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TRIAL YEAR PROGRAM PROPOSAL
NONG YAI SUGAR MILL

THAILAND

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PREFACE

This report contains a proposal for a one-year trial program for a cane energy project at the Nong Yai Sugar Mill in Chonburi, Thailand. The proposal was prepared in July and August, 1987 by a team of specialists sponsored by the Cane Energy Assessment Program of USAID and was carried out with the cooperation of USAID Bangkok, the Ministry of Industry, the Electric Generating Authority of Thailand, and the Management of the Nong Yai Mill.

At the time of writing it was unclear whether the trial year would be carried out exactly as proposed, but we at the Assessment Program concluded that the proposal and the associated Memorandum of Understanding (included here as Appendix C) would be of interest to many in the cane and energy communities who are familiar with the Thai project and the earlier pre-feasibility study entitled ELECTRIC POWER FROM CANE RESIDUES IN THAILAND: A TECHNICAL AND ECONOMIC ANALYSIS.

A distinctive feature of this proposal is that is was designed to form the basis for negotiations among the interested parties, helping to clarify the circumstances under which those parties, the national utility, private investors, and the many farmers, would experience a net gain from the experiment. To facilitate agreement, the team distributed the computer worksheet program projecting costs and benefits to give interested parties the opportunity to depict alternative scenarios and, if they wanted, examine and alter working assumptions.

Note that the proposal is the work of the team of experts and neither the actions it suggests nor the outcomes it depicts have been endorsed by USAID Bangkok, USAID Washington or the Cane Energy Assessment Program.

TRIAL YEAR PROGRAM PROPOSAL
CANE/ENERGY PROJECT, NONG YAI MILL

Introduction

This document summarizes the key elements of an implementation plan for a cane/energy trial year program proposed for the Nong Yai mill in the Eastern Region of Thailand. The plan was prepared by a team of specialists who worked closely with the technical staff of the mill, and served as the basis for discussions between the Ministry of Industry, the Electric Generating Authority of Thailand, the Management of the Nong Yai mill and USAID concerning the implementation of the proposed program. The proposal for a trial year program is based on the findings and recommendations in the lenghthier study entitled "ELECTRICITY PRODUCTION FROM CANE RESIDUES IN THAILAND: A TECHNICAL AND ECONOMIC ANALYSIS", completed in October, 1986. Readers interested in further technical information on such matters as the importance of electricity to Thai development and the widespread rural benefits stemming from the use of cane residues (tops and leaves) may wish to consult that study.

The proposed program has two primary objectives:

1. To demonstrate steady, controllable generation of electricity by the sugar industry both during and out of the processing season.

2. To determine the costs and agronomic impacts of collection, storage and transport of cane tops and leaves in Thailand and estimate the quantity that may be available as fuel.

It is the hope of the parties cooperating in the demonstration that if the program is successful, it will lead to commercial ventures with the goal of proving the economic attractiveness of this new source of power, while at the same time contributing to the welfare of sugar farmers, millers, and rural communities.

It is important to stress that the plan presented here is for an interim or "test" year, and arrangements suggested should not be considered binding on the institutions involved for future years. Because the program is a trial, involving production at a smaller than optimum scale as well as the testing of different harvesting, storage and transport methods, projected costs are considerably higher than might be expected if the demonstration leads to commercial operations in the future.

The analysis of costs and benefits, presented below and in Table 1, is based on the team's belief that, for the trial year, all parties involved should emerge as "winners." This means that the Ministry of Industry and the Sugar Board, along with USAID, should gain the information needed to determine the attractiveness of cane/energy production, the sugar mill lending its facilities for the trial year should not suffer financial loss, the farmers should receive compensation for the

provision of cane tops and leaves, and the Electric Generating Authority of Thailand should receive electricity at a price low enough so that it does not have to subsidize the experiment. The terms suggested below are designed to achieve these objectives.

Program Summary

The technical team recommends the following program for the trial year.

1. The generation of four megawatts of electricity for at least 210 days by the Nong Yai mill, using one 120 tonne/hour boiler and one 8000 MW turbogenerator, resulting in the production during the off-season of 3,750 kilowatts of power for export to the utility and 250 kilowatts of electricity for internal use in the mill. The production level chosen is based on the limits imposed by the existing transformer equipment at the site. For an illustration of the costs and benefits associated with a higher export level, see Table 2.

2. The production of up to 100,800 tonnes of excess bagasse to be used as fuel in the trial year, with any shortfall in this bagasse fuel to be made up by purchases of bagasse from other mills in the region.

3. The harvesting of 20,000 to 24,000 tonnes of unused cane residues (tops and leaves) during the harvest season, to be stored for subsequent transport to the mill during the off-season.

