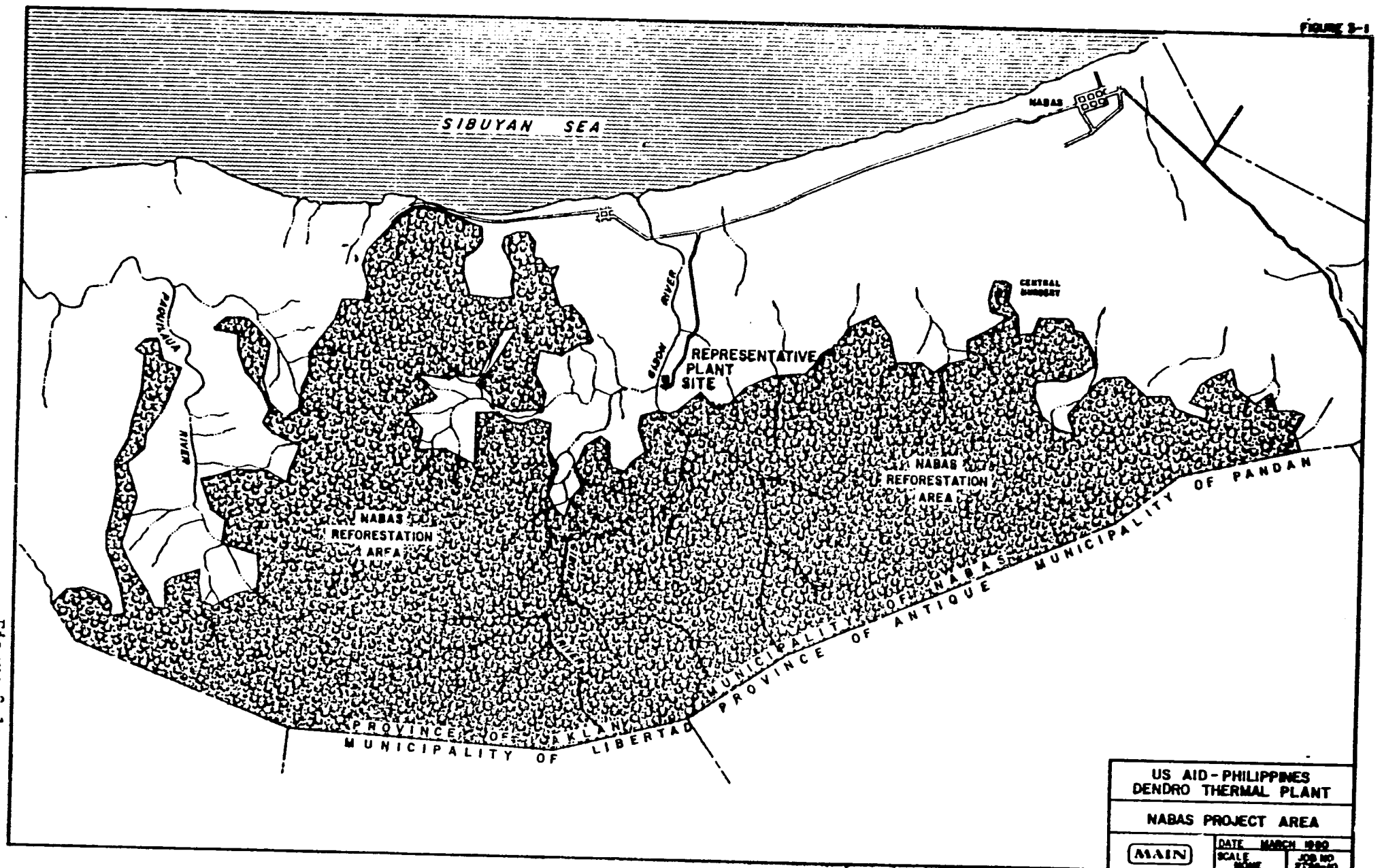


FIGURE 3-1
SIBUYAN SEA
NABAS
CENTRAL SUBSOIL
REPRESENTATIVE PLANT SITE
BUCOW RIVER
PAGOIS RIVER
MAIN
NABAS REFORESTATION AREA
NABAS REFORESTATION AREA
PROVINCE OF AKLAN
MUNICIPALITY OF LIBERTAD
PROVINCE OF ANTIQUE
MUNICIPALITY OF NABAS
MUNICIPALITY OF PANDAN
US AID - PHILIPPINES
DENDRO THERMAL PLANT
NABAS PROJECT AREA
MAIN
DATE MARCH 1980
SCALE NONE
JOB NO 2739-10

Figure 3-1

study may have to be expanded to include other areas. If not, the siting study may be limited to identifying an optimum site in the Nabas area.

Of prime concern is water volume available to the proposed plant during low flow periods. Inadequate flows during the dry season could result in reduced generation or, in extreme cases, no generation. A stream monitoring program is recommended for a minimum of six months which would span the driest months as determined by any available data or local residents. The stream monitoring program should be coordinated with the (Philippine) Bureau of Public Works, Water Resources Division.

A minimal monitoring may include the following procedures near the proposed point of intake:

(1) Determine a stream cross-section by measuring water depth at approximately every two meters across the width of the stream.

(2) Install a staff gauge in the river to monitor fluctuations in river depth.

(3) Record water depths twice a day.

(4) Flows should be recorded with a flow meter once water levels begin to drop at the beginning of the dry season. Flow meter readings should be taken for each cm drop in river level. Flow readings should be taken at points every two meters across the river width. At these points, total depth should be again noted and flow rates at 2/10 and 8/10 of the river depth measured.

(5) Such readings should continue throughout the dry season.

These data will permit a computation of water volumes during lowest flows. Obviously, more sophisticated monitoring techniques are available and are recommended if feasible.

In addition to approximating river volume during periods of low flow, other water users or potential users in the area must be identified. Conflicting uses during low flow periods may result in significant impacts to the project or downstream uses. An example of potentially significant impact would be the negative impact to downstream irrigation projects resulting from diversion of river water for project use.

If available water is found to be a limiting factor, alternatives include utilizing groundwater for boiler cooling and make-up water requirements, or discarding the area as being suitable. If sufficient water is found to be available, taking into account environmental considerations, identification of a plant site within the Nabas area can proceed. Appendix A includes a general siting methodology to be modified as required by local conditions and available data.

4 TRANSMISSION SYSTEM

During the field investigations on Panay, the possible areas for a dendro-thermal plant at Nabas and Tibiao were visited. Transmission requirements for each area were investigated as input to the preliminary site selection (Section 3). The Nabas area was selected as the preferred area for the generation unit. However, transmission considerations for both the Nabas and Tibiao areas are included herein.

4.1 EXISTING AND PROPOSED GENERATION RESOURCES

In 1979 the power for Panay was supplied by several isolated systems. In the south there was a privately owned utility which met the energy requirements of Iloilo City, as well as those of the suburban areas and some of the nearby rural areas. In the north there was a generating station at Panitan which supplied power to most of the remainder of the island. There were some small diesel sets in some isolated areas and there were other areas with no power.

A major expansion program is currently being undertaken. The two 5500 kW diesel generators now operating at Panitan are being augmented by four 7300 kW diesel driven generators in a new station at Dingle. One of these units was operating in late 1979 and the others are expected to be operating early in 1980. The two sources of power will be interconnected and the resulting system will have a firm capability of 33,000 kW. "Firm" power is defined as being the system resources with one unit out of service.

There is coal to be found on some of the Philippine islands and there are plans to construct a thermal plant in 1986 on the Aklan River in Kalibo. This plant will burn locally produced coal and have a capacity of 55,000 kW in one generator unit. Since this unit must be out of service from time to time for maintenance, the loads it normally would supply will

have to be fed from the diesels at Panitan and Dingle. This addition will increase the firm capability of the system to 40,000 kW.

Construction of a hydroelectric plant upstream from Kalibo on the Aklan river system is in the plans for 1990. This is conceived as a peaking plant with two 10,000 kW generators at 25% plant factor. With this addition, the firm output of the interconnected system will be 60,000 kW.

In the years between 1986 and 1990 consideration will be given to increasing the firm capability of the Panay resources. One possibility would be to increase the diesel capacity. This would not be by the installation of more diesels on the island, but by the use of Power Barges. There will be a number of these 32,000 kW units in the various systems and one might be considered for Panay. Another possibility that will be studied is the interconnection of the power system on Panay with the one that is developing on the island of Negros. The larger system formed by interconnecting these two power grids will require less reserve capacity than would be needed if the two systems continued to operate separately.

The present loads of Negros ($\pm$ 50,000 kW) are much greater than those of Panay and they are supplied from diesel driven sources. For the future loads, two new 7300 kW diesels are being installed and a station with three 37,500 kW geothermal powered units is being built. In 1985 a 55,000 kW coal-fired plant will be added, and a 60,000 kW peaking hydro station is contemplated. Two more geothermal units and another coal-fired thermal unit are in the plans for the more distant future.

The diesel generators that are being installed on these two islands are the last that are planned to be purchased. Thermal and hydro developments will be the generation resources for the future, with the present diesels becoming the reserve. The proposed dendro thermal plant will displace oil for the entire time that it operates up to 1986 and then, with or without the interconnection of the systems on Panay and Negros, the amount of oil it will displace will be drastically reduced. Oil-fired electric

power generation should be eliminated long before the dendro-thermal plant reaches the end of its useful life.

4.2 SYSTEM LOADS

Rural electric cooperatives were organized on the Island of Panay about five years ago to supply power to the small cities and rural areas. Progress has been rapid and, by the end of 1979, about 25% of the potential households and commercial customers were being served from the rural systems. Nabas is in the area of the Aklan Cooperative, and Tibiao is within the jurisdiction of the Antique Cooperative.

A range of mountains, extending from north to south of Panay on the west, limits the flat arable land in northwestern Aklan in the area around Nabas and in all of Antique. Within a radius of 10 km from Nabas there is not much more than 50 square kilometers of ideal farming land. To the south in Antique, the better farming land is limited to a thin strip between the sea and the foot of the mountains. In the 50 km north from Tibiao there is only about 75 square kilometers of ideal flat farming land, and in the 60 km strip to the south there is just 125 square kilometers. There is some terraced farming and some land is being cultivated on the lower slopes of the mountains but, even so, there are relatively few farms and therefore the region will remain sparcely populated and the potential for electric energy will be low as long as farming is the major means of livelihood for the people living there.

The Aklan Cooperative, which serves the whole province, had a peak load of 1985 kW in 1978, with an annual load factor of 19%. It was estimated that the 1979 peak load would reach 2550 kW and that the load factor will be about 24%. Low load factors are not uncommon in rural areas like those in Aklan, but these are lower than usual. One reason, no doubt, is that electric energy is new to the customers and up to now it has been used mainly for lighting. In addition, there have been very large increases in the number of customers each year; i.e., from 9,000 to 14,000 in 1979.

The 14,000 customers were all connected for the year-end peak, but the majority of the new customers would not have been using energy throughout the twelve months. These conditions will change as the customers find other uses for their electricity and all potential households become energy users. A 40% load factor may be achieved when this rural system matures.

Nabas is now supplied with electricity from the Aklan distribution system over a 35 km, 13.8 kV circuit which also serves all the rural services west of Kalibo. From Nabas this circuit runs south to the towns of Pandan and Libertad in northern Antique. One indicator of the loads to be expected in the Nabas area in the future is the 50 kVA transformer that will be installed in this region when the 69 kV transmission network is extended.

Electrification in Antique is not as far advanced as in Aklan. The capital, San Jose, is supplied from a small diesel in the city. This power source serves the local area and other towns as far north as Patnongon. In addition, the towns of Pandan and Libertad in the northern end of the province are served from the Aklan Coop at Nabas. At Tibiao there is a diesel generator that supplies the lighting needs of the city from dusk to midnight and, no doubt, other places are similarly served. There are also some places along the coast that have no electric service yet.

A dendro-thermal plant, even as small as 1000 kW, would be very lightly loaded if it were installed at Nabas or Tibiao to supply only the loads of these and adjacent areas. The energy produced from such a plant would only be a fraction of its capability and, therefore, the cost of each kilowatt hour generated would be very high. In addition, a thermal plant operating for an isolated local load would need a diesel or other source of power to operate the station auxiliaries each time the unit was started and also be required to supply the load every time the unit was out of service for maintenance. It is therefore recommended that the dendro-thermal plant be interconnected to the Panay power system. This will obviate the need for an auxiliary power source at the dendro-thermal plant and will enable the plant to deliver its output at a high load factor. The highest load factor and

lowest energy costs would be achieved with continuous operation. However, this is not possible in practice because the generator, turbine and boiler must be taken out of service occasionally for maintenance and because of the inevitable forced outages that will remove it from the line. An annual operating period of 310 days (85 percent) is assumed.

The transmission system into which the dendro-thermal plant would be interconnected had a load in December 1978 of 5300 kW, and in 1979 the load, as measured at the source of generation, was 8700 kW at 42% load factor.

4.3 EXISTING AND PROPOSED TRANSMISSION SYSTEM

In 1979 the transmission network on the Island of Panay consisted of two 69 kV circuits. One of these circuits will be modified to 138 kV in early 1980 when a transmission system at this voltage will be established to connect the Panitan generating station with the new Dingle generating station. This transmission system will continue southward to Santa Barbara. Appropriate transformer stations will begin operating, existing 69 kV lines will be rearranged and some new 69 kV circuits will be placed in service. When these changes and additions have been completed, the system will be as shown on the single line diagram of Figure 4-1. The transmission lines are shown geographically on Figure 4-2.

Construction of a 70 km, 69 kV transmission circuit from Tigbauan (near Iloilo) to Sibalom (near San Jose) is planned for 1981. This circuit will bring system power to Antique province. In 1983, one 69 kV circuit will be built from Altavas to Culasi (passing the future Aklan hydro development) and a second will be built from Kalibo to Nabas. These three lines, indicated on Figure 4-3, will make power available at the southern end, the central section, and the northern part of Antique, as can be seen from Figure 4-4.

FIGURE 4-1

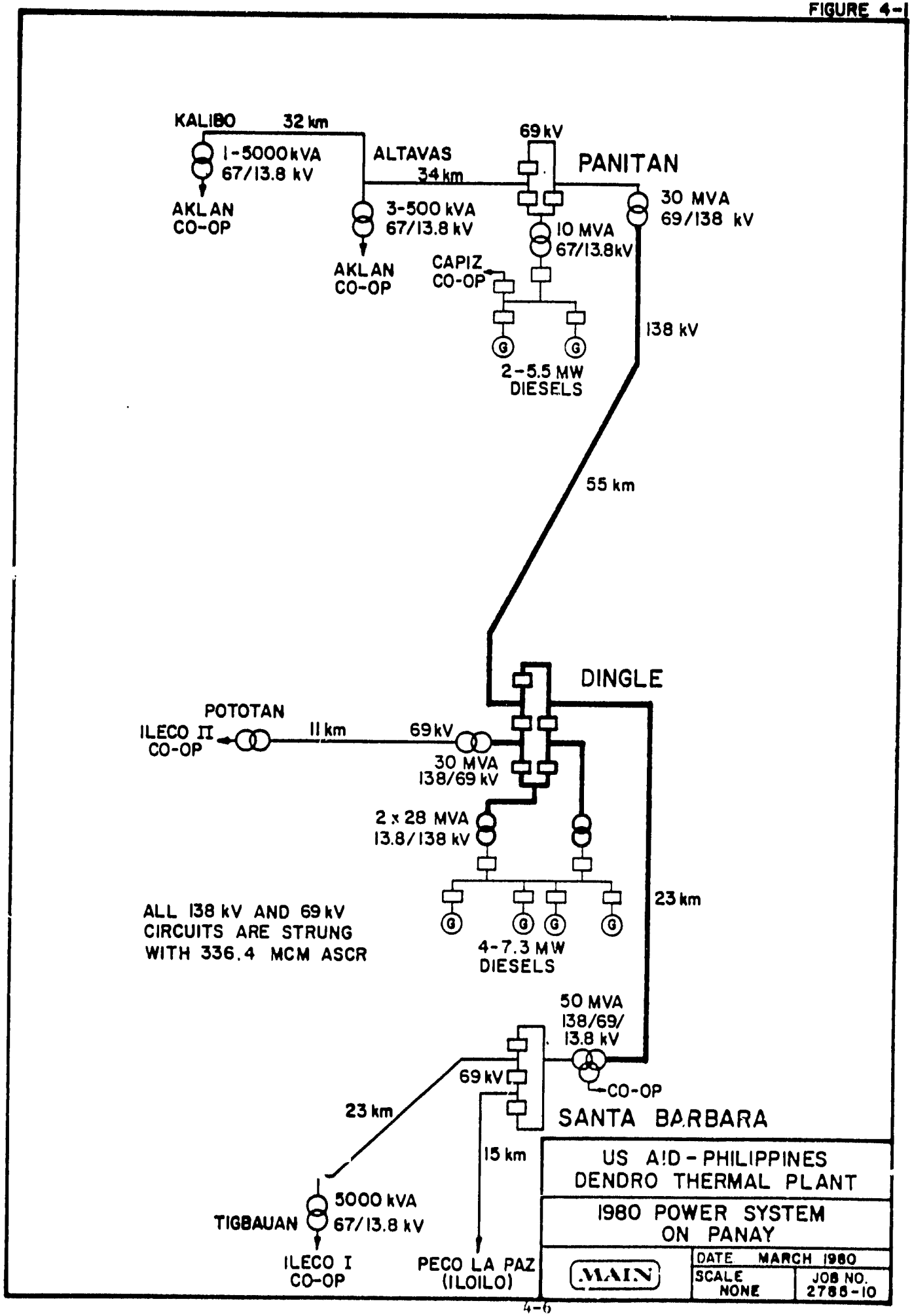

KALIBO
32 km
1-5000 kVA
67/13.8 kV
AKLAN
CO-OP
ALTAVAS
34 km
3-500 kVA
67/13.8 kV
AKLAN
CO-OP
69 kV
PANITAN
30 MVA
69/138 kV
10 MVA
67/13.8kV
CAPIZ
CO-OP
2-5.5 MW
DIESELS
138 kV
55 km
DINGLE
POTOTAN
ILECO II
CO-OP
11 km
69 kV
30 MVA
138/69 kV
2 x 28 MVA
13.8/138 kV
4-7.3 MW
DIESELS
23 km
ALL 138 kV AND 69 kV
CIRCUITS ARE STRUNG
WITH 336.4 MCM ASCR
50 MVA
138/69/
13.8 kV
CO-OP
69 kV
SANTA BARBARA
23 km
15 km
5000 kVA
TIGBAUAN
67/13.8 kV
ILECO I
CO-OP
PECO LA PAZ
(ILOILO)
US AID - PHILIPPINES
DENDRO THERMAL PLANT
1980 POWER SYSTEM
ON PANAY
MAIN
DATE MARCH 1980
SCALE NONE
JOB NO. 2786-10

FIGURE 4-2

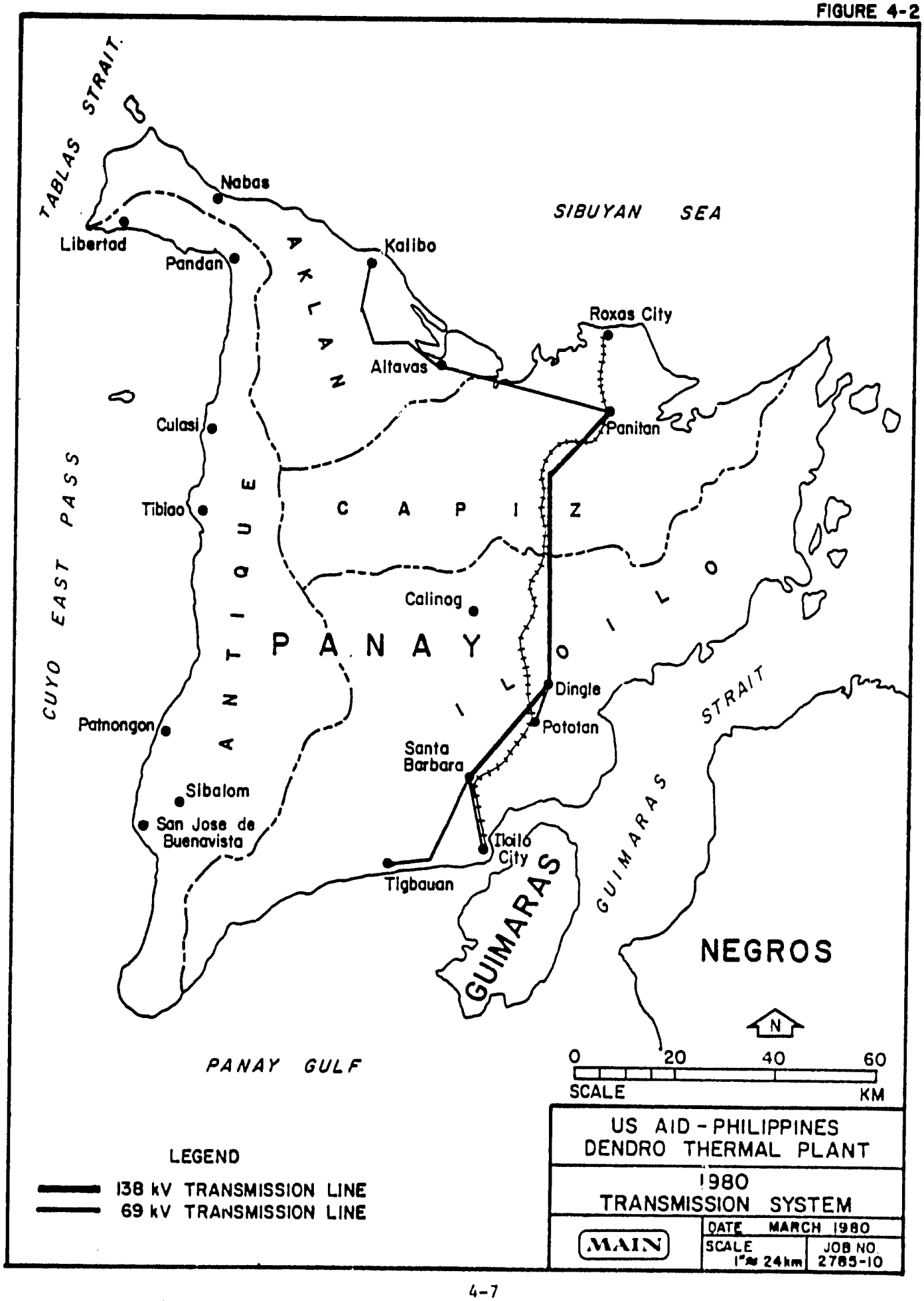

TABLAS STRAIT
SIBUYAN SEA
Nabas
Libertad
Pandan
Kalibo
AKLAN
Roxas City
Altavas
Panitan
Culasi
CUYO EAST PASS
Tibiao
ANTIQUE
CAPIZ
Calinog
PANAY
ILOILO
Dingle
Pototan
Patnongon
Santa Barbara
Sibalom
San Jose de Buenavista
Iloilo City
Tigbauan
GUIMARAS
GUIMARAS STRAIT
NEGROS
PANAY GULF
N
0 20 40 60
SCALE KM
LEGEND
138 kV TRANSMISSION LINE
69 kV TRANSMISSION LINE
US AID - PHILIPPINES
DENDRO THERMAL PLANT
1980
TRANSMISSION SYSTEM
MAIN
DATE MARCH 1980
SCALE 1" ≈ 24 km
JOB NO. 2765-10

FIGURE 4-3

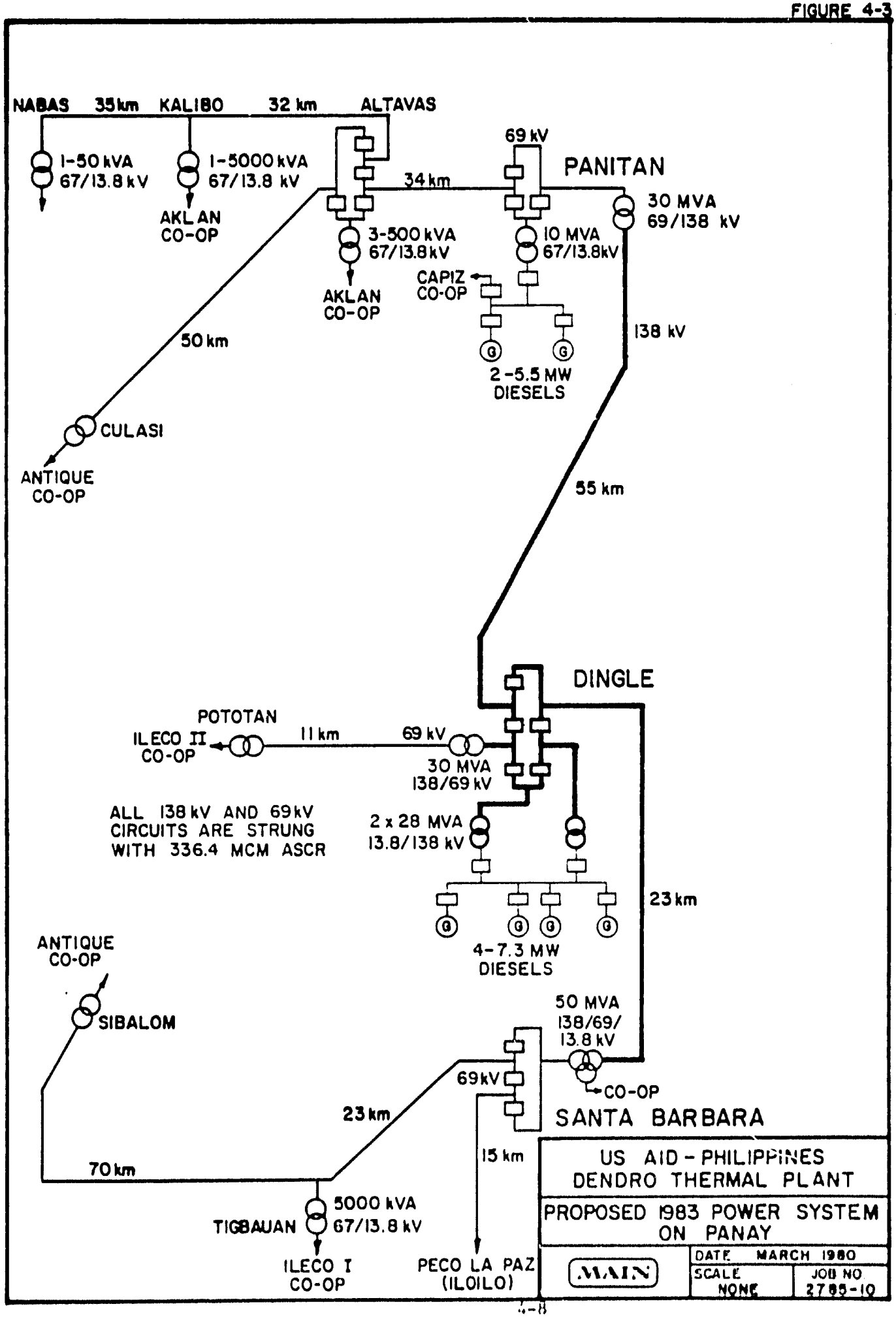
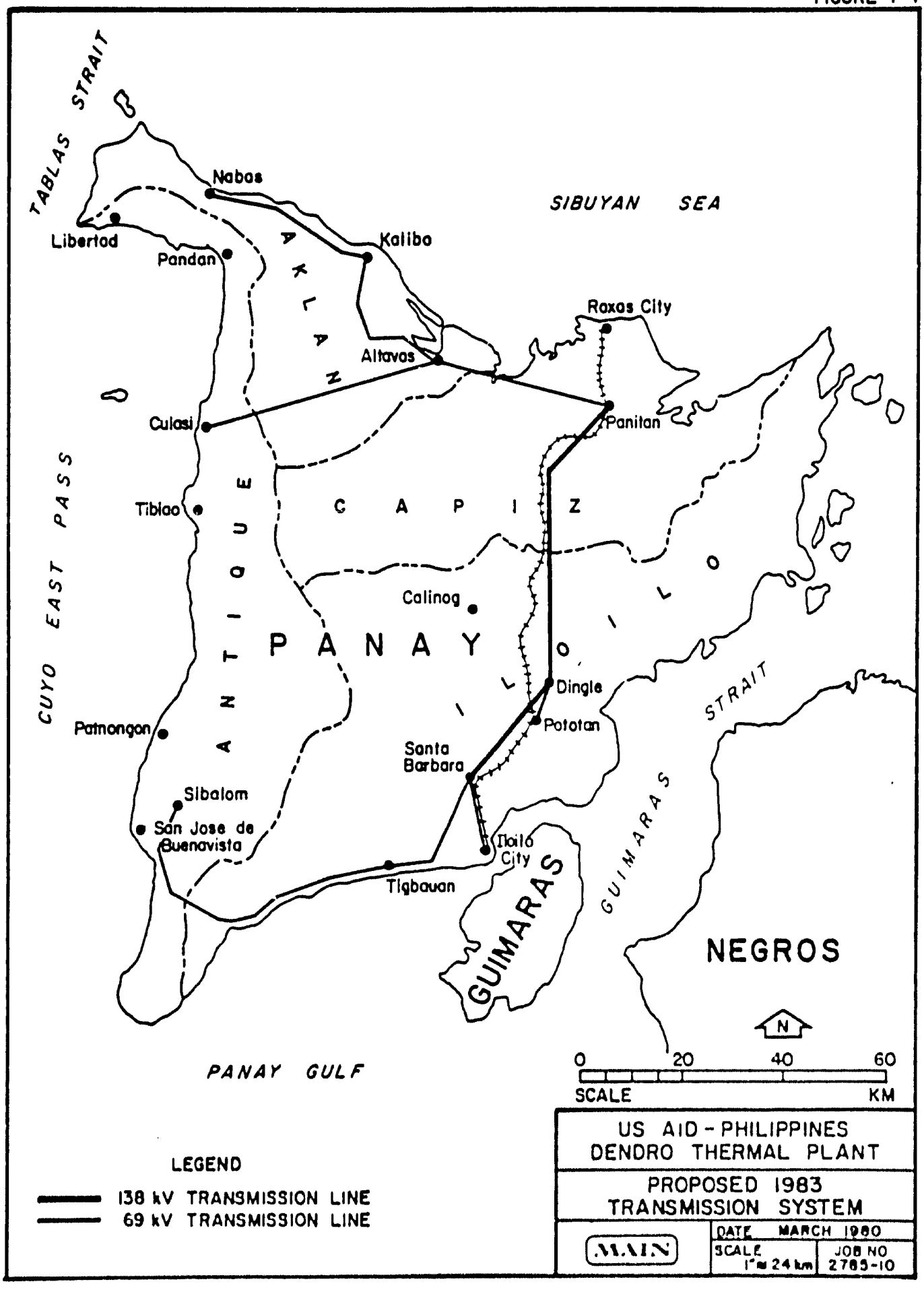

NABAS
35 km
KALIBO
32 km
ALTAVAS
1-50 kVA
67/13.8 kV
1-5000 kVA
67/13.8 kV
AKLAN
CO-OP
34 km
69 kV
PANITAN
30 MVA
69/138 kV
3-500 kVA
67/13.8 kV
AKLAN
CO-OP
10 MVA
67/13.8 kV
CAPIZ
CO-OP
2-5.5 MW
DIESELS
138 kV
50 km
CULASI
ANTIQUE
CO-OP
55 km
DINGLE
POTOTAN
ILECO II
CO-OP
11 km
69 kV
30 MVA
138/69 kV
ALL 138 kV AND 69 kV
CIRCUITS ARE STRUNG
WITH 336.4 MCM ASCR
2 x 28 MVA
13.8/138 kV
23 km
4-7.3 MW
DIESELS
ANTIQUE
CO-OP
SIBALOM
50 MVA
138/69/
13.8 kV
69 kV
CO-OP
SANTA BARBARA
23 km
15 km
70 km
5000 kVA
67/13.8 kV
TIGBAUAN
ILECO I
CO-OP
PECO LA PAZ
(ILOILO)
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1983 POWER SYSTEM
ON PANAY
MAIN
DATE MARCH 1980
SCALE NONE
JOB NO 2785-10

FIGURE 4-4


TABLAS STRAIT
SIBUYAN SEA
Nabas
Libertad
Pandan
Kalibo
AKLAN
Roxas City
Altavas
Panitan
Culasi
CUYO EAST PASS
Tibiao
ANTIQUE
CAPIZ
Calinog
PANAY
ILOILO
Dingle
Pototan
Patnongon
Santa Barbara
Sibalom
San Jose de Buenavista
Iloilo City
Tigbauan
GUIMARAS
GUIMARAS STRAIT
NEGROS
PANAY GULF
N
0 20 40 60
SCALE KM
LEGEND
138 kV TRANSMISSION LINE
69 kV TRANSMISSION LINE
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1983
TRANSMISSION SYSTEM
MAIN
DATE MARCH 1980
SCALE 1" = 24 km
JOB NO 2785-10

The proposed Panay thermal plant, scheduled for 1986, will be connected to the network by a 138 kV circuit, 55 km in length, from the plant site to Panitan. As shown on Figures 4-5 and 4-6, some additional 69 kV circuits in the central part of the island will also be operating in this period.

Figures 4-7 and 4-8 indicate how the Aklan hydro station would fit into the system and also how the network on Panay could be interconnected with the system on Negros. For this inter-system tie, a short length of 138 kV overhead line will run from Santa Barbara to the coast, then 3 km of submarine cable will traverse the channel to the island of Guimaras. Another overhead circuit will cross this island and 13 more kilometers of submarine cable will cross the Guimaras Straits. Some 138 kV transmission on Negros would permit an interconnection.

4.4 DENDRO-THERMAL PLANT/PANAY SYSTEM INTERCONNECTION

A dendro-thermal plant constructed in the Nabas area could be connected into the system as illustrated on Figure 4-9. The 69 kV circuit from Kalibo to Nabas that is scheduled for construction in 1983 would be extended about 6 km from its planned termination in Nabas to the dendro-thermal station site. Instead of installing the substation at Nabas, as presently planned, the distribution system would be served from the generating station bus.

A scheme for connecting a dendro-thermal plant located on the Tibiao River is depicted on Figure 4-10. The plan would be to re-route the proposed 69 kV transmission line from the Aklan hydro site to Culasi to a route from the hydro site to the Tibiao dendro plant. This transmission circuit would be about 4 km longer, but the substation at Culasi would not be needed if the distribution circuits originated at the dendro-thermal generator bus.

FIGURE 4-5

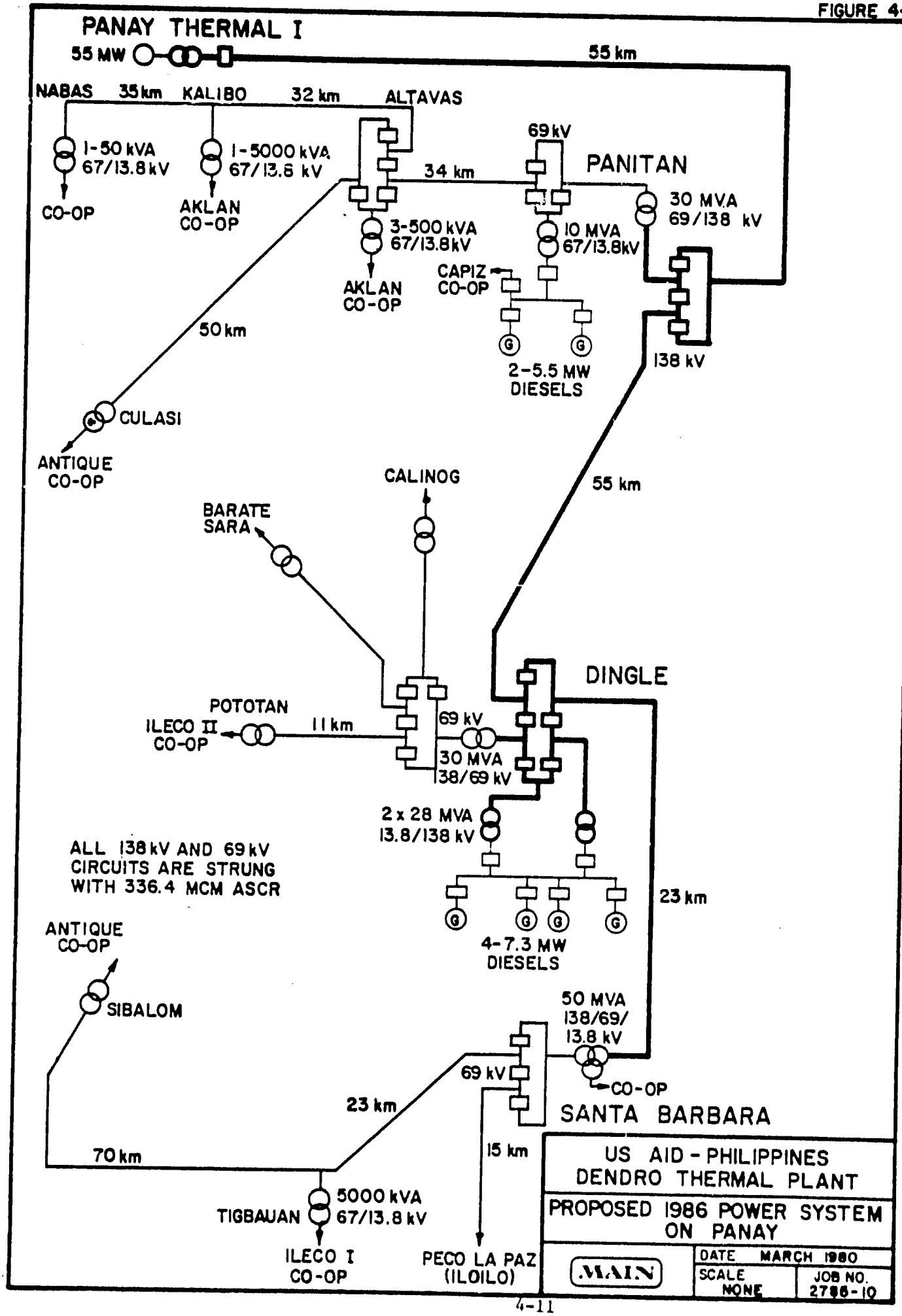

PANAY THERMAL I
55 MW
55 km
NABAS
35 km
KALIBO
32 km
ALTAVAS
1-50 kVA
67/13.8 kV
CO-OP
1-5000 kVA
67/13.8 kV
AKLAN
CO-OP
69 kV
PANITAN
34 km
30 MVA
69/138 kV
3-500 kVA
67/13.8 kV
AKLAN
CO-OP
10 MVA
67/13.8 kV
CAPIZ
CO-OP
50 km
2-5.5 MW
DIESELS
138 kV
CULASI
ANTIQUE
CO-OP
CALINOG
55 km
BARATE
SARA
DINGLE
POTOTAN
ILECO II
CO-OP
11 km
69 kV
30 MVA
138/69 kV
2 x 28 MVA
13.8/138 kV
ALL 138 kV AND 69 kV
CIRCUITS ARE STRUNG
WITH 336.4 MCM ASCR
23 km
4-7.3 MW
DIESELS
ANTIQUE
CO-OP
SIBALOM
50 MVA
138/69/
13.8 kV
69 kV
CO-OP
23 km
SANTA BARBARA
70 km
15 km
5000 kVA
67/13.8 kV
TIGBAUAN
ILECO I
CO-OP
PECO LA PAZ
(ILOILO)
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1986 POWER SYSTEM
ON PANAY
MAIN
DATE MARCH 1980
SCALE NONE
JOB NO. 2786-10

FIGURE 4-6

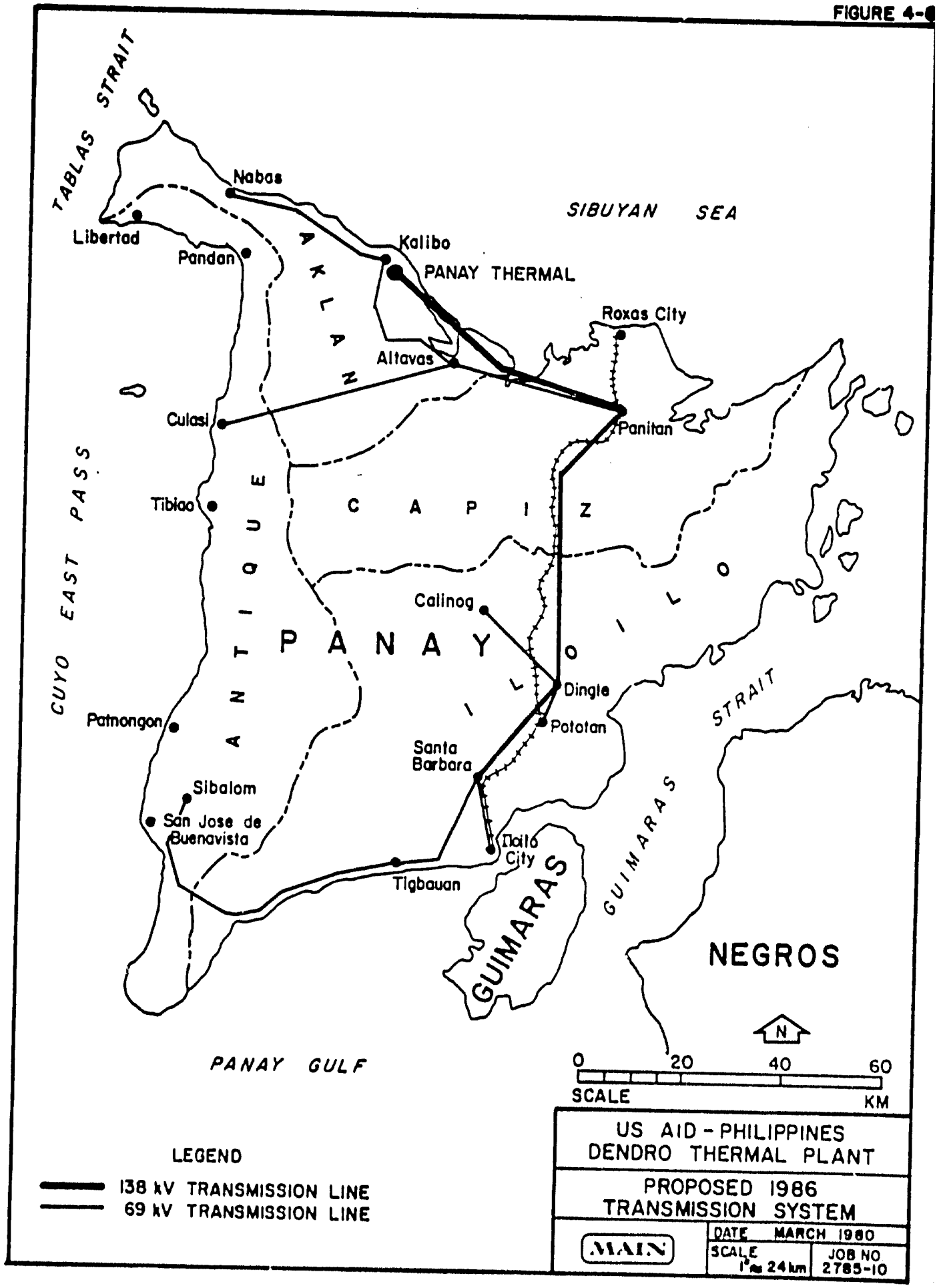

TABLAS STRAIT
Nabas
Libertad
Pandan
SIBUYAN SEA
Kalibo
PANAY THERMAL
AKLAN
Roxas City
Altavas
Culasi
Panitan
CUYO EAST PASS
Tibiao
CAPIZ
ANTIQUE
Calinog
PANAY
ILOILO
Dingle
Patnongon
Pototan
STRAIT
Santa Barbara
Sibalom
San Jose de Buenavista
Iloilo City
GUIMARAS
Tigbauan
GUIMARAS
NEGROS
PANAY GULF
N
0 20 40 60
SCALE KM
LEGEND
138 kV TRANSMISSION LINE
69 kV TRANSMISSION LINE
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1986
TRANSMISSION SYSTEM
MAIN
DATE MARCH 1980
SCALE 1" = 24 km
JOB NO 2785-10