Successful completion of this program will require, among other things:

a) the purchase and installation of new equipment in the power plant of the sugar mill;

b) the purchase of harvesting equipment for tops and leaves; and

c) the creation of a management system to plan and execute the program and oversee the collection of information.

Specific steps that need to be taken by those implementing the trial year are detailed in appendices A and B, attached.

Management

To assure the success of the trial year program the team recommends that USAID appoint a full-time coordinator to:

a) work closely with the institutions involved and the mill to make sure that all parties are informed concerning the progress of the program as it proceeds;

b) schedule, and assist, the work of consulting specialists in preparing the power system for off-season production and planning the harvest of fuel; and

c) supervise the collection of data that will be the basis for evaluating the program.

Administrative personnel needed by the mill are described in the Appendices. These include, at a minimum, a trained engineer to work with the power system and an experienced agricultural field manager to plan and implement the harvest, storage, transport and preparation of leaves and tops.

Costs and Benefits

The costs and benefits of the program outlined here are summarized in Table 1. They reflect an analysis of the "base case," described above, involving four megawatts (MW) net power export from the steam plant using 108,000 tonnes of bagasse and between 20,656 and 24,231 tonnes of tops and leaves (25%-35% moisture) for 210 days in the off-season. The mill will also attempt to export power during the 1988/89 milling period, as described in Appendix A, if equipment modifications can be completed before milling begins. More bagasse will be needed during this period. Surplus electricity will be generated during milling to show the mill's ability to hold power export constant while processing cane.

1. Fuel

The fuel quantities were determined by:

a) mill estimates of available bagasse; and

b) the quantities of tops and leaves that would provide a robust basis for trying different harvesting, storage and transport techniques while not exceeding the administrative and logistical limits of a test program.

Prices for mill bagasse (opportunity cost) are based on prices received in 1987 for bagasse sold to a paper facility in the Central Region. Prices for purchased bagasse are based on this price plus transport charges. Prices paid to farmers for the collection of residues (currently burned as waste) on their land has been set at 50 Baht/ton*. This is a fee to the farmer beyond the costs of harvesting and delivering the residue.

The team strongly recommends that the mill also consider the possibility of creating a market for usable agricultural residues delivered to the mill by posting a price of 200-250 baht per ton (at 25% moisture) to farmers who, on their own initiative, would like to take advantage of the trial year program

2. Capital Equipment

The type of capital investments required in the field and power plant are described in Appendices A and B. Prices for equipment are in U.S. dollars delivered to the site in Thailand. Capital investments have been amortized at 20% annual interest for five years.

*For reference, US $1 = Baht 25

3. Electricity Prices

Electricity prices are of two kinds: the price received by the mill for the sale of electricity; and the price credited to the mill for "displaced" electricity (electricity the mill now purchases from the grid but will supply through its own production during the trial year).

The price chosen by the team for electricity sold to the grid (1.10 Baht/kWh) is the lowest price which allows the mill to "break even" with a reasonable cushion (21 days) to accommodate the possible need to stop electricity production because of unforeseen problems, while compensating farmers at a modest level for the tops and leaves collected in the demonstration. This price is below the current average transfer price (1.26 Baht/kWh) which is also the price used in Table 1 to calculate benefits received by the public utility.

The price chosen by the team to value "displaced" internal electricity use (2.03 Baht/kWh) is the average price actually paid in 1986/87 by the Nong Yai mill in the "off-season".

4. Technical Assistance

The team recommends that The Ministry of Industry and USAID provide assistance of two kinds: a) six sets of equipment (balers, rakes, loaders) needed for the harvest of tops and leaves; and b) a project coordinator and a range of technical specialists to assist the mill in planning and implementing the trial year program and monitoring the results of that program. See Table 1 for estimates of the cost of this assistance. The availablity of either kind of support has not been determined at the time of preparation of this implementation plan.

5. Research

An important part of the trial year program is the collection of information concerning the technologies used, the costs of production of fuels and electricity, and the impact of harvesting trash residues on the crops and soils. Research and monitoring activities associated with the field activities are detailed in Appendix B. The team recommends that the Ministry of Industry, assisted by USAID, design and execute a program of research, using the Extension Service of the Office of the Cane and Sugar Board.

Table 1
Summary of Trial Year Annual Costs And Benefits*

	ß (000)	$ Equiv (000)	Per kWh ß	Per kWh $	Foreign** Exchange ($000)
COSTS					
Fuel (Collection Equipment, Bagasse, Trash, etc.)	16,515.3	660.6	0.82	0.033	166.0
Power Plant (Boiler, Grinder, Engineering, Personnel, etc.)	4,570.0	182.8	1.05	0.042	203.4
Subtotals	21,085.3	843.4	1.87	0.075	369.4
BENEFITS					
Power Sales (18.9 GWh @ ß 1.1)	20,790.0	831.6	1.10	0.044	--
Avoided Power Purchases (1.26 GWh @ ß 2.03)	2,557.8	102.3	2.03	0.081	--
Subtotals	23,347.8	933.9			--
NET BENEFITS	2,262.5	90.5	0.12	0.005	
Net Present Value (of invested capital @ 20%, 10 yrs.)	9,485.7	379.4			
Capital Payback (years)	4.25				

* Annual Costs and Benefits Summarized from Table A-1, Appendix.

** Foreign Exchange Costs shown here are incurred in Year 1; these costs are amortized over 5 years at 20% (prevailing commercial terms) and are included in annual costs.

Table 2
"BASE CASE"
CANE/ENERGY TRIAL YEAR COSTS/BENEFITS ANALYSIS
NET STEAM PLANT EXPORT OF 4 MW
Metric Tons (MT) and Bahts(ß)

	(ß)	US$ equiv*	Foreign Exchange
Fuel Costs			
Excess Bagasse: 70,000 MT @ ß 60	4,200,000	168,000	--
Purchased Bagasse: 30,800 MT @ ß 135	4,158,000	166,320	
Tops & Leaves**			
Equipment Capital Cost	4,150,000	166,000	$166,000
Equipment Annual Costs***	1,287,676	51,507	
Tractor Lease @ ß 157/MT	3,608,400	144,336	
Transport @ ß 70/MT	1,445,902	57,836	
Field Labor @ ß 23/MT	476,000	19,040	
Farm Return @ ß 50/MT	1,032,787	41,311	
Supplies @ 10/MT	206,557	8,262	
Subtotal Tops & Leaves Annual Costs	8,157,322	326,293	
Tops & Leaves Costs/MT	395	$16	
Tops & Leaves Costs/kWh	1.62	$0.06	
Total Fuel Costs	16,515,322	660,613	
Total Fuel Costs/kWh	0.82	0.03	$166,000
Power Plant			
Electrical System			
Electrical System Capital Cost	1,448,750	57,950	57,950
Electrical System Annual Capital Cost	484,433	19,377	
Design, procure, install	375,000	15,000	

* US $1 = ß25

** Costs in this category are for collection of 20,656 MT tops and leaves, approximately 25% moisture content.

*** Capital Costs in this table are amortized at 20% over 5 years, prevailing commercial terms.

Table 2 (cont.)
"BASE CASE"
CANE/ENERGY TRIAL YEAR COSTS/BENEFITS ANALYSIS
NET STEAM PLANT EXPORT OF 4 MW
Metric Tons (MT) and bahts(ß)

	(ß)	US$ equiv*	Foreign Exchange
Boiler			
Boiler Controls Capital Cost	710,000	28,400	$28,400
Boiler Controls Annual Cost	237,410	9,496	
Install, Procure Capital Cost	25,000	1,000	
Install, Procure Annual Cost	8,359	334	
Design Capital Cost	375,000	15,000	$15,000
Design Annual Cost	125,392	5,016	
Water Treatment	800,000	32,000	
Tub Grinder (shredder)			
Tub grinder Capital Cost	2,550,000	102,000	$102,000
Tub grinder Annual Cost	852,668	34,107	
Transport	50,000	2,000	
Operating Personnel			
Power Plant Manager	375,000	15,000	
Power Plant Operators	840,000	33,600	
Fuel Prep. Operators	420,000	16,800	
Communications			
Communications Capital Cost	5,000	200	
Communications Annual Cost	1,672	67	
Subtotal Power Plant Annual Costs	4,569,934	182,797	
Total Power Plant costs/kWh	0.23		
Power Plant Costs, Foreign Exchange			$203,350
TOTAL COSTS	21,085,256	$843,410	
Total costs/kWh	1.05	$0.04	$369,350
Cost of Capital	5 years	0.20 interest rate	

Table 2 (cont.)
"BASE CASE"
CANE/ENERGY TRIAL YEAR COSTS/BENEFITS ANALYSIS
NET STEAM PLANT EXPORT OF 4 MW
Metric Tons (MT) and Bahts (ß)