FIGURE 4-7

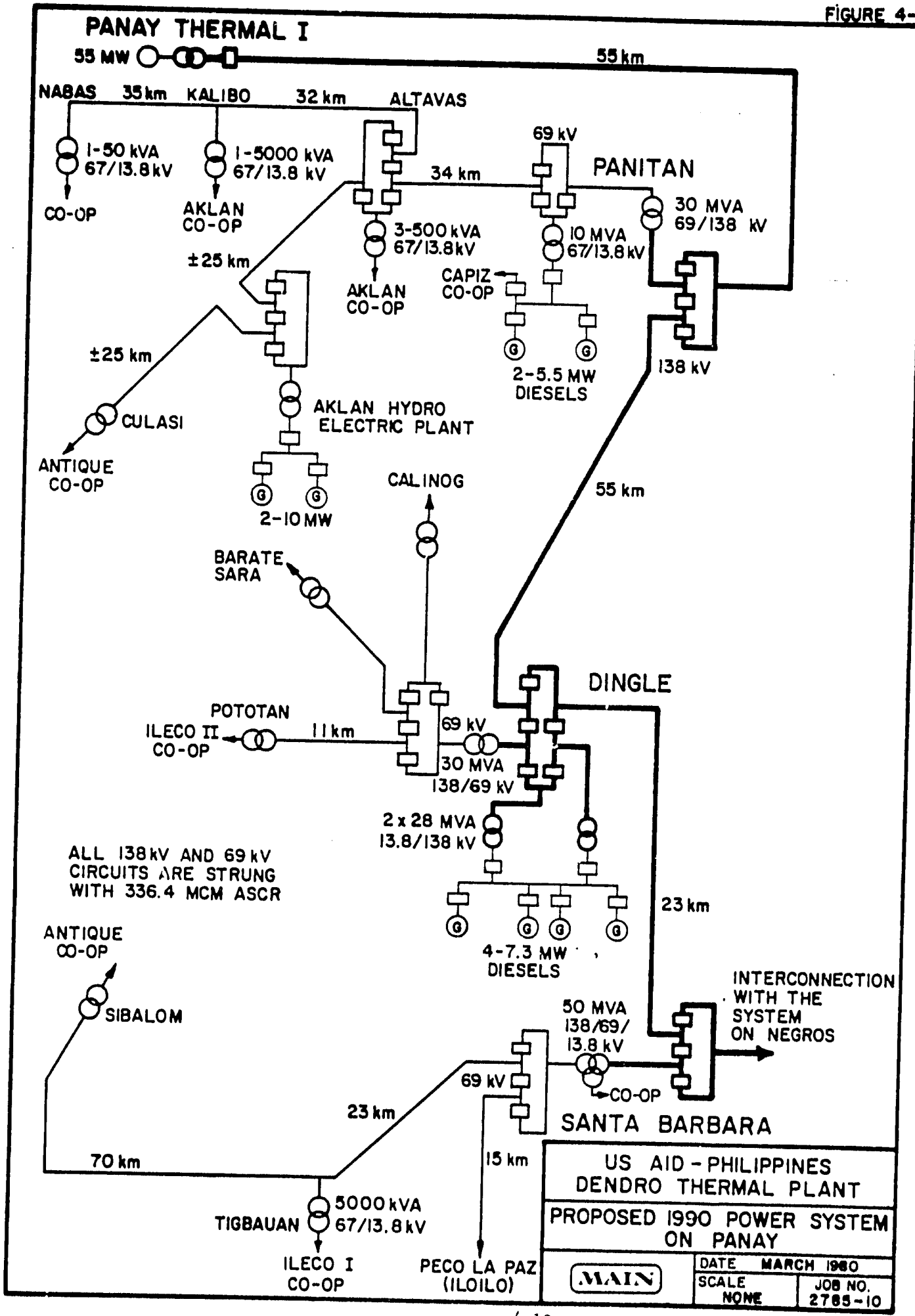

PANAY THERMAL I
55 MW
55 km
NABAS
35 km
KALIBO
32 km
ALTAVAS
1-50 kVA
67/13.8 kV
CO-OP
1-5000 kVA
67/13.8 kV
AKLAN
CO-OP
69 kV
34 km
PANITAN
30 MVA
69/138 kV
3-500 kVA
67/13.8 kV
AKLAN
CO-OP
10 MVA
67/13.8 kV
±25 km
CAPIZ
CO-OP
2-5.5 MW
DIESELS
138 kV
±25 km
CULASI
ANTIQUE
CO-OP
AKLAN HYDRO
ELECTRIC PLANT
2-10 MW
CALINOG
55 km
BARATE
SARA
DINGLE
POTOTAN
ILECO II
CO-OP
11 km
69 kV
30 MVA
138/69 kV
2 x 28 MVA
13.8/138 kV
ALL 138 kV AND 69 kV
CIRCUITS ARE STRUNG
WITH 336.4 MCM ASCR
23 km
4-7.3 MW
DIESELS
ANTIQUE
CO-OP
SIBALOM
INTERCONNECTION
WITH THE
SYSTEM
ON NEGROS
50 MVA
138/69/
13.8 kV
CO-OP
69 kV
23 km
SANTA BARBARA
70 km
15 km
5000 kVA
67/13.8 kV
TIGBAUAN
ILECO I
CO-OP
PECO LA PAZ
(ILOILO)
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1990 POWER SYSTEM
ON PANAY
MAIN
DATE MARCH 1980
SCALE NONE
JOB NO. 2785-10

FIGURE 4-8

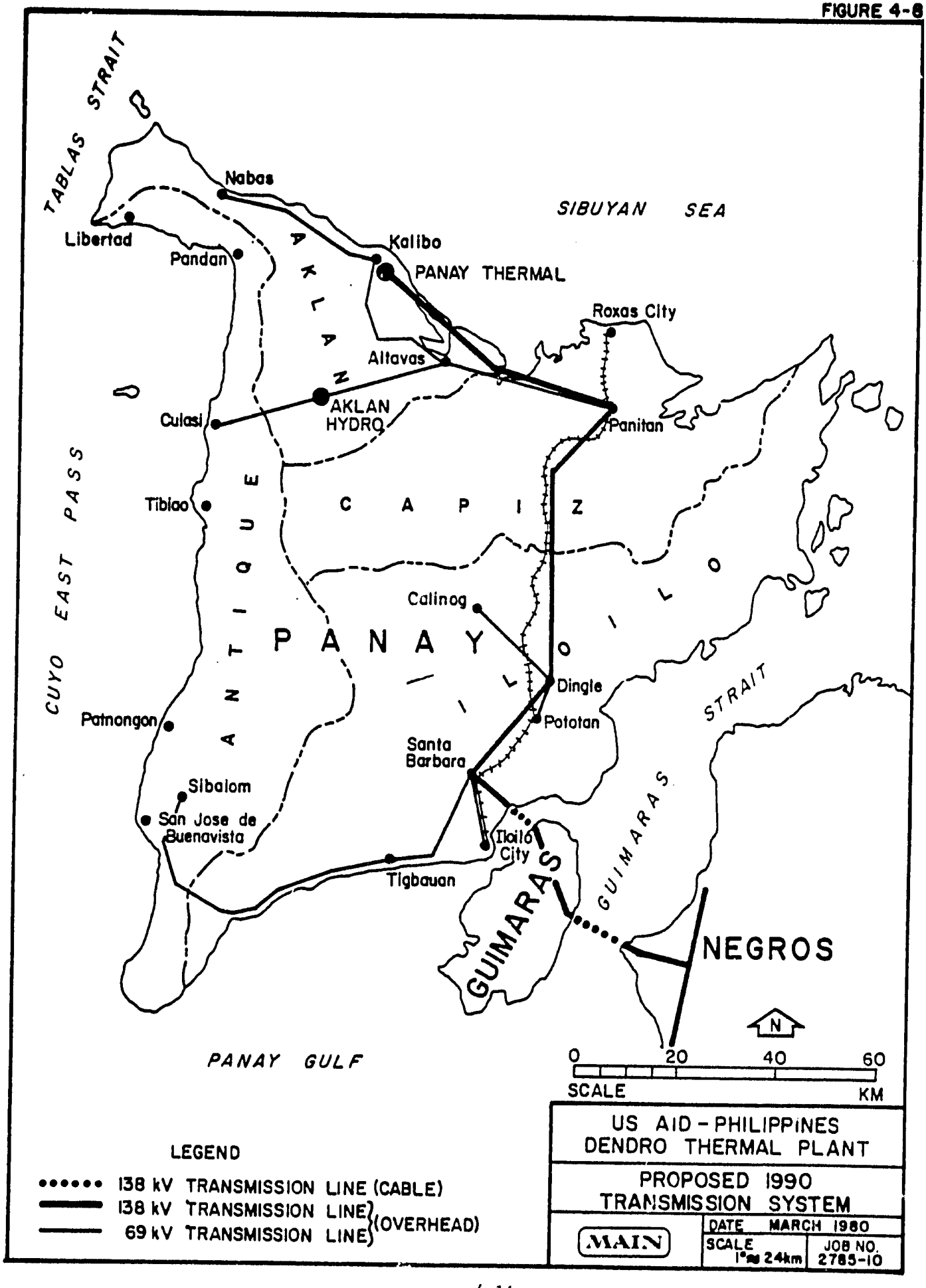
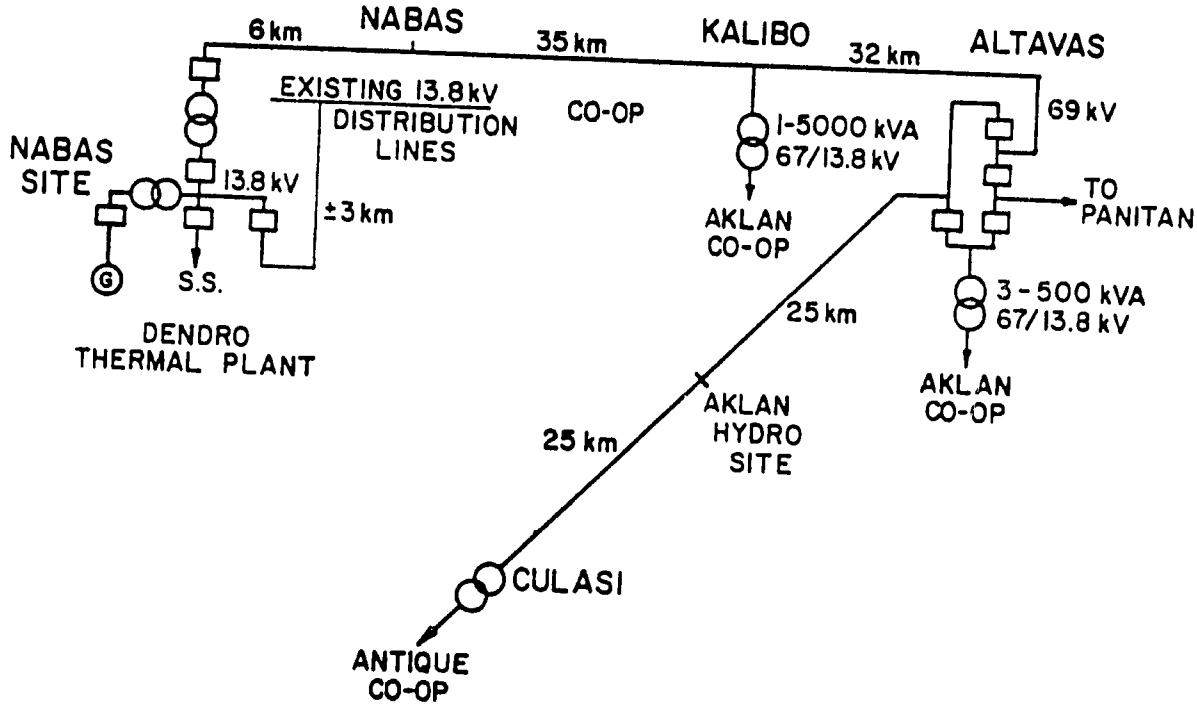
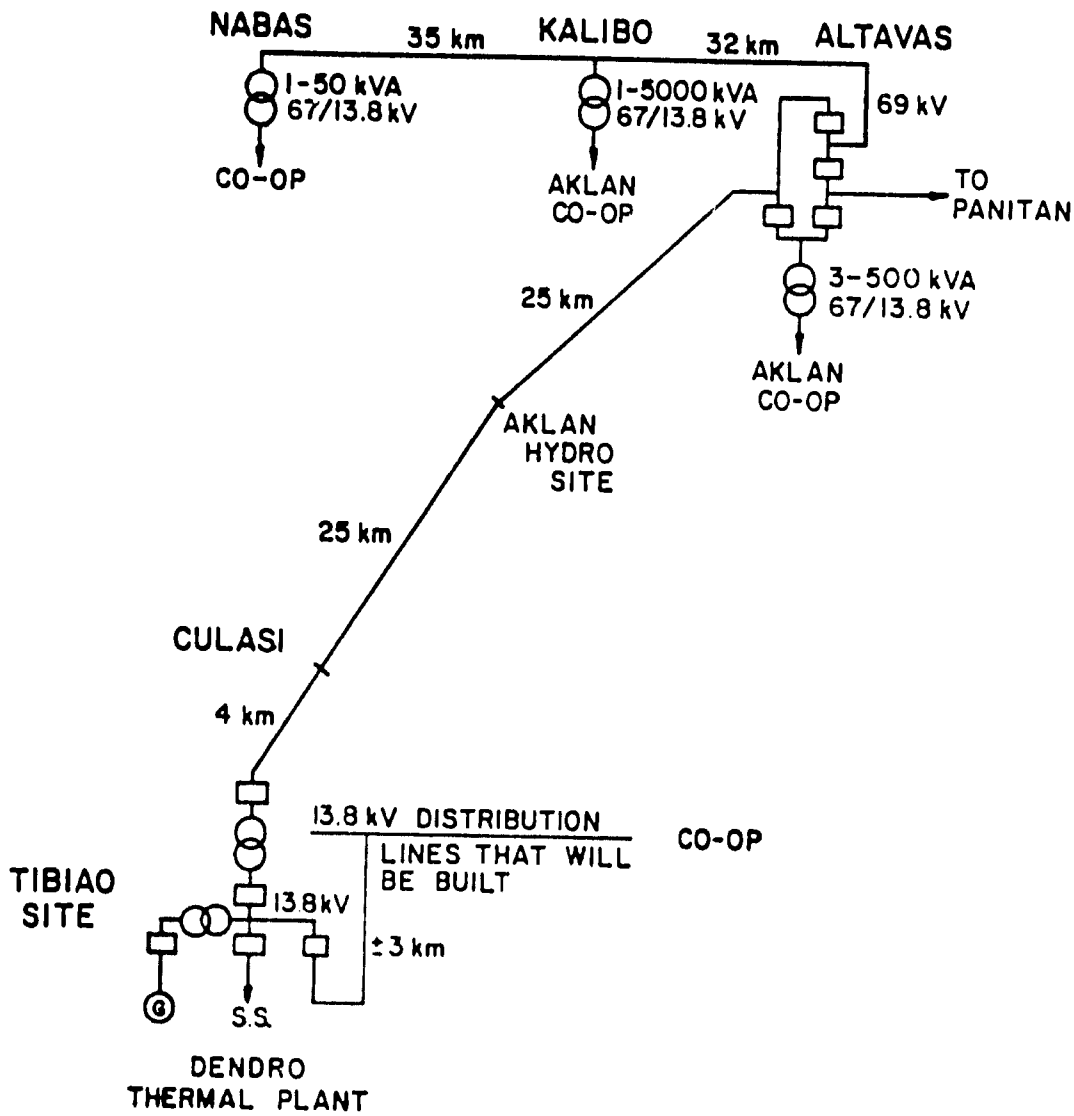

TABLAS STRAIT
SIBUYAN SEA
Nabas
Libertad
Pandan
Kalibo
PANAY THERMAL
AKLAN
Roxas City
Altavas
AKLAN HYDRO
Culasi
Panitan
CUYO EAST PASS
Tibiao
CAPIZ
ANTIQUE
Calinog
PANAY
ILOILO
Dingle
Pototan
Patnongon
Santa Barbara
STRAIT
Sibalom
San Jose de Buenavista
Iloilo City
GUIMARAS
Tigbauan
GUIMARAS
NEGROS
PANAY GULF
N
0 20 40 60
SCALE KM
LEGEND
138 kV TRANSMISSION LINE (CABLE)
138 kV TRANSMISSION LINE
69 kV TRANSMISSION LINE
(OVERHEAD)
US AID - PHILIPPINES
DENDRO THERMAL PLANT
PROPOSED 1990
TRANSMISSION SYSTEM
MAIN
DATE MARCH 1980
SCALE 1" = 24km
JOB NO. 2785-10

FIGURE 4-9



US AID-PHILIPPINES DENDRO THERMAL PLANT		
PROPOSED CONNECTION DENDRO THERMAL SITE-NABAS		
MAIN	DATE MARCH 1980	
	SCALE NONE	JOB NO. 2788-10

FIGURE 4-10



US AID - PHILIPPINES DENDRO THERMAL PLANT		
PROPOSED CONNECTION DENDRO THERMAL SITE - TIBIAO		
MAIN	DATE MARCH 1980	
	SCALE NONE	JOB NO 2786-10

5 GENERATION SYSTEM

5.1 SITE PREPARATION

Because only a representative plant site has been selected, a number of assumptions have been made regarding site preparation. Specifically:

- The plant will be located within 200 meters of a river.
- Topography will slope toward a river with a maximum difference in elevation on the site of 2 meters.
- The site will be graded.
- The site will be stripped of all surficial material to a depth of 0.3 meters. Subgrade fill will be bank-run gravel.
- All drainage will be conveyed away from the site via trenches. There will be culverts at all road crossings.
- Areas to be paved include all roads adjacent to the power plant structures. All other roads on the site will be gravel surfaced.

The cost estimate reflects areas as shown in the site plan; e.g., general leveling, internal roads.

5.2 FUEL HANDLING

The chip trucks, with an average capacity of $10m^3$, or 10 green tonnes, will drive into the plant site and back up to the unloading platform. An average total of 18 to 20 trucks per day will be unloaded by either of two small diesel front end loaders, called "bobcats", driven by a man. The bobcats operate on the unloading platform, driving into the back of the truck, scooping up chips in its 2-1/2 to 3 cu. yd. (1 m^3) bucket, backs out and dumps the chips through an opening in the platform into a double strand drag chain conveyor below the platform. A truck can be unloaded in an average one hour time period.

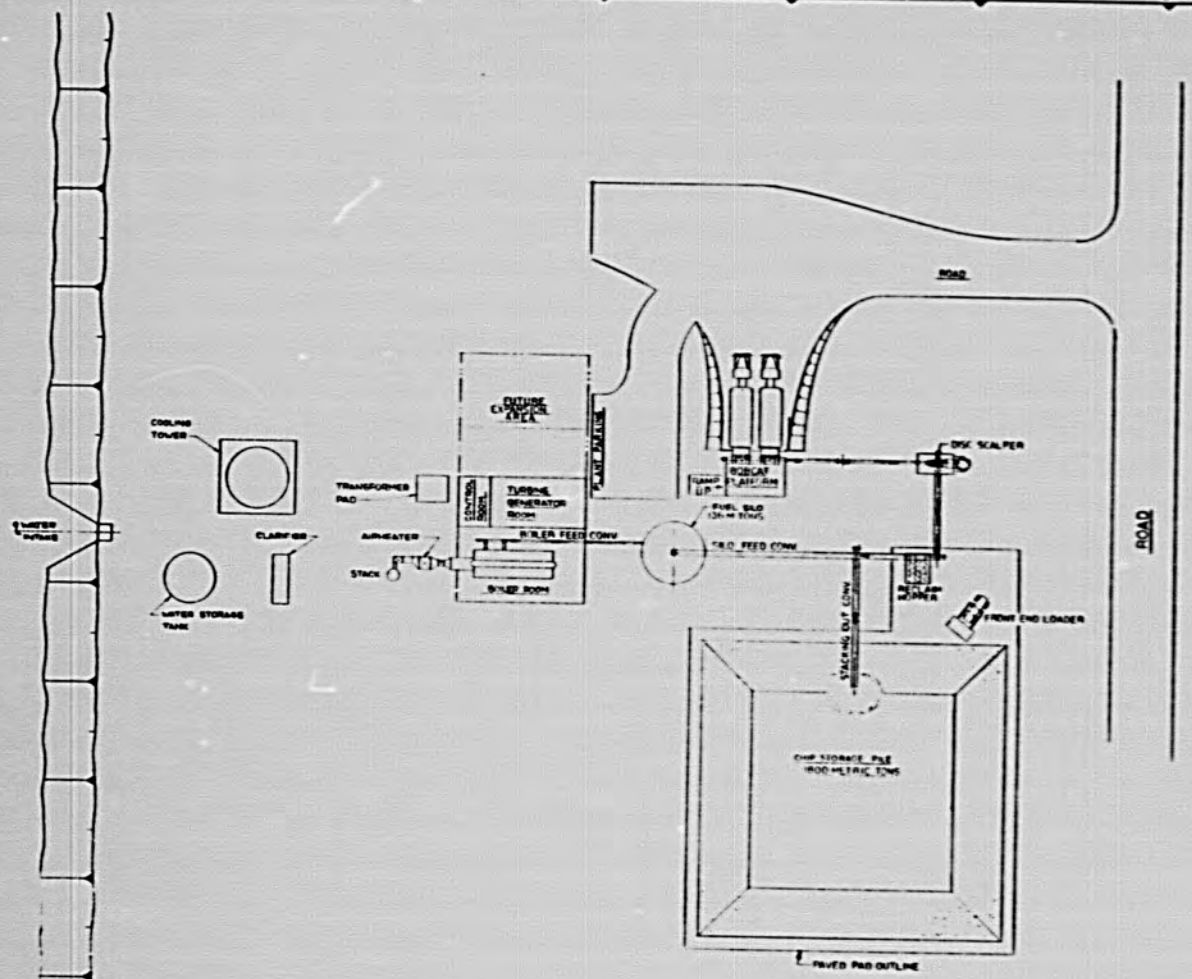
The platform will contain adjustable tail plates to allow for variable truck bed heights. After being emptied, the trucks will go to the fuel pump for refueling and then return to the satellite yard for chip refilling. The chips will be carried by the conveyor and discharged onto an inclined 30" belt conveyor up to a scalping disc screen.

A tramp metal magnet will be located over the head pulley of the belt conveyor to remove tramp metal from the chip flow. The disc screen will remove large, oversize slabs of wood, rocks, and stones, discharging them onto the ground.

The accepted chips will drop through the spaces between the rotating discs into another inclined belt conveyor which will carry them up and discharge into a two-way chute with a manually operated flop gate. One leg of the chute will discharge the chips onto an inclined double strand drag chain conveyor rising up 35 ft. (11 m) and discharging the chips onto a storage pile. The storage pile will be built by a leased, large rubber-tired, front-end loader with an 18 cu. yd. bucket driven by one of the bobcat operators. The base of the pile will be an asphalt paved pad, 125 ft. by 125 ft. (38m x 38m) in area and can hold a 20-day supply of 2000 tonnes. Pile height is 20 ft. (6 m). The other leg of the two-way chute will feed another inclined chain conveyor, carrying chips up and discharging into the fuel storage silo.

Fuel from storage will be reclaimed by the front end loader carrying chips in the bucket and discharging them into a hopper with an outfeed metering conveyor comprising 8-12" diameter (30 cm dia.) screws. The screws will discharge the chips onto the belt conveyor from the disc scalper. Reclaim from the pile will take place on the third shift, Saturday P.M. and Sunday. The silo will contain a one-day supply for reclaim on Sunday. See Figure 5-1 for a fuel flow diagram.

The following pages contain data used in establishing the design of the wood handling system and in developing the order of magnitude cost estimate.



U.S. AID PHILIPPINES
DENGRO THERMAL PLANT

GENERAL PILOT PLANT

2785 40 52

U.S. A I D PHILIPPINES DENDRO-THERMAL 2 MW GENERATING STATION	SHEET 1 OF 4 JOB NO. 2785-10-1 DATE: March 1980
DATA FOR BASIS OF DESIGN REPORT WOOD PREPARATION & HANDLING	MAIN

A. DESIGN DATA

Electric Power Generation MW/Hr.	2
Boiler Plant Output #Steam/Hr.	25,000#/Hr.
Fuel Ratio BD #wood/#steam	4.85:1
Fuel Required BD #wood/Hr.	5160
Fuel Required BDMT Wood/Hr.	2.34
Wood Input @ 35% moist. gr. Mt./Hr.	3.6
Wood Input @ 35% moist. gr. Mt./d.	86.4
Wood Input @ 35% moist. gr. Mt./wk.	604.8
Wood Input @ 35% moist. gr. Mt./yr.	26,8000
Operating days/year	310 d/yr.

B. TREE CHARACTERISTICS

1. Range - diameter breast high-inches	5-8
2. Range - height-feet	25-30

C. LAND & ROUNDWOOD DATA

Land Unit: hectare = 108,000 SF (330'x330' lot size)	
Tree Growth/hectare	10 BD Mt/Yr
@ 35% moist.	15.4 gr. Mt/Yr
Wood Unit Weight (OD)-solid-weighted ave. of species	42.7 #/cf
@ 35% moist.-solid	66 #/cf
Wood Unit weight @ 35% MC-loose in pile	22 #/cf
Wood Unit weight @ 35% MC-in silo	30 #/cf

D. ROUNDWOOD HARVESTING

CASE I Second year growth; 1st year Harvest:

Yearly roundwood requirement	26,800 gr.mt
Total gr. mt/ha (2 year growth)	31 gr.mt
Total hectares required	865
Total No. stems (@ 5000/ha)	4,325,000

DATA FOR BASIS OF DESIGN

REPORT

WOOD PREPARATION & HANDLING

MAIN

D. ROUNDWOOD HARVESTING (Continued)

Harvest rate per day (5 day/week, 261 day/year)	167 gr.mt
Harvest rate per hour (8 hour/day)	21 gr.mt

E. ROUNDWOOD HARVESTING

CASE II Third year growth & over; 2nd year Harvest & succeeding:

Yearly roundwood requirement	26,800 gr.mt
Total growth per hectare	46 gr.mt
Total hectares required	583 ha
Total no. stems (@ 5000/ha)	2,915,000
Harvest rate per day (5 day/week, 261 day/year)	167 gr.mt
Harvest rate per hour (8 hour/day)	21 gr.mt

F. SATELLITE CHIPPERS

Chipping Rate - MTPD	167-170
Mobile Chipper-'Morbark' Model 550 58" disc, 2 knife Horiz. Feed opng 18" V x 36" diag.	
Rated Cap English TPD	150-250
Rated Cap Metric TPD (x.907)	136-227
Number of chippers required	2
Average mton chipped per day	80-90
Feed rate for 5/8" to 3/4" chip size	98-100 ft/min.
Number of stems per feed cycle	3-4
Weight of 3-4 stems @ 300# ± each	1200#
Chipper Slide boom lift cap @ 5'	5000#
Chipper Slide boom lift cap @ 15' (max. reach)	1600#

DATA FOR BASIS OF DESIGN

REPORT

WOOD PREPARATION & HANDLING

MAIN

G. TRUCKS

Average capacity M^3	10
Average load - m ton	7-10
Number of trucks required-(3-4 each chipper)	6-8
Number of truck deliveries/day	16-20

H. TRUCK UNLOADING

Front End Loader-Melroe "Bobcat" 4-wheel diesel driven, 6'hi x 4'w x 8-1/9 with 1-1/2 to 2 cy bucket (60 cm^3). cap. mt.	0.7
Unloading Capacity Number of Trucks/Hour	1
Number of passes (fill & disch.) required for 10 mt	14
Maximum cycle time: travel into truck, fill bucket, backout, discharge chips - minutes	3
Maximum cycles per hour (allow for trim & cleaning)	20

I. WOOD FUEL HANDLING EQUIPMENT

Number of trucks unloaded per hour	2
Number of hours required min.-maximum	8-10
Capacity of handling system 2 @ 10 mt/hr.	20
Allowance for surging - 20%	5
Design Capacity of system mt/hr	25

J. TOTAL WOOD FUEL RECEIPTS

Number of mtons per day (160-200) average	180
Number of mtons for 5 days; mt average	900
Boiler usage: green mt/week @ 3.6 mt/hr	605
Surplus gained per week gr. mt	300

K. STORAGE SILO

Size 25' diameter x 26'-8" hi- usable units	68
Number of green mtons	136
Number of hours storage @ 3.6 to 4 mt/hr.	34
Number of hours required: Sat 4PM-Mon. 10AM	34

DATA FOR BASIS OF DESIGN

REPORT

WOOD PREPARATION & HANDLING

MAIN

L. OPEN STORAGE

Number of days required	20
Number of mtons @ 90 mt/d	1800
Base Size of pile @ 20 ft hi & 22 #/cf	120' x 120'

5.3 STEAM AND POWER GENERATION

5.3.1 Data for the Basis of Design and Cost Estimate

This section identifies the design concept recommended for a wood fired electric power generating station in the Philippines. First, basic design considerations are discussed. Second, a conceptual site plan and schematic flow diagram are presented. Lastly, major components of the plant are described. These descriptions are preliminary and will need to be refined prior to or during final design.

5.3.2 Design Considerations

When designing a steam generator for wood firing, the final design of the unit and auxiliary equipment must be carefully studied for compatibility with the fuel and its combustion products, and the variations in methods and operation must be evaluated using good judgment and engineering practice. Major areas of the unit design which must be evaluated for wood firing include auxiliary fuel firing, method of wood firing and burning, furnace design, superheater and generating bank design, air preheater design, particulate removal systems, and ash handling systems.

At this point in the project's history, however, design considerations must focus on basic engineering concepts; i.e., those which will establish the framework for final design. The following sections discuss design considerations which the study team feels will be important to the successful construction and operation of a wood-fired steam electric generating station in the Philippines.

5.3.3 General Philosophy

Simplicity has been adopted as a keynote for developing the concept of the power plant. Experience has shown that simplicity greatly enhances ease of operation and maintenance. It also reduces the need for extensive inventories of spare parts. Hence, overall costs are reduced. This concept applies to project construction as well as engineering design.

5.3.4 Fuel Preparation

Wood will be delivered to the plant site as wood chips. The wood can be fired as received, or dried prior to burning. The study team recommends the first of these two options for the following reasons:

A. There are basically two types of wood fuel dryers commercially available; (1) those that utilize the sensible heat of the flue gas to dry the wood fuel either in suspension or in rotary dryer drums; and (2) systems utilizing fossil fuel and/or wood "fines" fired burners connected to rotary drums.

The first system is more widely used since a separate combustion system for drying is not required. Depending upon the wood fuel drying requirements, the temperature of the flue gas exiting the boiler may be required to be higher than normal. This higher exit flue gas temperature will reduce the overall boiler efficiency gain from burning lower moisture wood.

Wood fuel is generally not dried below 30% moisture (wet basis) since high flue gas temperatures are required and problems exist with wood "fines" generation and potential for fires in the dryer. Fuel drying is most effective when the wood fuel has a high moisture content that precludes stable combustion of the fuel, or at least in the 55-65% moisture range. The wood supply for this project has a moisture content of 35% as received (see Appendix D). Drying wood of this low moisture content is not practical.

B. An objective of the project is power generation at as low a cost as practicable. Incorporating a fuel dryer will increase project costs. As it will also require power, it will reduce the net amount of power available.

C. Operation of the power plant at rated capacity would be dependent on operation of the fuel dryer unless the equipment is initially designed for the higher fuel moisture content at increased capital cost.

D. The use of wood fuel in its natural state minimizes the complexity of the plant and allows the greatest operating flexibility.

5.3.5 Fuel Firing

An extensive technology exists for burning wood fuel. Methods of firing can generally be classified as:

- Cell Firing
- Spreader Stoker Firing
- Suspension Firing
- Fluidized Bed Combustion
- Gasification

Each is briefly described below.

5.3.5.1 Cell Firing

As the name implies, the furnace is one or more refractory cells or boxes. It is generally a separate structure and heat released in the cell is transferred to the boiler.

The earliest wood furnaces were of the cell type and were known as "dutch ovens". The dutch oven is essentially a refractory box with or without grates. Fuel is piled on the floor of the cell and ignited. Combustion gases discharge from the side or back of the furnace into the boiler. The earlier dutch oven boilers were generally not airtight, requiring large amounts of excess air and, consequently, were not very efficient. In addition, since the combustion air could not be controlled,load varying response was poor.

The modern cell-type furnace consists of a cylindrical refractory cell in an airtight steel casing. Undergrate and overfire air are used to control combustion and load response. Fuel is fed into the cell from the upper side wall of the furnace and is set to maintain a small fuel pile on the grate on the bottom of the cell. This type of furnace is limited in capacity to about 60,000 lbs/hr of sceam and is

generally best applied to burning wood with a moisture content of less than 50% (wet basis).

Several "dutch oven" cell-type boilers firing bagasse are operating on Panay. Two units are installed at the Passi Sugar Central and seven units are installed at Central Santos Lopez, north of Iloilo City.

5.3.5.2 Spreader Stoker Firing

The furnace in this case is generally an integral unit with the boiler. Fuel is projected into the furnace over the fire with a uniform spreading action. This permits suspension burning of fine fuel particles. The heavier pieces that cannot be supported in the gas flow fall to the grate for combustion in a thin, fast-burning bed.

The modern spreader stoker installation consists of feeder-distributor units in widths and numbers as required to distribute the fuel uniformly over the width of the grate, specifically designed air-metering grates, forced draft fans for both undergrate and overfire air, dust collecting and reinjecting equipment, and combustion controls to co-ordinate fuel and air supply with load demand.

Spreader stoker systems use either mechanical or pneumatic means to move the fuel into the furnace. Both provide a continuous, well-distributed supply of fuel at an adequate rate.

These furnaces vary primarily in their grate design. The common types are fixed or stationary grates and continuous cleaning, traveling grates. Many variations in design exist for each type depending on manufacturer's preference, individual use, and desired operation characteristics. Three key factors influencing grate design include moisture of the wood fuel, the type of auxiliary fuels, and load demand variations anticipated.

5.3.5.3 Suspension Firing

There are several types of suspension burners commercially available. Generally, the wood fuel is pulverized, mixed with air in a burner, ignited, and discharged into a furnace. Several cyclonic types are available that mix the air and fuel in a relatively large cylindrical refractory furnace and combust the mixture within this furnace while the fuel and air circle around inside at relatively high speed.

The objective of this type of system is to completely burn the wood fuel before the combustion gases leave the burner furnace. This requires close control of fuel particle size and fuel moisture content.

5.3.5.4 Fluidized Bed Combustion

The fluidized bed takes its name from the fact that there is no grate as associated with the spreader stoker or most cell type furnaces. Rather, the fuel burns on a bed of flowing air which enters at the base of the furnace. The system is an outgrowth of a process first commercially used in Germany in 1926 for producing a raw gas feed stock from powdered coal.

Fluidized bed furnaces have been used extensively by the petrochemical industry for the catalytic cracking of crude oil. It is not until recently that fluid bed technology in the design of combustion systems has received much attention.

The bed in this type of furnace is an inert material, such as sand. At start-up the bed is preheated to a temperature of approximately 750°F. Air flow is increased to the point that the bed is essentially suspended, giving it a fluid characteristic. Fuel is blown downward through the air stream toward the bed. As it moves downard, the fuel burns in suspension or on the bed. The speed of combustion is dependent upon the air flow rate. As the stability of the bed is also dependent on a critical

air flow rate, major variations in load cannot be tolerated. In addition, high moisture content in the wood fuel, or fuel supply interruptions lasting more than a few minutes, will result in loss of bed temperature and subsequent loss of combustion.

In recent years, fluidized bed combustion has received considerable attention because of its ability to reduce undesirable emissions when burning sulfur bearing fuels; i.e., coal and oil. To date, there has been limited commercial application in the utility industry.

There have been a number of fluidized installations in the forest products industry that have achieved varying degrees of success generating low pressure steam from a waste heat boiler. A significant unsolved problem with this system is the amount of particulate in the hot combustion gases discharging from the fluid bed furnace carrying over into the waste heat boiler.

Additional research and practical application are needed before fluidized bed combustion can be considered proven technology.

5.3.5.5 Gasification

Gasification is a process which converts a solid fuel into a fuel gas. The technology of this type of system has been known for many years and has been applied primarily to coal. The primary process of gasification available today are air-driven oxidation/pyrolysis processes. Pyrolysis is a thermal process conducted with an absence of oxygen to produce gas, oils and char from a solid.

Wood gasifiers can be either directly connected to a boiler designed to burn low Btu gas or the gases can be cleaned and cooled and fired in a diesel engine with about 10% diesel fuel. These engine-fired units require relatively dry wood (25-30% moisture) and produce a toxic tar contaminated condensate in the cooling process which can represent a disposal problem.

An auxiliary fuel is required on start-up of a gasifier to establish the oxidation zone. Weak gas produced during the start-up is generally flared. Gasification control is primarily by varying the air feed and the fuel supply.

Gasifiers in use today have proved to be costly and are generally acknowledged to be experimental.

5.3.5.6 Recommended Firing Method

For the proposed project, a cell type firing system is recommended. This recommendation is based upon the following:

(a) Cell burning is a well-proven technology and a large number of cell-type furnaces are operating throughout the world.

(b) The capital cost of a cell-type system for the steaming capacity (30,000 lbs/hr) of the proposed boiler is substantially less than that of a comparably well-designed stoker fired unit. The proposed boiler is a relatively small unit which matches the cell type of firing system capacity.

(c) A cell-type furnace is relatively simple to operate and maintain.

(d) The efficiency of a modern airtight, cell-burning system is comparable to that of a stoker fired system.

(e) The unit will be firing chipped wood of a reasonably good quality and moisture content suitable for cell burning.

(f) Although cell firing is less responsive to load changes than stoker fired systems, load change response is not as critical in this case. This unit will be tied into the Island's

transmission grid and the steam power plant will be essentially base loaded. The electrical power swings will be taken by the Island's diesel generating plants.

For a larger capacity power plant, MAIN's recommendations would be for a stoker firing system.

5.3.6 Conceptual Flow Diagram and Site Plan

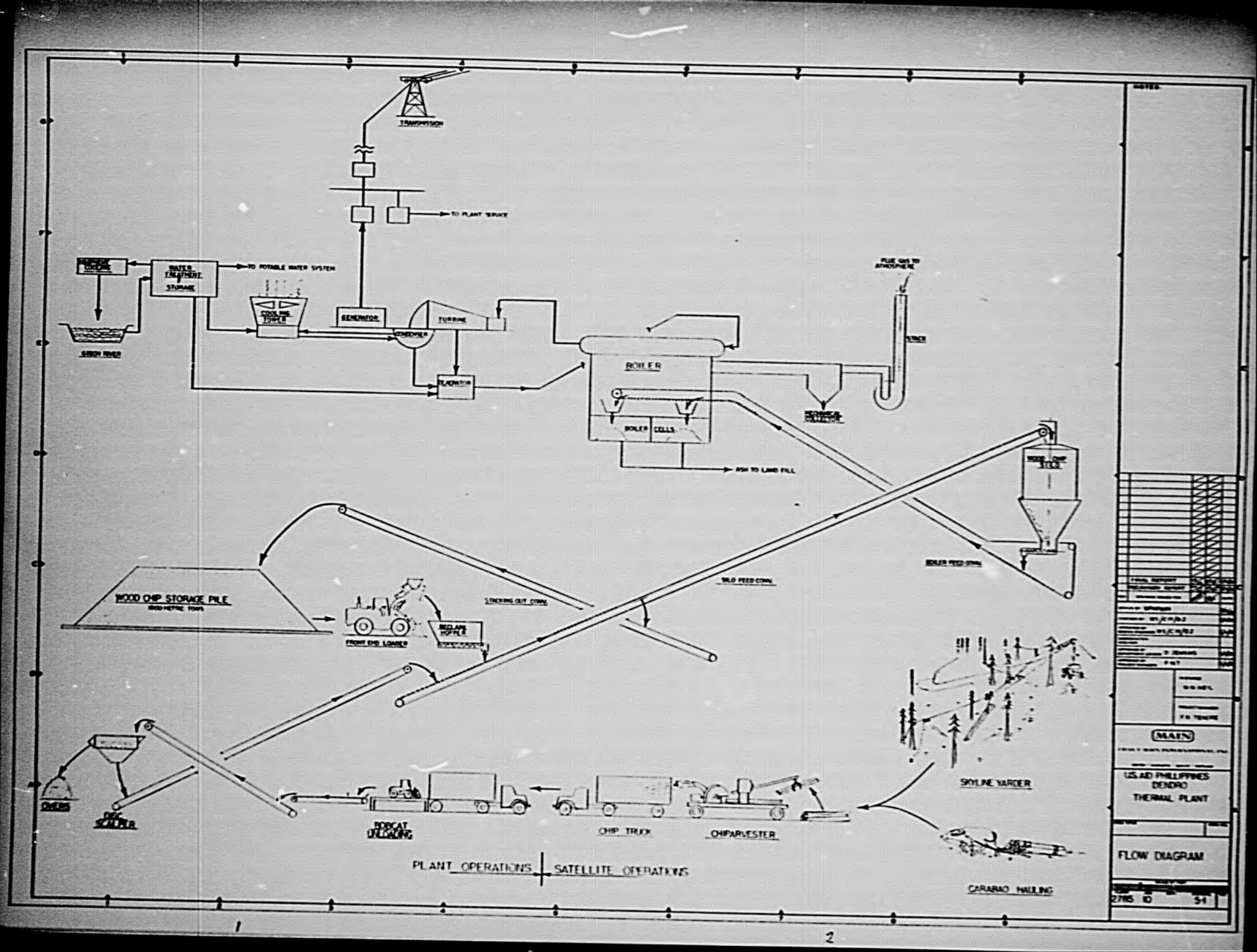
Figure 5-1 presents the schematic flow diagram for the proposed plant. Major components of the plant, from wood waste delivery to power transmission, are shown. Although presented earlier in the introduction to this report, this figure is presented here to help the reader visualize the total concept of the plant prior to reviewing its individual components.

A general plot plan for the proposed plant, which incorporates items identified in the schematic flow diagram, is presented in Figure 5-2. Terminology utilized on the plan is referred to throughout the text. The general arrangement of the plant is presented in Figure 5-3.

It must be stressed that the plan is not site specific. Additional work will be required before a specific location can be identified. Such work would include:

- Detailed topographic analysis
- Soil explorations
- Property surveys
- Land value appraisals
- Water quantity and quality analyses

A suggested area allowance for the plant site is approximately 10 hectares.


TRANSMISSION
TO PLANT SERVICE
WATER TREATMENT STORAGE
TO POTABLE WATER SYSTEM
COOLING TOWER
GENERATOR
CONDENSER
TURBINE
EVAPORATOR
BOILER
BOILER CELLS
ASH TO LAND FILL
FLUE GAS TO ATMOSPHERE
STACK
MECHANICAL COLLECTOR
WOOD CHIP SILO
BOILER FEED CONV.
SILO FEED CONV.
STACKING OUT CONV.
WOOD CHIP STORAGE PILE
FRONT END LOADER
RECLAIM HOPPER
OVERS
DEC SCALPER
BOBCAT UNLOADING
CHIP TRUCK
CHIPARVESTER
SKYLINE YARDER
CARABAO HAULING
PLANT OPERATIONS
SATELLITE OPERATIONS
MAIN
U.S.AID PHILIPPINES
DENDRO
THERMAL PLANT
FLOW DIAGRAM
2785 10 54

The remainder of this section discusses the basis of design by major design area. This information has been utilized by the study team in preparing the order of magnitude cost estimate presented in Section 7. The data do not represent final design conditions.

5.3.7 Heat Balance

A conceptual heat balance for the proposed power plant is shown in Figure 5-3.

5.3.8 Steam and Power Generation Equipment

Figure 5-4 presents a general arrangement for the proposed plant.

5.3.8.1 Boiler

The proposed boiler will be designed for 30,000 lbs/hr of steam at 625 psig, 750°F at the superheater outlet. The boiler consists of wood feeders, two refractory lined furnace cells with water-cooled grates, water-walled radiant furnace, superheater, boiler, tubular air heater, forced draft and induced draft fans, flues and ducts, steel stack and soot blowers. A mechanical (multiclone) fly ash collector will be installed for emission control.

The basis of design for the boiler is a wood heating value of 5,400 Btu's/lb at 35% moisture content, but the boiler is capable of burning wood up to 50% moisture.

5.3.8.2 Turbine Generator

The proposed turbine generator will be designed for 2000 kilowatts, with a turbine throttle of 600 psig, 750°F, and an exhaust pressure of 3-1/2" HgA. An uncontrolled extraction bleed point will

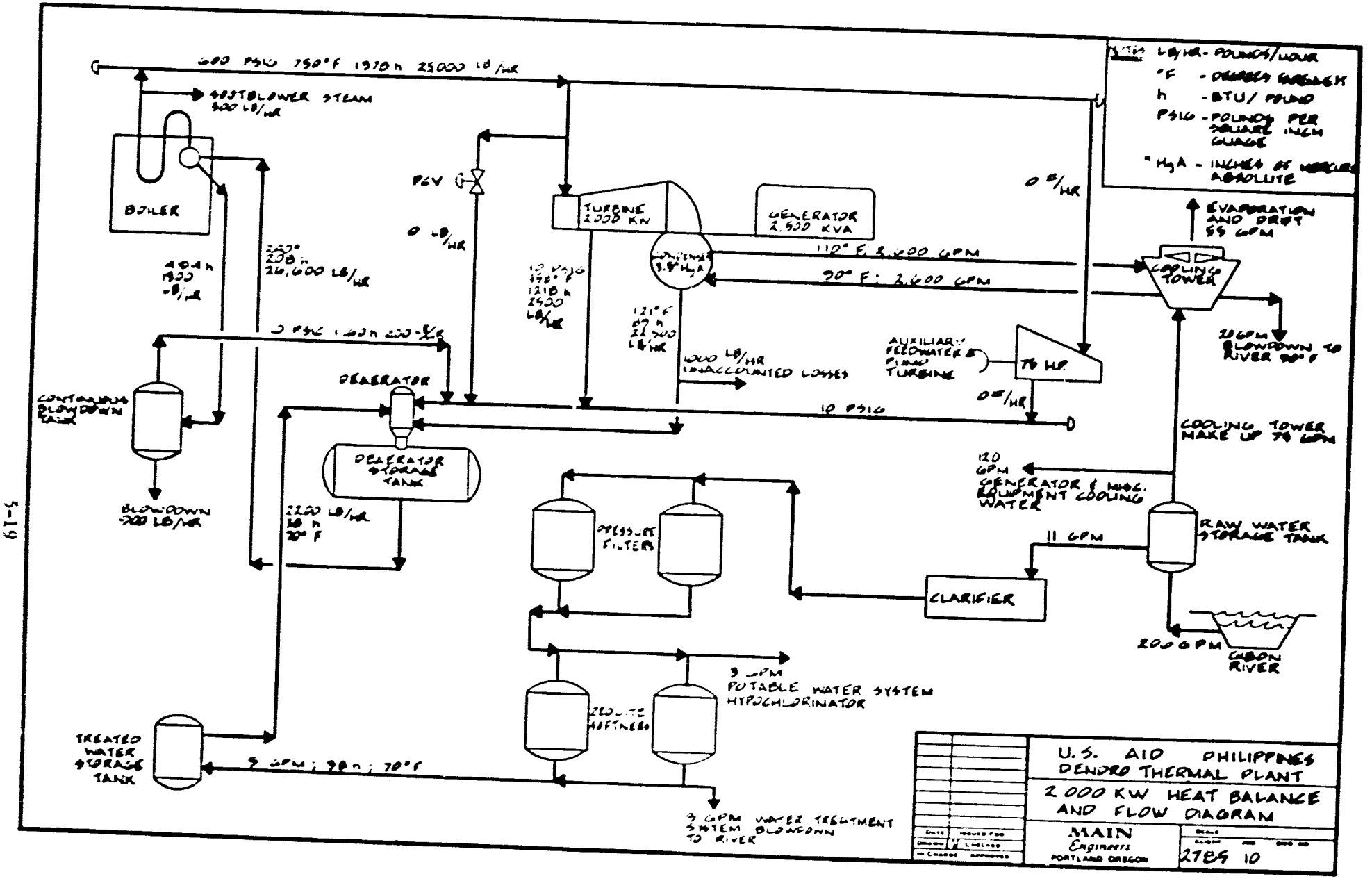
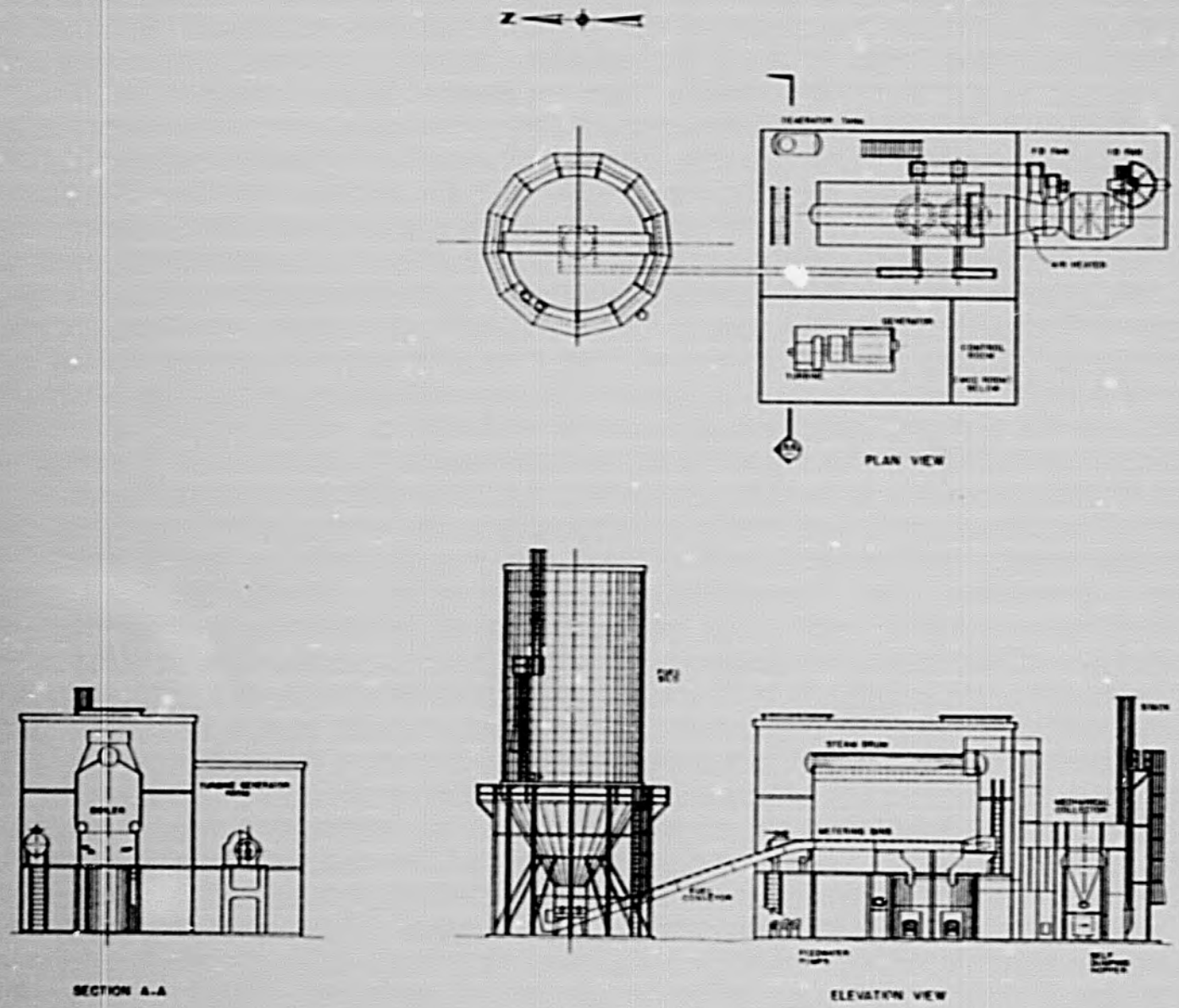

600 PSIG 750°F 1370 h 25,000 LB/HR
BOILER
PCV
0 LB/HR
TURBINE 2000 KW
GENERATOR 2,500 KVA
110° F; 2,600 GPM
90° F; 2,600 GPM
COOLING TOWER
EVAPORATION AND DRIFT 55 GPM
20 GPM BLOWDOWN TO RIVER 90° F
AUXILIARY FEEDWATER & FLUID TURBINE
75 HP
0 #/HR
1000 LB/HR UNACCOUNTED LOSSES
DEAERATOR
10 PSIG
CONTINUOUS BLOWDOWN TANK
BLOWDOWN 200 LB/HR
DEAERATOR STORAGE TANK
2200 LB/HR
COOLING TOWER MAKE UP 75 GPM
120 GPM GENERATOR & MISC. EQUIPMENT COOLING WATER
RAW WATER STORAGE TANK
11 GPM
CLARIFIER
PRESSURE FILTER
200 GPM
CABON RIVER
3 GPM POTABLE WATER SYSTEM HYPOCHLORINATOR
ZEOLITE SOFTNERS
TREATED WATER STORAGE TANK
3 GPM; 20 n; 70°F
3 GPM WATER TREATMENT SYSTEM BLOWDOWN TO RIVER
LB/HR - POUNDS/HOUR
°F - DEGREES FAHRENHEIT
h - BTU/POUND
PSIG - POUNDS PER SQUARE INCH GUAGE
" HgA - INCHES OF MERCURY ABSOLUTE
U.S. AID PHILIPPINES
DENDRO THERMAL PLANT
2 000 KW HEAT BALANCE AND FLOW DIAGRAM
MAIN Engineers
PORTLAND OREGON
27B5 10

FIGURE 5-3



US AID PHILIPPINES
DENORO
THERMAL PLANT

GENERAL ARRANGEMENT
2000 KW
THERMAL PLANT

2785 10 54

be provided at 10 psig for the deaerator feedwater heater. The turbine will have a rating of 2000 kW and will drive through a speed reducing gear, a generator rated at 2,500 kVA at 4,160 volts. The turbine will be complete with lubricating oil system, governing and control system, main trip and throttle valve, supervisory instrumentation, gland sealing system, condenser, condensate pumps, single cell cooling tower and circulating water pumping system.

5.3.8.3 Auxiliary Fuel

Since the intent of this system is to displace oil generated power from the grid with wood generated power, no auxiliary oil firing is being proposed for this boiler. This plant will be tied into the transmission grid of the Island of Panay, and power will be fed back from the grid to start up the power plant auxiliaries. Start-up of the boiler can be accomplished by building a small fire on the grates with kindling and lighting with a flare.

5.3.8.4 Feedwater

The proposed feedwater cycle will consist of a single deaerating feedwater heater with storage tank. One motor-driven and one turbine-driven boiler feedwater pump (both full capacity) will be supplied. The turbine driven feedwater pump will be relegated to standby service and operated only in the event of a power failure or a mechanical failure of the motor-driven pump.

5.3.8.5 Feedwater Makeup Treatment

The proposed feedwater treatment system will consist of a raw water clarifier, two pressure filters, two zeolite softeners with salt regeneration system, and a 5,000 gallon treated water storage tank.

5.3.8.6 Ash Handling

The ash handling system will be manual. Bottom ash will be raked from the grates onto the concrete floor in front of each cell's rake-out door. The ash will then be shovelled into self-dumping hoppers for disposal. Fly ash from hoppers in the furnace and from the mechanical fly ash collector will be mechanically conveyed and dropped by gravity into self-dumping hoppers for disposal.

It is estimated that approximately 995 tonnes per year of ash and char will be generated. Assuming an average density of 0.64 tonnes/m^3, this represents a volume of 1,555 m^3/yr. This volume of ash can be stored adjacent to the plant site or trucked to a remote location. This volume could vary, depending on the actual amount of ash and char generated.

5.3.8.7 Boiler Plant Structures

The proposed boiler, turbine generator and auxiliary equipment will be located in an enclosed building protected against rain and dust from the waste wood storage area. Access walkways required for maintenance or operation will be metal grating.

5.3.8.8 Design Data

The following pages contain data used in establishing the design of the plant and developing the order of magnitude cost estimate. The following areas are covered:

- Boiler
- Turbine Generator and Auxiliaries
- Mechanical Fly Ash Collector
- Wood Requirements
- Power Generation from Nabas Reforestation Area

SHEET 1 OF 1
JOB NO. 2785-10
DATE:

DATA FOR BASIS OF DESIGN

BOILER

MAIN

Wood Fired Boiler

Water tube, bottom supported with two refractory cylindrical cells, tubular air heater, induced draft and forced draft fans, flues, ducts, and mechanical fly ash collector and stack.

Steam Generating Capacity Firing Wood	30,000 lbs/hr
Steam Pressure at Superheater Outlet	625 psig
Steam Temperature at Superheater Outlet	750°F
Feedwater Temperature	240°F
Performance Wood Basis:	
Moisture Content (Wet Basis)	35%
High Heating Value - Bone Dry	8,300 BTU/lb
Heating Value as Fired @ 35% Moisture	5,400 BTU/lb
Ash (Wet Basis)	1.29%
Performance Wood Fuel Consumption @ Steam Generating Capacity	9,516 lb/hr

SHEET 1 OF 2
JOB NO. 2785-10
DATE:

DATA FOR BASIS OF DESIGN

TURBINE GENERATOR AND AUXILIARIES

MAIN

Turbine Generator

The turbine will be furnished with one uncontrolled extraction bleed point for feedwater heating. Also provided are excitation system, lube system, gland sealing system, hydraulic controls, turbine speed reducing gear, surface condenser, condensate pumps, cooling tower, cooling tower fan, and circulating water pumps.

Turbine Capacity	2,000 kw
Turbine Throttle Pressure	600 psig
Turbine Throttle Temperature	750°F
Turbine Uncontrolled Extraction Bleed	10 psig
Turbine Exhaust Pressure	3½" HgA
Generator Capacity	2,500 kVA @ 80% P.F., 4,160 Volts
Generator Speed	1,800 RPM
Surface Condensor Type	Two pass with divided water box
Condenser Cooling Water Inlet Temperature	90°F
Condenser Cooling Water Discharge Temperature	110°F

DATA FOR BASIS OF DESIGN

TURBINE GENERATOR AND AUXILIARIES

MAIN

Cooling Tower Type	Single Cell Mechanical Induced Draft
Cooling Tower Temperature Parameters	Twb = 80°F Tdb = 90°F Approach = 10° Range = 20°

	SHEET 1 OF 1 JOB NO. 2785-10 DATE:
DATA FOR BASIS OF DESIGN MECHANICAL FLYASH COLLECTOR	MAIN

A mechanical fly ash collector will be installed to control emissions of particulate into the atmosphere from the boiler. The mechanical collector will be of the multiple cyclone collecting tube design.

Average anticipated fly ash in flue gas leaving fly ash collector, lbs/hr	12.9 lb/hr
Maximum anticipated fly ash in flue gas leaving fly ash collector	15.5 lb/hr

DATA FOR BASIS OF DESIGN

WOOD REQUIREMENTS

MAIN

Turbine Generator Output	2,000 kW
Boiler Steam Output	25,000 lb/hr @ 625 psig, 750°F h = 1378 BTU/lb
Continuous Blowdown	1,300 lb/hr @ 700 psig, 505°F h = 494 BTU/lb
Sootblower Steam	300 lb/hr @ 625 psig, 750°F h = 1378 BTU/lb
Boiler Feedwater	26,600 lbs/hr @ 240°F h = 208 BTU/lb
Heating Value of Wood	5,400 BTU/lb @ 35% moisture (wet basis) as fired
Boiler Efficiency	70%
Heat Input	$= \frac{\text{Heat Output}}{\frac{\text{Efficiency}}{100}}$

DATA FOR BASIS OF DESIGN

WOOD REQUIREMENTS

MAIN

Calculations:

$$\text{Heat Input} = \frac{25{,}000\ (1378) + 1{,}300\ (494) + 300\ (1378) - 26{,}600\ (208)}{.70}$$

$$= 42{,}818{,}300 \text{ BTU's/hr}$$

$$\text{Amount of Wood} = \frac{\text{Heat Input}}{\text{Heating Value of Wood as Fired}}$$

$$= \frac{42{,}818{,}300 \text{ BTU/hr}}{5{,}400 \text{ BTU/lb}} = 7{,}930 \text{ lb/hr}$$

$$\text{Wood/kW} = \frac{7{,}930 \text{ lb/hr}}{2{,}000 \text{ kW/hr}} = 3.97 \text{ lbs/kW}$$

$$\frac{\text{Lb Steam}}{\text{Lb Wood}} = \frac{25{,}000 \text{ lb/hr}}{7{,}930 \text{ lb/hr}} = 3.15$$

5.3.9 Water Balance

A preliminary water balance for the proposed plant is presented below and shown graphically in Figure 5-5, Water and Wastewater Flow Diagram.

AVERAGE WATER BALANCE (GPM)

Water Supply		Water Effluent	
Boiler Make-up	5	Boiler Blowdown	2
Cooling Tower Make-up	75	Boiler Sootblowers to Atmosphere	1
Potable Water System	3	Cooling Tower Evaporation and Drift to Atmosphere	55
Equipment Cooling	120	Cooling Tower Blowdown	20
Water Treatment Blowdown	3	Sanitary Septic System	3
		Equipment Cooling	120
		Water Treatment Blowdown	3
		Unaccounted Losses	2
TOTAL	206	TOTAL	206

5.3.10 Solid Wastes

Solid wastes generated at the proposed plant will be primarily ash. Section 5.3.8.6 indicated that this may represent a volume of 1,555 cu. meters per year. Other solid wastes include miscellaneous trash generated by plant personnel (e.g., paper, scrap metal, etc.) and unburnable debris collected with the wood. Making an allowance of 1,000 cu. meters per year for these secondary sources, total solid waste volume could total approximately 2,600 cu. meters per year.

An area remote from or adjacent to the plant site should be designated for stockpiling this waste material. This area should be

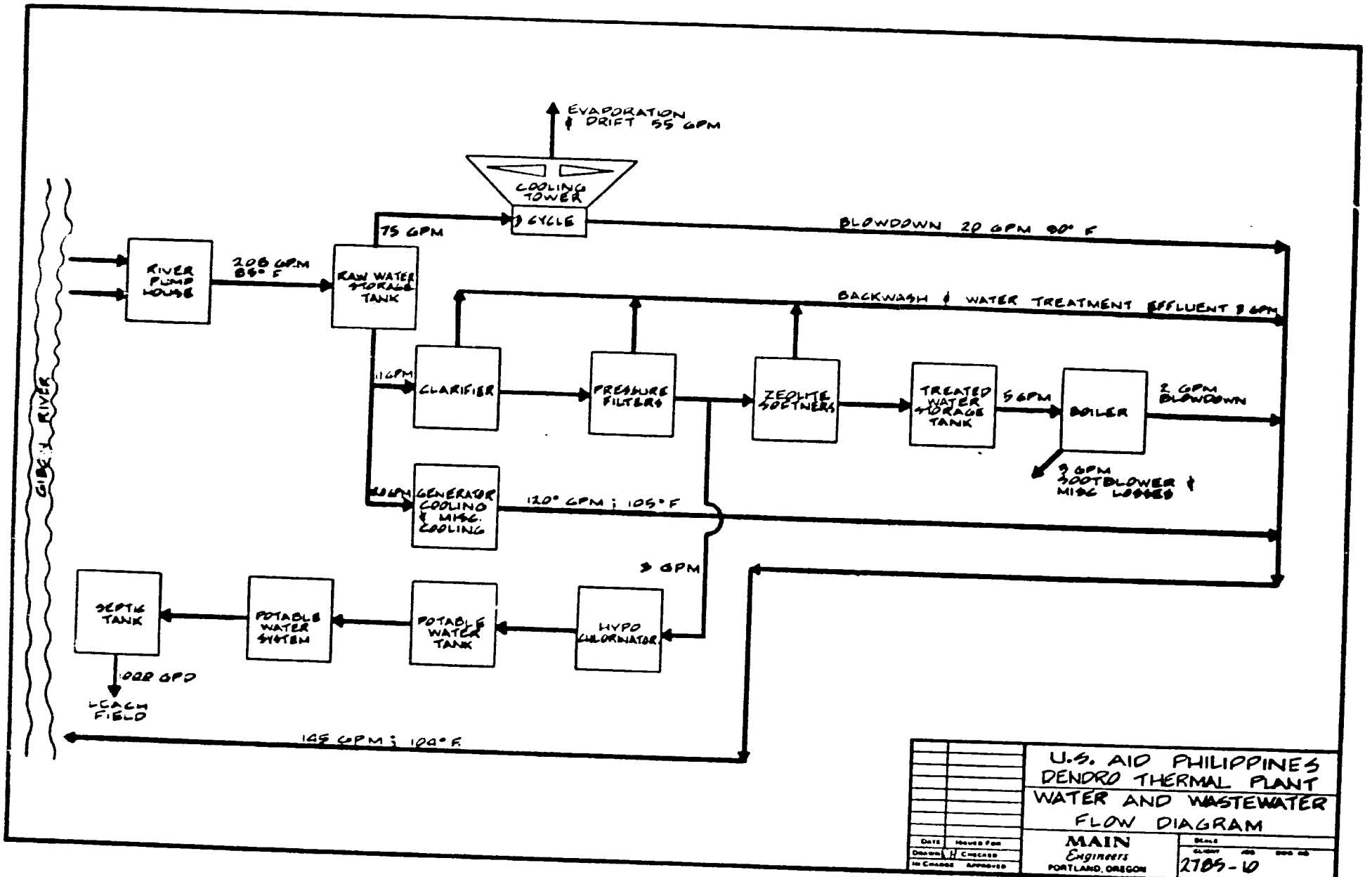

EVAPORATION & DRIFT 55 GPM
COOLING TOWER
CYCLE
75 GPM
BLOWDOWN 20 GPM 90° F
RIVER PUMP HOUSE
200 GPM 85° F
RAW WATER STORAGE TANK
BACKWASH & WATER TREATMENT EFFLUENT 3 GPM
GIBBS RIVER
11 GPM
CLARIFIER
PRESSURE FILTERS
ZEOLITE SOFTNERS
TREATED WATER STORAGE TANK
5 GPM
BOILER
2 GPM BLOWDOWN
3 GPM SOOTBLOWER & MISC LOSSES
GENERATOR COOLING & MISC. COOLING
120° GPM ; 105° F
3 GPM
SEPTIC TANK
POTABLE WATER SYSTEM
POTABLE WATER TANK
HYPO CHLORINATOR
1000 GPD
LEACH FIELD
145 GPM ; 100° F
U.S. AID PHILIPPINES
DENDRO THERMAL PLANT
WATER AND WASTEWATER
FLOW DIAGRAM
MAIN
Engineers
PORTLAND, OREGON
2785-10

FIGURE 5-5

designed to prevent stormwater runoff from carrying silt into nearby water courses. It should be located downwind of the plant. This will minimize air impacts around the plant due to fugitive dust picked up from the pile's surface. In this regard, surface compaction (e.g., by trucks or bulldozer) and earth covering should be considered.

5.3.11 Air Emissions

The major undesirable air emission from the proposed plant will be particulate matter. To control these potential emissions, a mechanical fly ash collector will be installed in the flue gas stream between the boiler outlet and the mechanical draft fan. The mechanical fly ash collector will be supplied with multiple cyclone collecting tubes.

The average particulate emissions after collection are estimated to be 12.9 lbs/hr. This represents a relatively low particulate emission level of 0.3 lbs/10^6 Btu fuel input. Reductions below this level would be possible only with the incorporation of more sophisticated particulate control mechanisms; e.g., a wet scrubber. Given the relatively undeveloped character of the area in which the plant would be located and the increased capital costs, incorporation of such equipment does not appear warranted at this time.

5.312 Chemical Requirements

Chemicals required by specific plant areas are noted below.

Plant Area	
Boiler Drum	Anydrous Disodium Phosphate
Deaerator	Sodium Sulphite (Na_2SO_3)
Zeolite Softener	Salt (NaCl)
Clarifier	Alum ($Al_2(SO_4)3$)
	Chlorine (Cl_2)
Potable Water Supply	Chlorine (Cl_2)
Cooling Tower	Sulfuric Acid; 66° Baume; 93.2% H_2SO4
	Sodium Hypochlorite (NaOCl)

5.3.13 Manning Schedule - Generation Plant

The proposed plant will require an operating and maintenance staff of 29 persons. A suggested classification of personnel, by shift, is shown below. The following staff will remain constant after plant start-up in December 1982.

Operating	Number Per Shift		Shift		Total
Plant Superintendent	1	x	1	=	1
Panel Operator	1	x	4	=	4
Boiler-Turbine Operator	1	x	4	=	4
Water Treatment Operator	1	x	4	=	4
Office Accounting	1	x	1	=	1
Secretary	1	x	1	=	1
Laborer	1	x	4	=	4
Bobcat Driver	2	x	2	=	4
General Operator	1	x	2	=	2
			Subtotal		25
Maintenance					
Mechanic					2
Electrician and Instrumentation Specialist					2
			Subtotal		4
			TOTAL		29

6.0 FUEL SUPPLY SYSTEM

6.1 INTRODUCTION

The fuel supply system includes the establishment and maintenance of the fuel plantations, harvesting procedures, and transport of the fuel to the plant. Each of the components includes different subcomponents, all of which are interrelated. All must be designed to permit an adequate, continuous flow of fuel to the project boiler/generator.

The framework for a general plantation management plan is suggested in this section. It is unrealistic to develop a detailed management plan for the proposed project at this time for numerous reasons. Foremost is the fact that the value and applicability of a management plan is only as good as the data and technical skill upon which it is based. Relatively little information is available concerning growth rates, silvicultural treatments, and harvesting techniques for the species considered, especially under the climatic, edaphic, and topographic conditions of Panay. Until such information becomes available, only a tentative management system should be proposed.

Within this general framework the operational details must be developed in conjunction with local foresters and project managers as the proposed project progresses. As will become apparent below, the management of the logistical components of producing and delivering fuelwood to the proposed dendro-thermal unit will be relatively complex. In the detailed planning these factors must be considered in developing an operational plan with an acceptable probability of meeting required production schedules. Schedules for plantation establishment, management, and harvest are suggested. These schedules may require modification, but the schedule of fuel consumption by the generating unit is constant if the desired level of generation is to be maintained.

The General Management Plan is separated in three basic sections: Nursery Practices; Plantation Establishment and Management; and Harvest and

Transport. Included within each section are recommended general procedures, factors to be considered in developing a detailed operational plan, and recommendations for further studies.

6.2 BASES FOR THE GENERAL PLANTATION MANAGEMENT PLAN

Included below are the basic factors and assumptions utilized to develop the general management plan:

6.2.1 Objectives

The general management plan is designed to achieve the following objectives to the degree considered to be feasible:

(1) Produce sufficient wood from the available land area to fuel a 2-megawatt (MW) dendro-thermal plant;

(2) Utilize labor-intensive practices to the greatest degree possible;

(3) Minimize negative environmental impact;

(4) Minimize costs of wood protection.

Some of these objectives are mutually exclusive and must, therefore, be judiciously balanced in the management plan.

6.2.2 Species Considered

Several species of fast-growing hardwoods are being planted at different sites throughout the Philippines, with wood pulp being the primary product. These include bagras (*Eucalyptus deglupta*), gubas (*Endospermum peltatun*), Moluccan sau (*Albizia falcataria*), Kaatoan bangkal (*Anthocepalus chinensis*), acacia (*Samanea saman*), agoho (*Casaurina rumphiana*),

ipil-ipil (Leucaena leucocephala), and yemane (Gmelina arborea). The latter three species are presently being planted on Panay and are considered by local sources to have the greatest growth potential of species presently being utilized in the reforestation effort on the island. In the Nabas and Tibiao reforestation areas, these species did exhibit superior growth in those observed reforested areas.

Most studies, to date, which have assessed the feasibility of wood-based power generation have concentrated exclusively on plantations of Leucaena. This species has many favorable characteristics; e.g., rapid growth, the ability to fix nitrogen, and vigorous coppicing. However, planting large areas with a single species (monoculture) is generally not recommendable from an ecological viewpoint. Because the majority of the scientific attention has been directed toward Leucaena, other species have, to a large degree, been relegated to a lower status. For example, few data on the silviculture, growth and yield of Gmelina and Casaurina are available, although both have favorable characteristics. Both Gmelina and Casaurina have growth rates generally comparable to those of Leucaena (see below). Gmelina is reported to coppice as vigorously as Leucaena, but is not a nitrogen fixing species. Casaurina does fix nitrogen, but does not coppice and must, therefore, be replanted after each harvest. The ability to convert atmospheric nitrogen to an organic form which can be utilized by plants is considered of primary importance. This reduces the need for applications of artificial nitrogenous fertilizer and generally serves to improve soil conditions. The seeds of Casaurina are much easier to handle and prepare than those of Gmelina - an important factor if tens of thousands of seedlings are to be produced.

Based on these factors, Leucaena leucocephala is recommended as the primary species for plantation establishment. The improved variety of Leucaena, known as K-8 or Mexican, is recommended. Limited data indicate that K-8 may yield greater volumes of wood on short rotations, although this higher yield may be at a sacrifice in seed production. In addition, the K-8 strain is the only strain for which relatively large quantities of genetically pure seed is presently available from controlled commercial sources.

Casaurina rumphiana is recommended for planting in conjunction with Leucaena. The nitrogen fixing capability is of primary concern in the selection of Casaurina for planting. The lack of coppicing ability will require replanting after harvest. However, unskilled labor can be utilized for this replanting and utilizing such labor is consistent with the management plan goals. To minimize the total area to be replanted after each harvest, a planting of 60 to 70 percent Leucaena, with the remainder being Casaurina, is recommended.

6.2.3 Growth Rates

Published growth rates for Leucaena vary widely, from three bone-dry metric tons per hectare per year (bdt/ha/yr) to 159 bdt/ha/yr. Unfortunately, few of these sources include data on site quality, silvicultural practices, age at harvest, etc. Murphy et al utilized an admittedly conservative estimate of 10 bdt/ha/yr for Leucaena but until the growth rates under the climatic and edaphic conditions of Panay can be more accurately estimated, a conservative approach is recommended.

Documented growth rates for Gmelina are difficult to obtain. Those found appeared to be from isolated measurements on selected areas and were not necessarily representative of growth rates under operational conditions. Growth rates for Gmelina ranged from 10 bdt/ha/yr to 25 bdt/ha/yr.

No documented growth rates were encountered for Casaurina. However, one reliable source from a private firm stated that field tests indicate that Casaurina growth rates equal or exceed those of Leucaena.

For computational purposes, an average growth rate of 10 bdt/ha/yr was used for each species. The growth rate estimates are often based on measurements of two to seven year old plantations or individual trees. Biologically speaking, growth rates are not linear. The highest growth rates occur in the first years of growth and decrease

thereafter. Because the establishment, management, and harvest of the fuelwood plantations will all take place during the early years of the trees' biological life, an assumption of linearity is not considered unrealistic for computational purposes.

Growth rates were also considered in making an initial recommendation for rotation length of three years. This minimizes the period of investment for the plantation and will also produce trees of a size which can maximize the use of local labor. At three years of age, a tree can be expected to be approximately 10 cm to 15 cm diameter at breast height (dbh) and 10 m to 15 m in height. These sizes will permit more harvesting operations to be carried out manually and with animals.

6.2.4 Available Land

Both the map of the Nabas Reforestation Project and internal Bureau of Forest Development communications indicate that the reforestation project includes 4,225 hectares. The assumption made by Murphy et al that 50% of this area could be utilized for fuel (short rotation biomass) production is considered realistic. Therefore, approximately 2,100 hectares are assumed as the land base for fuel production. The lands designated for reforestation do not include scattered areas presently vegetated with "native" forest within the boundaries of the reforestation area. As such, the 2,100 hectares available for fuel production are not necessarily in a continuous block.

The reforestation area is located in hilly, broken terrain ranging in elevation from 100 meters to 700 meters above sea level, with slopes up to 100% or more. Soils are eroded, but existing trails in the area do not indicate that soils are unusually erosion-prone or unstable.

6.2.5 Fuel Requirements for Generation

Available land, growth rates, and rotation length were coupled with steam generation requirements to determine the theoretical generation potential of the available area at Nabas. Appendix B includes these computations. Under the assumption that the wood will not be dried before being burned, approximately 875 hectares are required to generate one megawatt (MW) on a continuous basis. Drying the fuel does not significantly increase efficiencies or decrease fuel requirements (see Section 5.3.4). Thus, a green fuel basis was assumed. On this basis, the Nabas Reforestation Project represents a generation potential of 2.4 MWs.

6.3 GENERAL PLANTATION MANAGEMENT PLAN

The following is based on published and unpublished data, conversations with Philippine forestry and forest workers, field observations and project requirements. More extensive consultation with experienced forestry personnel in the northwestern portion of Panay will permit a more detailed body of knowledge to be directed to the problems of establishing and maintaining a fuelwood plantation of the magnitude required in the Nabas Reforestation Area. Accurate local knowledge is imperative since such basic data as aerial photography and detailed topographic maps are unavailable for the area. For example, the most detailed topographic maps available have 20 meter contours. These are of little value for such activities as road layout.

The recommendations included in each section may yield results of value not only to the proposed dendro-thermal project, but to the science of Philippine forestry in general. Therefore, the costs of such basic investigations should, when possible, be undertaken in cooperation with the University of the Philippines, Bureau of Forest Development, private companies, and international agencies. The cost associated with such cannot be attributed only to the proposed project.

6.3.1 Nursery Practices

6.3.1.1 Seed Source

The single most important component of seedling production is the selection of quality seed. The initial expense of buying genetically pure, or certified seed is insignificant compared to the economic consequences of not being able to meet the fuel requirements of a multi-million dollar dendro-thermal generation unit. Some Philippine sources of leucaena seed exercise control over the genetic purity of each strain. However, the general consensus is that the best seeds still come from international sources. Possible sources of certified leucaena are included in Appendix C.

Local sources of Casaurina seed are presently available and provide seed for seedling production in local nurseries. Elementary steps for improving the quality of the Casaurina seed are recommended below.

6.3.1.2 Seed Scarification

To obtain high and uniform germination of leucaena, scarification of the seeds is necessary. The recommended procedure is to soak the seeds in water maintained at 80°C for one to four minutes [3/], and then immerse in cold water. A second method is to heat water to the boiling point, remove it from the heat source and stir in an equal volume of seeds to be scarified. After three minutes, remove the seeds from water and dry before planting. Unscarified seed has a longer storage life than scarified seed. Therefore, only the volume of seed to be planted should be scarified.

6.3.1.3 Inoculation

After scarification, it is recommended that the seeds be inoculated with the correct strains of Rhyzobium to maximize

the nitrogen fixing ability. This is especially important in areas where the species have not been previously grown, as in the case in the Nabas Reforestation Area. For seed beds, the inoculum can be watered in after germination has occurred. Inoculation is especially important where leucaena is to be planted on acid soils. In those situations, the non-acid producing Rhizobium strain CB 81 should be used and, if the seed is not planted immediately, it should be lime-pelleted. Even then it should be stored in a refrigerator and planted within one week. Appendix C includes possible sources of inoculum. If commercial inoculum cannot be obtained, soil from under a stand of leucaena, which is known to be inoculated, can be used in the nursery as potting soil and for seed beds.

6.3.1.4 Fertilizer

Soil to be used for potting or seed beds should be tested for pH, nitrogen, phosphorus, and potassium. If pH is 5.0 or lower, application of agricultural lime is recommended. The equivalent of two to four tons of lime per hectare will be required to raise the pH from 5.0 to 5.5. If the soil is slightly alkaline; i.e., pH greater than 7.0, no measures are necessary. Fertilization with a complete fertilizer; e.g., 14-14-14 or 15-15-15, is initially recommended for nursery use. In acid soils, phosphorus availability is very low and may have to be supplied in larger amounts in the form of superphosphate (P_2O_5) if adequate liming is not done.

6.3.1.5 Seeding

The practice in most nurseries in the Nabas area is to produce potted seedlings by sowing seeds in small cylindrical plastic bags. The primary advantage of this type of seedling production is that the roots, especially the nutrient-absorbing hair roots, are relatively undamaged when field-planted. The continuation of this practice is recommended. Direct seeding of leucaena has been tested in some areas of the Philippines but results have been mixed. The best results have been in level areas where intensive land preparation; e.g., burning and plowing, were carried out.

Topography in the Nabas area does not permit such land preparation. Direct seeding also exposes the seed to rodents, birds, and other predators. To insure desired stocking, more seed must be sown or seeds must be pelletized. Direct seeding is not recommended at this time.

It has been suggested that, with a plastic bag "pot", the danger exists that the tap root of the seedling will grow in a circle inside the plastic bag and not form a true tap root when transplanted to the field.[4/] It is anticipated that the tap root would grow downward and establish a normal tap root once freed from the confinement of the plastic pot (a response known as geotrophism).

The seedlings should be tended in the nursery until they have attained a height of at least 20 to 30 cm, approximately 45 days. If greater heights can be obtained within the constraints of handling difficulties and available soil in the plastic bag "pots", it is recommended. Each additional centimeter of height will aid in outgrowing competing vegetation when transplanted in the field. Experience and research must determine the optimum combination of pot size, plant height, handling costs, and survival rates.

6.3.1.6 Operational Considerations

If the proposed planting schedule (see Section 7) is to be met, approximately 7.25 million seedlings must be planted during the first year of plantation establishment, and 2.93 million seedlings the second year. In subsequent years, only the Casaurina harvested in any given year will require replanting. Leucaena can be harvested for three to six rotations before the coppice sprouts decline in vigor and only t'en will replanting be required. Assuming [illegible]erination/nursery survival rate of 80 percent, then seeds for app[illegible]ely 9.06 million seedlings must be sown in the nursery the first [illegible] to produce the required number of seedlings (see Appendix B).

For 2,035 hectares to be successfully planted during plantation establishment and for this material to be successfully harvested, a network of roads must be established to permit access to all parts of the plantation throughout the year. Such access will permit seedling production to be accomplished in one central nursery with distribution by vehicle to satellite nurseries a few days before planting. By concentrating seedling production in a central nursery, expensive equipment; e.g., pumps and other irrigation facilities, need not be duplicated in satellite nurseries. These roads will also serve for plantation management and, finally, for harvest and delivery of fuelwood to the generation site.

The existing central nursery at the Nabas Reforestation Area would have to be expanded to approximately double its present production capacity to meet planting requirements. Satellite "nurseries", or delivery areas, would have to be established to permit delivery and care of enough seedlings to meet the planting requirements for a two to three day planting period.

6.3.1.7 Recommendations

1. For the production of leucaena seedlings, certified seed of the K-8 strain should be purchased. Once the plantation is established with seedlings of high genetic quality, an area near the geographical center of the plantation should be designated and managed as a seed production area.

2. For the production of casaurina seedlings, the "best" available seed should be used. This presently involves field collection of seeds from natural uncontrolled stands. After the initial establishment of the plantation, individual trees exhibiting favorable characteristics should be identified and maintained for seed production. A program to improve genetic quality of casaurina seed can range from seed collection from these superior trees to controlled breeding between selected parents for genetic improvement.

3. No information was found concerning the feasibility of inoculating casaurina seeds with the correct bacteria to improve its nitrogen fixing ability. Efforts should be made to identify the correct bacteria or, as a minimum, to try test inoculations with various bacteria to observe its effect on growth.

4. There has been some indication that leucaena may be compatible with mycorrhizal fungi. The development of mycorrhizal hypae on the root system of leucaena may greatly facilitate the uptake of minerals essential to growth, especially phosphorus. Basic research into the leucaena/micorrhizal relationship is recommended.

5. A larger seedling at the time of field transplanting will hav a greater advantage over competing vegetation. However, a larger seedling may require a larger pot with more soil to maintain its vigor. The larger plant will also require more time in the nursery with greater costs. The investigations of the effects of time in the nursery, pot size and potting soil volume, transplanting survival rates and production costs are recommended.

6. Levels of fertilization and other seed and soil preparation must be investigated to maximize nursery production and growth. Production of the largest, most vigorous seedling possible in the nursery (within given constraints) will minimize additional, more costly inputs once transplanted.

7. In addition to directly seeding in prepared plastic bag pots, a second alternative may be investigated. The seeds are germinated in seed beds. Once the cotyledons or first two primary leaves have appeared, pull the small plantlet from the soil, dip the roots in inoculum and micorrhizae, and transplant to plastic bags. These plants are then tended as potted seedlings until time for transplanting to the field.

6.3.2 Plantation Establishment and Maintenance

6.3.2.1 Land Preparation

Planting of seedlings to the field should be done during the rainy season. This essentially limits the planting operations to a period of six to seven months in the area of Nabas. Therefore, all operations required for planting which can be completed before the rainy season will facilitate the actual tree planting once it begins.

Two basic operations can be completed before planting is actually initiated. The first is land preparation. When the seedling is initially planted, an area approximately 0.5 meters around the tree should be cleared of vegetation. Where the land is vegetated with low woody vegetation (brush), cutting with brush hooks or bolos may be required. Experience has shown that clearing in strips one meter wide is the most efficient and effective means of brush clearing. The recommended spacing for planting is one meter by two meters. Therefore, clearing of one meter strips separated by one meter strips of uncleared land will permit planting by spacing one meter between seedlings along the cleared strip with two meters between (cleared and) planted rows. Where conditions permit, burning will reduce the competing vegetation still further.

In areas dominated primarily by cogon grasses, burning is the only realistic means of clearing the land before planting. Topography and the relatively large areas to be planted make plowing of an area an unrealistic alternative.

The second operation which can be carried out before planting begins is digging of the holes for planting. Since potted seedlings will be used, it is necessary to prepare the planting holes. Doing so before the rainy season facilitates planting once it begins, concentrating available labor on the actual planting process during the rainy season. This means that planting crew sizes can be reduced or numbers of planted

seedlings can be increased. Laborers employed for planting during the rainy season can also be used for land preparation for at least some of the dry season, thus stabilizing employment.