	(ß)	US$ equiv*	Foreign Exchange
Financial Benefits			
Net steam plant export (kWh)	20,160,000	806,400	
Return from grid sales	20,790,000	831,600	
total grid sales	18,900,000	75,600	
ß/kWh grid sales	1.10	.04	
Return from avoided purchases	2,557,800	102,312	
Total avoided purchases	1,260,000	50,400	
ß/kWh avoided purchases	2.03	.08	
Total Return	23,347,800	933,912	
Total Costs	21,085,256	843,410	
Net Returns	2,262,544	90,502	
per kWh	0.11	0.00	
NPV (@ 20%, 10 yrs.)	9,485,653	379,426	
Payback of Capital costs (yrs)	4.27		
Additional Project Benefits			
Total Unskilled Labor (days)	4,760		
Skilled Labor (driver - days)	6,404		
Total Labor (days)	11,164		
Total Labor hours/MT	4.32		
Farmer Income/MT Tops & Leaves	50	2	
Total Farmer Income	1,032,787	41,311	
Foreign Exchange Savings:			
- Energy import Displacement (35,275 bbls @ $18)			$477,340
- For. Capital Annual Costs			$634,950
			($150,610)

Table 2 (cont.)
"BASE CASE"
CANE/ENERGY TRIAL YEAR COSTS/BENEFITS ANALYSIS
NET STEAM PLANT EXPORT OF 4 MW
Metric Tons (MT) and Bahts (ß)

	(ß)	$US equiv	Foreign Exchange
USAID/Ministry of Industry Project/Demonstration Contribution			
Technical Assistance:			
Management Support			$150,000
Communications			$2,000
Agricultural Research			$28,000
Mill/Plant Consult.			$50,000
Field/Machinery Consult.			$40,000
Contingency			$45,000
Subtotal			$315,000
Machinery for Harvesting Tops & Leaves			$149,618
TOTAL			$464,618
Production Scenario			
Four MW Net Steam Plant Export			
Seven months (210 days), Off-Season Production			
Net Steam Plant Export, kWh/MT			
Bagasse, kWh/MT	150	6	
Tops & Leaves (25% m), kWh/MT	244	9.76	
Tops & Leaves (35% m), kWh/MT	208	8.32	
Total kWh (210 days)	20,160,000	806,400	
Tops & Leaves kWh (25%)	5,040,000	201,600	
Bagasse kWh (75%)	15,120,000	604,800	
Tons Bagasse	100,800	4,032	
Tons Tops & Leaves (25%)	20,656	826	
or			
Tons Tops & Leaves (35%)	24,231	969	
Total Export to Grid	18,900,000	756,000	
Total Displaced Purchase	1,260,000	50,400	

Cost/Benefit Distribution	Benefits/costs (ß)		
	MILL	EGAT	FARMERS
1. Sales to grid and displacement	2,262,544	0	
2. Grid sales below trans. price		3,024,000	
3. Sales of tops and leaves to mill			1,032,787
TOTALS	2,262,544	3,024,000	1,032,787

APPENDIX A

PRODUCTION OF ELECTRIC ENERGY FOR SALE

AT THE

NONG YAI SUGAR FACTORY

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1.0
INTRODUCTION

The goals of factory activities during the testing period are as follows:

a) Demonstrate steady, controllable export of electric energy during processing;

b) Demonstrate improved boiler efficiency by controlling excess air; and

c) Demonstrate preparation and firing of low moisture fuel in the 120 MT/hr boiler.

These goals will be accomplished by taking the following actions:

a) Install meters, protective relays and recorders on the existing electrical connection between the factory and the utility;

b) Install oxygen analyzer, transmitter and recorder and modify various controls on the 120 MT/hr boiler;

c) Purchase a portable, combination de-baling machine and shredder with a capacity of 25 MT/hr;

d) Hire an engineer with power generation training to direct power plant personnel; and

e) Hire a powerhouse operator on each shift whose function is to regulate generators to maintain steady electric energy exports.

Note: Metric tons for Power Plant denoted at "MT".

2.0
PRE-TESTING ACTIVITIES

2.1 Electrical Interconnection

A local electrical engineer, preferably on the staff of EGAT, and in conjunction with input from EGAT, should design and specify equipment needed to permit parallel operation between the factory and the utility. At present, parallel operation is practiced for only a short time, when the factory has started up its first generator and is decreasing the purchased power to zero. Continuous parallel operation requires consideration of the following:

a) Protective relaying to protect both factory and utility systems;

b) Indicating device to assist the factory power plant operator to regulate generation and export; and

c) Recorders to provide historic data on power flow and reactive power flow.