Preparing planting holes during the dry season will result in drying of the soil in and around the hole and may influence seedling survival and/or initial growth. This effect should be confined to those seedlings planted before the rains can completely replenish this moisture. However, the effects of stabilizing the labor force and maximizing the actual planting production would appear to justify use of this method during the initial planting season.

The sequence of digging holes and burning may influence the survival rate of seedlings once they are planted. In many areas of the Philippines, including Panay, many newly planted seedlings are girdled and killed by rat populations. Burning aids in controlling the rat population to some degree. However, some experienced foresters have indicated that the incidence of damage by rats is reduced still further if the area to be reforested is burned after digging the planting holes.

The recommended sequence of land preparation procedures is: (1) clear brush where necessary; (2) dig holes; and (3) burn the area to be planted. This is to be accomplished during the dry season, the final burning occurring at the end of the dry season. Native vegetation regrows sufficiently rapidly to minimize erosion and must, in fact, be controlled within a few months of burning.

6.3.2.2 Planting

Planting should begin after the start of rainy season and continue throughout. The planting season in the Nabas area is approximately May to December. The first two to three months of the first year of plantation establishment will be the period when actual field procedures are established and logistical problems will be encountered and (hopefully) solved. During this period, it is suggested that only one species, Leucaena, be planted to minimize organizational

difficulties. As the organizational capability increases, the second species, Casaurina, can also be planted.

Each species may be planted in alternating strips several meters in width, with the strips generally following the contours of topography or in blocks of one species. Theoretically, these strips would be harvested at different times, thus providing a certain degree of erosion control. But realistically, contour harvesting, regardless of the species mix harvested, will provide some erosion control. The fuel requirement for the dendro-thermal plant is not species specific and does not, therefore, dictate that harvesting be confined to a single species at any one time.

Harvest cuttings will occur approximately three years after planting. Relatively little time exists for intermediate cuttings. Even if some type of this cutting was considered, the extracted material would be very small and the physical intervention in the plantation could result in more damage than benefits. The economic benefits, if any, of intermediate cuttings of short rotation fuelwood plantations are unknown. Therefore, during the initial establishment of the plantation, seedlings will be planted at what will be considered the "final" spacings.

One meter by two meter spacing, 5000 trees per hectare, is recommended. At this spacing, crown closure can be expected, resulting in natural pruning and a relatively straight stem. Branching is confined to the upper portion of the stem. If it is found inefficient to harvest the tree crown, only a small percentage of the total volume will be lost. In addition, adequate space must remain between the "stumps" of harvested leucaena (stumps will be left to enhance coppicing) to minimize damage to them during skidding.

At the time of planting, application of one to two tablespoons of complete fertilizer; e.g., 14-14-14, in each planting hole is recommended. The fertilizer should be pulverized as much as possible to

permit rapid dissolution to minimize the possibility of "burning" the roots of seedlings. Fertilization at planting will shorten the period of slow initial growth after transplanting and minimize plantation maintenance.

6.3.2.3 Plantation Maintenance

The primary task in plantation maintenance is to regularly weed around each seedling to eliminate competition until the seedling can outgrow neighboring vegetation and successfully compete for moisture and nutrients. For the first four to eight months after planting, depending on seedling size at planting and rate of initial growth, vegetation within approximately 0.5 meter of the seedling will have to be cleared. This will be required every two to three months.

If the seedling survival rate after planting is below 90 percent after one year, it is recommended that a planting crew return to the original area during the second planting season and replace those seedlings which were lost. Because leucaena coppices, the success of the initial planting will determine the volume of available fuelwood for three to six future rotations. A decrease in the survival rate represents an equivalent loss of generation potential or increased land requirements.

After the initial harvest of leucaena and for several rotations thereafter, sprouting from the stumps of harvested trees will provide trees for the subsequent rotation. The sprouting is prolific and from three to eight sprouts per stump can be expected. All but one or two of these sprouts should be cut to permit the "best" sprout(s) to take full advantage of the established root system. This "thinning" of sprouts can be easily accomplished with bolos. However, care should be exercised not to damage the sprout(s) to be left for the next fuel crop. This "thinning" should take place within a few months of sprouting.

Fertilization of plantation after the initial planting is not recommended at this time. The conservative growth rates

assumed and the recommended plantation area will provide the volume of fuelwood required to supply the proposed dendro-thermal plant. Accelerated growth is not required to meet these needs and the cost of artificial fertilizer is high and can be expected to increase still further. Until the increased rates of growth resulting from fertilization (see Recommendations below) can be evaluated economically, a broad program of fertilization with artificial fertilizers is not recommended.

One study[13/] has indicated that wood and bark ash may be applied to the forest as a low strength, slow release fertilizer. The ash produced by the dendro-thermal plant equates to approximately 13 truck loads per month. This ash must be disposed of. An alternative may be to dispose of it in the plantation with some positive effects (although they may be minimal) on forest growth.

6.3.2.4 Operational Considerations

Specific areas to be reforested and the scheduling of reforestation within those areas will be a function of many factors, of which accessibility will be the most important. The suggested planting schedule (see Section 7) requires that 1,450 hectares be reforested the first year. This requires the transportation of approximately 240 and 160 laborers and supervisory staff daily for clearing and planting, respectively. Adequate roads and vehicles are essential to meet this logistic requirement. These same roads will be utilized for plantation maintenance, will serve as rudimentary firebreaks and, of still greater importance, will provide the primary means of collecting and delivering the harvested fuelwood to the dendro-thermal plant. These roads must be designed to permit access during the rainy season by the vehicles proposed for harvesting. Few, if any, adequate roads exist within the Nabas Reforestation Area. Therefore, adequate roads must be constructed prior to the reforestation effort. This will require appropriate scheduling, layout of roads, and road construction planning. Road layout must also take into consideration harvesting plans.

LABOR REQUIREMENTS

NURSERY

Year 1

Maximum seedling production to reforest 250 ha/mo

250 ha/mo * 5000 seedlings/ha = $1.25 * 10^6$ seedlings/mo
assuming 80% germination

$1.25 * 10^6$ seedling ÷ 0.80 = $1.56 * 10^6$ seedlings

If each seedling spends 2 mo. in the nursery, maximum capacity of nursery must be

$1.56 * 10^6 * 2 = 3.12 * 10^6$ seedlings

The existing production capacity of the Nabas Central Nursery is $1.3 * 10^6$ seedlings. Therefore, the existing facilities must be expanded by a factor of 2.4.

Existing staff must be increased to approximately 29 people.

Year 2

Maximum seedling production to reforest 100 ha/mo

100 ha/mo * 5000 seedlings/ha = $0.50 * 10^6$ seedlings/mo
assuming 80% germination

$0.50 * 10^6$ seedling ÷ 0.80 = $0.63 * 10^6$ seedlings/mo

If each seedling spends 2 mo. in the nursery, maximum capacity of nursery must be

$0.63 * 10^6 * 2 = 1.26 * 10^6$ seedlings

Therefore, the staffing requirement would approximate the present staffing of 15 personnel.

PLANTATION - LAND PREPARATION

Year 1

Prepare 1,450 ha in ~ 6 months ≅ 242 ha/mo

242 ha/mo ÷ 21 days/mo 1/ = 11.5 ha/day

11.5 ha/day * 20 man days/ha = 231 men

Clearing Crew = 231 men

Year 2

Prepare 585 ha in ~ 6 months ≅ 98 ha/mo

98 ha/mo ÷ 21 days/mo 1/ = 4.7 ha/day

4.7 ha/day * 20 man days/ha = 94 men

Clearing Crew = 94 men

Year 3+

Prepare 176 ha (585 * 0.30 (30% Casaurina)) in - 6 mo ≅ 30 ha/mo

30 ha/mo ÷ 21 days/mo 1/ = 1.4 ha/day

1.4 ha/da * 20 man days/ha = 28 men

Clearing Crew = 28 men

1/ Effective working days

PLANTATION - PLANTING

Year 1

Maximum planting required - 250 ha/mo

250 ha/mo ÷ 21 days/mo [1/] = 11.9 ha/day

11.9 ha/day * 5,000 seedlings/ha = 59,500 seedlings/day

59,500 seedling/day ÷ 400 seedlings/man day ≅ 149 men

Planting Crew = 149 men

Year 2

Maximum planting required - 100 ha/mo

100 ha/mo ÷ 21 days/mo [1/] = 4.8 ha/day

4.8 ha/day * 5,000 seedlings/ha = 24,000 seedlings/day

24,000 seedlings/day ÷ 400 seedlings/man day = 60 men

Planting Crew = 60 men

Year 3

Maximum planting required - 100 ha/mo * 0.30 Casaurina = 30 ha/mo

30 ha/mo ÷ 21 days/mo = 1.4 ha/day

1.4 ha/day * 5000 seedlings/ha = 7,000 seedlings/day

7,000 seedlings/day ÷ 400 seedlings/man day = 18 men

Planting Crew = 18 men

1/ Effective work days

PLANTATION - WEEDING

Year 1

Required weeding - 250 ha/mo once every 3 months

250 ha/mo ÷ 21 days/mo = 11.9 ha/day

11.9 ha/day * 5 man days/ha = 60 men

Weeding Crew = 60 men to weed 250 ha/mo on a 3 month weeding cycle. One crew can therefore weed 750 ha (250 ha/mo * 3 mo/cycle = 750 ha/cycle).

Year 2

Required weeding - 100 ha/mo once every 3 months

100 ha/mo ÷ 21 days/mo = 4.8 ha/day

4.8 ha/day * 5 man days/ha = 24 men

Weeding Crew = 24 men to weed 300 ha on a 3 month weeding cycle.

Weeding requirements for the plantation established during Year 1 will overlap with weeding requirements for the plantation established during Year 2. This overlap and total size of the weeding crew are graphically presented on the following sheet.

WEEDING MANPOWER REQUIREMENT

YEAR 1

Month	Planting Season							Dry Season					
	M	J	J	A	S	O	N	D	J	F	M	A	
	X			62			62			62			
		X			62			62			62		Crew 1
			X			62			62			62	
				X			62			62			62
					X			62			62		62
						X			62			62	62
							X			62			62

Crew 2

X = Month of planting.

60 = Labor requirement for weeding of that area at 3-month intervals.

YEAR 2

Month	Planting Season							Dry Season				
	M	J	J	A	S	O	N	D	J	F	M	A
	X			25			25			25		
		X			25			25			25	
			X			25			25			25
				X			25			25			25
					X			25			25			25
						X			25			25			25
							X			25			25			25

	1981								1982												1983							
	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Total Weeding Crew Labor				62		62		124		186		124		124		87		25		50		75		50		25		25
					62		124		124		124		124		62		25		50		50		50		50		25	

PLANTATION - HARVESTING

As previously discussed, during the first year of harvest 865 ha will be harvested and 585 ha will be harvested in all subsequent years. A larger area is harvested the first year since the trees to be cut are only two years old, are smaller, and a larger area must be harvested to provide the required volume. In all subsequent harvests, the trees will be at least three years old, will be larger, and not as much area will have to be harvested. Although the areas are different in size, the volumes of wood are the same.

Year 1 (of harvest)

The area to be harvested daily is

865 ha ÷ 12 mo ÷ 21 effective work days/mo = 3.43 ha/day

or 3.43 ha/day * 31 tonnes of wood/ha = 106 tonnes/day

Year 2 (of harvest)

The area to be harvested daily is

585 ha ÷ 12 mo ÷ 21 work days/mo = 2.32 ha/day

or 2.32 ha/day * 46 tonnes of wood/ha = 106 tonnes/day

FELLING

Maximum labor requirements will be for felling and skidding.

Year 1 (of harvesting)

Assume felling one (1) tree every minute with a 1.5 hp chain saw for six (6) effective work hours per day. Each feller will cut

60 trees/hr * 6 hr/day = 360 trees/day/feller

During Year 1 (of harvest) 3.43 ha/day must be harvested or a daily harvest of

3.43 ha day * 5000 trees/ha = 17,150 trees/day

Therefore,

17,150 trees/day ÷ 360 trees/day/feller = 48 fellers (and chain saws) are required

Year 2+ (of harvesting

Although less area will be harvested after the first year of harvest, increased diameter and height will create additional problems. Therefore, it is assumed that an equal number of fellers (48) will be required in subsequent years.

SKIDDING

Year 1

Carabao (water buffalo) can skid 0.4 m^3 of green wood effectively for distances of 500 m on relatively level ($\leq$ 20 percent) ground. (See Reference). One such round trip (one turn) is one km in length. Assuming a carabao travels at an average of 3 km/hr, an average of one turn per hour is not unrealistic. If five effective turns per day are assumed, then one carabao can skid:

$$5 \text{ turns/day} * 0.4 \text{ m}^3\text{/turn} = 2.0 \text{ m}^3\text{/day of wood}$$

To meet minimum daily harvest requirements:

$$3.43 \text{ ha/day} * 31 \text{ green tonnes/ha} = 106 \text{ tonnes/day}$$

$$106 \text{ tonnes/day} * 1.05 \text{ m}^3\text{/tonne} = 112 \text{ m}^3\text{/day to harvest}$$

Therefore,

$$112 \text{ m}^3\text{/day} \div 2.0 \text{ m}^3\text{/day/carabao} = 56 \text{ carabao and driver teams}$$

Year 2

The same volume of wood will be required each year to fire the dendro-thermal plant. Therefore, the same number of carabao will be required each year.

ROADING AND VEHICLE REQUIREMENTS

YEAR	1981	1982	1983
Roads, km			
All weather, Gravel	10	5	
Dirt	10	5	
Vehicles, Units			
Pickups (Fiera)	8		
Tractors	2		

CAPITAL COSTS

YEAR		1981	1982	1983
Roads, km				
All weather, Gravel	@ P 1,750,000/km	P 1.8×10^6	P 0.9×10^6	
Dirt	@ P 1,500,000/km	P 1.5×10^6	P 0.75×10^6	
Vehicles, Units				
Pickups	@ P 40,000	P 0.32×10^6		
Tractors	@ P 222,000	P 0.44×10^6		

APPENDIX C

SOURCES OF LEUCAENA SEED AND INOCULUM

APPENDIX C

SOURCES OF LEUCAENA SEEDS AND INOCULUM

The following may be able to supply leucaena seed and inoculum:

SEEDS

Australia: CSIRO, Division of Tropical Crops and Pastures, Mill Road, St. Lucia, Brisbane, Queensland 4067, Australia (cv Peru, cv, Cunningham).

* Hawaii: J. L. Brewbaker, Department of Horticulture, University of Hawaii, Honolulu, Hawaii 96822, USA; Lowe, Inc., Honolulu, Hawaii, USA.

Malawi: R. Savory, F.A.O. Livestock Project, Box 613 Lilongwe, Malawi (cvs Peru, Cunningham, Hawaii Giant (K8 and Ivory Coast).

Mexico: G. Sanchez Rodriguez, Banco de Mexico, Hermenegildo Galena #1, Ciudad Altamirano, Guerrero, Mexico.

Philippines: Emil Javier, Director, Institute of Plant Breeding, University of the Philippines at Los Banos, College, Laguna (cv Peru and other varieties).

USA (continental): Southern Regional Plant Introduction Station, Georgia 30212.

INOCULUM

Australia: R. A. Date, CSIRO, Division of Tropical Crops and Pastures, Mill Road, St. Lucia, Brisband, Queensland 4067.

Hawaii: S. Whitney, Miftal, University of Hawaii, Maui Agricultural Research Center, P. O. Box 187, Kula, Maui, Hawaii 96790.

* Confirmed Availability

Malawi: Department of Agricultural Research, Ministry of Agriculture and Natural Resources, P. O. Box 30134, Lilongwe 3

Papua, New Guinea: D. E. Shaw, Department of Primary Industries, Konedobu, Papua, New Guinea (acid and alkaline).

United Kingdom: Rothamsted Experimental Station, Harpenden, Herts, England AL5 2JQ.

* USA (continental): J. Burton, Nitragin Corporation, 3101 West Tuster Avenue, Milwaukee, Wisconsin 53209.

* Confirmed Availability

Source: 20/

APPENDIX D

RESULTS OF WOOD AND WATER ANALYSES

Fuel Engineering Company of New York

Energy and Environmental Services

30 CLAIRMONT AVENUE • THORNWOOD, N.Y. 10594 • (914) 769-7900

Test Report # 306365

Sample Identification Leucaena leucocephala

Date Received 2/7/1980

P.O. # 1000

Sampled by: (You) (Us) Date: _____

CERTIFICATE OF ANALYSIS

Approved by FW

Date Mailed 2/13/1980

Chas. T. Main, International, Inc.
Southeast TowerPrudential Center
Boston, Mass. 02199
Attn: Mr. D. Jenkins

RECEIVED
FEB 19 1980

	AS RECEIVED 1/	DRY	
Moisture	35.38%	XXXXX	
Ash	1.29%	1.99	
Heating Value	5421	8389	8559 MAF

Bulk Density 38.5 #/Ft^{3}dry

1/ See note following Certificates of Analysis

AS A MUTUAL PROTECTION ... AUTHORIZATION FOR PUBLICATION ... WRITTEN APPROVAL.

Fuel Engineering Company of New York

Energy and Environmental Services

30 CLAIRMONT AVENUE • THORNWOOD, N.Y. 10594 • (914) 769-7900

Test Report # 306367 **Sample Identification** Casaurina rumphiana

Date Received 2/7/1980

P.O. # 1000 **Sampled by: (You) (Us) Date:** _____

CERTIFICATE OF ANALYSIS

Approved by NW

Date Mailed 2/13/1980

Chas. T. Main, International, Inc.
Southeast Tower
Prudential Center
Boston, Mass 02199
Attn: Mr. D. Jenkins

RECEIVED
CHAS. T. MAIN, Inc.
FEB 19 1980

	AS RECEIVED 1/	DRY	
Moisture	33.51%	XXXXX	
Ash	0.60%	0.91%	
Heating Value:	5406	8131	8205 MAF

Bulk Density 52.5 #/Ft^3 Dry

1/ See note following Certificates of Analysis

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Fuel Engineering Company of New York

Energy and Environmental Services

30 CLAIRMONT AVENUE • THORNWOOD, N.Y. 10594 • (914) 769-7900

Test Report # 306366 **Sample Identification** Gmelina arborea

Date Received 2/7/1980

P.O. # 1000 **Sampled by: (You) (Us) Date:**

CERTIFICATE OF ANALYSIS

Approved by FW

Date Mailed 2/13/1980

Chas. T. Main, International, Inc.
Southeast Tower
Prudential Center
Boston, Mass. 02199
Attn: Mr. D. Jenkins

RECEIVED
CHAS. T. MAIN, Inc.
FEB 19 1980

	AS RECEIVED 1/	DRY		
Moisture	30.80%	XXXXXX		
Ash	0.48%	0.69%		
Heating Value:	5646	8160	8216	MAF

Bulk Density 47.3 #/Ft^3 Dry

1/ See note following Certificates of Analysis

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CHAS. T. MAIN, INC.

LABORATORY ANALYSIS FILE DATA

SOUTHEAST TOWER, PRUDENTIAL CENTER, BOSTON, MASSACHUSETTS 02199 • TELEPHONE 617-262-3200

SAMPLE NUMBERS
1
2

JOB NO: 2785-10-1 CLIENT: USAID (Philippines)

DATE REC'D: 1/3/80 (in lab) SAMPLE BROUGHT IN BY: June Matte

REFER RESULTS TO: D. F. Jenkins (X100) BY: (DATE) ASAP

SAMPLE NO.	DATE TAKEN	SAMPLE DESCRIPTION
1	12/11/79	Tibiao River
~~2~~	~~12/11/79~~	Gibon River (Nabas)

TEST DATA - ALL RESULTS IN mg/l UNLESS OTHERWISE NOTED.

TEST PARAMETER	– SAMPLE NUMBER – 1	2	Units
pH		7.10	–
Total Alkalinity		105.	mg/l as $CaCO_3$
Total Hardness		110.	Same
Calcium Hardness		80.	mg/l as Ca
Total Suspended Sol.		1.	mg/l
Total Dissolved Sol.		86.	mg/l
Chloride		8.0	mg/l Cl^-
Sulfate		3.3	mg/l SO_4^-
Color		5	Color Units
Silica		0.45	mg/l as SiO_2 - Sample Not Digested
Total Metals:			
Fe		0.04	mg/l
Mg		1.8	mg/l
Na		1.6	mg/l
K		0.36	mg/l

COMMENTS: Samples not cooled or preserved. Hold Sample 1. Further testing was not feasible due to limited sample volume.

DATE COMPLETED 1/16/80

SHEPPARD T. POWELL ASSOCIATES
CONSULTING ENGINEERS AND CHEMISTS

HILARY E. BACON
JOHN W. SIEGMUND
ELMER L. KNOEDLER
WILLIAM J. LEWIS
WILLIAM E. CHESNEY
JAMES S. POOLE
STRATI YORGIADIS

31 LIGHT ST
BALTIMORE, MARYLAND 21202

301-685-3210
CABLE ADDRESS: SHEPOW

February 1, 1980

RECEIVED
CHAS. T. MAIN, INC.
FEB 11 1980
REFER TO
NOTED

Chas. T. Main, Inc.
1800 S.W. First Avenue
Portland, Oregon 97201

Attention: Mr. Colin Miller

Subject: Dendro Thermal Power Plant
Panai Island
Republic of Phillipines

Gentlemen:

Since your telephone call of January 30 asking for assistance on the above project, we have studied the analysis of the Gibon River water which you read to us, and the implications for its use as make-up to the proposed boiler and cooling tower. This letter gives our preliminary Conclusions and Recommendations.

QUALITY OF THE RIVER WATER

In Table 1 we give the analysis that you read to us adjusted to balance cations and anions (in terms of calcium carbonate). It contains 110 ppm of bicarbonate hardness, roughly two-thirds calcium and one-third magnesium. Chlorides and sulfates are relatively low and are balanced by sodium and potassium. Silica is apparently less than one-half ppm, which is favorable. As is the case with many river waters, it contains organic matter represented by five color units, but we have no data on turbidity.

On the basis of this single analysis, the water should be acceptable for cooling tower make-up, but it is possible that turbidity or pollution not revealed by this tabulation may require revision of this opinion. We recommend that you investigate other installations using water from this and similar rivers in the area to learn whether there are possible sources of trouble. Pending further information, we will calculate cooling tower requirements using the river water.

Treatment required for boiler feed make-up will be considered in a following section.

REQUIREMENTS FOR TREATMENT OF COOLING TOWER CIRCULATING WATER

Table 1 includes the estimated composition of the water after three cycles of concentration in the cooling tower and under the analysis in Column 2 we have calculated the Calcium Carbonate Saturation Index, which is +.74. This forecasts the formation of calcium carbonate scale without treatment to lower either the calcium hardness or the bicarbonate alkalinity, or both. We recommend addition of sulfuric acid to lower the alkalinity to 130 ppm which will adjust the Index to +.10, slightly away from the corrosive level but not high enough to cause a scale problem. Should any trouble in this direction be experienced, a minor adjustment will cure it. This should be guided by calculation of the cleanliness (fouling factor) of the condenser.

The feed of 66° Baume sulfuric acid is estimated to be 70 ppm based on the make-up, or a total of 63 pounds per day (a little over 4 gallons). This can be purchased in drums or carboys, whichever is available on the Island. As shown in the drawing, we recommend a volumetric meter on the make-up supply and a meter-paced piston diaphragm pump to add the acid. It would probably be better to dilute the acid to ten percent, which would bring the daily volume to a little under 75 gallons. A plastic solution tank with supports and means for delivering the concentrated acid from the drum or carboy will be needed. Suggested vendors of the entire assembly include Wallace & Tiernan and B-I-F.

It is probable that a similar assembly will be needed to feed sodium hypochlorite for control of slime and algae. Here again, conditions on the Island should be investigated to learn the experience of other operators of cooling towers.

FEEDWATER AND BOILER WATER TREATMENT

We recommend filtration and zeolite softening for treatment of boiler feedwater make-up.

You informed us that steam generation will be approximately 25,000 lbs. per hour, and we have estimated that the feedwater will be five percent make-up and ninety-five percent condensate. At five percent boiler blowdown, there will be twenty-one concentrations of feedwater solids in the boiler water. The make-up will only be 2.5 gpm, which calls for a very small treatment system.

We recommend adding sodium sulfite to the deaerator storage tank to maintain 15 - 20 ppm in the boiler water; also, anhydrous disodium phosphate to maintain 20 - 40 ppm of PO_4 in the boiler water.

We do not recommend chelants.

In Table 2 we show the analysis of make-up, feedwater and boiler water. It will be seen that five percent blowdown will maintain less than 250 ppm of dissolved solids, very low silica, and 40 ppm of methyl orange alkalinity, of which about three-fourths is phenolphthalein alkalinity. This is really everything that is necessary to protect the boiler from scale and corrosion, particularly in view of the low silica. A Vendor-Consultant may want to add organic polymers for several purposes, but we are not aware that anything of this kind will be needed.

EQUIPMENT REQUIRED

For this small system, there is no reason why a package-type clarifier and filters should not be used.

We have been in touch with two manufacturers: Neptune Microfloc and The Permutit Company.

We talked to Neptune Microfloc in Corvallis, Oregon and obtained information on their smallest Water Boy Unit WB-14, capacity 10 gpm. This is a self-contained assembly, 4' wide, 7' long and 5' tall. It includes chemical feeders, coagulators, tubular settlers and a filter, and the price is $20,000. These units are in stock. In addition, you should provide filtered water storage to provide smooth operation, and you will need two small zeolite softeners. We attach a table showing parameters for the softeners. (Table 3)

Permutit's nearest office offers a 5' x 8' Spaulding Precipitator, chemical feeds and two 20" filters -- their smallest bottling plant assembly. They will add two 20" zeolite softeners, and the total price is $30,000.

We have asked Doug Andrews of Permutit and Rick Jaccarino of Neptune Microfloc to mail directly to you simple drawings which will show what they are offering, as well as their quotation. This will all be sent to our office, also. It was considered the best way to get the information into your hands promptly.

Also needed will be chemical solution tanks and pumps to feed continuously sodium sulfite to the deaerator storage tank and phosphate directly to the boiler drum.

We suggest that you review our letter and all of this information and then discuss the project with us by telephone. If you want us to expand this into a more lengthy report for your client, we will be glad to do so.

Yours very truly,

SHEPPARD T. POWELL ASSOCIATES

H. E. Bacon

H. E. Bacon

HEB:jk

TABLE 1

WATER ANALYSIS AND TREATMENT CALCULATIONS

DENDRO THERMAL POWER PLANT
GIBON RIVER, ISLAND OF PANAI, PHILLIPINES
(AGENCY FOR INTERNAL DEVELOPMENT)

	(A) Raw Water	(B) At 3 Concentrations	(C) + H_2SO_4 For Scale Control
Calcium	80.0	240	240
Magnesium	30.0	90	90
TOTAL HARDNESS	110.0	330	330
Sodium and Potassium	14.6	43	43
TOTAL CATIONS	124.6	373	373
Chloride	11.2	33	33
Sulfate	3.4	10.2	210.2
MINERAL ACID IONS	14.6	43	243
Bicarbonate	110	330	130
TOTAL ANIONS	124.6	373	373
Total Dissolved Solids	192	576	370
Silica as SiO_2	[illegible].5		
Carbon Dioxide as CO_2	25		
pH	7.1	7.40	7.14
Color Units	5		
Suspended Solids	1.0		
Iron	.04		

Saturation Index Calculations:	(B)	(C)
pCa	2.63	2.63
pAlk	2.18	2.58
C	1,85	1.83
pH_s	6.66	7.04
pH_a	7.40	7.14
S.I.	+.74	+.10

TABLE 2

WATER ANALYSIS AND TREATMENT CALCULATIONS

MAKE-UP, FEEDWATER AND BOILER WATER

DENDRO THERMAL POWER PLANT

	Filtered River Water(1)	Zeolite Softened	Deaerated Feedwater(2)	Boiler Water Ions(3)
Calcium	80	0.7	tr	0
Magnesium	30	0.3	tr	0
TOTAL HARDNESS	110	1.0	.05	
Sodium and Potassium	14	123	7.15	84
TOTAL CATIONS	124	124	7.20	
Chloride	14	14	.70	10
Sulfate	21	21	1.05	21
Phosphate as PO_4				30
Sulfite as SO_3			1.00	17
MINERAL ACID IONS	35	35	2.75	
Bicarbonate	89	89	1.45	
Carbonate			3.00	19
Hydroxide				21
TOTAL ANIONS	124	124	7.20	
Total Dissolved Solids				225
Silica as SiO_2	.45	.45		0.5
Carbon Dioxide as CO_2	25			
pH	7.1			10.7
Color Units	tr			
Turbidity Units	tr			
Conductivity, micromhos				450
P Alkalinity	0	0	1.50	31.5
M Alkalinity	89	89	4.45	40

(1) 20 ppm alum, 2 ppm chlorine

(2) 5% make-up + 1 ppm sulfite

(3) 5% blowdown + 30 ppm phosphate

TABLE 3

PARAMETERS FOR ZEOLITE SOFTENING SYSTEM USING STYRENE-DIVINYL BENZENE CATION EXCHANGE RESIN

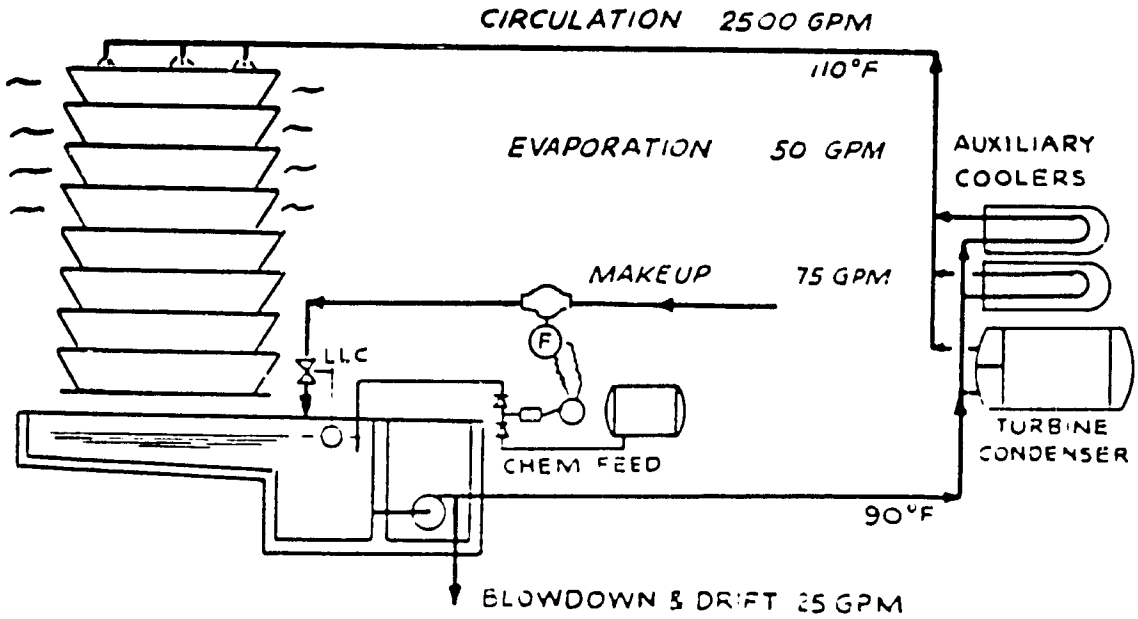
DENDRO THERMAL POWER PLANT

Number of Units	2
Diameter	20 Inches
Side Height	5 Feet
Bed Depth 30 Inches Equal To	5.5 Cubic Feet
Capacity @ 20 Kilograins Per Foot^3	110 Kilograins
Hardness of Influent	6.4 Grains Per Gallon
Water Produced Per Cycle	17,188 Gallons
Flow 2.5 GPM Equal To	3,600 Gallons Per Day
Length of Run	4.8 Days
Salt for Regeneration (Recommended to Assure Zero Hardness)	7.5 Pounds Per Cubic Foot
Total Per Cycle	41.25 Pounds
Saturated Brine	16.6 Gallons

SHEPPARD T. POWELL ASSOCIATES
CONSULTING ENGINEERS BALTIMORE, MD.

Date: 1/31/80
J.O.No: 2224
Sheet: 1
By: H.E.B.

Client: CHAS. T. MAIN, PORTLAND, OREGON
Subject: A.I.D., PHILLIPINES, DENDRO THERMAL POWER PLANT
COOLING TOWER TREATMENT TO PREVENT SCALE



Constituents as ppm $CaCO_3$	River Water	+ H_2SO_4, 70 ppm	x 3 Concentrations
Calcium Hardness	80	80	240
Alkalinity	110	43.3	130
Dissolved Solids	192	123	370
Sulfate	3.4	70.1	210
pCa			2.63
pAlk			2.58
$C_{110°}$			1.83
$pH_{sat.}$			7.04
pH_a	7.10		7.14
Saturation Index			+ .10

APPENDIX E

RESPONSES TO AID COMMENTS ON DRAFT REPORT

May 13, 1980

RECEIVED
CHAS. T. MAIN, INC.
MAY 15 1980
REFER TO
FILED

Mr. Frank M. Tenore
Project Manager
Chas. T. Main Intn'l, Inc.
Southeast Tower
Prudential Center
Boston, Massachusetts
02199

SUBJECT: Contract No. AID/otr-C-1646
Study of Dendro-Thermal Plant
Philippines - Draft Report

Dear Mr. Tenore:

The draft report for the proposed Dendro Thermal Plant in the Philippines addresses the items in the Scope of Work and is generally acceptable. There are, however, some clarifications and elaborations needed and a few omissions have been noted in review of the draft. Items that follow reflect comments of the Agency for International Development reviewers in the Philippines and Washington:

1) Water requirements for the plant are shown as 500 GPM in Section 3.1.1; 206 GPM in Section 5.39; 61 GPM in Section 8.3.2; and 2016 GPM in Section 8.3.4. Presumably, the 206 GPM figure shown in the water balance is the correct figure. Please clarify.

2) During much of the year, the wood chips could be air dried to a moisture content of about 20 percent to increase boiler efficiency. How would this effect plant operations? (The samples taken at the site would presumably not have been considered green wood at the time of testing.)

3) It is our understanding that fluidized bed combustion systems are sold commercially and that some of these units have been in operation for 2 plus years. Section 5.3.5.4. should be more specific about operating experience of such installations.

4) Typical plant operation of 310 days per year as shown in Section 5.2 seems low. What are the estimated scheduled and unscheduled outages that limit availability to 85%?

5) Using the average ash content of about 0.80% reported in the lab analysis, it appears ash generation would be much less than the 995 tons per year reported in Section 5.3.8.6.

6) The presentation in Section 6 dealing with regeneration, silvicultural and harvesting methods for fuel supply is clear, but lacks detail particularly in the discussions regarding species selection and projected growth rates. There is no mention of specific site characteristics, particularly soil

data, which are necessary to select species, and estimate site fertility. For example, the primary species recommended, Leucaena, does not grow well on highly acidic soils. Soil acidity is not discussed. The report correctly notes that "published growth rates for Leucaena vary widely" then cites an "admittedly conservative" growth rate for Leucaena. A more substative evaluation of the growth potential of Leucaena in terms of the prospective plantation areas would permit greater confidence in the calculations of fuelwood production presented in the Appendix.

7) The plan for fuel supply shows 2100 ha needed to support a 2mw plant with first harvest two years after planting. The plantation size is stated to be larger than needed to sustain fuel supply because of the initial harvest in two years. It would be useful to consider a longer growth period, thereby reducing the acreage and harvest/delivery system costs as well as the additional cost of planting excess acreage for the one year earlier harvest.

8) Section 6.2.5 refers to Section 5.4. This section is missing from the report.

9) The generation potential is left out of Section 6.2.5.

10) To avoid a monoculture, foresters in the Philippines have suggested that the woody vegetation growing in the plantation area should not be cut during land preparation.

11) Burning alone is not sufficient to kill cogon grass. The grass must be continually grubbed out until the trees shade out the cogon.

12) All planting in the Nabas area should be done before the end of October to allow at least 2 months of rain to establish root systems.

13) Laborers involved in plantation operations might be located in temporary quarters in the hills -- not shuttled back and forth as suggested in Section 6.3.2.4.

14) Use of a permanent cableway system to deliver fuel to the plant should be considered. A similar system is currently being used by a mining company in Baguio to deliver whole logs to a sawmill and sawn lumber to the end-use point. The Main team viewed this operation. Why was this alternative discarded without discussion?

15) The project cost estimate contains insufficient detail to permit adequate analysis as indicated by the following questions:

a) What items are included in the site preparation for the plant? If it only covers clearing, grubbing, and grading, the estimate appears much too high.

b) What equipment is included under wood processing, and what local currency costs are associated with this line item? This estimate also appears to be high.

c) What items are included in general plant and support services?

d) If road transport is used in lieu of a cableway, we would envision a 4-meter access road shoved through with a dozer and grader. The surface would be graveled and drainage structures provided only where absolutely essential. Under the Agency for Internation Development-financed rural road program in Aklan and Antique, the average cost of 6-meter feeder roads with 15-20 centimeters of gravel surfacing and adequate drainage structures was about pesos 200,000 per kilometer in 1979. The per kilometer cost for plantation access roads probably would not exceed that figure even considering possible difference in terrain. The estimate appears to be high by a factor of 7 or 8 at a minimum.

e) A price list of all major equipment required should be shown.

f) The capital investment of $3,880 per installed kilowatt required for the plant alone does not compare with previous estimates of $1,000 - $1,500 per kilowatt provided by equipment suppliers.

Back-up material, including quantities and associated unit costs, should be presented and identified with Table 7-1 to support the summary estimate in the table.

16) Why are cost plus contracts rather than unit price contracts recommended for the site preparation and access road construction?

17) If construction were to commence in January 1982, as suggested under alternative 2 of Section 7.4.1, it would be the beginning of the dry season, not the middle of the rainy season.

18) The plant consumption of 16.5 percent of electricity generated appears high. Please identify and quantify requirements for plant operations.

19) Clarify sentence 3 under Section 9.3.2.2. If the total work force is 275 and the annual cost is pesos 552,000, the average salary is about pesos 2,000 per year. This annual salary is less than any of those shown in Section 6.3.4.

20) Two different wholesale prices for diesel fuel are used in the discussion under Section 9, $1.00 and $1.16 per gallon. The latter is more appropriate.

21) The average cost of delivered wood quoted in Section 9.6.1 should be pesos 117 per ton, not $117.00 per ton.

22) Why are capital costs of the diesel plant excluded from the analysis in Table 9.7?

23) The economic feasibility is based on comparisons with existing diesel plant generated electricity considering fuel substitution only. As a general application for other sites, it would be useful to include comparisons of dendro thermal plant capital and operating costs with capital and operating costs of alternative plants in the country's system expansion plans using forward pricing costs rather than the existing diesel plant costs.

Upon consideration of these comments and incorporation of explanatory materias requested, the report may be printed in final and the tcopies sent to this office.

Sincerely,

Wilson J. Hodgin
Chief Engineer
Office of Project
Development
Bureau for Asia

cc: SER/CM:LStanfield
DS/ENGR:JCabrero
ASIA/TR/STEP:NBrown
USAID/Manila:JBaird

The following points respond to individual comments made by AID in its letter of May 13, 1980.

1. The 500 gpm in Section 3.1.1 was an initial estimate used as a preliminary site selection criterion. The 206 gpm in Section 5.3.9 is the requirement for intake cooling water. This volume of water was determined during the project design, after the preliminary site selection was completed. The 61 gpm noted in Section 8.3.2 is the net water requirement of the plant. As noted on Figure 5-5, plant intake from the Gibon River is 206 gpm and plant discharge to the river is 145 gpm, resulting in a net water requirement of 61 gpm. The 2016 gpm in Section 8.3.4 has been corrected to read 206 gpm.

2. The wood chips will arrive at the plant at a moisture content of approximately 35%. The chips will be piled. MAIN has found that, even during a dry season, only the outer layer (a few centimeters in depth) of a chip pile will dry slightly. During rainy periods, a properly shaped chip pile will shed water, resulting in significant increases in moisture content only in the outer layer of the chip pile. Therefore, the moisture content of the internal portion of pile will not vary significantly and the net annual effect on the outer layer of the pile will be minimal.

   The wood samples were taken from freshly-cut trees, sealed in plastic at the time of cutting, and submitted for analysis. Therefore, the "AS RECEIVED" data refer to the "green" condition. The "dry" data refer to oven-dried samples.

3. Fluidized bed combustion systems are being sold commercially, particularly in the wood products industry. These units supply heat directly to lumber kilns and/or waste heat boilers generating low pressure steam (usually less than 250 psig).

Specific operating problems or disadvantages that have been cited include:

(a) Large quantity of abrasive particulates carrying over from the fluid bed to the boiler, causing erosion of components.

(b) Large power requirements for the fluidizing fan.

(c) Ash removal problems and clinker formations in the fluid bed.

Wood products plants do not generally operate on a 24-hour, 7-day week schedule. Loss of steam for short periods of time due to equipment failure is not as critical as for power generation applications.

Although some fluid bed systems have been operating for a number of years, fluid bed operating experience does not approach that of cell burners. In a remote area, such as the proposed plant site where technical resources are limited, the equipment should be as time-proven as practicable. Furthermore, since the cost for a fluid bed for this project is approximately the same as the cell burning system, there is no justification for a fluid bed system.

4. A unit availability of 85% (310 operating days per year) has been employed by MAIN and the World Bank for small utility (non-industrial) generating units in developing countries. That criterion is employed in this report. Scheduled outages will be required for regular maintenance procedures. Unscheduled outages result from unforeseeable circumstances.

5. Ash Calculation: Wood ash consists of both inorganic ash and char (unburned hydrocarbons).

Basis: Ipil-Ipil 1.29% Ash (inorganic ash wet base)
Fuel Burned 7,930 lbs/hr as fired (wet)

<u>Inorganic Ash Quantity</u>:

(7,930 lbs/hr wood) (24 hrs/day) (310 days/yr) (.0129 ash)

= 761,000 lbs/yr ash

= 761,100 lbs/hr - (12.9 lbs/hr ash to atmos.) (310 days/yr) (24 hrs/day)

= 665,000 lbs/yr inorganic ash for disposal

Based on test results, char can represent as much as two times the inorganic ash.

Char Quantity:

(7,930 lbs/hr wood) (24 hrs/day) (310 days/yr) (.0129 x 2 char)

= 1,522,000 lbs/yr - maximum quantity of char for design basis.

Maximum Quantity of Ash and Char for Disposal:

1,522,000	char
665,000	ash
2,187,000	lbs/yr maximum

$$\frac{2{,}187{,}000 \text{ lbs/yr}}{2{,}200 \text{ lbs/tonne}} = 995 \text{ tonnes/yr}^{*}$$

* NOTE: This represents a conservative value for design purposes. The actual value could be less.

6. The general management plan was not designed to be detailed or site specific (see Section 6.1). It is correct that some authors have indicated that Leucaena may be sensitive to acidic coil conditions and that this characteristic may be more closely linked to phosphorus and/or calcium availability than soil pH. No detailed soils data were available for the project area at the time of the study. The typical chemical analysis of a broad soil series as noted by Murphy, et al, and the analysis of one or two soil samples from the project area are of little value in evaluating site specific characteristics.

A sounder approach is to evaluate growth of vegetation on those soils when detailed information is lacking. Leucaena is presently being used in the reforestation effort on Panay. Its growth rate is favorable and superior to other species being utilized. Although reliable data and information were lacking, the recommendation for Leucaena was not without basis. A systematic soil sampling program throughout the plantation area is recommended in Section 6.3.2.5.