2.2 Boiler Controls - 120 T/hr Boiler

In order to shift from a bagasse incineration mode of operation to one which seeks to conserve bagasse to produce export electric energy for sale, the first step is to increase boiler efficiencies by reducing excess air levels. It is estimated that the boilers currently operate at 55% efficiency. It is proposed to add control and indicating equipment to increase the 120 MT/hr. boiler efficiency to approximately 65.4% on bagasse. Reduction of excess air to below 100% will be accomplished by installing an in-situ oxygen analyzer to be located in the duct at the exist of the boiler bank, just ahead of the air heater. This analyzer will transmit the oxygen content of the spent flue gas to a recorder.

Section 4.2 specifies a new air flow transmitter as well as controls and relays needed to modify the existing control system. Section 4.4 estimates time needed by a control system engineer to design and specify the exact system and equipment required. Design work should take place immediately to allow adequate time for delivery.

2.3 Boiler - Other

Prior to the test and during the current off-season, the 120 MT/hr. boiler should be thoroughly inspected and sealed against air inleakage. All controls and instruments should be calibrated and all dampers inspected, stroked and their drives serviced. The main steam pressure and temperature gauges as well as the gas and air temperature recorders should be calibrated. These activities are part of routine repair activities; however, special attention should be given to the 120 MT/hr. unit.

2.4 Evaporators

One of the three sets of evaporators must be used to condense the added steam produced during the season due to increased generation from the backpressure turbine generators. Preparations must also be made during the off-season for use of one evaporator train to condense steam from proposed power generation during the 1988 off-season. In order to accomplish this, the following repair season activities must be accomplished:

a) Check all condensate, steam, vapor and condensate water isolating valves for tight seating;

b) Provide for condensate return to the boiler from second through fifth body evaporators for off-season make-up water;

c) Equip evaporator supply tank with provision to add at least 250 MT/hr. of water, with the majority coming from feed-water condensate; and

d) Prepare for use of cooling water to maintain one set of evaporators operating during off-season.

2.5 Testing Schedule

The schedule of testing is dependent upon delivery of the interconnect electrical devices and additional boiler control equipment. If the schedule can be expedited, the first export of electric energy to the utility can occur shortly after the start of the 1987/1988 processing campaign. Should this occur, it is recommended that export to the utility be gradually raised, over a period of several weeks, to obtain operating experience in load and voltage control under conditions of changing factory and utility system loads and voltages.

Should installation of new equipment be delayed until after the 1987/1988 processing campaign, gradual increase in export will not be required for off-season operation. It is expected that the first off-season generation will uncover open or leaking steam interconnections which will require shutdown to blank off. The earlier in the off-season these problems are discovered, the less effect off-season generation will have on normal repair activity*.

2.6 Fuel Preparation

Part of the fuel for off-season operation will come from baled, dry cane tops and leaves. Processing and shredding of baled material should be tested as soon as the preparation equipment and bales of cane tops and leaves are available.

*Caution: Boiler interconnections pose a hazard to boiler repair crews. Check to see that no leakage from the live boiler to the shutdown boilers occurs before entering steam drums of idle boilers. Intermittent blow-down interconnections are of particular concern.

3.0
OPERATING PLANS AND SYSTEM MONITORING

3.1 Operation - Processing Season

The intention of these activities is as follows:

a) Operate 120 MT/hr. at lowest possible excess air and highest possible load to conserve bagasse fuel; and

b) Operate 8,000 kW turbine-generator to control export kilowatts and voltage.

Recommendations are as follows:

a) Operate 120 MT/hr. boiler bagasse feeders at fixed speed, to maintain 120 MT/hr. output;

b) Adjust Fuel/Air ratio to maintain oxygen in flue gas below 10% (100% Excess Air);

c) Operate two 3,000 kW turbogenerators at fixed load (3,000 kW each) and fixed excitation voltage; and

d) Operate the 8,000 kW to maintain target export of 1-3 MW by manually adjusting speed/load control. Adjust excitation to maintain factory bus voltage of 3,300 volts.

Monitoring requirements while processing are as follows:

Location	Variable	Record
120 MT/hr. Boiler	Oxygen, %	Continuous and hourly
"	Steam Pressure	Hourly
"	Steam flow	Hourly
"	Exist Gas Temperature	Continuous and hourly
"	Steam temperature	Hourly
"	Various Draft Gauges	Hourly
Utility Tie	Kilowatts in/out	Continuous and Hourly
"	Voltage	Hourly
"	VARS in/out	Continuous
System	Power Factor	Hourly
"	Total Generation, kW	Hourly
"	Bagasse Moisture	3 x per day, minimum
"	Bagasse Pol	3 x per day, minimum
"	Bagasse Ash	1 x per week

3.2 Operation - Off-Season

The intention of these activities is as follows:

a) Operate 120 MT/hr. boiler only, at lowest possible excess air;

b) Operate 8,000 kW turbogenerator only, to control export kilowatts and voltage; and

c) Operate one evaporator set to provide condensing for turbogenerator exhaust steam.