A more substantive evaluation of the growth potential of Leucaena on Panay was not realistic in view of the general lack of data for the growing

conditions of Panay. Murphy et al evaluated the biological feasibility of growing fuel wood on Panay. After reviewing the data and local conditions, the MAIN team did not feel that the estimated growth of 10 bdt/ha/yr was unrealistic. The team agreed that a conservative approach was recommendable to insure that the multi-million dollar power plant would not become idle due to lack of fuel. The establishment of permanent sample plots to monitor growth is recommended in Section 6.3.2.5.

7. The accelerated plantation schedule was developed at the request of AID/W to get the plant "on line" at the earliest possible date. After the third year of harvest, the additional hectareage required for the accelerated schedule can be utilized to produce domestic firewood for the local populace (see Section 8.3.1), thus reducing the pressure on the fuel wood plantation from "firewood poachers".

8. Section 6.2.5 should refer to Section 5.3.4, not Section 5.4. The text is corrected.

9. The generation potential represented by the available area within the Nabas Reforestation Project is 2.4 MWs, requiring 875 hectares per MW.

10. The intent of Section 6.3.2.1 was to indicate that only grasses and brush were to be cleared. The scattered areas presently vegetated with "native" forest (Section 6.2.4) should be maintained for soil stabilization.

    The term "monoculture" refers to economic as well as ecological considerations. Ecologically, a monoculture may be subject to a pathologic or entomologic catastrophe. This, in turn, would result in an economic catastrophe if the generation plant depended on that single tree species for fuel. Therefore, to reduce the probability of such an ecological/economic occurrence, two species of economic value are recommended for plantation establishment.

11. Burning is only recommended to clear the land prior to planting. Weeding (grubbing) is discussed in Section 6.3.2.3 and is included in plantation scheduling in Appendix B.

12. As noted in Appendix B, the planting operation is scheduled to be terminated in November. This permits an adequate period of one month for root systems to become established.

13. It is considered unrealistic to house, feed, and maintain a field crew of several hundred workers "in temporary quarters in the hills".

14. A permanent cableway system is inflexible. Trucks and all-weather roads would still be required to haul logs to the cable head. The costs of construction and equipment (drives, winches and brakes) for a long cable system are high for the relatively low value product (fuel wood) being transported. (Where employed, such systems are typically used for high value products.) Several additional handling procedures (choking and unchoking log bundles to and from the cable) would be required, increasing costs and danger to the workers.

    Dependence on a single line of supply (the cable) is not recommended for a plant which must be continuously supplied with wood. A single mechanical failure could significantly slow wood delivery. Due to the above disadvantages and an estimated order of magnitude cost of $6,000,000 (P. 44,400,000), the permanent cableway system alternative was not pursued.

15(a). The following items are included under the category of site preparation:

Clear and Grub - (remove stumps)
Earthwork - (2200 CY)
Gravel Surfaced Road - (6000 LF-perimeter road, including sub-base prep, base and gravel)
Paved Roads - (900 LF adjacent to power plant)
Fence - (including gates, etc.) (6000 LF)
Fire Pump House including:
- Fire Pumps (1 electric, 1 diesel)
- Valves, controls, etc.
- Fire Loop (1000 LF)
- Hydrants, House, Tools
- Steel Storage Tank

Septic Tank with Field and Sanitary Sewers

Storm Sewers and Ditches

Yard Lighting (power plant area)

Communications including:

- PBX
- Communication Line

Gate House

Potable Water Distribution Piping

Office (for 3 people) including:

- HVAC
- Lighting

Lockers, Rest Room, Break Area

Shop including:

- HVAC
- Lighting
- Equipment and Supplies (included in Client and other charges)

Water Intake Structure including:

- Pump
- Miscellaneous Piping

15(b). A complete list of major equipment is included at the end of this Appendix. Generally, local currency costs include contractor-furnished materials and local labor wages. The estimate for wood processing was high. The estimated cost of harvesting equipment had been incorrectly included in this figure. Other minor reallocations of items to the Boiler Turbine Generator were also made. These changes are reflected in Table 7-1 and Section 9.

15(c) The line item General Plant and Support Services includes painting as well as structures (unloading piers, etc.) for the wood processing at the plant site. See the equipment list at the end of this Appendix.

15(d) Several estimates of construction costs were obtained for six-meter gravel roadways. These ranged from P. 150,000 per km to P. 1,750,000 per km with intermediate costs. Sources included costs for government agencies

and private companies. The high figure was developed by a Manila engineering firm and was employed as a conservative estimate. Included at the end of this Appendix is the summary of an economic analysis for the proposed project in which a road construction cost of P. 200,000 per km is employed. This provides analyses for both extremes of the range of costs. This does not result in any change in the conclusions of the report.

15(e). A price list of all equipment is included at the end of this Appendix.

15(f). It has been MAIN's experience that equipment suppliers do not usually include in their estimates (unless specifically directed) such items as transmission and substations, site preparation, yard services, civil work, underground piping, general plant and support services, shipping, indirect construction costs, contingencies, professional services, and client and other miscellaneous charges. Deducting these items from MAIN's estimate would decrease the power plant cost to about $2,285/kW, of which approximately $800/kW is for wood processing. Often, it is not until an overall project estimate is prepared that the above associated costs appear. Furthermore, unless specific operating parameters are specified to vendors, they may quote less expensive equipment, sacrificing future operating costs. The life cycle costs may be much greater for lower prices equipment unless properly specified.

16. Cost plus contracts with fixed fees are preferred over unit price type contracts for site preparation and access road construction for the following reasons:

(a) Either type contract is adequate when dealing with this type of construction where so many "hidden" or unknown items may exist - hidden rock, abandoned systems not on record, ruins, weather effects on length of job, etc. However, we feel that the cost plus fix fee approach allows the client more control over actual cost while keeping the contractor's profit margin within reason for the job scope.

(b) The requirements for record keeping and accurate measurements of various quantities of items increase with unit pricing - requiring larger administrative and technical staff on site.

17. The text has been modified.

18. Electric motors, connected capacity, and internal plant service load are summarized below.

PRELIMINARY MOTOR LIST

Boiler Plant	Connected HP	
Storage Bin Agitator	5 HP	
Storage Bin Outfeed	3 HP	
Conveyor to Metering Bin	5 HP	
Metering Bin Screw	2 @ 3 HP	
Cell Feed Screw	2 @ 3 HP	
F.D. Fan	25 HP	
I.D. Fan	60 HP	
Boiler Feedwater Pump	75 HP	
Grate Water Pump	5 HP	
Air Compressor	10 HP	
Feedwater Treatment Transfer Pump	2 @ 3 HP	
Deaerator Transfer Pump	2 @ 3 HP	
Turbine Generator and Auxiliaries		
Condensor Cond. Pumps	2 @ 5 HP	
Cooling Tower Recirculating Pumps	2 @ 75 HP	
River Pumps	3 @ 5 HP	
Cooling Tower Fan	50 HP	
Oil Pump (T-G)	3 HP	
Turbine Room Crane	7½ HP	(Hoist)
	½ HP	(Trolley)
	1½ HP	(Bridge)
Miscellaneous Unlisted	2 @ 5 HP	
		460 HP

Wood Processing

Unloading Conveyor	30 HP	
Inclined Conveyor Belt	2 @ 15 HP	
Disc Scalper	15 HP	
Pile Out Conveyor	40 HP	
Reclaim Hopper and Outfeed Conveyor	25 HP	
Silo Feed Conveyor	50 HP	
		190 HP

Total Connected HP =	650 HP	
Less Installed Spares	-100	
	550 HP	
Multiply by .8 Load Factor	x .8	
Operating HP	440 HP	
	x .746 kW/HP	
TOTAL PLANT SERVICE LOAD		329 kW

$$\frac{\text{329 kW (Service Load}}{\text{2000 kW (Plant Output)}} = 16.5\%$$

Plant service power requirements for a small wood-fired power plant can be expected to be somewhat higher as a percentage of kWh generation than that of a larger wood or fossil-fired plant. This is due primarily to material handling horsepower requirements not decreasing proportionally with plant size.

19. The annual labor cost to maintain the staff of 275 persons is P. 991,933. The cost originally noted (P. 552,246) is for the harvesting staff only. The text is corrected.

20. The cost of $1.16 per gallon of diesel fuel was used in all calculations. The $1.00 per gallon has been corrected to read $1.16.

21. The text is corrected.

22. The capital costs of the diesel plant were excluded from the analyses because the economic feasibility study was to evaluate the operating costs of the dendro-thermal unit with the operating costs of the most likely alternative - in this case, diesel. Logically, since a new 2 MW diesel unit would not be constructed because of its uneconomical size, the obvious comparison was to examine the operating costs of 2 MW of dendro-thermal generation with the equivalent costs of 2 MW of existing diesel generation. Including the capital cost of a new diesel plant would, therefore, present an unrealistic situation.

23. MAIN agrees that these comparisons would be useful.

SUPPLEMENTARY ECONOMIC ANALYSIS

ALTERNATIVE ROAD COSTS

In response to question 15(d), a supplementary analysis was performed using road costs of P 200,000/km for gravel roads and P 180,000/km for dirt roads.

The following tables have been prepared to reflect the difference of roading costs to the overall economic costs of the dendro-thermal. These tables correspond directly to similar labels in the main report.

TABLE 7-1A

ORDER OF MAGNITUDE COST ESTIMATE

DENDRO-THERMAL GENERATING PLANT

(1980 Philippine Pesos)

(ALTERNATIVE ROAD COSTS)

	Local Currency	Foreign Currency	Total Currency
Site Preparation	P 6,497,200	P -	P 6,497,200
Wood Processing	1,576,200	4,684,200	6,260,400
Boiler Turbine Generator Complex	8,635,800	15,458,600	24,094,400
Transmission & Substation	207,200	2,271,800	2,479,000
General Plant & Support Services	1,280,200	-	1,280,200
Subtotal	P 18,196,600	P 22,414,600	P 40,611,200
Shipping		1,924,000	1,924,000
Labor	- 3,788,800	-	- 3,788,800
Subtotal - Plant	P 14,407,800	P 24,338,600	P 38,746,400
Fuelwood Plantation			
Administration	240,000		240,000
Nursery	63,250		63,250
Land Preparation	55,500		55,500
Planting	15,000		15,000
Maintenance	19,000		19,000
Harvest		3,492,800	3,492,800
Vehicles	320,000		320,000
Roads	6,270,000		6,270,000
Subtotal - Plantation	6,982,750	3,492,800	10,475,550
TOTAL - DIRECT COST	21,390,550	27,831,400	49,221,950
Indirect Construction Cost + 20%	4,278,110		4,278,110
Contingency + 15%	3,208,583	4,174,710	7,383,293
Specific Cost	28,877,243	32,006,110	60,883,353
Professional Services + 5%	1,443,862	1,600,306	3,044,168
Client & Other Charges + 2%	606,442	672,128	1,278,570
TOTAL COST	P 30,927,547	P 34,278,544	P 65,206,091

TABLE 9-3A

PLANTATION INVESTMENT COSTS

1980 Pesos

(ALTERNATIVE ROAD COSTS)

1981		10,056,528
1982		5,028,264
	TOTAL	15,084,792

Present Worth Analysis

Discount Rate	Present Value
4.0	14,318,651
8.0	13,622,526
12.0	12,987,544
16.0	12,406,240
20.0	11,872,290

TABLE 9-4A

PLANTATION OPERATING COSTS, 1983-2007

1980 Pesos

(ALTERNATIVE ROAD COSTS)

1983	2,603,079
1984	2,596,235
1985	2,596,235
1986	2,596,235
1987	2,596,235
1988	2,596,235
1989	2,596,235
1990	2,983,121
1991	2,983,121
1992	2,983,121
1993	2,596,235
1994	2,596,235
1995	2,596,235
1996	2,596,235
1997	2,596,235
1998	2,596,235
1999	2,596,235
2000	2,983,121
2001	2,983,121
2002	2,983,121
2003	2,596,235
2004	2,596,235
2005	2,596,235
2006	2,596,235
2007	2,596,235

Present Worth Analysis

Discount Rate	4%	8%	12%	16%	20%
Present Value	38,768,706	24,495,713	16,680,819	12,048,543	9,107,624

TABLE 9-5A

LEVELIZED PAYMENTS FOR FUELWOOD

(1983 - 2007)

(ALTERNATIVE ROAD COSTS)

Analysis 1: Average Operation and Maintenance Charges on the Wood Plantation Per Year:

P 2,712,301 or

P 101/tonne

Analysis 2: Average Operation and Maintenance Charges Plus 20% Per Year:

P 3,254,761 or

P 121/tonne

Analysis 3: Investment (25-Year, 8% Loan by Equal Payments) Plus Operation and Maintenance Expenses:

Loan Repayment	P 1,413,125
Operation and Maintenance	P 2,712,301
	P 4,125,426

or P 370/tonne

Present Worth Analysis

(Pesos)

Discount Rate	Analysis 1	Analysis 2	Analysis 3
4%	39,175,095	47,010,111	59,585,554
8%	24,822,708	29,787,247	37,755,486
12%	16,958,669	20,350,401	25,794,236
16%	12,289,795	14,747,754	18,692,852
20%	9,318,990	11,182,787	14,174,239

TABLE 9-7A

COMPARISON OF DENDRO-THERMAL AND DIESEL GENERATION

Present Worth Analysis

(1980 Pesos)

(ALTERNATIVE ROAD COSTS)

	Discount Rate				
	4%	8%	12%	16%	20%
DENDRO-THERMAL OPTION					
1. Investment, 1981-1982					
1.a Generation Facility	43,013,076	42,289,738	39,833,671	37,609,962	35,589,286
1.b Plantation	14,318,651	13,622,526	12,987,544	12,406,240	11,872,290
1.c Sub-Total	57,331,727	55,912,264	52,821,215	50,016,202	47,461,576
2. Operating Expenses, 1983-2007					
2.a Generation Facility	6,706,763	4,249,639	2,903,318	2,104,009	1,595,407
2.b Plantation	38,768,706	24,495,713	16,680,819	12,048,543	9,107,624
2.c Sub-Total	45,475,469	28,745,352	19,584,137	14,152,552	10,703,031
Levelized Wood Payment Plans					
2.b.1 O&M Only	39,175,095	24,822,708	16,958,669	12,289,795	9,318,990
2.b.2 O&M + 20%	47,010,111	29,787,247	20,350,401	14,747,754	11,182,787
2.b.3 O&M + 1.b Loan Repayment Plan	59,585,554	37,755,486	25,794,236	18,692,852	14,174,239
3. Totals					
3.a All Costs 1.c + 2.c	102,807,196	84,657,616	72,405,352	64,168,754	58,164,607
3.b O&M + Plantation Loan 2.a + 2.b.3	66,292,317	42,005,125	28,697,554	20,796,861	15,769,646
3.c O&M + Generation Facility, 1.a + 2.c	88,488,545	71,035,090	59,417,808	51,762,514	46,292,317
O&M Only					
3.d 2.a + 2.b.1	45,881,858	29,072,347	19,861,987	14,393,804	10,914,397
3.e 2.a + 2.b.2	53,716,874	34,036,886	23,253,719	16,851,763	12,778,194
DIESEL OPTION					
4. Operating Expenses, 1983-2007					
4.a O&M (Less Fuel)	1,938,490	1,228,295	839,161	608,132	461,129
4.b Fuel	138,373,614	84,413,844	55,889,084	39,427,751	29,271,993
4.c Total	140,312,104	85,642,139	56,678,245	40,035,883	29,733,122
4.d Operating Costs for 12.5% Reduced Output from Dendro-Thermal Plant	122,773,091	74,936,872	49,593,464	35,031,398	26,016,482

Comparison of Operating Costs

The comparison of dendro-thermal and diesel generation can be found in Table 9-7A. The operating expenses for the dendro-thermal option (line 2.c) are well below the diesel option for all discount rates in this study. In all of the operation and maintenance comparisons with diesel (based on discounted cash flows, lines 2.b.1, 2.b.2, 2.b.3), the dendro-thermal facility remains the most economic. Even if loan repayment for the plantation investment cost is included in the "operating cost" (line 3.b), the dendro-thermal alternative remains significantly less expensive than generation by diesel under the assumed fuel escalation rates.

Comparisons Including Investment Considerations

Because the dendro-thermal plant is of such a small size and therefore cannot achieve significant returns to scale, the investment costs are extremely large compared to the operating cost. Including the investment costs in the present worth analysis for the dendro-thermal alternative (line 3.a) shows that, at an 8% discount rate, the present worth value of the dendro-thermal plant is actually 1.16% lower than the operation of equivalent diesel (line 4.c).

Interestingly, line 3.c shows that, if a similar plant were located where the plantation investment was negligible (wood available and easily harvested), then even a 2 MW plant would be viable compared to operating diesel generation at less than a 12% discount rate.

Comparison Between Alternative Road Costs for the Dendro-Thermal Option

The summary of the economic analysis of the dendro-thermal option for the original roading costs (base case) and the option for the alternative roading costs (alternative case) are found in Table 9-7 and 9-7A, respectively. From this summary, the investment cost for the base case is seen to be five times higher than the investment cost for the alternative

case. When examining the total costs of the two plants (line 3.a), which includes plant and plantation investment and operating costs, the base case option is 63% higher in cost than the alternative case. The base case is moderately higher in operation and maintenance costs (16%) than the alternative case.

Generally, it can be stated that in every case the alternative dendro-thermal option, which includes the lower road costs, is moderately to significantly lower than the base case dendro-thermal options for all discount rates examined.

ENGINEERING COST ESTIMATE

AND EQUIPMENT LIST

The following break-down of equipment and project costs approximately correspond to the categories noted on Table 7-1. This cost includes all major equipment, but does not necessarily include all minor items considered in the preparation of Table 7-1.

The final item, Harvesting Equipment, includes those costs included within the Fuelwood Plantation costs of Table 7-1 under the line item, Harvest.

All estimates in the following list are presented in U.S. dollars. A conversion rate of 7.4 pesos per dollar must be applied for comparison with figures in the report.

SITE PREPARATION

CIVIL, SITE PREP. AND YARD WORK

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
	Clear And Grub (Remove Stumps)	AC	40	600.-	2,400				1200.-	48,000	50,400
	Earthwork	CY	2200	2.50	5,500				6.-	13,200	18,700
	Gravel Surfaced Roads (18') (Incls. Sub. Base Prep., Base And Gravel)	LF	6000	4.50	27,000				1.-	6,000	33,000
	Paved Roads (18') (Incl. All Costs)	LF	900	9.50	8,500				2.-	18,000	10,300
	Fence (Incls. Gates, Etc.)	LF	6000	7.50	45,000				2.50	15,000	60,000
	Fire Pump House	SF	300	40.-	12,000				45.-	13,500	25,500
	Fire Pumps (Elec. / Diesel)				50,000					5,000	55,000
	Valves, Ctsl., Etc.	Allowance		(85%)	11,000				(15%)	2,000	13,000
	Fire Loop	LF	1000	30.-	30,000				5.-	5,000	35,000
	Hydrants, House, Tools	EA	10	700.-	7,000				200.-	2,000	9,000
	Stl. Storage Tank	US Gal.	30,000	25¢	7,500				15¢	4,500	12,000
	Septic Tnak w/Field Sanitary Sewers	EA	1	2500.	2,500				1500.-	1,500	4,00
		Allowance		(60%)	1,500				(40%)	1,000	2,5
	TOTAL										

MAIN

ESTIMATED BY EAF

DATE 2/29/80

CHECKED BY

DATE

CLIENT AID/Philippines

PROJECT

JOB NO. 2785-10-1 SHEET 1 OF

ACCOUNT

SYSTEM

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
	Storm Sewers And Ditches	Allowance		(50%)	5,000				(50%)	5,000	10,000
	Yard Lighting (Power Plant Area)	Allowance		(60%)	12,000				(40%)	8,000	20,000
	Communications-PBX	Allowance								10,000	10,000
	Comm. Line	Allowance								5,000	5,000
	Gate House (without Personnel Facilities)	SF	150	40.-	6,000				45.-	6,800	12,800
	Potable Water Distbr. Piping	Allowance		(40%)	2,000				(60%)	3,000	5,000
	Office (3 people) (Incl. HVAC, Liting, Furniture)	SF	500	65.-	32,500				45.-	6,800	39,300
	Lockers, Rest Rm., Break Area (30 people)	SF	1000	50.-	50,000				45.-	45,000	95,000
	Shop (Incl. HVAC, Liting) (Equip. And Supplies In Client And Other Charges)	SF	500	45.-	22,500				45.-	22,500	45,000
	TOTAL										

MAIN

ESTIMATED BY EAF
DATE 2/29/80
CHECKED BY
DATE

CLIENT AID/Philippines
PROJECT
JOB NO. 2785-10-1 SHEET 2 OF

ACCOUNT
SYSTEM

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
	Water Intake Struc.					6,000				4,000	10,000
	Pump					2,000				1,000	3,000
	Misc. Piping					5,000				5,000	10,000
	Recirc. Piping (Buried)	LF	200	15		3,000	5			1,000	4,000
	Thrust Blks.					500				500	1,000
	Unestimated Items And Confidence Factor (20%)										116,000
	TOTAL										

MAIN

ESTIMATED BY EAF
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CLIENT AID/Philippines
PROJECT
JOB NO. 2785-10-1 SHEET 3 OF

ACCOUNT
SYSTEM

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	SITE PREP.										
1	Clear, grub & strip 1.5'	cy	4500						3-	15000	15000
	Area 200' x 400 = 80,000 SF										
2	Fill & Grade all area except	cy	4200	2		8500			3.50	15500	24000
	paved area										
	Area 80,000-25,000 = 55,000 SF x 2' fill (compacted)										
3	Paving - blacktop										
	2" wear & 4" base courses	SY	1800	12		21000			8-	15000	36000
	Pile base 125' SQ		1800+								
000 CF	Gravel base & subbase 1' & 2'	cy	2800	8		15000			7.50	14000	29000
4	Pile drainage collection	LF	500	8		4000			9-	5000	9000
	Open ditch & Underground piping										
	incl. trenching & bedding										
5	Fire Protection @ Pile	LF	500	8		4000			9-	5000	9000
	Hydrants, hoses, houses	Ea.	5	2000		10000			1000	5000	15000
6	Culverts, CB's etc.	LF	54	200		11000			/300	16000	27000
	TOTAL										

MAIN

ESTIMATED BY WES
DATE 3/6/80
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DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO. 2785-10-3 SHEET SP1 OF 1

ACCOUNT
SYSTEM

WOOD PROCESSING

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
1,2	Truck Unloaders	Ea.	2	30000	60000						60000
	Melroe Bobcat 2½ cy bucket										
3	Unloading Conv. 2 strand chain	LF	50	600	30000	1500	500	30	10 mh/ft	15000	46500
	c/w drive, etc.										
	Motor 30 HP				1000	200	10	30		300	1500
	Hopper 20' lg x 3' h	Ton	1	500	500	200	10	30		300	1000
	Discharge Chute	Ton	1	500	500	200	10	30		300	1000
	Drive Platform	Ton	2	1000	2000	200	28	30		800	3000
4	Inclined 30" belt conv.	LF	40	500	20000	1000	320	30	8 mh/ft	10000	31000
	12' rise c/w walkway, covers,										
	drive & tail takeup										
	Motor 15 HP				600	100	10	30		300	1000
	Drive base & disch. chute	Ton	2	1000	2000	200	28	30		800	3000
5	Magnet & Rect. Cabinet				10000	1000	130	30		4000	15000
	4.0 Kw c/w slings, cables etc.	Wt. =	4000#								
6	Trolley & Monorail etc.				500	100	13	30		400	1000
	Manual c/w haul bar										
	TOTAL										

MAIN

ESTIMATED BY WES
DATE 3/5/80
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DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO. 2785-10
SHEET 3 OF 5

ACCOUNT
SYSTEM Wood Handling

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER-FURNISHED TOTAL COST	CONTRACTOR-FURNISHED TOTAL COST	MAN-HOURS	RATE	UNIT COST	TOTAL COST	
7	Disc Scalper RDS-40 (6000#)	Ea.	1		18000	1000	100	30		3000	22000
	Motor 15 HP				600	100	10	30		300	1000
	Disch. Chute & Skirts	Ton	2	1500	3000	500	50	30		1500	5000
	Slide rails & Winch				3000	500	50	30		1500	5000
9	Pile out conv. 2 strand chain	LF	60	800	48000	2000	720	30	12 mh/ft	22000	72000
	c/w walk, drive, frame, bents &										
	drive platform										
	Motor 40 HP				1200	200	20	30		600	2000
10	Reclaim Hopper & Outfeed	LF	18		25000	1000	130	30		4000	30000
	Screws c/w drive & frame										
	8 screws 12" dia. 14' cc brg.	(Wt.=	12000#)								
	Motor 25 HP				1000	100		30		400	1500
	Disch. chute & skirts	Ton	3		3000	500	50	30		1500	5000
	TOTAL										

MAIN

ESTIMATED BY WES
DATE 3/6/80
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DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO. 2785-10 SHEET 4 OF 5

ACCOUNT
SYSTEM Wood Handling

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
8	Silo Feed Conv.	LF	110	800	88000	4000	1100	30	10 mh/ft	33000	125000
	L - 100' Rise 55' 28° c/w										
	Single strand Esco chain with										
	30" flights, walkway, truss etc										
	Motor 50 HP				2000	500	50	30		1500	4000
	Disch. chute & drive base	Ton	2		2000	500	50	30		1500	4000
	Drop out gate & chute to pile	Ton	3	2000	6000	1000	100	30		3000	10000
	out conv. c/w manual operator										
	Front-End Loader - Plant	Ea.	1	180000	180000						180000
	c/w 18 cy chip bucket										
	Caterpillar 980 or equal F.O.B.										
	Boston										
	Spare Parts				10000						10000
	Misc. Piping									10500	
	Misc. Freight				20500						20500
	Misc. Parts				30000						30000
	TOTAL										

ESTIMATED BY WES
DATE 3/11/80
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DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO 2785-10-3
SHEET 5 OF 5

ACCOUNT
SYSTEM Woodhandling

MAIN

COST ESTIMATE

ITEM	DESCRIPTION ELECTRICAL	UNIT	QUAN.	MATERIALS UNIT COST	MATERIALS OWNER-FURNISHED TOTAL COST	MATERIALS CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION MAN-HOURS	INSTALLATION RATE	INSTALLATION UNIT COST	INSTALLATION TOTAL COST	TOTALS
	3/4 - 500 MCM 600V Feeder	LF	200	10	2000	500	150	30		4500	7000
	2-4"-3-500+ Ground	LF	500		7000	4500	250	30		7500	19000
	Grounding				1000	500	50	30		1500	3000
	Collect. Conv. Mtr. 30HP	Ea.	1		1500	700	130	30		3800	6000
	Belt Convs. & Scalper 15HP	Ea.	3	1000/700	3000	2100	360	30	120 Mh. Ea	10900	15000
	Pile Out Conv. Mtr. 40HP	Ea.	1		1400	700	130	30		3900	6000
	Reclaim Conv. 25HP Mtr.	Ea.	1		1200	700	120	30		3600	5500
	Magnet 4.0 KW DC				900	700	120	30		3600	4200
	Power Receptacles	Ea.	4		1500	600	160	30		4800	6900
	Misc.				1400	600	150	30		4400	6400
	Sub Total				20900	11500				48500	
	Lighting										
	Scalper Structure	SF	300	2/3	600	900	150	30		4500	6000
	Yard & Road Floodlighting	Ea.	4	1000/500	4000	2000	200	30		6000	12000
	Lighting Wiring, Cabinets	LF	1000		1500	1500	1000	30		3000	6000
	Grinder Motors										10000
	TOTAL										

ESTIMATED BY WES/HDY
DATE 3/6/80
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DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO. 2785-10-3 SHEET E1 OF

ACCOUNT
SYSTEM Wood Handling

MAIN

COST ESTIMATE

ITEM	DESCRIPTION PROCESS CONTROL	UNIT	QUAN	MATERIALS UNIT COST	MATERIALS OWNER-FURNISHED TOTAL COST	MATERIALS CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION MAN-HOURS	INSTALLATION RATE	INSTALLATION UNIT COST	INSTALLATION TOTAL COST	TOTALS
	Control Panel				5000	1000	60	30		2000	8000
	Annuciator Wiring (Field)				2000	1500	180	30		5500	9000
	Communication					1000	35	30		1000	2000
	Misc.					500	17	30		500	1000
	TOTAL										

ESTIMATED BY WES/HDY
DATE 3/6/80
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CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2 MW Sta.
JOB NO. 2785-10-3 SHEET PC1 OF

ACCOUNT
SYSTEM

MAIN

BOILER TURBINE GENERATOR COMPLEX

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	Boiler Plant:				850,000		11,500	$35/MH		400,000	1,250,000
	Wellons Co.										
	625 PSIG, 750°F, 30,000 #/HR,										
	2 Cells, F.D. System, I.D.										
	System, F.W. Pumps, Turbine										
	Drive, D.A. Tank, Multiclone,										
	Air Heater, Controls, Electri-										
	cal, Meter Bin, Feeders, Com-										
	pressor, Boiler House, Ash										
	Conveyors, Chip Storage										
	Bin, F.W. Piping, Trm, Piping										
	And Valves In Boiler Plant										
	TOTAL										

MAIN

ESTIMATED BY _____
DATE _____
CHECKED BY _____
DATE _____

CLIENT AID/Philippines
PROJECT _____
JOB NO. 2785-10-1 SHEET 1 OF _____

ACCOUNT _____
SYSTEM _____

TURBINE GENERATOR

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	Turbine-Generator				350,000		2800	$35/MH		100,000	450,000
	W/Gear; Elliot 2,000 KW,										
	2500 KVA , .8 P.F., 4160 V										
	Metering Panel, Switchgear				50,000					Incl.	50,000
	Check Relay, Oil System,										
	TENC Generator, 10 PSIG Un-										
	controlled Ext., 600 #, 750°F										
	Throttle, 3½ "HgA Backpressure:										
	Mtd. On Base Plate										
	Condensor, 2 Pass Divided Head				60,000		300	$35/MH		10,000	70,000
	Box, 90/10 CuNi 20 BWG, Ejectors										
	Turbine Crane 7½ Ton P & H				35,000		100	$35/MH		3,500	38,500
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT AID/Philippines

PROJECT _____

JOB NO. 2785-10-1 SHEET 2 OF _____

ACCOUNT _____

SYSTEM _____

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	Cooling Tower										
	Marley #459-201				33,000		400	$35/MH		15,000	48,000
	Single Cell										
	50 HP Fan W/Drive										
	Cooling Tower Water Treatment System				5,000		150			5,000	10,000
	Cooling Twr. Recirc. Pumps		2	7000	14,000	Extra Valves 10,000	150			5,000	29,000
	2600 GPM 60 FT. TDH										
	Cooling Tower Instrumentation				5,000					5,000	10,000
	TOTAL										

MAIN

ESTIMATED BY _____
DATE _____
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DATE _____

CLIENT AID/Philippines
PROJECT _____
JOB NO. 2785-10-1 SHEET 3 OF _____

ACCOUNT _____
SYSTEM _____

F.W. TREATMENT

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	F.W. Treatment:										
	Clarifier, 60 GPM, Permutit Co. Skid Mtd.; 8'x5'x10'-6" High				20,000		60	$35/MH		2,000	22,000
	Filters: 12 GPM, Permutit Co. 2 Units #SFD 20" Ø 4'-0" S.S.; 100# Code; Manual				3,000		60			2,000	5,000
	Zeolite Softners, Permutit Co. 2 Units #DMD-20 20" Ø; 4'-0" S.S. W/Regen. System; Manual				3,500		60			2,000	5,500
	Continuous Blowdown Tank And System				1,500		30			1,000	2,500
	Chemical Feed System				1,500		30			1,000	3,500
	Treated Water Stg. Tk.; S.S. 5,000 Gal. 10' Ø x 10' S.S. Shop Assem. 7,000 #				17,000		60			2,000	19,000
	TOTAL										

MAIN

ESTIMATED BY _____
DATE _____
CHECKED BY _____
DATE _____

CLIENT AID/Philippines
PROJECT _____
JOB NO. 2785-10-1 SHEET 4 OF _____

ACCOUNT _____
SYSTEM _____

F.W. TREATMENT

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	F.W. Treatment		2	1200	2,400		60	$35/MH		2,000	4,400
	Booster Pumps-Goulds, 60 FT. TDH; 15 GPM										
	Deaerator Transfer Pumps; Goulds 15 GPM; 60 FT. TDH		2	1200	2,400		60			2,000	4,400
	River Pumps; Goulds 125 GPM; 75 FT. TDH Vertical		3	3000	9,000		90			3,000	12,000
	Potable Water Hypochlorinater Wallace And Tiernal, 5 GPM Potable Water				1,000		15			500	1,500
	Raw Water Storage Pumps; Goulds 125 GPM, 25' FT. TDH		3		9,000		90			3,000	12,000
	River Trash Rack 6'x20'				25,000		250	$35/MH		10,000	35,000
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT AID/Philippines

PROJECT _____

JOB NO. 2785-10-1 SHEET 5 OF _____

ACCOUNT _____

SYSTEM _____

PIPING

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTA
	Piping: (Not Included In										
	Wellons Bid) (Includes Valves)										
	Cooling Tower:										
	Water Recirc.										
	600 FT. 14" Ø			$4200/100 FT.		26,000	210 100FT	$35		44,000	
	T-G Condensate 600 FT. 4" Ø			$1400/100 FT.		8,400	100 100FT	$35		21,000	
	(4) 14" Gate Valves			$2500		10,000		$35		2,000	
	River Water										
	1500 FT. 6" Ø			$2100/100 FT.		45,000	126 100FT	$35		66,000	
	400 FT. 4" Ø			$1400/100 FT.		5,600	100 100FT	$35		14,000	
	400 FT. 2" Ø			$1050/100 FT.		4,280	80 100FT	$35		11,000	
	F.W. Transfer:										
	300 FT. 2" Ø			$1500/100 FT.		4,500	110 100FT	$35		11,500	
	(D.A.) 300 Ft. 2" Ø			$1500/100 FT.		4,500	110 100FT	$35		11,500	
	Misc. 500 FT. 1" Ø			$1000/100 FT.		5,000	80 100FT	$35		14,000	
	500 FT. 2" Ø			$1500/100 FT.		7,500	110 100FT	$35		19,200	
	Steam-ASTM A106 SCH. 40										
	600# 200 FT. 4" Ø Std.			$2000/100 FT.		4,000	140 100FT	$35		9,800	
	10# 200 FT. 4" Ø Std.			$2000/100 FT.		4,000	140 100FT	$35		9,800	
	Misc. 200 FT. 2" Ø			$1500/100 FT.		3,000	110 100FT	$35		7,700	
	200 FT. 1" Ø			$1000/100 FT.		2,000	80 100FT	$35		5,600	
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT AID/Philippines

PROJECT _____

JOB NO. 2785-10-1 SHEET 6 OF _____

ACCOUNT _____

SYSTEM _____

PIPING

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
	Piping (Con't)										
	Blowdown:										
	300 FT. 1" ø		$1000/100 FT.		3,000		80 100	$35		8,400	11,400
	T-G Misc. Piping										
	Oil, Water, Stm, FTC.										
	100 FT. 4" ø		$2000/100 FT.		2,000		140 100	$35		4,900	6,900
	100 FT. 2" ø		$1500/100 FT.		1,500		110 100	$35		3,900	5,400
	100 FT. 1" ø		$1000/100 FT.		1,000		80 100	$35		2,800	3,800
	PCV System (To D.A.)										
	2" ø CV					2,000				200	2,200
	100 FT. 2" ø		$1500/100 FT.		1,500		110 100	$35		3,900	5,400
	100 FT. 4" ø		$2000/100 FT.		2,000		140 100	$35		4,900	6,900
	Loop Cost				3,000					3,000	6,000
	Insulation (Casi)										
	500 FT. 4" ø		$200/100 FT.		500					500	1,000
	400 FT. 2" ø		$170/100 FT.		350					350	700
	600 FT. 1" ø		$150/100 FT.		500					500	1,000
	Piping and Insul. Contingency										
	For Omitted Items-10%				15,000					2,800	
	TOTAL										

MAIN

ESTIMATED BY _____
DATE _____
CHECKED BY _____
DATE _____

CLIENT AID/Philippines
PROJECT _____
JOB NO. 2785-10-1 SHEET 7 OF _____

ACCOUNT _____
SYSTEM _____

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER - FURNISHED TOTAL COST	CONTRACTOR - FURNISHED TOTAL COST	MAN - HOURS	RATE	UNIT COST	TOTAL COST	
	HVAC Allowance					25,000				25,000	50,000
	TOTAL										

MAIN

ESTIMATED BY _____
DATE _____
CHECKED BY _____
DATE _____

CLIENT AID/Philippines
PROJECT _____
JOB NO. 2785-10-1 SHEET 8 OF _____

ACCOUNT _____
SYSTEM _____

ELECTRICAL

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER-FURNISHED TOTAL COST	CONTRACTOR-FURNISHED TOTAL COST	MAN-HOURS	RATE	UNIT COST	TOTAL COST	
	One 750 KVA, 480 V Unit Substation				23,000		200	$35		7,000	30,000
	5 KV And 480 V Feeder Cable, Conduit And Supports				5,000		114	$35		4,000	9,000
	Motor Starters, Controls, And Cabling				57,000		2200	$35		77,000	134,000
	Control Circuits				8,000		257	$35		9,000	17,000
	Lighting				20,000		914	$35		32,000	52,000
	Grounding				5,000		85	$35		3,000	8,000
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT AID/Philippines

PROJECT _____

JOB NO. 2785-10-1 SHEET _____ OF _____

ACCOUNT _____

SYSTEM _____

INSTRUMENTATION NOT INCLUDED WITH EQUIPMENT

Raw Water Storage Tank Level	$ 15,000
Clarifier Level Control Loop	$ 6,000
Treated Water Storage Level	$ 6,000
D.A. Level Control	$ 12,000
D.A. Overflow Valve	$ 3,000
Blowdown Control Level	$ 5,000
Condenser Hotwell Level Control	$ 10,000
O_2 Controller	$ 15,000
Opacity Monitor	$ 25,000
Turbine-Generator Bearing Temp. Monitor	$ 10,000
Condensor Pressure Control	$ 5,000
Steam Flow Meters (2)	$ 20,000
Annunciator Board And Sensors	$ 20,000
Pressure And Temp. Indicators (50)	$ 10,000
	$ 162,000
	$ 33,000
20% Unestimated Items	$ 195,000

TURBINE-GENERATOR AND AUX. STRUCTURES

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN	MATERIALS			INSTALLATION				TOTALS
				UNIT COST	OWNER-FURNISHED TOTAL COST	CONTRACTOR-FURNISHED TOTAL COST	MAN-HOURS	RATE	UNIT COST	TOTAL COST	
	Cooling Tower Basin	CY	60	150.-		9,000			225.-	13,500	22,500
	Turbine Bldg. FDNS	CY	30	65		2,000	135			4,000	6,000
	(Incl. Control Bldg.) Slab	CY	65	150		9,800	200			13,000	22,800
	(2 flrs.) (Stl. Frm., Siding										
	Roof, Walls, Etc.) Superstr.	SF	1000	50		50,000	30			30,000	80,000
	Pedestal					25,000				15,000	40,000
	Unestimated Items And										
	Confidence Factor (20%)										34,000
	TOTAL										

MAIN

ESTIMATED BY EAF

DATE 2/29/80

CHECKED BY

DATE

CLIENT AID/Philippines

PROJECT

JOB NO. 2785-10-1 SHEET 4 OF

ACCOUNT

SYSTEM

TRANSMISSION AND SUBSTATION

COST ESTIMATE

ITEM	DESCRIPTION	UNIT	QUAN.	MATERIALS: UNIT COST	MATERIALS: OWNER-FURNISHED TOTAL COST	MATERIALS: CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION: MAN-HOURS	INSTALLATION: RATE	INSTALLATION: UNIT COST	INSTALLATION: TOTAL COST	TOTALS
	Foundations			$US	1000					2000	3000
	Grounding				300					1000	1300
	Structures				8000					2000	10000
	Transformers				60000					8000	68000
	Conduit				300					600	900
	Conductors				2000					2000	4000
	Lighting				200					200	400
	Insulators				1000					500	1500
	Air Breaks & Disconnects				13000					4000	17000
	Lightning Arrestors				600					200	800
	Circuit Breakers		2		20000					5000	25000
	Fence				2000					500	2500
	Grading and Surfacing				500					2000	2500
	Transmission Line - 69 kV	km	6	27000	115000					47000	162000
	Distribution Line - 13.8 kV	km	3	12000	25000					11000	36000
									SUBTOTAL	86000	335200
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT AID/Philippines

PROJECT _____

JOB NO. 2785-10-1 SHEET 1 OF 1

ACCOUNT _____

SYSTEM Transmission & Generating Plant Substation

677 ESTIMATING — FORM A

GENERAL PLANT AND SUPPORT SERVICES

COST ESTIMATE

ITEM	DESCRIPTION STRUCTURES & EQUIP. FDN.	UNIT	QUAN.	MATERIALS UNIT COST	MATERIALS OWNER-FURNISHED TOTAL COST	MATERIALS CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION MAN-HOURS	INSTALLATION RATE	INSTALLATION UNIT COST	INSTALLATION TOTAL COST	TOTALS
1	Bobcat Platform & Ramp	Ton	20	800	16000	1000	200	30	300/T	6000	23000
2	Scalper Platform & Struct.	Ton	15	800	12000	1000	170	30	300/T	5000	18000
	Openside, roofdeck, stairs										
	12' x 20' x 20' hi										
3	Equipment & structure	Ea.	30	4000		12000	1200	20	8000	24000	36000
	Fdns. & Conv. bents & bolts										
4	Cond. piers (3' hi)	Ea.	40	1000		4000	400	20	2000	8000	12000
	1' above grade & anch. bolts										
5	Twoway chute Platform	Ton	10	800	8000	1000	100	30	300/T	3000	12000
	Stairs, railing & grating										
6	Misc. Items	Ton	10	1200	12000	1000	200	30	600/T	6000	19000
7	Misc. Painting					10000				43000	53000
	TOTAL										

MAIN

ESTIMATED BY WES

DATE 3/6/80

CHECKED BY

DATE

CLIENT U.S. AID

PROJECT Philippines Dendro-Thermal 2 MW Sta.

JOB NO. 2785-10-3 SHEET STI OF 1

ACCOUNT

SYSTEM

HARVESTING EQUIPMENT

COST ESTIMATE

ITEM	DESCRIPTION SATELLITE AREA	UNIT	QUAN.	MATERIALS UNIT COST	MATERIALS OWNER-FURNISHED TOTAL COST	MATERIALS CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION MAN-HOURS	INSTALLATION RATE	INSTALLATION UNIT COST	INSTALLATION TOTAL COST	TOTALS
	Cable Harvest System										
	Smith Timbermasters	Ea.	2	40000	80000	P.O.E. Boston					80000
	Oper. range 600 m; 3300# load										
	one-end suspended, 1600# fully										
	suspended, Line speed 250 m/min										
	haul-in; Line speed 380 m/min										
	haul-back										
	Wire Ropes 3/8"/5/16"	LF	30000	$.65	20000						20000
	sets of 10,000' ea. for above										
	+10,000 extra										
	Radio Comm. Sys. Walkie Talkies				1000						1000
	Flemming Locking Carriages	Ea.	2	3000	6000						6000
	Tractor 50-75 HP	Ea.	2	30000	60000						60000
	Spare Parts			10000							10000
	Chippers-Mobile Type	Ea.	2	110000	220000						220000
	Morbark "Chiparvester" Model 550										
	150-250 TPD, 18" dia. max.										
	Slide boom 22' reach										
	WT903 Cummins Diesel										
	TOTAL										

ESTIMATED BY PAS/WES
DATE 3/5/80
CHECKED BY
DATE

CLIENT U.S. AID
PROJECT Philippines Dendro-Thermal 2MW Sta.
JOB NO. 2785-10 SHEET 1 OF 5

ACCOUNT
SYSTEM

MAIN

COST ESTIMATE

ITEM	DESCRIPTION SATELLITE AREA	UNIT	QUAN.	MATERIALS UNIT COST	MATERIALS OWNER-FURNISHED TOTAL COST	MATERIALS CONTRACTOR-FURNISHED TOTAL COST	INSTALLATION MAN-HOURS	INSTALLATION RATE	INSTALLATION UNIT COST	INSTALLATION TOTAL COST	TOTALS
	Freight-Winn Mich.-Bos	CWT	600	$10	6000						6000
	for 30,000#-1000 mi @ $.01/cwt/										
	mile										
	Spare Parts				20000						20000
	Winch. diesel driven off	Ea.	1		25000						25000
	chipper 100 m haul incl.										
	grapple, shackles, etc.										
	Knife grinder c/w base & frame				22000	2000	270	30		8000	32000
	Coolant pump, cables etc.										
	Carriage Motor 5 HP				INCL.						
	Coolant Pump Mtr 1 HP				INCL.						
	Freight				2000						2000
	TOTAL										

MAIN

ESTIMATED BY _____

DATE _____

CHECKED BY _____

DATE _____

CLIENT _____

PROJECT _____

JOB NO _____ SHEET _____ OF _____

ACCOUNT _____

SYSTEM _____

The pronounced topography of the Reforestation Area precludes the use of mechanical planting. One study [5/] has indicated that the most satisfactory tool for general reforestation purposes is the oval-blade planting hoe. This instrument penetrates the soil more easily than a straight-edged hoe and does not compact the soil as does a wooden dibble stick. The blade of the hoe also has cutting edges which can be used to clear any remaining vegetation around the hole.

6.3.2.5 Recommendations

Few reliable data are available concerning growth and yield of leucaena in the Philippines and fewer data still on casaurina. The data that are available frequently come from a few trees or research plots whose results are not representative of plantations under operational conditions. The establishment of a large plantation of fast-growing hardwood species provides an ideal opportunity to collect data which can provide information important to plantation management. The value of this information becomes even greater by virtue of the fact that growth and yield data can be compiled for one commercial rotation in a very short period of time. This eliminates the need for many assumptions concerning, and extrapolations of, growth data as is necessary for species with rotations of greater length than that permitted by the need for information.

The following recommendations deal only with very basic information requirements necessary for characterization of basic stand parameters, estimation of growth rates, and evaluation of alternative management schemes. These recommendations must be modified as project goals change and additional information becomes available. It is strongly recommended that the entity which manages the fuelwood plantation work closely with the Bureau of Forest Development and University of Philippines. The proposed fuelwood plantation represents an ideal research and teaching tool relative to operational forestry.

1. After the fuelwood plantation is completely established, excess labor can be utilized for fertilization. A systematic sampling of soils throughout the plantation area will permit an accurate "prescription" for area-specific fertilization, thus eliminating excess fertilization and expenses. Although it may be unrealistic to manually fertilize the entire plantation, increased production can be expected and the fertilized areas will permit the collection of growth and yield data to evaluate the feasibility of more extensive fertilization.

2. After initial planting, a regeneration survey should be designed and carried out to sample planted areas for stocking; i.e., rate of seedling survival. This should be carried out in the latter half of the first dry season following initial planting to permit preparations for replanting, if necessary. Replanting is recommended if stocking is below 90 percent.

3. The economic and biological feasibility of using herbicides for land preparation and/or week control should be investigated.

4. Permanent sample plots should be established in the fuelwood plantation to monitor growth, survival, coppice characteristics, vigor of stump sprouts, and any differences resulting from nursery management of seedlings; e.g., potted seedlings versus bare-root seedlings. The opportunity should also be taken advantage of to plant some areas at various spacings; e.g., one meter by one meter, to investigate relative growth and productivity. Experimental plots to investigate levels and types of fertilization (artificial and ash) are also recommended at some stage of the project. Such plots should be established for each species of tree planted.

5. In addition to Levcaena and Casaurina several other species of trees especially legumes with their favorable characteristics, have demonstrated promising characteristics which may deserve review in the context of short-rotation biomass production. The feasibility of planting selected species for observation should be considered. See

"Tropical Legumes: Resources for the Future" 2/ with special reference to species in the genus Acacia (e.g. auriculaeformis and magnium) and genus Calliandra.

The system of experimental plots should be established in a manner consistent with principles of experimental design Measurements should be taken every two to four months to provide a continuous record of those data of interest. Such a system should be designed and maintained in cooperation with the agricultural and forestry entities of the Republic. Ideally, these experimental plots would be established and monitored after the initial planting. However, such establishment may not be realistic until after the initial efforts of plantation establishment are completed and the project is operational.

6.3.3 Harvest and Transport

6.3.3.1 General Considerations

Harvesting of the fuelwood will begin approximately two years after initial planting. In all subsequent years, trees will be harvested after at least three years of growth. Consequently, 865 hectares of plantation will have to be harvested during the first year of harvest to produce the volume of fuelwood required. In subsequent years, only 585 hectares will need to be harvested. See Section 7 for a suggested harvesting schedule and Appendix B for basic computations.

The most notable characteristics of the plantation to be harvested are the steep slopes throughout the area, the small size of the trees, and the relatively large volume of fuelwood to be harvested. This combination of factors presents a unique situation for which little operational experience is available in the Philippines or in any other countries. The different harvesting systems considered to cope with these conditions are discussed below.

6.3.3.2 Harvesting Systems Considered

The principal constraint on the efficient harvest of fuel wood from the Nabas Reforestation Area and transport to the proposed plant site is a combination of severe topography and relatively low value of the fuel wood. On relatively level terrain, mechanized or labor-intensive harvest methods can be utilized, as determined by the economic feasibility of each. In areas of severe topography labor-intensive harvesting procedures are frequently not feasible from physical and environmental standpoints, i.e. animal logging is not effective on steep slopes and the additional road requirements dictated by severe topography may be environmentally unacceptable. The harvesting system proposed for the dendro-thermal project includes components of both capital-intensive and labor-intensive harvest methods.

The recommended system is designed to minimize the cost of harvest and transport, minimize environmental impacts, and maximize the use of locally available labor while meeting the fuel requirements of the dendro-thermal plant.

Several different harvest/delivery systems were considered. The system and/or major system components are discussed below.

1. Sluicing or Pipeline Concept - The use of a slurry pipeline to convey chips from satellite chipping yards to the plant site was investigated. The following disadvantages were identified.

   (a) Water must be pumped up to the sluice, possibly several hundred meters to the top of the sluice.

   (b) Chips must be delivered by trucks from the satellite chippers and dumped at the sluice area and then fed into the sluice.

   (c) The chips in the sluice will absorb water which will raise the moisture content of the chips and thus decrease the steam generation output.

   (d) The slurry must discharge across three large dewatering screens. The water then must be screened to remove dirt, bark and wood fines through a three-step process before discharging to the settling basin and then back to the river.

   (e) The sluice or pipeline must be able to run around hills, cross gullies or ravines and be supported for its full length.

Due to the above disadvantages and the high order of magnitude estimated cost, this concept was eliminated.

2. Trucking Whole Stems to Plant - This concept was investigated and resulted in the following disadvantages:

   (a) All harvested logs must be hauled to central concentration yards for loading onto trucks.

   (b) Large log handling equipment which is very expensive will be required at the concentration yard and plant site.

(c) Log storage at the plant site will require approximately 12 hectares.

(d) If short log (3 m) hauling is preferred, then bucking the stems to this length will require additional men and saws along with a high cost log handling and chipping system at the plant.

(e) Additional dirt and debris accumulation on the logs resulting from additional handling before chipping.

Due to the above disadvantages and the high order of magnitude estimated cost, this concept was eliminated.

3. River Driving Logs - This system was investigated and disregarded for the following reasons:

(1) Stream profile and year-round flows are inadequate for floating the required volume of logs downstream. Modification of the streambed would be required which could result in significant environmental impacts.

(2) A transportation system would be required to deliver logs to the river.

(3) An additional log handling system would be required to pull the logs from the river and deliver to on-site chipper.

(4) The moisture content of the logs and produced chips would be increased, resulting in decreased boiler efficiency.

For these reasons, this alternative was not pursued in greater detail.

6.3.3.3 Recommended Harvesting System

The recommended harvesting system can basically be described as follows: Two areas will be harvested simultaneously. In each area, fellers will cut trees with chain saws. Where topographic conditions permit, carabao (water buffalo) will be used to skid trees to a landing where a small portable chipper will chip the trees for transport. Where slopes are too steep to permit the use of carabao, a portable high-lead cable system (with a small spar attached to a tractor) will be used to yard the trees uphill to a landing. From this landing carabao will be used to skid the trees to the chipper. Chips will be hauled by truck to the dendro-thermal plant. The primary components of this system are described below.

Tree Felling

In an effort to minimize erosion and stabilize soil, strip harvesting is recommended. Under this scheme fellers would fell trees in strips several meters wide (40 m - 60 m) roughly parallel to topographic contours. The operational logistics of this scheme must be determined in the field.

Fellers will utilize small power chain saws (1.5 hp). The investment for a small saw is minimal, productivity is increased, and a clean straight cut produced by a saw may produce healthier sprouts in Leucaena than an uneven cut with an ax or bolo. The small size of the trees will permit felling in such a direction to facilitate skidding or yarding. Casausina should be cut as close to the ground line as possible to facilitate skidding and subsequent replanting. Leucaena should be cut approximately 30 cm to 40 cm above the ground to permit a firm base for sprouts and to place sprouts above any competing vegetation. A clean downward sloping cut should be made to insure that rainwater readily runs off the stump.

All bucking and limbing should be done by the feller immediately after felling. It is anticipated that three length skidding will be possible

thus eliminating the need for bucking. However, a common way to harvest firewood in the Philippines is to buck trees to three-meter lengths, loading these on small wooden sleds, and skidding the loaded sleds to the destination. Therefore, tree length skidding may meet some resistance.

Limbing of the main stem is recommended rather than simply topping the tree. More wood will be available for skidding to the chipper and the remaining slash (branches and residue) will not be as bulky.

It is also recommended that felling occur at least one week before skidding operations begin. This will permit leaves to fall (returning nutrients to the soil) which will facilitate manual handling of the stems and skidding.

Carabao Skidding

Use of carabao for skidding of small trees over level or slightly rolling terrain is a low cost substitute for short-distance skidding by four-wheeled machine skidders. Carabao skidding has the following advantages:

- The animals are adaptable, not easily excited, and easy to train;
- They are particularly useful in roadless and swampy areas, and where heavy equipment cannot be risked in rainy periods;
- They have a minimal opportunity cost during agricultural off-seasons; and
- They are economical where timber is too small or scattered to justify machine skidders.

The disadvantages are that:

- The carabao is a non-sweating animal that needs frequent bathing on hot days to keep down its temperature, requiring the presence of nearby water holes;

- Carabaos are susceptible to overwork and hoof-and-mouth disease, and their lifetime expectancy in woods work is much less than in farm work;

- The modest pulling capacity of a carabao working singly limits the size of load it can skid to .30-.45 cubic meters;

- Carabaos cannot work on steep slopes; and

- Forage grasses are sometimes difficult to find in forested areas.

Yet before the era of mechanized logging, the carabao was the principal means of ground transport. Logs of up to three or four cubic meters were pulled with the aid of several carabaos hitched together. Devices to facilitate hauling included: (1) crude sleds made from the natural forks of small trees; (2) carabao carts, either with spoke wheels or solid wooden wheels; (3) narrow-gauge railroads in which wooden poles served as the rails, and the railroad car was pulled by carabaos. However, the latter two were restricted to level terrain. 5/

Carabao can be most effectively used for skidding in terrain of less than 20 percent slope. On leveler terrain carabao can skid larger loads for greater distances. In logging areas with steeper slopes contouring skid trails across contour lines can increase the load/distance factor.

In the proposed harvesting system, carabao will be used for two purposes. In relatively level areas carabao will skid directly from the felling site to the portable chippers. The trees will be small enough and lying closely enough together (from an original 1 meter by 2 meter spacing) that the bases of stems can be thrown together to form a bundle of trees for skidding. A pair of laborers can prestack stems into bundles suitable for skidding to speed the manuvering of the animal and hooking up of the logs.

The construction and use of small wood sleds, as characterized in Figure 6-1, is recommended to slightly raise the forward end of the bundle of stems. Such a sled will decrease ground resistance and enable the

bundle of stems to slip past ground obstacles. This is especially important in the stands of Leucaena where "stumps" approximately 30 cm tall will remain after felling. Such sleds are presently used to skid pieces of firewood two to three meters in length.

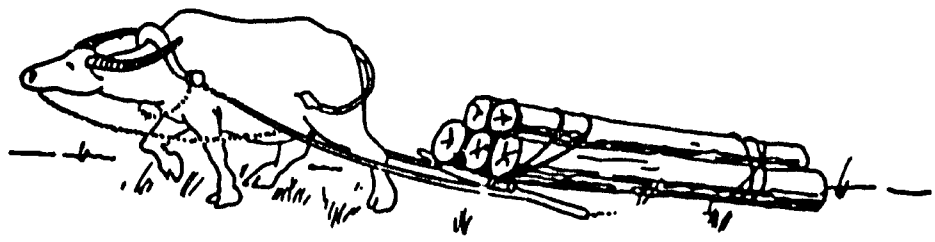
In areas which are too steep to skid with carabao, a portable cable skidder will be used (see below). The cable system will skid individual stems and bundles of stems uphill to a landing. From this landing carabao will be used to skid stems from the cable landing to the chipper. The trail constructed to permit the tractor-mounted cable system to be driven to the setup point will serve as a skidding trail for the carabao.

It is anticipated that skidding with single carabao will be the most efficient. Bundles of stems weighing enough to require more than one animal will probably be too bulky and unwieldy to handle under most conditions in the plantation area. However, operational experience will determine if skidding with teams of carabao is recommendable.

Figure 6-1

CARABAO SKIDDING WITH SLED

Source: 5/



Portable Cable System

The portable cable system is included among a number of systems known as standing skyline yarders. The standing skyline system is one of the most economical and energy efficient means of yarding timber by cable over varying terrain and moderately long yarding distances (200 - 600 meters). The yarding sequence for a standing skyline system is generally as follows: (refer to Figure 6-2).

- The haul-back line pulls the carriage into the woods.
- The chokerman signals the yarder operator by radio (walkie-talkie) to stop the carriage.
- The choker drops down from the carriage on the end of the haul in or lift line.
- The chokerman pulls out the line from the carriage and attaches it to one or more logs.
- The chokerman signals the yarder operator by radio to winch in the haul-in line pulling the logs to the carriage.
- The brake pressure is eased off the haul-back and the haul-in pulls the carriage toward the landing with the turn of logs partially or completely suspended underneath.
- At the landing the suspended turn is lowered to the ground by slacking the haul-in line and is unhooked by the yarder operator or chaser.
- If the lift line is fitted with a "Flemming" quick release hook, the turns are automatically unchokered when knowered to the ground.
- The yarding cycle is repeated.

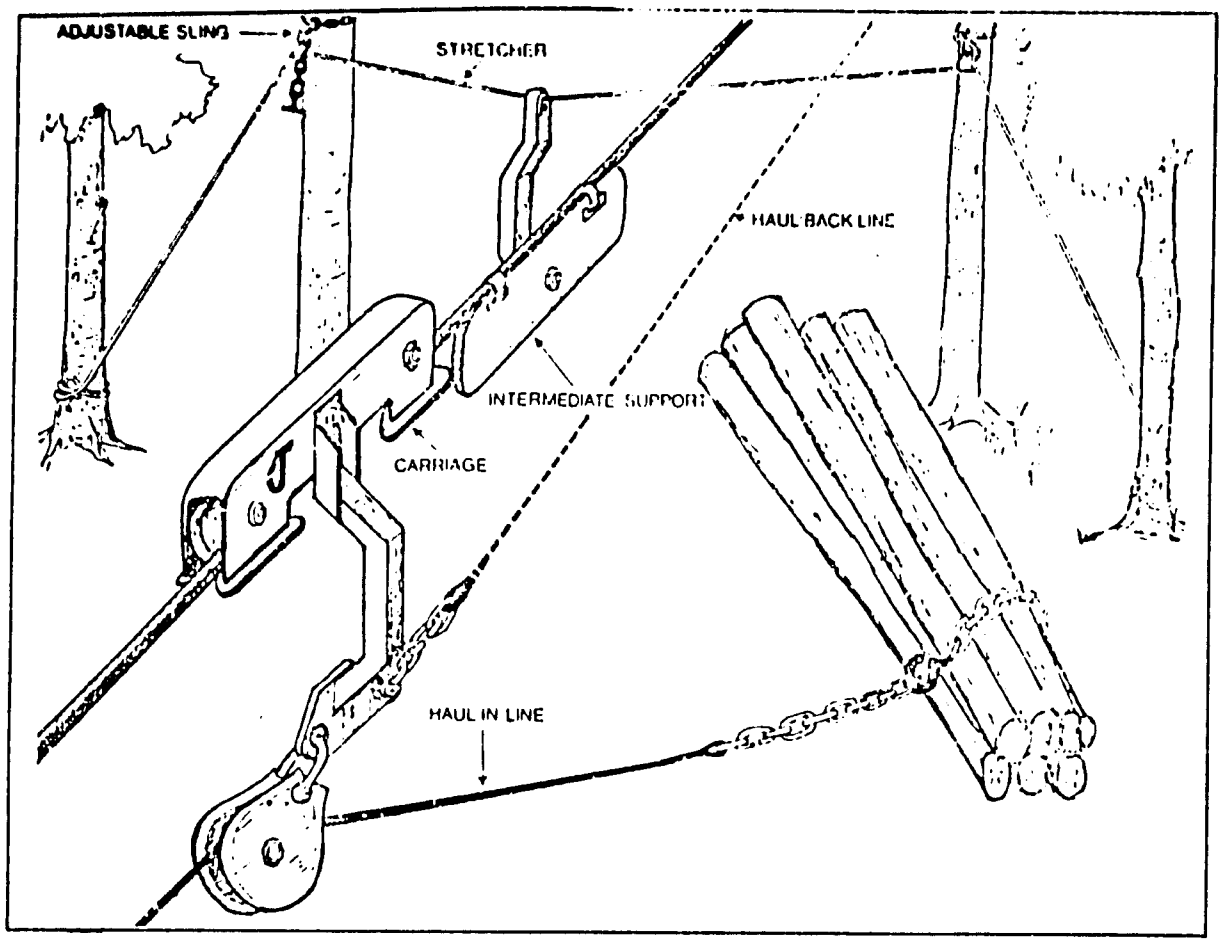


Figure 6-2 General Standing Skyline Yarder Layout Source: 16/

The recommended standing skyline yarder system is the "Smith Timbermaster." The "Timbermaster" is a well engineered machine of rugged yet compact design. The unit is trailer mounted for ease of movement and is powered by a standard farm tractor (see Figure 6-3). A detailed system description is provided.

Two operators are required for the "Timbermaster," one to run the yarder and one to set chokers. The yarder operator runs the system with two hand levers, one for the mainline winch and one for the haul-back winch. Throttle speed is controlled by a foot pedal with a control cable leading to the farm tractor power unit. If a self releasing choker hook is used, the yarder operator does not have to double as chaser and the turns can be quickly dropped at the landing allowing the skyline carriage to return to the woods without delay. Communications between the choker setter and yarder operator are by radio.

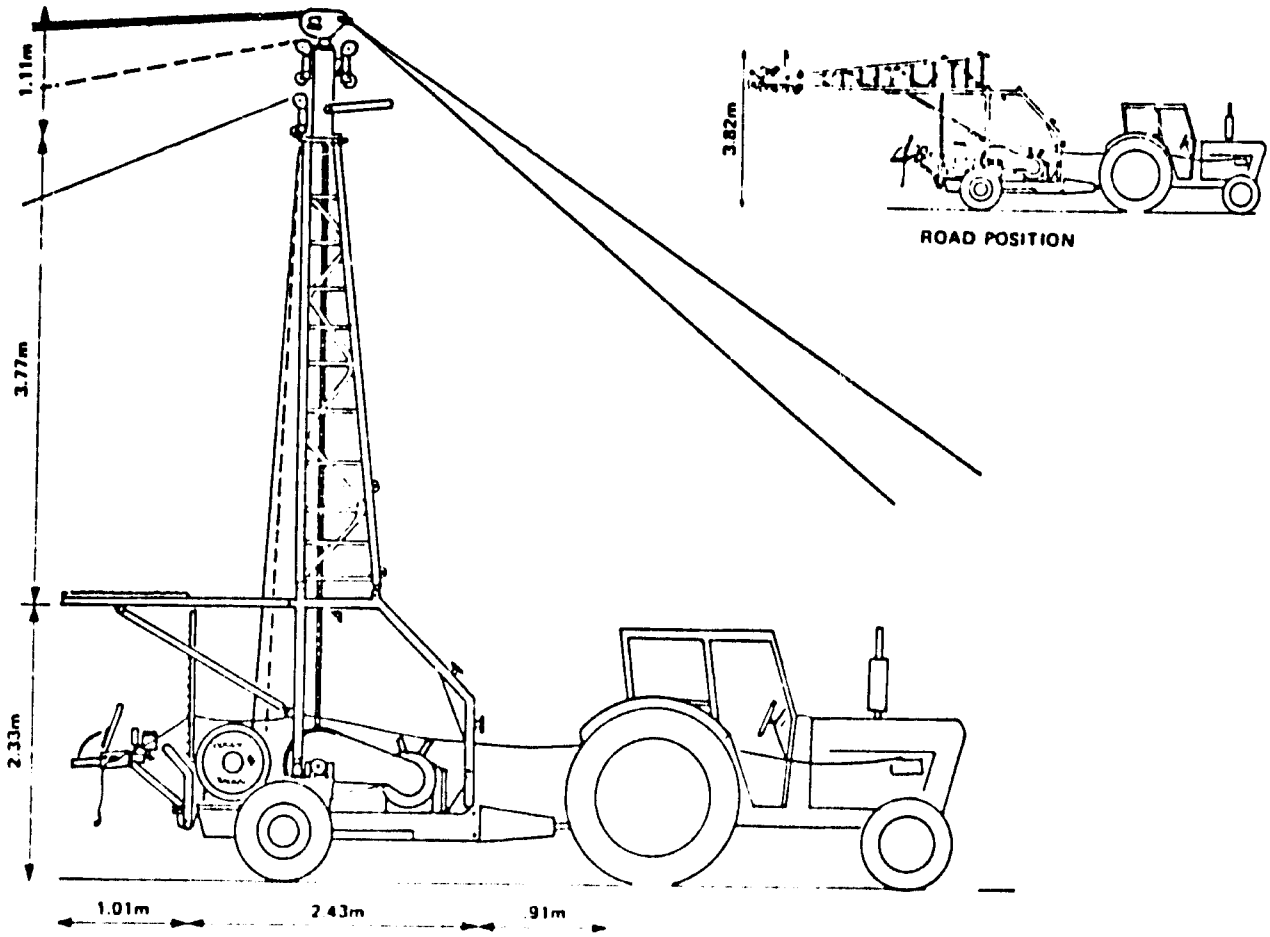


Figure 6-3. Representative Sketch of Timbermaster Type Standing Skyline Yarder

Source: 16/

Transportation and set up of the "Timbermaster" is fast and easy. The farm tractor power unit pulls the yarder from site to site. The 24-ft. (7.3 meter) tower is quickly raised from the horizontal transport position to the vertical operating position by a hydraulic cylinder powered from the tractor hydraulics. Three guylines are used to stabilize the tower, then the main cables are pulled into position using the polypropylene strawline and the strawline drum. An average move and setup of a 1000 ft. (300 meter) skyline road generally takes two men slightly over one hour.

Residual stand damage and soil disturbance is very low since the "Timbermaster" uses a locking skyline carriage which holds the loads well off the ground during transport to the landing. The locking carriage also greatly increases the fuel efficiency of the system and reduces cable and brake wear since the haul-back and mainline (haul-in) do not have to work against each other to hold the load off the ground.

Terrain, soil conditions, and weather have little effect on the operation of the "Timbermaster". Since the carriage is powered back to the woods by the haul-back line and powered to the landing by the haul-in line, it is not dependent on gravity for movement in either direction, but gravity can still be used to significantly reduce the energy inputs required. Since carriage movement is not dependent on gravity, upslope, downslope, or level skyline settings can be easily yarded. Ground conditions also have little effect since the carriage travels on an overhead cable. Mud, rocks, etc. only slow the system's operation when they become a hinderance to the chokerman.

The operating range of the "Timbermaster" can extend up to 2000 ft. (600 meters) thus giving the potential of working a 4000 ft. (1200 meters) wide strip from a single access road. For long distance yarding or yarding over broken terrain, intermediate skyline supports are used. A unique high speed haul-back winch returns the carriage to the woods at speeds up to 1200 fpm (365 meters/minute). Speeds on the haul-in may reach 800 fpm (240 meters/minute) with a maximum 2 ton line pull.

Compared with the line pull developed by skidder winches, this may not seem like much but the lifting effect on the skyline compensates for the power differential and results in much less residual stand damage.

The design of the "Timbermaster" incorporates many features for the safety of the operator. A sturdy, shielded operator's cab is positioned for good visibility of the landing and logging corridor. The simple controls cut operator mistakes to a minimum. The self-releasing choker hook eliminates the need for the operator to leave the machine to unhook logs on the landing. In the rare case of a carriage runaway, there is an emergency skyline release which drops the carriage and load instantly to the ground.

General Data - "Smith Timbermaster"

Operating range: with 9 mm (3/8") wire ropes - 450 meters (1500 ft.)
with 8 mm (5/16") wire ropes - 600 meters (2000 ft.)

Winch drum capacities:

Haul-in:	with 9 mm (3/8") wire rope - 450 meters (1500 ft.)
	with 8 mm (5/16") wire rope - 600 meters (2000 ft.)
Haul-back:	with 9 mm (3/8") wire rope - 900 meters (3000 ft.)
	with 8 mm (5/16") wire rope - 1200 meters (4000 ft.)
Skyline:	with 13 mm (1/2") wire rope - 600 meters (2000 ft.)
Strawline:	with 6 mm (1/4") polypropylene rope - 1200 meters

Line speeds:

Haul-in:	0-250 meters/minute (820 fpm)
Haul-back:	0-380 meters/minuts (1250 fpm)

Line speed and power control: throttle and interchangeable chain sprocket drives

Line pull:

Haul-in: with 8 mm (5/16") wire rope - 2000 kg (4400 lbs.)

Load capacity: one end suspended - 1500 kg. (3300 lbs.)
fully suspended - 750 kg (1600 lbs.)

Guylines: 3-13 mm (1/2") x 40 meters (130 ft.)

Tower:

Height: 24 ft. (7.3 meters)

Construction: Single, box steel mast

Erection: Hydraulic

Weight: Not available

Controls: Excellent

Winch clutches and brakes: hydraulic

Throttle: Foot pedal with control cable to tractor

Operator visibility:

Of landing: excellent

Of winch drums: excellent

Operator protection: excellent

Minimum crew size: 1 yarder operator
1 chokerman

Power source: from the PTO of a 50-75 hp (37-56 kW) farm tractor

Mounting: trailer

Standard skyline carriage: load-locking, multi-span

Special features: epicyclic haul-back clutch

Optional equipment: self-releasing choker hook

Additional equipment needed for operation:

- Farm tractor
- Radio communications system
- Wire ropes

Portable Chippers

Felled trees will be skidded by the portable yarder and/or carabao to one of two concentration yards where portable satellite chippers will be set up to chip the collected material.

When the concentration yard has been nearly filled with stored logs, the two mobile chippers will be located and stabilized for their 30-day chipping operation. Logs will be hauled by an oxen/man team to a position approximately 100 meters from the chippers. There the logs will be choked and hauled to a point within the chippers' boom reach by a diesel-driven winch. The logs are then unchoked and the cable choker is hauled back to the 100 meter position for another log load.

The chipper operator will then boom out, pick up logs and feed them into the chipper. The chips will be blown into the open end of a trailer or covered truck located close to the chipper discharge spout and at an angle of approximately 45 degrees.

When the trailer is filled, the doors are closed and the truck drives off to the Plant. A second truck is located beside the first one and the spout is rotated slightly to blow chips into it. This procedure continues until the day's production of 200$\pm$ metric tons is obtained.

The chippers will require refueling twice a day. The chipper knives will be changed once per day. The dull knives will be put into a knife box and taken to the Plant for sharpening on a knife grinder that is located in the Maintenance Shop.

These satellite yards will remain permanently open areas for the next harvest/chipping cycle every three years. Each satellite yard will require an area of approximately 3 to 5 hectares.

Chip Transportation

Chips will be transported via truck from the chipping site to the plant site. It is recommended that this be contracted to independent truckers. The initial investment for several trucks is thus avoided during the first years of the project when investment costs are already high. The responsibility for truck maintenance is that of the contractor, thus avoiding the additional investment for maintenance facilities. If the purchase of trucks for the project appears feasible after the project has become established, then the additional investment may be justified.

6.3.4 Manning Schedule - Plantation

The project fuelwood plantation will employ a varying number of personnel as a function of season and magnitude of each project component. Beginning in 1983, the work force will stabilize at approximately 275 persons. Suggested staffing levels for each project component are suggested below. The bases for computing numbers of laborers are presented in Appendix B. Salaries are based on the work of Semana and Bawagan [17/] and have been updated to 1980 dollars. A composite manpower schedule is included in Section 7.

PLANTATION ADMINISTRATION

Position	Salary	YEAR 1980	1981	1982	1983+
Project Supervisor	P19,794	1	1	1	1
Secretary	9,060	1	2	2	2
Personnel Officer	9,567	1	1	1	1
Accountant	9,037	1	1	1	1
Cashier	6,830		1	1	1
Admin. Assistant	9,037	1	1	1	1
Mechanics	5,753		2	2	1
Typist	5,094		1	1	
Laborer (Utility)	4,494		1	1	1
	Subtotal	5	11	11	9

PLANTATION NURSERY

Position	Salary	YEAR 1980	1981	1982	1983+
Nursery Supervisor	11,339	1	1	1	1
Foreman	10,125	2	4	2	2
Propagators	8,541	4	6	3	3
Laborers	3,000	8	8	4	4
Handling	3,432	4	4	2	2
Drivers	5,753	1	6	3	3
	Subtotal	20	29	15	15

PLANTATION LAND PREPARATION

Position	Salary	YEAR 1980-81*	1981-82	1982-83+
Supervisor (planting)				
Foreman	P10,125	6	4	1
Laborers	3,000	231	94	28
	Subtotal	237	98	29

* See Composite Manpower Schedule in Section 7.

PLANTATION PLANTING

Position	Salary	YEAR 1980	1981	1982	1983+
Supervisor	P15,878		1	1	1
Sector Foremen	10,125		3	2	1
Laborers	3,000		149	60	18
Driver & Service	5,753		8	5	2
	Subtotal		161	68	22

PLANTATION MAINTENANCE

(Weeding, etc.)

Position	Salary	YEAR 1980	1981	1982	1983+
Supervisor	P14,243		1	1	1
Field Foremen	10,125		3	3	3
Laborers**	3,000		84	89	89
	Subtotal		88	93	93

** Monthly Average - See Section 7 and Appendix B

PLANTATION HARVESTING

Position	Salary	YEAR 1980	1981	1982	1983+
Harvest Supervisor	P15,878			1	1
Field Supervisor	11,339			2	2
Field Foremen	10,125			4	4
Fellers	3,000			48	48
Skidders	3,000			56	56
Cable Yard Operators	10,125			2	2
Yarder Assistants	3,000			4	4
Choker Setters	3,000			8	8
Chipper Operators	10,125	(2 shifts)		4	4
Haulers (Chipper Landing)	3,000	(2 shifts)		12	12
	Subtotal			141	141

For TOTAL, see Composite Manpower Schedule - Section 7.

7 PROJECT COST ESTIMATE AND IMPLEMENTATION PLAN

This section presents an Order of Magnitude cost estimate for the proposed dendro-thermal generating plant and the implementation plan necessary to construct the plant within the desired time frame and to effectively operate the plant thereafter. Both the cost estimate and implementation plan are presented for project transmission, the generating plant, and the fuelwood plantation. This section summarizes estimates and schedules, discussed elsewhere in this report.

7.1 BASIS OF COST ESTIMATE

The major equipment costs included herein are based on recent estimate prices received from United States equipment suppliers. All other cost estimates are based on current 1979 prices using MAIN's own historical data of costs of recently completed similar projects. Where costs are expressed in Philippine currency, a conversion rate of 7.4 Pesos equals one U. S. dollar has been used.

Construction costs are based on those presently in effect in the Philippines.

The estimate assumes that AID will purchase all major equipment and materials and that a general contractor will be hired to install all equipment according to plans provided by AID's engineer. All purchasing will be on a U. S. competitive bid basis.

The estimate and schedule assume that field work will be performed on a 40-hour per week basis.

An escalation allowance of 15% per year is included.

Costs have been organized by major construction elements and fuelwood plantation components.

In keeping with standard engineering practice, the order of magnitude cost estimate should not be considered to be of appropriation level accuracy. Actual costs may vary from those shown by a factor of 0% to 25%.

7.2 DEFINITION OF TERMS USED IN COST ESTIMATE

7.2.1 Shipping

Costs of shipping from U.S. ports to the representative plant site have been estimated. These include freight from U.S. ports to Manila, off-loading in Manila to a smaller ship or barge to Port Washington on Panay, and land transport to the representative plant site. Shipping costs include cost for insurance.

7.2.2 Labor Adjustment

This factor makes allowances for the productivity of the Philippine personnel and Philippine salaries relative to their United States counterparts, upon which original estimates were based.

7.2.3 Indirect Construction Costs

The costs for indirect construction include the following:

- Field Office and Labor Expense
  - Office Expense
    - Permits and Licenses
    - Stationery Supplies
    - Office Furniture and Equipment
    - Telephone and Telegraph
    - Janitor and Supplies
  - Labor Expense
    - Safety Equipment
    - Inclement Weather Gear
    - First Aid Supplies
    - Construction Camp Operations
    - Construction Camp Facilities
    - Operate Camp Facilities

- Engineering Equipment
  - Drafting Supplies
  - Surveying Equipment and Supplies
  - Testing Apparatus

- Construction Field Staff
  - Surveyors
  - Inspectors
  - Clerk Typists
  - Bookkeepers
  - Data Processing Technicians
  - Engineering Clerks
  - Warehouse Clerks

o Construction Buildings

- Field Office
- Change Buildings
- Tool Room and Storage
- Warehouse Facilities
- Toilet Building/Portables

- Office Facilities (Mfg., Engrs., etc.)
  - Electrical Power
  - Sewage System

- Transport Services
  - Access Roads and Bridges
  - Parking Areas
  - Temporary Railroad
  - Special Transport Facilities

o Expendable Supplies

- Concrete Form Materials
- Special Equipment Rentals
- Fuels, Oils and Lubricants
- Chemicals
- Gases
- Water and Power Charges
- Miscellaneous Materials - Civil
- Miscellaneous Materials - Electrical

o Off-site Storage and Transportation

o Wage Related Costs
  - Industry Promotion

- Premium Pay
  - Overtime Premium
  - Paid Holidays
  - Absence and Sick Leave

- Construction Service Contracts

  - Survey and Layout
  - Testing Laboratory
  - Non-Destructive Testing
  - Guard Service
  - Toilet Service
  - Trash Disposal
  - Chemical Cleaning
  - Other Service Contracts
  - Erection Shelters
  - Other Buildings (Guards, Paint, etc.)

- Construction Tools and Equipment

  - Heavy Equipment
  - Automotive Equipment
  - Equipment Maintenance

- Temporary Facilities

  - Inclement Weather Facilities
    Structures and Enclosures

  - Distribution Systems
    Potable Water
    Compressed Air
    Communications
    Fuel Gas Tanks and Piling

7.2.4 <u>Professional Services</u>

Costs for professional services include:

- Engineering, Design and Related Services

- Project Management

- Construction Management

- Other Services

  - Startup and Testing
  - Procurement Services
  - Inspection and Expediting
  - Outside Consultants

- Architectural Services

7.2.5 Client and Other Charges

These costs include charges which may be incurred directly by the client. They include:

- Client Charges
  - Field Operations
    - Field Office Staff Salaries
    - Field Office Furniture and Equipment
    - Field Automotive Equipment
  - General Office Operations
    - General Office Salaries
- Land Acquisition Costs
- Capitalized Startup Costs
- Spare Parts
- Operation Tools and Equipment
- Service Engineers

7.2.6 Contingency

An allowance is included for variables that normally occur during a project, but are not definable at the time of estimate preparation. Examples include underestimated or unforeseen items, and items that may undergo minor modifications before or during construction. This allowance does not cover changes to the project scope. This allowance is a judgmental factor and is a function of project complexity, schedule, available site data, and other factors. For this project the contingency allowance has been calculated as 15% of estimated total direct project cost, less escalation.

7.2.7 Cost Estimate Exclusions

Work items which have not been estimated as part of this study include:

- o Work Performed Prior to the Start of Detail Engineering
  - Environmental/River Monitoring Studies
- o Miscellaneous Capital Costs and Expenses
  - Legal Services
  - Royalties
  - Extended Construction Schedule
  - Financing
  - Environmental Studies and Monitoring
  - Miscellaneous Fees and Permits
- o Taxes and Insurance
  - Insurance Fees
  - Property Taxes
  - Sales Taxes
  - Federal and Local Taxes

7.3 ORDER OF MAGNITUDE COST ESTIMATES

The order of magnitude cost estimate, presented in Table 7-1, presents cost estimates for the three major project components: (1) transmission and distribution; (2) generation facility; and (3) the fuelwood plantation.

7.4 PROJECT SCHEDULES

7.4.1 Engineering and Construction

The schedules, as proposed and submitted herein, (Figures 7-1, 7-2 and 7-3), are based on project authorization no later than October 15, 1980. We estimate the project duration to be 27 months, resulting in the dendro-thermal plant "on line" by December 15, 1982.

TABLE 7-1

ORDER OF MAGNITUDE COST ESTIMATE

DENDRO-THERMAL GENERATING PLANT

(1980 Philippine Pesos)

	Local Currency	Foreign Currency	Total Currency
Site Preparation	P 6,497,200	P -	P 6,497,200
Wood Processing	1,576,200	4,684,200	6,260,400
Boiler Turbine Generator Complex	8,635,800	15,458,600	24,094,400
Transmission & Substation	207,200	2,271,800	2,479,000
General Plant & Support Services	1,280,200	-	1,280,200
Subtotal	P 18,196,600	P 22,414,600	P 40,611,200
Shipping		1,924,000	1,924,000
Labor	- 3,788,800	-	- 3,788,800
Subtotal - Plant	P 14,407,800	P 24,338,600	P 38,746,400
Fuelwood Plantation			
Administration	P 240,000		P 240,000
Nursery	63,250		63,250
Land Preparation	55,500		55,500
Planting	15,000		15,000
Maintenance	19,000		19,000
Harvest		3,492,800	3,492,800
Vehicles	320,000		320,000
Roads	49,237,500		49,237,500
Subtotal - Plantation	P 49,950,250	P 3,492,800	P 53,443,050
TOTAL - DIRECT COST	P 64,358,050	P 27,831,400	P 92,189,450
Indirect Construction Cost + 20%	12,871,610		12,871,610
Contingency + 15%	9,653,708	4,174,710	13,828,418
Specific Cost	P 86,883,368	P 32,006,110	P 118,889,478
Professional Services + 5%	4,344,168		4,344,168
Client & Other Charges + 2%	1,737,667		1,737,667
TOTAL COST	P 92,965,203	P 32,006,110	P 124,971,313

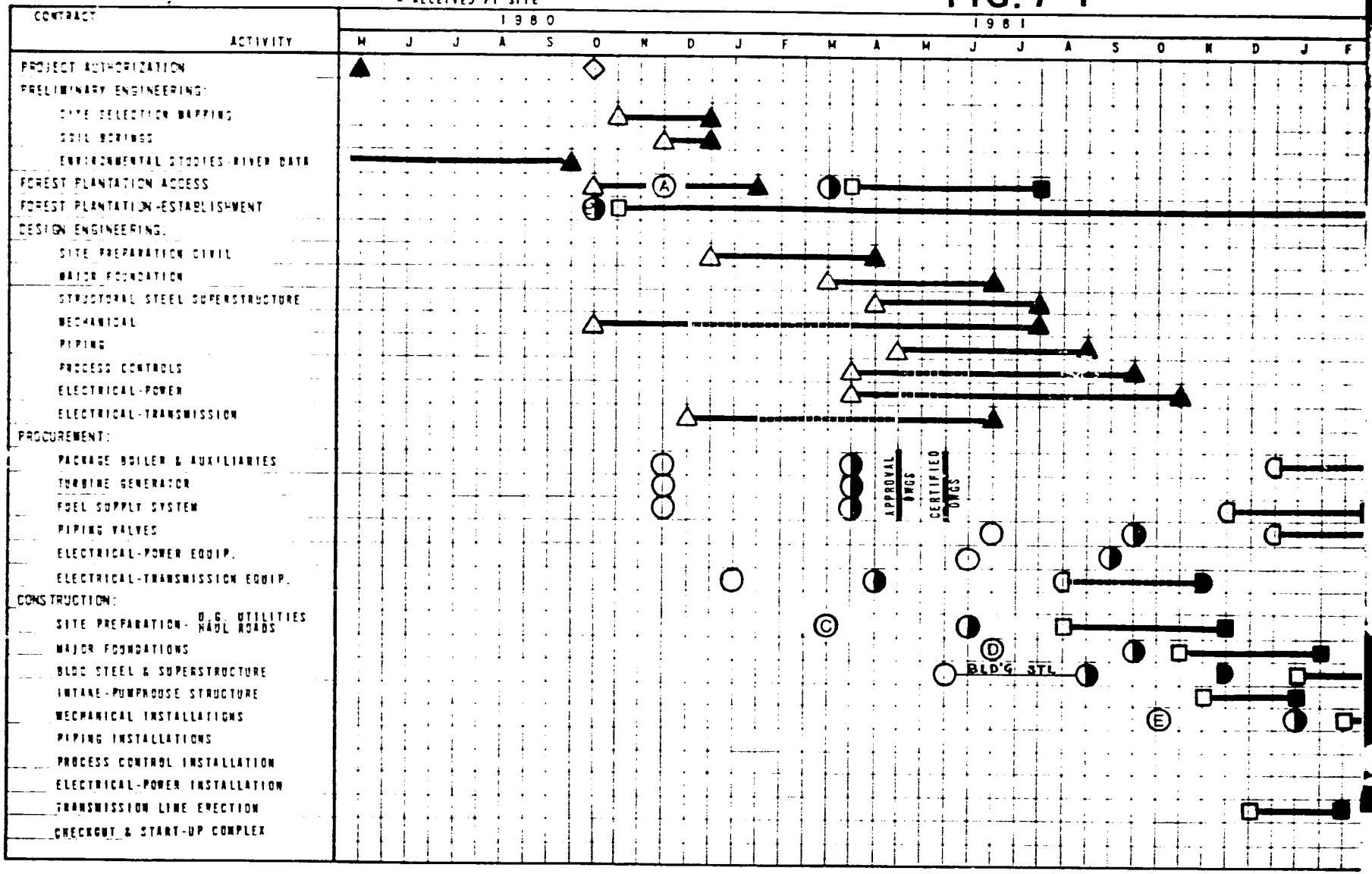
MAIN

NOTES.