Recommendations are as follows:

a) Operate the 120 MT/hr. boiler with fuel in automatic control to maintain pressure;

b) Bias fuel/air ratio to maintain oxygen in flue gas below 10%.

c) Operate evaporators to recover sweet water condensates and avoid chemical pre-treatment of feedwater.

d) Maintain bus voltage and export kilowatts on 8,000 kW turbogenerator by manual control. Should over-voltage occur, disconnect bus capacitors as required.

Monitor the following variables:

Location	Variable	Record
120 MT/hr. Boiler	Oxygen, %	Continuous and hourly
"	Steam Pressure	Hourly
"	Steam Temperature	Hourly
"	Steam Flow	Hourly
"	Exist Gas Temperature	Continuous and hourly
"	Various Draft Gauges	Hourly
Utility Tie	Kilowatts in/out	Continuous and Hourly
"	Voltage	Hourly
"	VARS in/out	Hourly
System	Power Factor	Hourly
"	Total Generation, kW	Hourly
"	Fuel moisture	3 x per day
"	Fuel Ash	1 x per week

4.0
CAPITAL COST PROJECTION

4.1 Electric Interconnect Devices

	Unit Cost US$	Total US$
Relays - Mtl. Cost		
1 - Transf. Diff'l (STD)	1,600	1,600
1 - Bus " (PVP)	1,200	1,200
1 - Grnd. - Dir.O/C(JBCG)	1,350	1,350
6 - Dir.O/C (JCB)	1,200	7,200
1 - Synch Check (IJS)	1,000	1,000
1 - Pwr. Dir. (GGP)	2,500	2,500
Sub Total	=	14,850
CT/PT		
6 - Bush. Type CT - 22 Kv	700	4,200
3 - PT - 22 Kv	2,200	6,600
6 - CT - 5 Kv	425	2,550
3 - PT - 5 Kv	1,750	5,250
Sub Total	=	18,600
Indicators and Recorders		
2 - Voltmeter	250	500
1 - Kw - in/out	500	500
2 - WHM, in and out	2,000	4,000
1 - P.F. Meter - in/out	1,500	1,500
4 - Transducers-Watt,VAR,WATT,VAR1,	500	6,000
1 - 2 Pen recorder (KW and VAR)	5,000	5,000
Sub Total	=	17,500
Misc. Devices		
Lot - Control/Wire	1,000	1,000
Lot - Switches	2,000	2,000
2 - Cubicles	2,000	4,000
Sub Total	=	7,000

Installation Labor			
40 Man-Months		250	10,000
GRAND TOTAL	Mtl.		57,950
	Labor		10,000
	TOTAL		67,950

4.2 Boiler and Controls Devices

1 -	O_2 Probe and recorder	15,000	15,000
1 -	Air Flow x mtr.	1,650	1,650
1 -	Temp Recorder - 10 T/Cs	5,250	5,250
1 -	M/A Station	1,000	1,000
2 -	x - relay	500	1,000
1 -	Controller	2,500	2,500
	Misc. Panel Devices	2,000	2,000
	Sub Total	=	28,400

Installation

Labor 4 Man-Months	250	1,000

TOTAL

Material	=	$28,400
Labor	=	1,000
		$29,400

4.3 Fuel Preparation

		US $
1 -	25 MT/hr WHO Grinder	81,000
	Freight 16T X $1,000	16,000
	Local Haul	2,000
	Spare Parts (hammers & grates)	5,000
	TOTAL	104,000

4.4 Engineering & Procurement

Electrical (Local)	
4 Man-Month @ 1,000	= $ 4,000
Controls: (Foreign)	
1 Man-Month + Travel	= 15,000
Procurement (Local)	
1 Man-Month	= 1,000
TOTAL	$20,000

4.5 Summary of Costs

	Foreign	Domestic Local
Elect. Interconnect	57,950	10,000
Boiler Controls	28,400	1,000
Fuel Preparation	102,000	2,000
Engineering/Procurement	15,000	5,000
	203,350	18,000
	$221,350	

5.0
PERSONNEL REQUIREMENTS

It is recommended that the factory staff be augmented by the following personnel:

a) Power Systems Engineer

Provide one full-time mechanical or electrical engineer to supervise power plant operations. This person should be a graduate engineer with experience in power plant operation. A general knowledge of sugar factory operation is preferred;

b) Power Generation Operators

Provide four full-time operators to operate the turbogenerator controls. Their function is to control power export and voltage to maintain steady (firm) delivery to the utility; and

c) Power Plant and Fuel Preparation Labor

Provide adequate personnel to operate boiler, turbogenerator, fuel preparation equipment, and fuel delivery equipment.