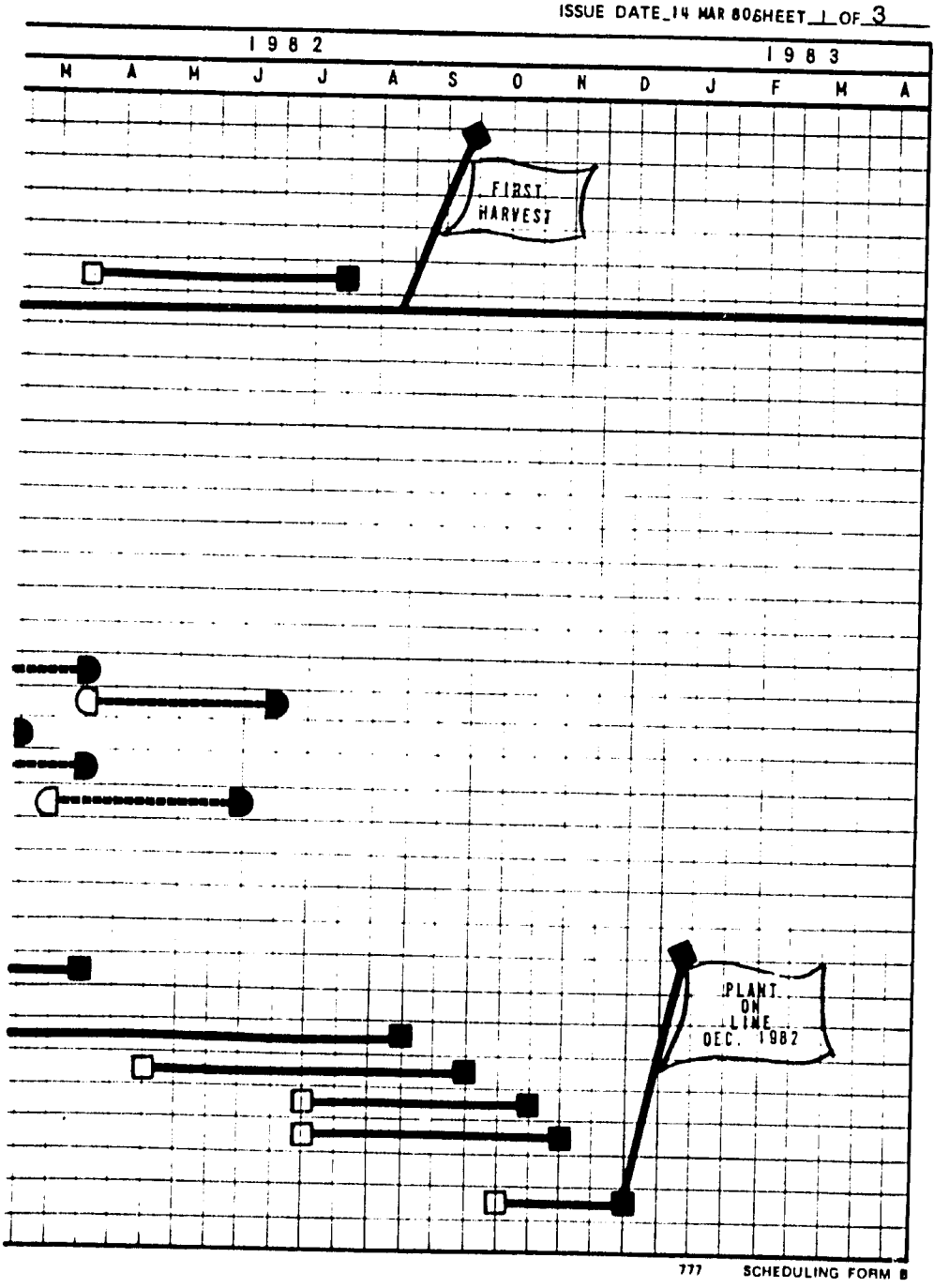
1. SEE SHEET 2 FOR DETAILS ON REFORESTATION PROGRAM.
2. - SHIPPING DATE - US PORT
   - RECEIVED AT SITE

2000 kW DENDRO THERMAL PLANT
PANAY, THE PHILIPPINES
TOTAL PROJECT SCHEDULE

FIG. 7-1



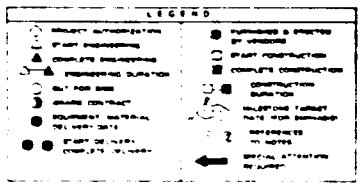
CLIENT U.S. AID-PHILIPPINES
PROJECT DENDRO THERMAL PLANT
JOB NO. 2785-ID-1
SCHEDULED BY R.A.F. DATE 5 MAR 80
CHECKED BY _____ DATE _____
ISSUE DATE 14 MAR 80 SHEET 1 OF 3



777 SCHEDULING FORM B

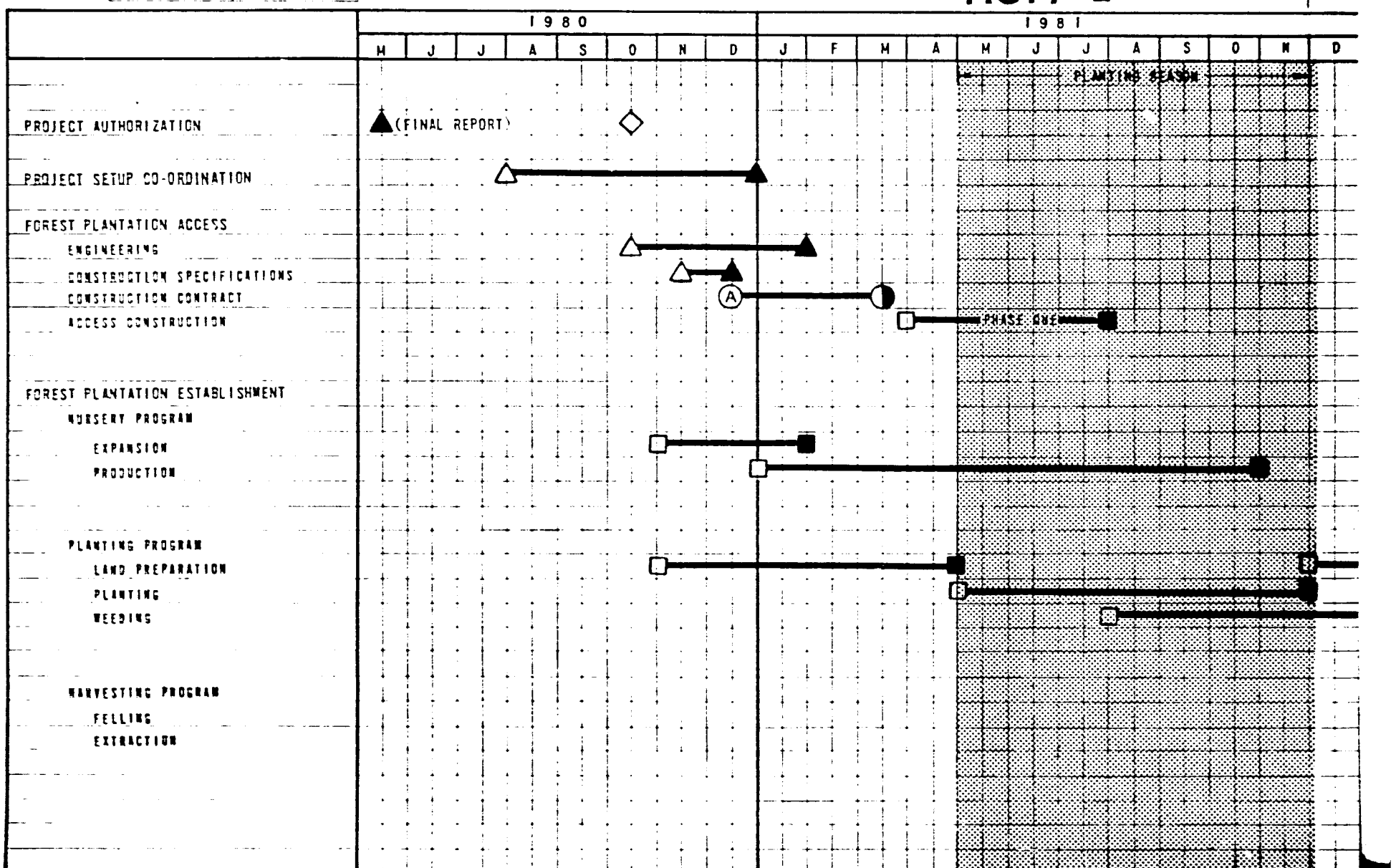
FIG. 7-1

MAIN



2 MW DENDRO THERMAL PLANT
PANAY, PHILIPPINES
REFORESTATION PROGRAM SCHEDULE

FIG. 7-2



CLIENT U.S. AID-PHILIPPINES
PROJECT DENDRO THERMAL PLANT
JOB NO. 2785-10-1
SCHEDULED BY R.A.F. DATE 6 MAR 80
CHECKED BY _____ DATE _____
ISSUE DATE 14 MAR 80 SHEET 2 OF 3

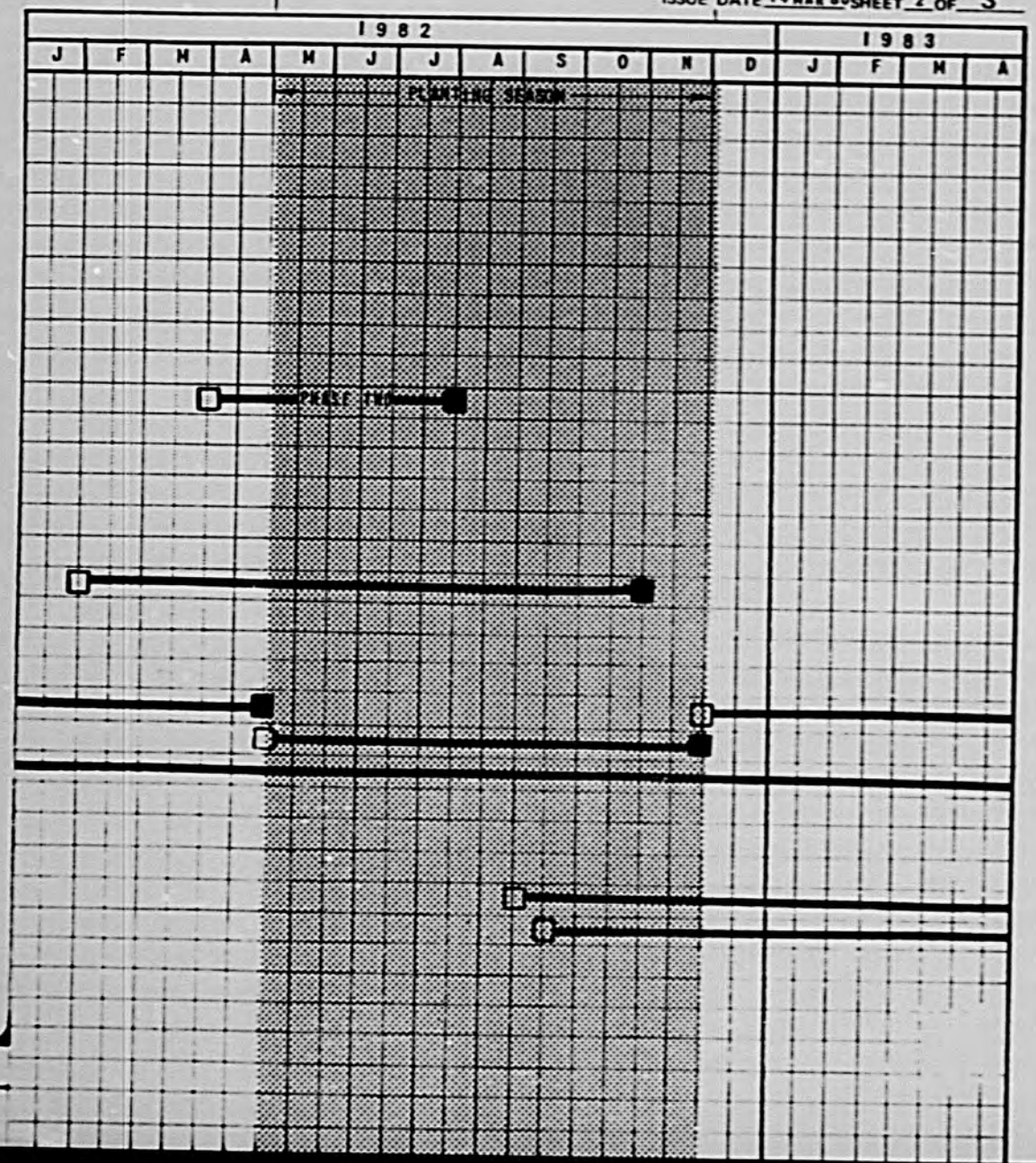
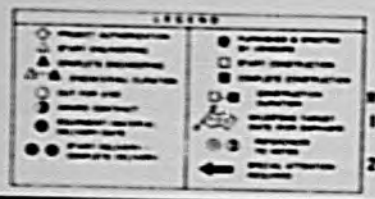


FIG. 7-2

MAIN



NOTES:
1. SEE SHEET 2 FOR DETAILS on REFORESTATION PROGRAM.
2. - SHIPPING DATE - US PORT
   - RECEIVED AT SITE

2000 kW DENDRO THERMAL PLANT
PANAY, THE PHILIPPINES
TOTAL PROJECT SCHEDULE

FIG. 7-3

CONTRACT / ACTIVITY

1980: M J J A S O N D
1981: J F M A M J J A S O N D J F

PROJECT AUTHORIZATION
PRELIMINARY ENGINEERING:
- SITE SELECTION/MAPPING
- SOIL BORINGS
- ENVIRONMENTAL STUDIES-RIVER DATA

FOREST PLANTATION ACCESS
FOREST PLANTATION-ESTABLISHMENT
DESIGN ENGINEERING:
- SITE PREPARATION/CIVIL
- MAJOR FOUNDATION
- STRUCTURAL STEEL/SUPERSTRUCTURE
- MECHANICAL
- PIPING
- PROCESS CONTROLS
- ELECTRICAL-POWER
- ELECTRICAL-TRANSMISSION

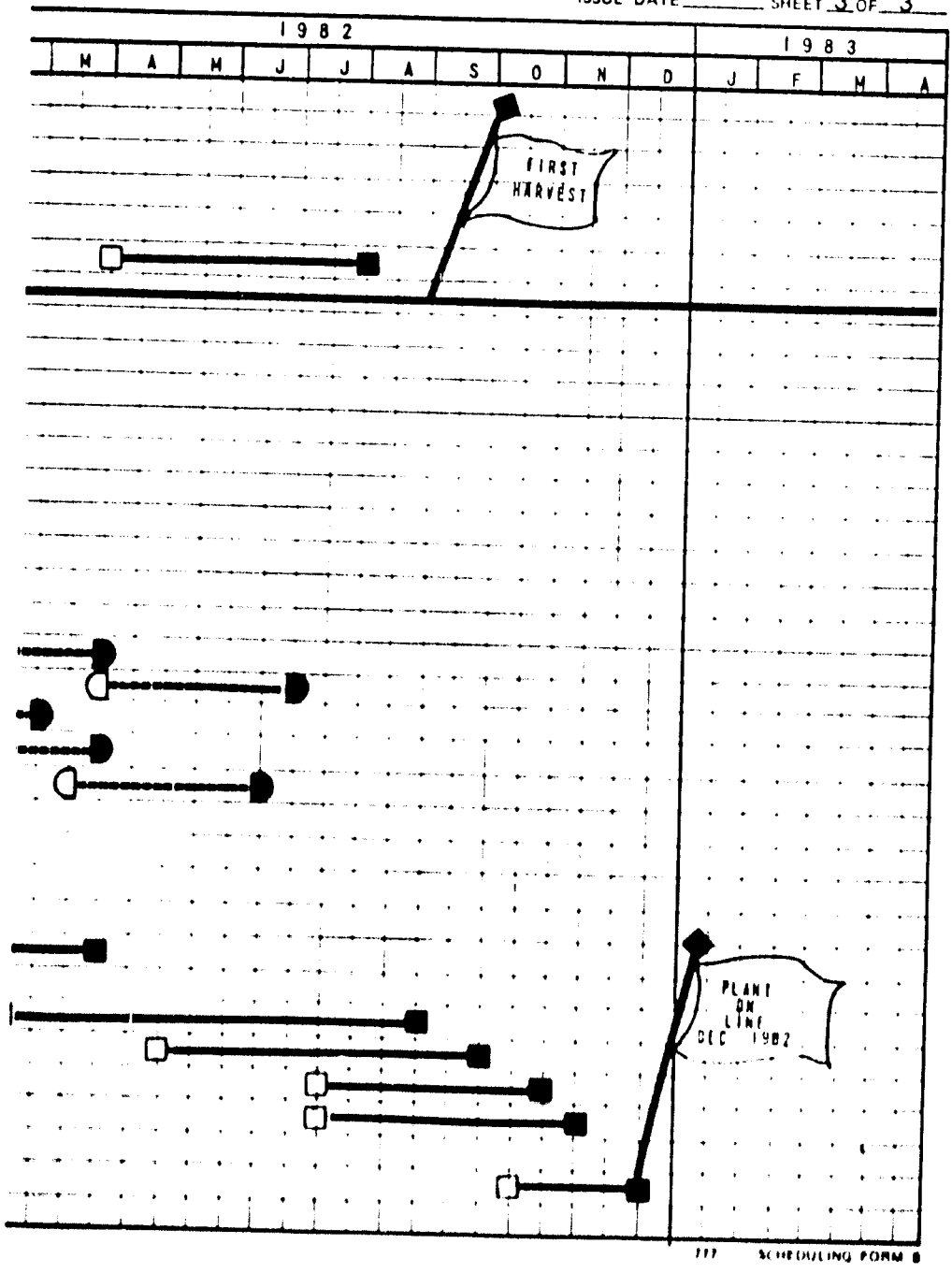
PROCUREMENT:
- PACKAGE BOILER & AUXILIARIES
- TURBINE GENERATOR
- FUEL SUPPLY SYSTEM
- PIPING/VALVES
- ELECTRICAL-POWER EQUIP.
- ELECTRICAL-TRANSMISSION EQUIP.

CONSTRUCTION:
- SITE PREPARATION- U.G. UTILITIES / HAUL ROADS
- MAJOR FOUNDATIONS
- BLDG STEEL & SUPERSTRUCTURE
- INTAKE-PUMPHOUSE STRUCTURE
- MECHANICAL INSTALLATIONS
- PIPING INSTALLATIONS
- PROCESS CONTROL INSTALLATION
- ELECTRICAL-POWER INSTALLATION
- TRANSMISSION LINE ERECTION
- CHECKOUT & START-UP COMPLEX

APPROVAL DWGS
CERTIFIED DWGS
BLDG STL.

FIG. 7-3

CLIENT U.S. AID-PHILIPPINES
PROJECT DENDRO THERMAL PLANT
JOB NO. 2785-10-1
SCHEDULED BY R.A.F. DATE 5 MAR 80
CHECKED BY _____ DATE _____
ISSUE DATE 14 MAR 80 SHEET 3 OF 3



The schedule logic is dictated by the following milestone events:

(1) All environmental data, including the required river flow data, be initiated prior to project authorization.

(2) Purchasing of the Package Boiler and Auxiliaries by April 1, 1981, with shipment no later than December 31, 1981.

(3) Purchasing of the Boiler Fuel Feed System by April 1, 1981, with shipment no later than December 1, 1981.

(4) Purchasing of 2 MW Turbine Generator by April 1, 1981, with shipment no later than April 1, 1982.

(5) A very aggressive forestation program dedicated to achieving the critical "First Harvest" of trees no later than the end of August 1982. (See Figure 7-3).

The schedules are predicated on the "best available" information available at the time with the following assumptions and/or items called to your attention:

(1) Design engineering will commence upon completion of preliminary engineering phase. Total duration of design engineering is anticipated to be ten months with the respective, responsible discipline engineers commencing early enough to procure the major equipment items under their jurisdiction.

(2) Engineering and construction work durations are based on a normal 40-hour work week of five days.

(3) Contract bidding periods are to be three months in duration to allow sufficient time for United States and Philippine approval procedures.

(4) Equipment purchased in the United States will be shipped to site via steamship through the Port of Manila and then to Port Washington, Panay. Total shipping time (U.S. dockside to site) must not exceed three months.

(5) Structural steel for project is to be purchased and fabricated locally.

(6) Construction contractors should be able to mobilize within one month of contract award date. Also, the responsible erecting contractor will receive equipment at dockside, Port Washington, and transport to project site.

MAIN recommends that the following construction contract packages be processed and issued as shown on Figure 7-1:

Contract	Description	Type
A	Forest Plantation Access	Cost Plus w/Fixed Fee
B	Forest Plantation Establishment	By Local Agency
C	Site Preparation	Cost Plus w/Fixed Fee
D	Major Foundation, Building Steel Erection, Superstructure and Primary Electrical Transmission	Lump Sum
E	Mechanical, Piping, Process Control & Electrical Power	Lump Sum

It is felt that this sequence allows the most economical overall project duration without jeopardizing the engineering and procurement phases, while generating construction bid packages attractive enough to entice the more competent contractors in the Philippine area.

Alternative construction contract sequencing is as follows:

(1) Individual discipline construction contract packages, as shown on Figure 7-3:

Contract	Description	Type
A	Forest Plantation Access	Cost Plus W/Fixed Fee
B	Forest Plantation Establishment	By Local Agency
C	Site Preparation	Cost Plus w/Fixed Fee
D	Major Foundations	Lump Sum
E	Building Steel/Superstructure and Pump House	Lump Sum
F	Electrical Transmission	Lump Sum
G	Mechanical Installation	Lump Sum
H	Piping Installation	Lump Sum
I	Process Control Installation	Lump Sum
J	Electrical (Power) Installation	Lump Sum

Alternate One would allow the completion of the project within the same time period but increase engineering and construction management cost due to the number of contracts to be let and coordinated. Furthermore, MAIN feels that the monetary value of each contract may not be sufficient enough to attract properly qualified contractors.

(2) One General Contractor on a lump sum basis.

This sequence allows for the best possible situation from the engineering standpoint since engineering has to be 90-95% complete prior to bidding, and 100% complete prior to award. The anticipated bid period would be September 1, 1981 through December 1, 1981. The major drawback to this sequence is that construction would not start until January 1982, with completion the end of April 1983 - a 4-1/2 month extension to the project schedule.

(3) A General Contractor on a cost plus fixed fee basis.

The concept would allow completion as shown on Figure 7-1. The anticipated bidding period would be from April 15, 1981 through July 15, 1981.

Alternate Three is the worst position from the standpoint of engineering cost due to the "fast tracking" techniques required. Further, this type of contract requires an extensive construction management team to watch construction cost, not to mention the loss of contractor incentive to maintain schedule. No improvement to the project completion date can be realized since the end date is predicated on major equipment deliveries and not the construction duration.

7.4.2 Plantation

Figure 7-2 presents a detailed activity schedule for the establishment, maintenance, and harvesting of the fuelwood plantation. This schedule is designed to produce sufficient fuel within a two-year period to permit plant start-up.

Figure 7-4 presents a Project Labor Schedule, by activity, for the plantation component of the project.

See Appendix B for a detailed computation of personnel requirements.

MAIN

LEGEND

2000 kW DENDRO THERMAL PLANT
PANAY, PHILIPPINES
PROJECT MANPOWER SCHEDULE
FIG. 7-4

	1980								1981														
	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
PLANTATION ADMINISTRATION							5	5	11	11	11	11	11	11	11	11	11	11	11	11	11	11
NURSERY PROGRAM							20	20	29	29	29	29	29	29	29	29	29	29	29	29	15	15
PLANTATION ESTABLISHMENT																						
LAND PREPARATION							237	237	237	237	237	237										
PLANTING													161	161	161	161	161	161	161	98	98	98
WEEDING																62	62	62	124	124	124	186
HARVEST																						
FELLING																						
EXTRACTION																						
MISC. LANDING																						
THERMAL PLANT																						
CONSTRUCTION																						
OPERATION																25	25	30	35	50	60	65
TOTALS							262	262	277	277	277	277	201	201	201	288	298	279	360	312	318	375

CLIENT U.S. AID-PHILIPPINES
PROJECT DENDRO THERMAL PLANT
JOB NO. 2785-10-1
SCHEDULED BY DFJ DATE 14 MAR 80
CHECKED BY _____ DATE _____
ISSUE DATE 14 MAR 80 SHEET 1 OF 1

1982										1983			
M	A	M	J	J	A	S	O	N	D	J	F	M	A
11	11	11	11	11	11	11	11	11	11	9	9	9	9
15	15	15	15	15	15	15	15	15	15	15	15	15	15
98	98								29	29	29	29	29
		68	68	68	68	68	68	68					
124	124	124	124	62	87	25	25	50	50	50	75	50	50
						48	48	48	48	48	48	48	48
						56	56	56	56	56	56	56	56
						37	37	37	37	37	37	37	37
70	70	70	70	60	50	35	30	25	20				
								10	29	29	29	29	29
318	318	288	288	216	231	295	290	320	295	273	278	273	215

FIG. 7-4

8 ENVIRONMENTAL EVALUATION

8.1 APPROACH

The following environmental evaluation was designed to identify potentially significant impacts to the socio-cultural and bio-physical environments if the proposed dendro-thermal power generation project were to be initiated. Both positive and negative impacts are addressed. Mitigative actions during planning, design, construction, and operation are recommended as appropriate to minimize or eliminate negative impact.

This evaluation is presented in a format compatible with that of an Initial Environmental Examination as outlined in AID's Environmental Procedures. However,this environmental evaluation is not necessarily intended to comply with the requirements of that document.

The Republic of the Philippines has passed various articles of legislation into law dealing with environmental quality.[9/] The majority of this legislation, to date,attempts to establish a framework within which regulatory guidelines can be developed and enforced. This legislation was considered in the environmental evaluation. Environmental guidelines established by the World Bank [8/] for industrialization in developing countries were also consulted relative to the potential significance of project related impacts.

The level of detail of the environmental evaluation was designed to be commensurate with the level of detail employed in other components of the feasibility study. Lack of detailed site-specific engineering data could render a detailed environmental data of little or no real value if project parameters were to be modified at the next, more refined level of study, or if the project were found to be unfeasible. However, areas of potentially significant impact, as identified at the feasibility level of study, would provide an indication of the types of assessments required during later studies.

The approach employed in the environmental evaluation was to: (1) identify commitments of resources necessary for the project, the processes involved in the generation of energy, and the residual products resulting from this generation; (2) visit the reforestation area and representative plant site to identify environmental components representing potential impacts; and (3) interview local and national authorities to identify potential conflicts with planning objectives and to establish the magnitude and implications of potential impacts.

Potential impacts were evaluated and are presented as generic and site-specific impacts. Generic impacts are an inherent result of wood-fueled energy generation due to the characteristics of the fuel, availability of the fuel, and the state-of-the-art of boiler (generation) technology. Site (or area) specific impacts are associated with or are the direct result of conditions in the area where the generation unit would be located, methods used to transport and deliver fuel, etc. This distinction is made to permit a flexibility in overall impact evaluation. Generic impacts will result from the proposed project regardless of location. However, interaction with site-specific conditions may result in site-specific impacts which vary at alternative sites. This methodology is employed to provide a framework which permits re-evaluation of potential impacts if other than the recommended area is considered at a later date.

Once potential impacts are identified, mitigation procedures are recommended to eliminate or minimize negative impacts.

8.2 EXISTING ENVIRONMENT

The project is located on the northwest portion of the Island of Panay in Aklan Province (see Figure 3-1). Both the proposed fuel production area (the Nabas Reforestation Area) and the representative dendrothermal plant site are located in the Municipality of Nabas. The representative plant site is located on the east bank of and adjacent to the Gibon River, approximately 1.5 km upstream from its outflow to the Sibuyan

Sea. The northern limit of the reforestation area is located roughly one km south of the representative dendro-thermal plant site.

The nearest population center is the Village of Nabas, approximately six km southeast of the representative plant site, with a population of 1,543 inhabitants. The rural population of the Municipality of Nabas, 15,051, is confined almost exclusively to the level coastal plain where rice farming is the primary economic activity. Unlike some other reforestation areas on the Island of Panay and in other regions of the Philippines, few settlers, or squatters, are reportedly found in the Nabas Reforestation Area.

The existing environment in the vicinity of the representative plant site is dominated by socioeconomic factors, while the existing environment in the reforestation area is primarily associated with bio-physical factors. Available demographic and employment data are limited to the 1975 provincial census [6]. The most detailed reporting is by municipality. Of the 110,000 inhabitants of the Province of Aklan, 80 percent are reported as being "gainfully employed". Of the male population between the ages of 15 and 59 (the group representing a potential source of project laborers), approximately 76 percent is reported to be gainfully employed. However, roughly 63 percent of this group participate in agricultural activities, many of which are seasonal.

Land in the vicinity of the representative plant site is utilized almost exclusively for rice production. Paddies ranging in size from five hectares to 25 hectares are irrigated with water diverted from the Gibon River and distributed via small earthen canals. The canal system is rudimentary and manually modified as required to meet irrigation needs. No data are available concerning volumes of irrigation water diverted from the Gibon River.

Houses in the area are scattered and could be avoided during the development of the representative plant site.

Rodents and small birds were the only terrestrial wildlife reported in the agricultural land in the vicinity of the representative plant site. The aquatic species noted by local residents included milkfish, mudfish, and freshwater shrimp. These species are apparently found in most major streams and rivers in the area.

There are no major sources of air pollution in the Nabas area. No data concerning sanitary water quality of the Gibon River are available. However, some residences reportedly use the river as a domestic water supply with no ill effects. No unusual health problems in the area were reported by local residents.

The Nabas Reforestation Area is a government-owned tract of land approximately 4000 hectares in area, located in the hills inland from the coast. The physical characteristics of the reforestation area are typified by pronounced hills or mountains ranging from 100 to 700 meters above mean sea level. Few level areas can be found. Slopes in excess of 50 percent are encountered over much of the area.

No quantitative data exist concerning existing vegetation within the reforestation area are available. The majority of the area appears to be vegetated by cogon grass. Some rather small areas (50 ha to 100 ha) of native forest are scattered in ravines and on some steep slopes where they escaped the fire and other land clearing efforts of local slash-and-burn agriculturalists (kaingineros). Still other larger areas are in successional stages between these two extremes, being vegetated with low, woody shrubs.

Land use within the reforestation area is severely limited by restrictions on use of a reforestation area. Some small, abandoned banana plantations are scattered among native vegetation at lower elevations. A few cattle reportedly roam the grassy areas. Reforestation efforts are the primary activity in the area.

The only economic activity in the reforestation area is associated with the Bureau of Forest Development's reforestation effort. Approximately 15 people were employed in nursery activities and 20 people in plantation establishment activities in 1979.

Local residents report little wildlife in the Reforestation Area. Only rodents, birds, and some "small mammals" were mentioned.

A poor road presently exists to the representative project site from the main coastal road, but no roads exist between the site and reforestation area.

8.3 POTENTIAL ENVIRONMENTAL IMPACTS

Of the foreseeable potential impacts associated with the proposed project, those considered to be potentially significant are discussed below. Positive and negative socioeconomic impacts are discussed independently of positive and negative bio-physical impacts.

8.3.1 Socioeconomic Impacts - Positive

Project-related employment represents the most potentially significant impact to the socioeconomic conditions of the area. Unemployment among males between the ages of 15 and 59; i.e., the group which can provide the unskilled labor required in the proposed project, is estimated at 24 percent from the 1975 census. Of the males in this age group which are employed, nearly 50 percent are employed in agricultural activities. These activities are seasonal, thus representing underutilization of individuals employed therein.

The proposed dendro-thermal project will require a peak employment of over 300 employees during plantation establishment and construction, a relatively steady labor requirement of 275 employees in subsequent years. A large percentage of this labor requirement will be for unskilled workers

and will provide a direct market for local, unemployed laborers. The degree to which project labor requirements will aid in stabilizing seasonal fluctuations in employment will largely depend on the employment policy of the project. A labor force must be available year-round to insure continuous and reliable operation of the wood supply component of the project. Competing demands for labor from the agricultural sector of the area cannot be allowed to destabilize or reduce the project labor force. Therefore, only those project components which can be accomplished during periods of low employment in the agricultural sector should utilize unemployed agricultural laborers.

The economic benefits to the Village of Nabas and Kalibo will be significant. A majority of the project labor is expected to originate from the immediate project area. This will mean that a large percentage of wages earned by local laborers will remain in that area. The influx of money to the area will benefit existing businesses and will also stimulate the establishment of new businesses with associated secondary and terciary benefits.

Many of these new businesses will increase the availability of goods and services presently found in the area. For example, domestic firewood is in critically short supply in the Kalibo/Nabas area. This shortage has reached the point that the dried petioles (bases) of coconut leaves are presently collected, dried, bundled, and sold for firewood. Some of the area scheduled for reforestation will be available for the production of domestic firewood after the first harvest. (During the first year of harvest, the trees to be harvested will only be two years old. Subsequent harvests will be in areas of three year old trees. To compensate for this reduced volume per hectare during the first year of harvest, it is necessary to plant and harvest an additional 285 hectares of land. After the initial harvest, these 285 hectares will not be required to meet the fuel requirements of the dendro-thermal plant and can be designated to produce wood for other purposes; e.g, domestic firewood.)

New business can be expected to develop to offer goods and services which are presently unavailable in the local area; e.g., suppliers

of specialized mechanical services. New industries may develop. For instance, increasing prices for low-grade sawn wood products and the source of raw material in an expanding hardwood plantation may stimulate the installation of sawmills in the area. Such a scenario is considered probable within the life of the proposed dendro-thermal project. All such "spin-off" industries can be expected to benefit the local area to varying degrees.

The organization and management of a project of the magnitude of that proposed will expose local people to these principles. Development of a management capability by local individuals may result in benefits to other local commercial enterprises. On a larger scale, the experience gained through the successes and failures within the overall operation of the dendro-thermal project will serve as a basis to judge the feasibility of other, larger dendro-thermal projects in the Philippines, and as a basis to improve the planning and management of any new operation.

The proposed dendro-thermal plant will be linked to the existing transmission grid of Panay. The dendro-thermal plant will operate at full capacity and provide a portion of the system's baseload. As such, generation from the other petroleum-fueled generators on the system can be reduced and petroleum costs can be saved. This operational strategy is consistent with the policy of the government to reduce dependence on foreign petroleum products and to reduce foreign expenditures.

The proposed dendro-thermal project will provide an opportunity to more rapidly advance the national goals of reforestation and conservation while providing a means of financing such a program. The relatively large fuel wood plantations will also provide an opportunity for the scientific forestry community to gain knowledge relative to operational aspects of managing large-scale plantations of those species involved.

8.3.2 Socioeconomic Impacts - Negative

Project-related employment will result in positive economic impacts, but may also result in conditions which may be interpreted

as negative impacts. Approximately 56 skilled and semi-skilled employees will be required for project construction and operation. Those associated with the operational phase, as well as some involved in the construction phase, can be expected to relocate permanently (for one to two years in the case of construction personnel) to Nabas. Increased demands for facilities and services, such as housing and transportation, can be expected to be met by the private sector. However, increased demands on public facilities and services, such as schools and medical facilities, may require increased public expenditures and/or increased efficiencies of existing facilities and services.

Wood is a relatively clean fuel. It contains little sulfur and its relatively low combustion temperature results in relatively little nitrogen oxide. Because of the impacts to the health of the surrounding population and reduction in agricultural crops associated with fossil fuel generation, as well as particulate matter resulting from combustion of wood, a mechanical fly ash collector is included in the plant design. This collector is designed to reduce fly ash emission to a rate of 0.3 pounds (0.14 kg) per million Btu fuel input. No standards of performance for a plant of this size have been promulgated by the U. S. Government for comparison. The relatively low density of population will minimize real numbers of people likely to experience health difficulties associated with air emissions from the operating dendro-thermal plant. The greatest number of health and safety problems can be expected to be confined to project workers rather than the population in the surrounding area.

A by-product of the operation of a generation project such as that proposed, is the solid waste which must be properly disposed of. This will include not only ash from the combustion of wood, but residues from the demineralization and clarification of natural river water and secondary solid waste from the plant area. Approximately 1555 m^3 of ash per year will be generated and 1000 m^3 of other debris; e.g. paper, scrap metal, etc., will be collected.

The non-ash solid waste can be disposed of in several suitable areas near the plant. It has been suggested that wood ash may be

disposed of by applying it to soil as a slow release, low strength fertilizer.[13/] [14/] The volume of wood ash produced by the dendro-thermal plant represents approximately 13 truck loads per month. This could bd transported to the plantation area and spread. However, its light texture may make it susceptible to blowing, with subsequent air quality problems, during the dry season and inconvenient to handle and spread when wet.

If dumped in a land fill, a site should be located above areas susceptible to flooding. A top covering of soil is recommended to reduce impacts from wind erosion. Water erosion can be minimized through proper site engineering of the land fill area.

The representative plant site is located in an area predominated by rice paddies. The area required for installation of the plant, including the wood storage area, is approximately 10 hectares. The plant site will, of course, displace rice production in that area. The present owners and/or workers will require compensation for the loss of land and lost production.

The location of the representative plant site may require the relocation of some small irrigation canals. These canals were originally constructed manually and can be reconstructed around the representative site. The relocation of irrigation is not expected to represent a significant expenditure of manpower or a potential decrease in production from rice paddies irrigated by those canals.

The proposed dendro-thermal generation plant will have a net requirement of approximately 61 gallons per minute (3.85 liters per second) of water from the Gibon River for cooling and make-up water. No data are available indicating downstream water use or, as noted in Section 3, flows of the Gibon River during the driest months of the year. Until such data are available to indicate otherwise, the possibility exists that water requirements for the proposed plant may result in negative impacts to downstream water users during low flow periods.

To minimize the potential for impact resulting from conflicting water use, monitoring of flows of the Gibon River during the driest months of the year, and establishing downstream water uses during the same period are necessary.

Project-related traffic during the construction phase will pass through the Village of Nabas en route from port facilities in New Washington or Kalibo to the representative plant site. This will result in an increased hazard to the people and animals along this route. However, inhabitants are accustomed to vehicular traffic in the area and the increase in incidence of accidents is expected to be low. Increased traffic may also result in some inconvenience to the inhabitants adjacent to the primary route in terms of noise, slight degradation of air quality resulting from fugitive dust and hydrocarbon emissions from the truck engines, and infrequent local congestion on the roads.

During operation of the project, the majority of the traffic will be confined to project roads between the representative project site and the reforestation area.

8.3.3 Bio-Physical Impacts - Positive

No indisputably positive impacts to the bio-physical environment can be attributed to the proposed dendro-thermal project. Two points may initially appear positive. The reforestation area was previously cleared of vegetative cover and was extensively eroded. Reforestation, accelerated by this project, will aid in stabilizing the soil and minimizing erosion. In addition, reforesting with tree species capable of transforming atmospheric nitrogen to organic nitrogen in the soil will improve soil conditions in the area.

Both points may be true to a certain degree. However, the positive effect of soil stabilization will be nullified to some degree by the increased erosion resulting from road construction and harvesting

activities. This is especially true in light of the pronounced topography in the area. Likewise, the improvement in soil fertility will be offset somewhat by the extraction of a much broader range of nutrients from the soil by harvesting and removing a very high percent of the biomass from short rotation crops. In reality, the trees will be contributing nitrogen and some vegetative matter to the soil, but will be extracting many more and unknown quantities of other nutrients. Applications of artificial fertilizer may be required to replace these nutrients and insure the desired rate of plantation growth.

It is anticipated that the net impact of the soil stabilization and soil improvement components of the reforestation and forest management program will, indeed, be positive. Only extensive and extended research can provide a definitive answer.

8.3.4 Bio-Physical Impacts - Negative

The two components of the bio-physical environment which are most likely to be negatively impacted are water quality and air quality.

Generic impacts to the water resource will be both short-term and long-term, and closely related to the aquatic ecosystem. A short-term, construction-related impact is increased sedimentation resulting from road building and site preparation. The degree of sedimentation and turbidity in the Gibon River will depend heavily on site-specific factors such as soil characteristics, slope, specific construction procedures, etc. Sedimentation and turbidity levels are expected to fall well within natural variations during the rainy season.

Long-term impacts to the water resource will include those associated with the volume of cooling water intake for the boiler, as well as the temperature, chemical composition, and volume differential of discharge water to the river or impoundment. Approximately 12.99 liters

per second, or 206 gallons per minute, will be withdrawn from the river for plant cooling and process water. Approximately 70 percent of this volume of water will be returned to the Gibon River with the difference entering the atmosphere as evaporation from the plant cooling tower (see Figure 5-5, Water and Wastewater Flow Diagram). The water discharged to the river will be approximately 11°C warmer than the ambient water. The impact of this temperature differential will depend primarily on the total flow of the Gibon River in the area of discharge and the rate of mixing of the heated discharge in the river. The full impact of the temperature differential would be confined to a relatively limited area downstream of the discharge site. Until the ecosystem of the Gibon River is detailed, the impact of thermal pollution cannot be estimated and the significance of that impact cannot be evaluated.

The chemical composition of the discharge water will include increased concentrations of naturally occurring suspended and dissolved solids. The levels of total dissolved and suspended solids, total alkalinity, and metals resulting from similar wood-fired plants and anticipated in this plant are below accepted standards in the United States.

The pH of the discharged water will be adjusted to between 6.0 and 9.0.

The aquatic ecosystem will be impacted by the short-term increases in sedimentation and turbidity in the Gibon River. However, the aquatic organisms in the river have adapted to the naturally high sedimentation and turbidity levels during the rainy season and should not be adversely affected by the relatively small increases anticipated during the construction of the project.

Combustion of wood results in low levels of sulfur and nitrous oxides. Particulate matter will be controlled by a mechanical fly ash collector in the plant.

The change in vegetative cover in the reforestation area from grassland/brushland to managed forest plantations is not expected to result in permanent negative impacts to the terrestrial wildlife population. Only 50 percent of the reforestation area is designated for project-related reforestation. That wildlife inhabiting those vegetation types being displaced will be forced to migrate to nearby areas not designated for reforestation. Less mobile species may be lost during land preparation and clearing operations. However, the loss of some individuals of a species is not expected to alter the population dynamics of that species. No species of terrestrial or aquatic wildlife recognized as threatened or endangered has the Island of Panay included within its recognized range.

8.4 UNAVOIDABLE ADVERSE IMPACTS

Land will be pre-empted from other uses on project roads and the representative project site. Increased traffic during project construction will result in local traffic congestion and increase in ambient hydrocarbon levels. Gaseous and particulate atmospheric emissions and aqueous effluents with temperatures slightly above ambient levels will result from operation of the proposed dendro-thermal plant.

8.5 MITIGATION CONSIDERATIONS

(1) A detailed assessment of labor availability for the proposed project is recommended. If the anticipated number of laborers from outside the immediate area cannot be adequately serviced with existing housing facilities, health care facilities, etc., advanced planning and improvements or expansions of those facilities may be required to meet the increased demand. A cooperative effort between local leaders and agencies and responsible administrators of the proposed project is recommended.