6.0
ROLE OF EGAT

It is recommended that EGAT design, procure and install those electrical devices described in Section 4.1.

Further, it may be that EGAT can recommend or provide the Power Systems Engineer described in Section 5.0.

During the trial year, EGAT should provide a continuous contact point between the factory and their dispatch control. Such contact may be a load dispatcher who periodically calls the factory power plant to request export information or issue instructions for power curtailment during system upsets.

At a management level, it is recommended that EGAT assist the factory in evaluating trial year performance and in making projections for future export.

7.0
INTERPRETATION OF TRIAL YEAR DATA

Data collected during the trial year will be evaluated for the following:

a) Effect of export on EGAT system;

b) Effect of dry fuel on boiler feed control, steam pressure, and steam temperature control;

c) Conveying and handling charactistics of dry fuel;

d) Fuel preparation and maintenace costs for dry fuel;

e) Net energy production per unit of fuel; and

f) Miscellaneous operating problems.

Interpretation of this information will be utilized to project future energy export expansion.

8.0
FUTURE IMPROVEMENTS

Improvements to increase net export energy to the utility fall into two basic categories:

a) Sugar processing improvements to reduce energy consumption; and

b) Power plant improvements to improve power plant efficiency.

8.1 Sugar Processing Improvements

Deaerating Feedwater Heater

Calculations based on published information indicate that high pressure steam consumption exceeds expected low pressure steam requirement by a margin of nearly 2:1, hence the evaporator stations may be forced to boil water to avoid venting of low pressure steam. Incorporation of a deaerating feedwater heater would cost approximately $200,000 and accomplish the following:

a) Reduce, by approximately 20 - 25%, the amount of exhaust steam which must currently be sent to the evaporators during processing, but performs no useful evaporation. The equivalent of 17 MT/hr. of bagasse would be saved, or approximately 10% of bagasse production, which equates to an increase in net export of 2,500 kW with no increase in fuel consumption during processing;

b) Reduce, during, the off-season, the amount of fuel burned by 10%, or increase net export by approximately 600 kW; and

c) Reduce corrosion due to oxygen pitting inside boiler tubes, which was evident during inspection of damaged tubes.

Reduced Bagasse Moisture

In general, reducing bagasse moisture by modifications or additions to milling equipment offers both extraction benefits as well as thermal efficiency improvements. Alternatively, drying using flue gas offers no extraction improvement but greater thermal efficiency improvement. Estimating capital and operating costs associated with reducing bagasse moisture as well as estimating increased export are beyond the scope of this study, however previous studies at other locations have indicated that each percentage reduction in moisture improves boiler efficiency by 0.3 - 0.5%. A 5% reduction in bagasse moisture at Nong Yai would yield 500-1,000 additional kW of export energy with the existing boilers and turbogenerators.

8.2 Power Plant Improvements

With success in collecting cane leaves and tops from the fields, a number of economically successful power plant improvements are possible.

New 204 MT/hr Boiler and 35 MW Turbogenerator

A 204 MT/hr (450,000#/hr) boiler operating at 61 bar (900 psig.) and 482°C (900°F) with a nominal 30 MW, single-automatic-extracting-condensing turbine generator would produce 22 MW of export power to the utility during processing and 20 MW during the refining period on existing bagasse supplies. Maintaining a power export of 30 MW during seven months of the off-season would require providing approximately 230,000 Tonnes of 25% moisture tops and leaves. Capital investment for the new facilities, including an independent cooling power system would be $40,000,000. Approximately 213,000,000 kWh would be exported annually to the utility.

The existing turbogenerators would not be needed during the processing season. They would be kept as stand-by in case the main turbogenerator failed during grinding. The factory would continue to use 186 MT/hr of existing boiler capacity while processing to provide motive steam for the mills and shredders. Depending on the heat balance within the factory and refinery, use of existing exhaust steam from the mills and shredders may eliminate the need for 1 bar extraction on the new turbogenerator. If this is the case, the new turbogenerator could be a straight condensing turbogenerator with a 4 - heater cycle which would improve the heat rate of the system, increasing net electricity export by about 10 percent.

New 204 MT/hr Boiler and 45 MW Turbogenerator

This approach permits utilizing the full capacity of the new boiler during the off-season and requires providing 324,000 tonnes of 25% moisture tops and leaves. An investment of $42,250,000 would be required, and export power would be as follows:

Processing Season	= 22 MW
Refining Season	= 20.6 MW
Off-Season	= 40.0 MW

Total export energy would be 263,900,000 kWh per year.