(2) Monitoring of annual flows, especially during low flow periods, should be undertaken in the Gibon River. Present users of water should be identified. The volume of water needed by each user and periods of use should be determined.

(3) A detailed sampling of aquatic life in the Gibon River in the vicinity of the representative plant site is recommended. By determining types of aquatic organisms present, a range of acceptable temperature increases may be established. If the anticipated project-related temperature differentials are considered too great, other types of discharge (e.g, diffused discharge structure), or cooling techniques (e.g., on-site cooling ponds) may be considered.

(4) During the design and construction of project roads, adequate erosion control procedures should be observed. This is particularly important in the steep topography in the reforestation area.

9 ECONOMIC EVALUATION OF DENDRO-THERMAL VERSUS EXISTING GENERATION

9.1 INTRODUCTION

In order to determine the economic feasibility of a 2 megawatt dendro-thermal plant, a comparison was made of the economics of dendro-thermal versus its replacement generation, approximately 2 MW of power from the island's existing diesel generation system. The dendro-thermal plant would be built, in part, as a demonstration plant to further establish the economics and operating characteristics of using local wood for electric generation. The technology of diesel generation is already established on Panay. Logically, the National Power Corporation (NPC) would not build an additional 2 MW unit of diesel because of its uneconomic size. Therefore, a reasonable comparison is to examine the costs of 2 megawatts of the dendro-thermal generation in contrast with the equivalent cost of 2 MW of existing diesel generation. The assumption underlying the economic analysis is that the dendro-thermal plant would replace existing diesel generation should the operating cost of the plant prove to be lower than diesel generation. This would allow the Philippines to use its natural resources and slow the outflow of foreign exchange spent on petroleum.

The dendro-thermal generating plant was evaluated on the basis of capital investment cost for the plantation, the plant and transmission system, as well as annual operating and maintenance costs. This analysis provides an examination of the total life-cycle costs of the generation system by utilizing a discounted cash flow methodology. Comparison was made with the estimated future operating costs of diesel generation during the life of the dendro-thermal plant. No weight was given for the increase in generation capacity by adding the dendro-thermal plant. The opportunity cost of capital (discount rate) is parameterized in this study. Section 9.5 discusses the opportunity cost of capital for the Philippines.

Because of the multiple uses for wood on Panay and adjacent locations in the Philippines, current and future competing markets for the

fuelwood were examined. The current price of wood, similar to that supplied to the plant, is examined in Section 9.7.

9.2 METHOD OF ANALYSIS

For this particular study, the discounted value of future expenditures was chosen as the tool to examine the cost of each form of generation in constant dollars, taking into account investment and operating expenditures over the useful life of the project. The discounted cash flow, as developed for the alternatives, analyzes the costs in terms of January 1, 1980 prices, including no escalation for inflation. It also assumes a constant exchange rate of one peso equal to $.1351 U.S. dollars, or $U.S. 1.00 equals P 7.40. These costs were distributed on a yearly basis to simulate the costs incurred during the construction and operation of a plant during its useful life. The life of the dendro plant was estimated to be 25 years, based on experience. The identified alternative, 2 MW equivalence of diesel generation, was also examined over a period of 25 years. The cost of new transmission to tie the dendro-thermal plant to the island's grid is included in the capital cost estimate for the wood-fired generating plant.

9.3 DENDRO-THERMAL POWER GENERATION

The following section describes the use and results of the present value or discounted cash flow method of analysis as applied to the dendro-thermal electric power generating plant and its associated fuelwood plantation.

9.3.1 Generation Facility and Related Transmission

9.3.1.1 Investment

The investment associated with the actual generation of power includes the capital cost of establishing the wood

plantation and the capital cost of constructing the generating plant and associated transmission facilities. Each of these sets of costs will be presented independently to allow for a clearer comparison of costs between the plantation and the generating station. First, we will describe the generation facility. (See Table 9-1.)

The capital costs incurred in the site development and construction of the 2 megawatt dendro-thermal generation facility have been estimated to be P 48,045,536, based on the costs developed by MAIN's engineers. (See Table 9-1.) The total investment cost includes fuelwood processing facilities, the boiler turbine generator complex, and general plant services and support buildings.

As described in Section 4, additional transmission links must be constructed to connect the dendro-thermal station to the existing grid. The current transmission system extends from Nabas to within 6 km of the proposed plant site. The 69 kV line is estimated to cost P 200,000 a kilometer, for a total cost of 1,200,000. Distribution is also required at a unit cost of P 88,800 per kilometer for a 13.8 kV line of 3 km, for a total cost of P 266,400. Additional costs associated with the system amount to P 1,012,600 to form a total transmission and distribution investment cost of P 2,479,000, including substation and construction cost. These figures were based on recent transmission line installation experience of NPC from Santa Barbara to Pico La Paz in Antique, located on the west coast of Panay. The costs associated with this new transmission is included in the capital cost present worth analysis in Table 9-1.

The total capital necessary to construct these facilities is thus approximately 48 million pesos. Approximately one third will be completed in the first year, and two thirds in the second year. Construction is assumed to begin in 1981. The project was evaluated for a wide range of discount rates, 4 to 20 percent. The present value (1980) of these outlays for the various discount rates is shown at the bottom of Table 9-1.

TABLE 9-1

DENDRO-THERMAL PLANT INVESTMENT COSTS

1980 Pesos

1981		16,015,178
1982		32,030,358
	TOTAL	48,045,536

Present Worth Analysis

Discount Rate	Present Value
4.0	45,013,076
8.0	42,289,738
12.0	39,833,671
16.0	37,609,962
20.0	35,589,286

This small scale dendro-thermal generation facility is very capital intensive. Although the gross rated output is 2 megawatts, approximately 16.5% is for internal plant use. Thus, the net output is 1.67 megawatts. The cost per installed net capacity is then P 32,946 per kilowatt, or 4,452 dollars per kilowatt.

9.3.1.2 Operation and Maintenance

The total operation and maintenance costs for the dendro-thermal generating station were determined to be P 464,807 on an annual basis, including transmission, in 1980 pesos. The total annual cost for the plant was based on a combination of fixed and variable costs, excluding fuel costs. The station's staff, as discussed in Section 5.13 would consist of 29 people, including administration and technical personnel. This estimate was based on MAIN's experience with other wood-burning plants and an assessment of the local skills available in the Philippines to operate this plant. These salaries are consistent with present wage levels for the respective skills in the Philippines. The estimated operating cost includes both salaries and fringes. The variable operating and maintenance cost of the dendro-thermal generating plant was estimated at P 62.55 per kW installed by the NPC in April 1979, based on prior experience with other thermal plants. The Study Team escalated this amount by 15% to reflect inflation and additional costs related specifically to dendro generating facilities. Variable operating and maintenance expense includes the costs of the maintenance items, chemicals, and other miscellaneous goods required for operation. The total operation and maintenance costs for a wood-burning generating facility usually run higher than those for a conventional thermal station due to a higher degree of complexity in the equipment and the addition of a separate wood handling system.

The total annual operating and maintenance cost for the plant also includes the maintenance of the transmission line. This cost is estimated to be P 61,975, based on figures currently used by the National Power Corporation (April 1979) and represents 2.5% of the

TABLE 9-2

DENDRO-THERMAL PLANT OPERATING COSTS
(Excluding Fuel Costs)
1980 Pesos

Annual Operating and Maintenance Expenses (Excluding Fuel)

Generation Facility	402,370
Transmission Lines	61,975
	464,345

Present Worth Analysis

Annual Costs Incurred 1983-2007

Discount Rate (%)	Present Value
4.0	6,706,763
8.0	4,249,639
12.0	2,903,318
16.0	2,104,009
20.0	1,595,407

investment cost. The annual costs and present value of 25 years of operation, from 1983 to 2007, is shown in Table 9-2.

9.3.2 Plantation

9.3.2.1 Investment

The capital cost associated with the establishment of the plantation in the Nabas area, currently allocated for reforestation, was determined to be those one-time expenditures which were necessary to allow the first harvesting cycle to begin. These disbursements included site improvement and infrastructure, harvesting equipment, animal teams, chipping equipment, and trucks. The investment includes 15 kilometers of dirt roads at P 1,500,000/km for construction and 15 kilometers of gravel roads constructed at P 1,750,000 per kilometer for the transportation network from the forest to the plant. The total investment cost for roading is P 48,750,000 in direct costs, including the O&M cost for roading constructed in the first year. These investment costs were developed in the plantation management plan text. The costs were based on local equipment and construction costs in the Aklan area. The total costs, P 76,957,992, serve as the investment figure for the discounted cash flow analysis in Table 9-3. The road improvements were assigned as project costs although they may have other benefits to the region.

9.3.2.2 Operating Costs of Fuelwood Plantation and Transportation

It was estimated that the annual operation and maintenance cost of the plantation during the initial two-year planting cycle will be P 2,609,521. For the first two years, up to 300 persons are required to prepare the plantation areas, begin the nursery cycle, plant the seedlings, and perform weeding. Once the plantation has been established, the work force will be maintained by a staff of 275 persons at an annual cost of P 991,933. The total annual fixed and variable operating and maintenance costs are P 2,609,521 for plantation establishment and maintenance, and P 2,222,635 for plantation harvest.

TABLE 9-3

PLANTATION INVESTMENT COSTS

1980 Pesos

1981		51,305,328
1982		25,652,664
	TOTAL	76,957,992

Present Worth Analysis

Discount Rate	Present Value
4.0	73,049,376
8.0	69,497,958
12.0	66,258,475
16.0	63,292,839
20.0	60,568,790

The cost of transportation of the fuelwood includes those costs incurred in moving the wood after chipping from the landing to the unloading of the chips for processing at the plant site. It has been assumed that these trucks will not be owned or operated by the plant but, instead, the responsibility for transportation will be contracted out to an individual or group of individuals. The costs of the contracts are based on the current contract rates in the area, based on a fixed charge determined by the weight of the payload carried. The fixed charge is P 2 per tonne per kilometer on gravel roads, and P .90 per tonne per kilometer on concrete roads. Since the roads associated with travel to the plant are gravel, the P 2 per tonne charge was used. These costs are based on rates set for contracts through December 1979.

The total transportation cost is based on 7445 trips of 15 km with approximately 7.6 m^3 per 10 tonne truck to move the annual fuel supply of 26,800 tonnes of wood per year. The total transportation cost per annum was thus estimated at P 804,100. The cash flow for 25 years of operating the plantation is shown in Table 9-4, along with the discounted present values.

9.4 DIESEL GENERATION

The present electric system on the island of Panay is solely comprised of diesel generation facilities. The system will bring on three additional diesel generators at a new station located in Dingle in early 1980. This will bring the total firm power capability of the system up to 33 MW, (defining firm capability as the total of the system's potential power, less the largest unit). In order to compare an equivalent form of generation with the dendro-thermal plant, we have chosen the most likely alternative form that would be used --- diesel.

It is necessary to examine the costs associated with diesel generation because the underlying assumption of this project is that the use of the renewable energy source would ease the foreign exchange burden

TABLE 9-4

PLANTATION OPERATING COSTS, 1983-2007

1980 Pesos

1983	3,033,579
1984	3,026,735
1985	3,026,735
1986	3,026,735
1987	3,026,735
1988	3,026,735
1989	3,026,735
1990	3,413,621
1991	3,413,621
1992	3,413,621
1993	3,026,735
1994	3,026,735
1995	3,026,735
1996	3,026,735
1997	3,026,735
1998	3,026,735
1999	3,026,735
2000	3,413,621
2001	3,413,621
2002	3,413,621
2003	3,026,735
2004	3,026,735
2005	3,026,735
2006	3,026,735
2007	3,026,735

Present Worth Analysis

Discount Rate	4%	8%	12%	16%	20%
Present Value	44,986,629	28,435,606	19,372,521	13,999,196	10,586,746

TABLE 9-5

LEVELIZED PAYMENTS FOR FUELWOOD

(1983 - 2007)

Analysis 1: Average Operation and Maintenance Charges on the Wood Plantation Per Year:

P 3,142,809 or

P 117/tonne

Analysis 2: Average Operation and Maintenance Charges Plus 20% Per Year

P 3,771,371 or

P 141/tonne

Analysis 3: Investment (25-Year, 8% Loan by Equal Payments) Plus Operation and Maintenance Expenses

Loan Repayment	P 7,209,331
Operation and Maintenance	P 3,142,809
	P10,352,140

or P 386/tonne

Present Worth Analysis

(Pesos)

Discount Rate	Analysis 1	Analysis 2	Analysis 3
4%	45,393,134	54,471,763	149,521,042
8%	28,762,674	34,515,210	94,741,750
12%	19,650,421	23,580,507	64,726,781
16%	14,240,484	17,088,582	46,906,919
20%	10,798,140	12,957,768	35,568,134

by replacing the need for imported oil. The object of the dendro-thermal plant, therefore, is not to add two additional megawatts of energy to the island's system, but rather to replace two existing megawatts of diesel fired power. Thus, we have examined the operating costs of diesel generation over a life equal to the 25 years of dendro-thermal operation.

The amount of diesel power that was analyzed for operational cost was the same amount of salable power produced by the dendro-thermal plant, plus 3% which is absorbed by in-house use. This makes the number of kilowatt hours produced by the diesel to be 12,054,461 per year. The heat rate of the diesel plant is estimated to be 10,000 Btu's/kWh. To determine the cost of fuel per kWh, the Study Team used $1.16 per gallon based on the present wholesale world price for diesel fuel. These estimates reflect January 1, 1980 prices. To represent the annual fuel cost for diesel generation over time, it was necessary to escalate the fuel cost. MAIN estimated an escalation rate of 5% per annum until 1985 and 2% over the remainder of the term until year 2007. This method was chosen to reflect the upward trend of the price of diesel fuel to escalate above the rate of inflation.

Other operation and maintenance expenses were estimated to be P 65.79 per installed kW capacity from NPC records (April 1979). For 2 MW of diesel generation this cost is P 131,580 with an additional general administrative cost of P 2,632 per annum.

The results of the discounted cash flow analysis of operating an equivalent diesel plant from 1983 to 2007 are found in Table 9-6. The present value of the stream of costs in 1980 dollars is P 85,642,139 to produce 11,703,360 (net) kWh per year, discounted at 8%.

9.5 OPPORTUNITY COST OF CAPITAL

In order to give insight into an appropriate discount rate for the present worth analysis for comparing costs of alternative forms of

TABLE 9-6

DIESEL GENERATION OF 12,054,461 KILOWATT HOURS
OPERATING COSTS ONLY (1983-2007)

(1980 Pesos)

	O&M (Less Fuel)	Escalating Fuel Cost
1983	134,212	7,375,974
1984	134,212	7,744,773
1985	134,212	8,132,011
1986	134,212	8,294,652
1987	134,212	8,460,544
1988	134,212	8,629,755
1989	134,212	8,802,350
1990	134,212	8,978,398
1991	134,212	9,157,966
1992	134,212	9,341,125
1993	134,212	9,527,947
1994	134,212	9,718,506
1995	134,212	9,912,876
1996	134,212	10,111,134
1997	134,212	10,313,357
1998	134,212	10,519,624
1999	134,212	10,730,016
2000	134,212	10,944,616
2001	134,212	11,163,509
2002	134,212	11,386,779
2003	134,212	11,614,515
2004	134,212	11,846,805
2005	134,212	12,083,741
2006	134,212	12,325,416
2007	134,212	12,571,924

Present Value Analysis

Discount Rate	O&M (Less Fuel)	Fuel	Total
4%	1,938,490	138,373,614	140,312,104
8%	1,228,295	84,413,844	85,642,139
12%	839,161	55,839,084	56,678,245
16%	608,132	39,417,751	40,025,883
20%	461,129	29,271,993	29,733,122

generation, the opportunity cost of capital in the Philippines was examined. It would appear that the "real" cost of money, without inflation, is around eight percent. MAIN performed sensitivity studies ranging from 4% to 20% discount rates.

In the case of utility projects which are capitally intensive, the majority of debt generated would be from foreign sources. This is especially true in the Philippine experience where the pursuit of rapid development has exhausted the local market for funds and forced the government to seek funds elsewhere. Therefore, when examining the cost of capital in a utility context, it is necessary to explore the cost of raising foreign capital and equity investors as well as local capital.

One of the factors having an influence on the interest rates that must be paid overseas is the debt service ratio of the borrower. The debt service ratio is the comparison of the sum of interest payments and repayment of principal on external public debt to the inflow of foreign exchange earned on exports by the individual country. The current debt service ratio is near 20% for the Philippines which is the ceiling that has been set by the IMF. The IMF has set 20% as the limit because it feels that borrowing above this level would make debt servicing an impossible burden.

The Philippine government has petitioned the IMF to increase the limit allocated for acquiring debt. In the meantime, the government has been dealing in supplier's credits and special leasing arrangements not requiring government guarantees which are not limited by the IMF in order to proceed with development plans. The high debt service ratio and the recent increase in the volume of foreign borrowing have substantially increased interest rates. In the past, the external financial needs of the Philippines have been met primarily by international agencies whose interest rates have been between 8.7 and 9%. These 'soft' funds have become scarce, however. The alternative is commercial banks.

The most common measurement of the commercial bank U.S. dollar rate is the London Interbank Offer Rate (LIBOR). The spread is currently

one to two points above LIBOR, depending on the borrower's credit status. The LIBOR rate is currently in the 17% range and government agencies have been obtaining a spread of .75 points above LIBOR, with private companies receiving 1 to 1.25 points above the going rate.

The above rate is a nominal interest rate and reflects the movement of the market in relation to demand and inflationary pressures. In order to determine the true or real economic cost to the Republic of the Philippines of borrowing these funds, inflation must be taken out. If the nominal cost of money is 18 percent and inflation is considered to be 10 percent, then the real cost of money is 7.3 percent.

The real opportunity cost of capital in the United States is generally considered, on average, to be a lower rate than 7.3 percent, and private investments in the Philippines generally yield much higher than 8 percent real return, depending on risks. Thus, MAIN has parameterized the cost of capital from a low of 4 percent to a high of 20 percent.

In discounting future costs for economic analysis, it is important to choose a discount rate which is appropriate for the prices which are being discounted. If future prices are expressed in constant terms, the cost of capital should not include any allowance for inflation. Analysis of historic real rates of return permits an estimate of the probable future cost of money to be made by discounting for the effects of anticipated inflation.

9.6 COMPARISON OF DENDRO-THERMAL VERSUS DIESEL ALTERNATIVE

There are several levels of economic comparisons which MAIN has derived, based on the needs of AID. The analysis is confounded by whether, and how, the very large investments needed for the dendro-thermal generation facility and plantation are incorporated. First, we will examine the operating characteristics of a small dendro-thermal plant versus diesel. Then, we will examine the costs including investment considerations.

9.6.1 Comparison of Operating Costs

Estimates for operating the dendro-thermal plant and plantation appear in Tables 9-2 and 9-4. The average cost estimate for maintaining the plantation, harvesting the wood, and delivering the wood to the dendro-thermal plant is, roughly, P 3,142,000 per year for 26,800 tonnes of wood, or an average cost of P117 per tonne (excluding the plantation investment). Together with the cost of operating the dendro-thermal plant, P 464,345 per year, the total annual operating cost of producing power from wood would be, roughly, P 3,600,000. If the plant's net production is 11,700,000 kWh, then the annual operating cost is P .308/kWh.

By comparison, the estimated operating cost of producing equivalent power from a diesel generator in 1983 would be, roughly, P 7,500,000. (See Table 9-6.) This assumes a wholesale fuel price of, roughly, $1.16 per U. S. gallon in January 1980 constant dollars. The net kilowatt hour cost is, roughly, P .64, or nearly double the wood-burning facility. If it is assumed that the price of oil will continue to rise above the rate of inflation and the economies of the dendro-thermal plant remain the same, then the cost differential becomes ever larger after 1983.

There are several ways of looking at the levelized cost characteristics of the plantation. Table 9-5 shows three analyses of levelized annual charges which may be applied for wood received at the plant. Analysis 1 is the same as the one discussed above. Analysis 2 applies an increase of 20 percent for hiring subcontractors for planting and harvesting. Analysis 3 includes all the plantation costs, including the investment. It assumes a separate corporation is established to build the plantation and roads and supply the dendro-thermal plant with wood. If the plantation investment of P 76,958,000 is financed with a loan to be paid back in equal payments for 25 years at an 8 percent interest rate above inflation, then the loan repayment is $7,209,000 for an annual total cost of P 10,352,140 just for the plantation costs. Including the cost of operating the dendro-thermal plant increases the annual operating budget to P 10,800,000 per year.

The operating cost for diesel generation does not exceed this cost until 2000 assuming MAIN's escalation rate for oil prices.

Including the time value of money in the analysis, Table 9-7 presents comparisons of present worth analyses for various discount rates. It can be seen that just the operating cost of the dendro-thermal plant (line 2.c, 3.d, or 3.e) is significantly less than the totals for the diesel option (line 4.c) for all discount rates. Yet, if loan repayment for the plantation investment cost is included in the "operating cost" (line 3.b), then the dendro-thermal option is significantly more expensive than generation by diesel under the assumed fuel escalation rates.

9.6.2 Comparisons Including Investment Considerations

Because the dendro-thermal plant is of such a small size and therefore cannot achieve significant returns to scale, the investment costs are extremely large compared to the operating costs. Including the investment costs in the present worth analysis for the dendro-thermal alternative (line 3.a) shows that, at an 8% discount rate, the present worth value is 69 percent higher than the operation of equivalent diesel (line 4.c).

Interestingly, line 3.c shows that, if a similar plant were located where the plantation investment was negligible (wood available and easily harvested), then even a 2 MW plant would be viable compared to operating diesel generation at less than an 8 percent discount rate.

9.6.3 Sensitivity Analysis, Reduction in Output from Dendro-Thermal Plant

If the dendro-thermal plant's output is reduced by 12.5 percent, which is possible if the rainy season significantly hampers wood harvesting operations, then the equivalent diesel option appears in line 4.d for comparison with the dendro-thermal costs which remain the same. This does not significantly change the comparisons mentioned above.

9.6.4 Oil Price Considerations

The analysis presented is very much dependent on the world price of future oil. A moderation in oil prices would mean the dendro-thermal option is less attractive, while higher escalation rates increase the viability of such a project.

9.7 ALTERNATIVE USES OF THE WOOD

The purpose of this section is to identify existing markets for the species utilized for reforestation and the impacts these competing markets could have on the price and supply of the fuelwood for the dendro-thermal generating plant. Recognizing that an increase in the price of one of the alternative uses for the fuelwood could result in the wood being diverted from the plant in a free market system, MAIN recommends that the plantation should be owned and operated by the owners of the dendro-thermal plant. Under these circumstances, the fuelwood would continue to be produced for the plant up to the point that the wood could be sold for an alternate use at a price higher than the cost of the next competing available fuel. At that point, it would be more economic to sell the wood at the higher price and buy the cheaper fuel to operate the plant. It is therefore important to examine the existing markets for the tree species to determine if any developed competition exists. The following section evaluates six of these markets. Approximate (1979) prices per green tonne are presented for each alternative use where possible.

9.7.1 Industrial Firewood

There is currently a market on Panay for firewood used as a secondary fuel to fire industrial boilers. The market for the back-up fuel is comprised primarily of two sugar centrals which burn bagasse, the waste product of the sugar cane, as fuel for processing. Traditionally, oil has served as the supplementary fuel for the boilers, but the current trend in oil prices has made most other alternative fuels attractive. The

sugar centrals would prefer to buy as much wood as they could to augment the bagasse supplies and displace as much oil as possible. At the present time, this firewood market has been restricted to an area located in relatively close proximity to the sugar centrals.

Leucaena is the primary species used for firewood. In 1979, one of the sugar centrals, Central Santos Lopez, was paying P 120 per ton for leucaena delivered in 3-meter lengths to the plant. (For domestic use leucaena is usually split and cut into short lengths to be bundled.) Leucaena is also sold on the open market for commercial use by cubic meter lots of stacked wood. The stacked cubic meters have a market value of P 70 to P 90. This roughly equates to P 92 to P 118 per green tonne. Prices for firewood on Negros (in the form of chips) is also P 125 per tonne delivered to the buyer. This industrial use of firewood is directly competitive with domestic firewood use and is a potential competitor for wood raised on the fuelwood plantation. It should be noted, however, that the demand for industrial firewood by the sugar centrals on Panay is a seasonal demand as the centrals are operated only half of the year during harvesting season. The pressure on the firewood supply is somewhat lessened by the fact that bagasse is their primary fuel and wood provides only the supplementary firing fuel. The sugar centrals do not foresee a time when they would depend on wood entirely as their secondary fuel source. The purchase price for this firewood is also influenced by the distance that it is hauled. Beyond a certain geographic area, it no longer becomes economical to haul the wood into the area.

9.7.2 Domestic Firewood

The primary use of firewood on the Island of Panay is fuel for domestic cooking and heating. Even in those homes supplied with electricity, use is almost exclusively for lighting and, therefore, residents are still dependent on the local supply of wood for household use.

The majority of domestic firewood is sold in bundles approximately one foot in diameter by two feet long. Whole logs are sold

at a price of P 30 per cubic meter stacked. The smaller household bundles sell for a price of P 1. This equates to 80 pesos per cubic meter (roughly one tonne) of green wood. Leucaena is the most common species used as firewood on Panay. The extreme shortage of firewood due to high consumption and lack of planned source regeneration programs has forced the suppliers of fuelwood to turn to gathering the bases (petioles) of coconut fronds and bundling them to augment wood supplies. As firewood becomes scarcer in the urban environs, the wood will have to be transported greater distances to maintain the present level of supply. This additional transportation charge will necessarily be added to the present price of firewood. Therefore, the combined forces of a limited supply and escalating transport costs can only continue to put upward pressure on fuelwood prices.

As the population on the Island of Panay increases, the demand for firewood should increase proportionately. This population growth taxes available firewood supplies in two ways: (1) by increasing the actual volume of firewood required, and (2) further denuding existing forested areas by a larger population practicing slash and burn agriculture. Some of this growth in demand for firewood could partially be met by including additional areas on the fuelwood plantation for domestic firewood supplies to be grown. This would have the dual purpose of protecting the rest of the plantation from local insurgents and stabilizing the price of domestic firewood to some degree by increasing the available supply to the populace. If this step is not taken, the scarcity of the firewood supply could bid the price up beyond the reach of many. MAIN recommends that, in addition to areas required to supply fuelwood to the dendro-thermal plant, other areas be reforested to produce domestic firewood to meet an existing and certainly growing need to supply both heating and cooking energy which would not otherwise be provided by the 2 MW plant.

9.7.3 Charcoal

There is an existing market in the Philippines for charcoal to be used as fuel for smelting and chemical processes. The advantages of

charcoal over green wood are a high, even level of heat and a low level of secondary combustion products. The production of charcoal requires the partial combustion of green wood in a low oxygen atmosphere. This process results in a greater heating value per tonne of fuel (wood vs charcoal), but at a greater absolute cost and cost per million Btu's (MBtu).

Leucaena is presently being used to produce charcoal. The charcoaling process increases the heating value per tonne of fuel at an additional cost per MBtu. The increased cost does not make charcoal a realistic alternative fuel for the dendro-thermal plant. However, the market for charcoal in other areas does represent a competitive market for the fuelwood produced in the Nabas Reforestation Area.

Charcoal is being used in a number of locations in the Philippines for industrial processes. The demand for charcoal for these tasks has been such on Mindanao that it has been profitable to import the wood from as far as Northern Samar by boat. Currently, one forest products firm is paying between P 470 and P 510 per tonne, based on quality and transportation distance of the charcoal to their plant on Mindanao. This equals approximately P 102 to P 111 per cubic meter of green wood.

It appears at this time that use of potential fuelwood species as charcoal for industrial purposes could prove to be a lucrative alternative use. The final evidence for using leucaena has not yet been presented, so this question remains somewhat hypothetical. The amount of charcoal required will be a function of number of industries who can or do use this form of fuel in processing when it is the cheapest alternative. It would appear that this market should show substantial growth and then level off.

In the case of the fuelwood plantation, it would again seem that it is more economical to produce fuelwood for the plant and not produce charcoal up to the point that the price paid for charcoal is above the price of oil.

9.7.4 Sawtimber

The two species recommended for the proposed fuelwood plantation are leucaena and casaurina. At this time neither species is currently being raised and sold for commercial sawtimber. Both species, however, are now being used as crude construction materials by the local populace where they are available. Especially in the case of leucaena, the species is relatively new to the Philippine forest industry and the full spectrum of its uses are still being explored. Because of its rapid growth, MAIN has estimated that leucaena could be harvested for sawtimber between twelve and fifteen years of age. In order to determine the effect of a competing commercial market in leucaena and casaurina, current market prices for similar species commercially available have been extrapolated. A species with similar rapid growth characteristics is the gmelina. It is harvested for sawtimber between twelve and fifteen years of age. Gmelina was selling for P 3700 per thousand board feet (MBF), kiln-dried. The costs associated with the finished product are P 375 per MBF for shipment to the sawmill, and P 150 per MBF for processing at the mill, based on December 1979 estimates of a products firm based on Mindanao. Assuming a 50% efficiency in sawing lumber, this equates to, roughly, P 675 per cubic meter of green wood.

As the demand for wood products increases and the worldwide availability decreases, it becomes more likely that fast-growing hardwoods, such as leucaena and casaurina, will become commercially acceptable. Within the 25-year useful life of the dendro-thermal plant, this seems probable. An alternative use of the plantation is, therefore, sawtimber. With proper planning and foresight, sawtimber and fuelwood need not be incompatible end products of the plantation. Thinning in a sawtimber stand can provide fuel for generation and provide intermediate income during the longer term sawtimber investment. A local sawmill may be powered by energy from the dendro-thermal plant, and waste from the sawmill can be used as fuel for generation. The compatibility of fuelwood and sawtimber, or the conversion from the former to the latter, will depend on both biological and economic variables.

9.7.5 Alcohol Production

The technology for converting biomass to alcohol has long been known. The basic process involves the biological conversion of starches and sugars to alcohol. As such, the best biomass materials include those with a high carbohydrate content; e.g., bagasse, yucca, etc. Wood is a relatively poor material for alcohol production, not only because of its carbohydrate content, but because lignin is difficult to break down in the most common alcohol-producing reactions.

Although some preliminary computations have indicated that the economic return from wood-based alcohol production may be attractive [19/], there is no indication that an adequate market exists for the product. If a market were to develop (for example, if gasohol were to become politically or economically popular), then other sources of raw material for alcohol production would be more logical. Several countries, most notably Brazil, have highly developed alcohol industries and, in each case, materials high in carbohydrates (e.g., sugar cane and cassava) serve as a raw material. Commercially viable, wood-based alcohol production is not considered a realistic alternative market for the fuelwood plantation within the plant life.

9.8 CONCLUSIONS: THE ECONOMICS OF DENDRO-THERMAL GENERATION

The present study addresses only the economic feasibility of dendro-thermal generation on Panay. Other than diesel, no alternative means of generation have been addressed or an "optimum" mix of generation within the short or long term. The relatively large investment of the dendro-thermal plant may appear less attractive if evaluated in light of these other considerations.

Considering potential alternative markets for wood raised in the reforestation area, a fuelwood plantation may be a reasonable investment with or without a power plant. The major cost associated with plantation establishment is for roads. These roads should possibly be considered part of a long-range regional development plan. As such, the costs would not be strictly allocated to the project, thus making the project even more economically attractive.

The study shows that the operating costs of raising wood and utilizing it as a generation fuel on Panay is presently more economical than diesel generation. The disadvantage of the proposed plant includes the relatively high investment per unit output. With a larger plant and its associated economics of scale and more favorable conditions for the fuel plantation, dendro-thermal generation may be a very attractive alternative to oil-based generation in the Philippines.

TABLE 9-7

COMPARISON OF DENDRO-THERMAL AND DIESEL GENERATION

Present Worth Analysis
(1980 Pesos)

	Discount Rate				
	4%	8%	12%	16%	20%
DEN. ?-THERMAL OPTION					
1. Investment, 1981-1982					
1.a Generation Facility	43,013,076	42,289,738	39,833,671	37,609,962	35,589,286
1.b Plantation	73,049,376	69,497,958	66,258,475	63,292,839	60,568,790
1.c Sub-Total	116,062,452	111,787,696	106,092,146	100,902,801	96,158,076
2. Operating Expenses, 1983-2007					
2.a Generation Facility	6,706,763	4,249,639	2,903,318	2,104,009	1,595,407
2.b Plantation	44,986,629	28,435,606	19,372,521	13,999,196	10,586,746
2.c Sub-Total	51,693,392	32,685,245	22,275,839	16,103,205	12,182,153
Levelized Wood Payment Plans					
2.b.1 O&M Only	45,393,134	28,762,674	19,650,421	14,240,484	10,798,140
2.b.2 O&M + 20%	54,471,763	34,515,210	23,580,507	17,088,582	12,957,768
2.b.3 O&M + 1.b Loan Repayment Plan	149,521,042	94,741,750	64,726,781	46,906,919	35,568,134
3. Totals					
3.a All Costs 1.c + 2.c	167,755,844	144,472,941	128,367,985	117,006,006	108,340,229
3.b O&M + Plantation Loan 2.a + 2.b.3	156,227,805	98,991,389	67,630,099	49,010,928	37,163,541
3.c O&M + Generation Facility, 1.a + 2.c	94,706,468	74,974,983	62,109,510	53,713,167	47,771,439
O&M Only					
3.d 2.a + 2.b.1	52,099,897	33,012,313	22,553,739	16,344,493	12,393,547
3.e 2.a + 2.b.2	61,178,526	38,764,849	26,483,825	19,192,591	14,553,175
DIESEL OPTION					
4. Operating Expenses, 1983-2007					
4.a O&M (Less Fuel)	1,938,490	1,228,295	839,161	608,132	461,129
4.b Fuel	138,373,614	84,413,844	55,889,084	39,427,751	29,271,993
4.c Total	140,312,104	85,642,139	56,678,245	40,035,883	29,733,122
4.d Operating Costs for 12.5% Reduced Output from Dendro-Thermal Plant	122,773,091	74,936,872	49,593,464	35,031,398	26,016,482

10 INSTITUTIONAL CONSIDERATIONS

The analysis and recommendations made in this report have been done so with no reference to the institutional body, or bodies, which will be responsible for the operation and, ultimately, the success or failure of the proposed project.

Both the National Power Corporation (NPC) and National Electrification Administration (NEA) are charged with generation and "distribution" of electrical energy. The areas of responsibility of each entity are basically determined by the magnitude of the generation project. The NPC is responsible for larger generation projects; e.g., the generation units at Dingle and Panitan, and transmission. The NEA is generally responsible for smaller generation projects and the distribution of power purchased from NPC. Area cooperatives are the responsibility of NEA. Both agencies apparently possess the technical expertise to operate and maintain the dendro-thermal generation unit.

Neither agency, however, can provide the expertise in the field of forestry necessary to establish and manage the fuelwood plantation. Only the Bureau of Forest Development (BFD) presently has a technical infrastructure approaching that required by the proposed dendro-thermal project. However, two factors suggest that the BFD may not provide the "best" alternative to management of the fuel plantation. First, the BFD is legislatively charged with the (re)establishment and husbandry of the Philippine forest resource. This does not include the harvest of that resource; i.e., the BFD could not provide the complete range of services, specifically harvesting, required for the production and delivery of fuelwood to the dendro-thermal plant.

Secondly, data indicate that the costs of BFD administered projects and activities are significantly higher than those of similar projects and activities carried out by private companies and individuals. This does not necessarily imply inefficiencies on the part of BFD, but may reflect different

project goals between BFD and the private entities. Nevertheless, for the dendro-thermal plant to be economically viable, the entity responsible for plantation management and fuelwood production must strive for maximum efficiency.

Three basic alternatives exist for the production of fuelwood. The first is that the mandate of the Bureau of Forest Development be expanded to permit its participation in the harvesting of forest resources. The basic philosophies of the BFD would have to be redirected toward increased project efficiencies rather than other public goals.

The second alternative requires the establishment of forestry expertise within the agency responsible for the dendro-thermal project. This would require developing a staff of graduate foresters and technicians to administer the fuelwood plantation. Under this scenario, the fuelwood production would be under direct control of the project management.

The third alternative involves the management of the fuelwood plantation by private individuals or entity. The management of the dendro-thermal plant would contract for the production and delivery of fuelwood to the plant site. Under this scenario, a private forestry company could manage the plantation and "sell" fuelwood to the plant. Likewise, a fuelwood cooperative could produce the fuelwood. The concept of wood-producing cooperatives is presently being employed by the Paper Industries Corporation of the Philippines (PICOP) to successfully produce pulpwood in Mindanao. Small farmers tend forested areas and, with technical advice provided by PICOP, produce wood and sell it to PICOP at prices frequently lower than those from larger producers.

These latter two alternatives may present difficulties in that the plantation area is located on government land administered by BFD. The legal feasibility of non-BFD management on this land must be investigated.

The 25-year life of the dendro-thermal project provides ample time to establish plantation management policies. However, if the dendro-thermal plant is to be constructed and is to go "on line" within the time frame necessary to be beneficial, then a major organizational effort is required to establish the fuelwood plantation within the short time period of two years. No new organization could be established and be expected to carry out a reforestation effort of the magnitude proposed for this project in a two-year period. The only organization which could possibly muster the technical and logistic capability within this short time is the Bureau of Forest Development. Therefore, it is recommended that the initial phases of the plantation establishment and management be accomplished via the established BFD organization. Once the initial phase is completed, alternative management schemes may be considered.

Another critical component in meeting the proposed project schedule (see Section 7) is the initial coordination between institutions and agencies during the latter part of 1980 and first months of 1981. Primary aspects of project organization must be completed before the initiation of the 1981 planting season if the necessary reforestation effort is to be completed as scheduled. If not completed, the danger exists that fuelwood will not be available in sufficient quantities to meet the fuel requirement of the plant during the first year of operation.

As with any project, a well-organized training program must be prepared and implemented beginning in the earliest stages of the program. This includes training of plant operators to operate and maintain the plant equipment, as well as field personnel in the fuelwood plantation.

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APPENDIX A

GENERAL SITING METHODOLOGY

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GENERAL SITING METHODOLOGY

The siting of any facility follows a basic sequence of events which, if correctly carried out, will identify a site for the facility which optimizes conditions within the context of the siting methodology.

The first step in the siting sequence is to identify those parameters important in selecting a suitable site for the facility. These parameters will, of necessity, depend on the range of conditions; e.g., geographical or biological, which must be considered. For example, if the purpose of the siting study is to select a site for a dendro-thermal plant within the Republic of the Philippines, the parameters must include a much wider range of conditions than if only the Island of Panay is to be considered. Likewise, the siting parameters and their detail will vary as a function of the final site detail required. If only the identification of a suitable area (several square kilometers) is required, siting parameters will differ from those necessary to identify a specific plant site (a few hectares) where construction can begin. The following parameters are considered minimal for siting a dendro-thermal plant in the general area near the Nabas Reforestation Area where fuelwood will be produced. Additional parameters may be included as area-specific conditions become evident.

Water Availability - The proposed 2 MW generating facility will require 206 gpm of water for cooling and makeup water needs. This water must be available year-round, even during low-flow periods if the plant is to continue generation. Flow data, especially for low-flow periods (roughly, June through September), must be developed through direct monitoring of the Gibon River and any other waterways to be considered, or through appropriate hydrologic correlation studies. Different points on any one waterway; e.g., above and below points of confluence with major tributaries, should also be considered.

Downstream Water Uses - Users of water downstream of the proposed plant site must be identified, as well as their approximate water requirements. During low-flow periods, adequate water may be available to meet both the requirements of the dendro-thermal plant and the downstream users.

Environmental Considerations - The proposed dendro-thermal plant will have two effects on the aquatic ecology of the Gibon River (or other water body) downstream of the plant. Total flow will be reduced and water temperature will be increased. A detailed siting study should determine if these two factors will result in unacceptable adverse impact to the downstream ecosystem.

The above factors will determine the adequacy of the Gibon River as a source of plant cooling/makeup water. If flows are inadequate, other sources of water must be considered as a primary source or supplementary source (during low-flow periods). This may include other waterways or the use of ground-water.

If the Gibon River, or a certain segment of it, can serve as an adequate water source, the next step in siting is to determine those areas near the river which can (or cannot) serve as potential plant sites. By identifying exclusionary areas (areas which cannot or should not be used as a plant site), remaining areas represent potential plants. Factors to be considered in identifying exclusionary areas include the following:

Land Use - The proposed plant site will require approximately 10 hectares of land. Areas considered exclusionary may include residential areas; primary irrigation canals; and agricultural areas of significance; e.g., research areas.

Miscellaneous Considerations - Other factors, such as susceptibility to flooding, may be considered as an exclusionary area.

With the identification of exclusionary areas, the plant site can be selected by applying any additional selection criteria to the remaining areas. These criteria may include geological/foundation considerations, ease of road building, etc.

APPENDIX B

COMPUTATION OF PROJECT REQUIREMENTS

GENERAL PROJECT REQUIREMENTS

FUELWOOD REQUIREMENTS FOR GENERATION

For 2 MW 7,930 lbs. of wood/hour at 35% moisture content (green basis)

7,930 lbs/hr ÷ 2,200 lbs/tonne (metric ton) = 3.60 green tonnes/hr.

3.60 tonnes/hr * 24 hrs/day * 310 operating days/yr =
26,784 green tonnes/yr
≅ 26,800 green tonnes/yr

GROWTH RATE OF FUELWOOD PLANTATION

Assumed 10 bone dry tonnes per hectare per year (bdt/ha/yr) (see Section 6.2.3)

@ 35% moisture, 10 bdt/ha/yr = 15.4 green tonnes/ha/yr (gt/ha/yr)

Harvest after a two-year rotation will yield:

15.4 gt/ha/yr * 2 = 30.8 gt/ha ~ 31 gt/ha

Harvest after a three-year rotation will yield

15.4 gt/ha/yr * 3 = 46.2 gt/ha ~ 46 gt/ha

LAND REQUIREMENTS

To accelerate the project in-service date, the harvest operation will begin two years after the initial planting. Thereafter, three year old trees will be harvested.

To meet the annual fuel requirement of 26,800 green tonnes/year by harvesting after a two-year rotation

26,800 green tonnes/year ÷ 31 green tonnes/hectare =

876 ha/yr must be harvested during the first year of harvest.

Thereafter, to meet the annual fuel requirement of 26,800 green tonnes/year by harvesting after a three year rotation

26,800 gt/yr ÷ 46 gt/ha 585 ha/yr must be harvested

Therefore, the total area required for a three year rotation fuelwood plantation is:

	865 ha (for year 1 harvest)
	585 ha (for year 2 harvest)
	585 ha (for year 3 harvest)
Total Area Required:	2,035 ha (for a 3 year rotation)

ACCELERATED PLANTATION ESTABLISHMENT

To shorten the period of time between project initiation and plant start-up, a "normal" three year planting schedule is shortened to two years. This is accomplished by planting during the first planting year that area which will be harvested during the first two years. That area planted during the second planting year will be harvested during the third year of harvest. For example:

Area 1 - 865 ha	- Planted Year 1;	Harvested Year 3;	Two years old
Area 2 - 585 ha	- Planted Year 1;	Harvested Year 4;	Three years old
Area 3 - 585 ha	- Planted Year 2;	Harvested Year 5;	Three years old

During Year 6, Area 1 will again be ready for harvest at three years old, and so on.

Therefore, during Planting Year 1, all nursery activities, land clearing, planting, and weeding must result in the reforestation of 1,450 ha (865 ha + 585 ha). During Planting Year 2, this effort is reduced to the level necessary to reforest 585 ha.