Two 204 MT/hr Boiler and 55 MW Turbogenerator

This alternative completely replaces existing boilers and turbogenerators at a capital cost of $55,000,000. The turbogenerator would be a double-automatic, extracting-condensing machine to provide mill motive steam and boiling house steam. A total of 409,000 Tonnes per year of 25% moisture tops and leaves would be required. Export power would be 40 MW (316,800,000 kWh annually) throughout the year. Only one boiler would be utilized during the off-season.

8.3 Conclusions

There is potential to provide significant amounts of export electric energy at Nong Yai sugar factory by improving steam economy and by using all fiber available to the mill. The sugar processing equipment is modern and is operated at very high standards. While the export of electric energy will be a new experience for factory personnel, this factory already has a record of accomplishing difficult tasks in short periods of time.

9.0

COST ESTIMATE - 35 MW TURBOGENERATOR AND 204 MT/HR. BOILER

$U.S. Millions

1	Boiler, 450,000 #/hr. at $25/#	12.0
1	35 MW Extracting/Condensing Turbogenerator	5.0
	Condenser and T/G auxiliaries	2.0
	Piping	2.0
	Electrical & Interconnect	4.0
	Structure, Foundation, Buildings	1.5
	Engineering	2.5
	Project Management, Training, Start-up	2.5
	Miscellaneous Materials	4.0
	subtotal	35.5
	Construction, Thai labor - 600,000 man hours	1.0
	subtotal	36.5
	Contingency - 10%	3.6
	Total	40.1

APPENDIX B

COLLECTION AND STORAGE OF CANE TOPS AND LEAVES

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1.0
BACKGROUND

Because of the short duration of the harvest season in Thailand, sugar mills must identify fuels to supplement bagasse if they hope to generate electricity throughout the year. Year round generation is necessary to receive higher prices for the electricity sold and to justify capital investments in new equipment with higher efficiency.

When sugar cane is harvested, the tops and leaves are separated from the millable cane and left behind in the fields. These tops and leaves are a large potential source of biomass fuel with combustion characteristics similar to bagasse.

During the proposed trial year a reasonable quantity of tops and leaves will be collected and used for boiler fuel to demonstrate the technical and economic feasibility of this technology under existing conditions in Thailand and to obtain cost and performance data that an investor will need before deciding to invest in a cane energy system based on the use of tops and leaves. Six sets of baling equipment will be procured and operated during the trial year.

The operations involved in the collection of cane tops and leaves are similar to the standard operations which have been developed to harvest forage crops (for livestock feed) in many areas of the world, particularly North America. Conventional forage harvesting equipment has been used successfully to harvest cane tops and leaves at several locations. Using knowledge from these other applications, several of the most suitable equipment models will be selected and tested in Thailand during the trial year.

2.0
SUPPLY OF TOPS AND LEAVES

The supply of top and leaves available to a mill is influenced by several factors that for the Nong Yai mill, are as follows:

Tonnes cane milled per year:	1,200,000 tonnes
Cane producing area:	200,000 rai (32,000 ha)
Number of growers:	533
Typical crop cycle:	One plant crop, 1 - 3 ratoons.
Irrigated area:	None
Harvest method:	All hand cut, unburnt
Harvest season:	Start mid-December, end early April
Row spacing:	1.2 m
Typical yields:	7 tonnes cane/rai
Typical yields for final ratoon crops:	4 - 6 tonnes/rai

The projected quantities of tops and leaves available from fields to be replanted can be calculated as follows:

Area to be replanted	33 % x 200,000 rai 66,667 rai/year
Average yield, tops and leaves	= 0.66 x cane yield = 0.66 x 4 tonnes/rai 2.64 tonnes/rai at 50 % mcwb

(M.c.w.b. is moisture content wet basis, defined as the weight of moisture in the material divided by the total weight of the material).

The tops and leaves will be sun-dried in the field before harvesting. Expected moisture content when baled is 25% mcwb.

Yield, tops and leaves at 25 % mcwb = 2.64 tonnes/rai x factor for 25% mcwb.
= 2.64 x (.6667)
= <u>1.76 tonnes/rai</u>

Material efficiency for recovery	Net recovery per Unit Area	Total Available from 66,667 rai
80%	1.408 tonne/rai	93,867 tonne
70%	1.232 "	82,134 "
60%	1.056 "	70,400 "

Fuel requirements are determined by the electric power generating rate, duration of operation, and the proportion of fuel to come from tops and leaves in relation to bagasse or other fuels. During the trial year, if the power plant were operating entirely on 25% mcwb tops and leaves, the fuel requirements would be:

Electric generating level, MW net steam plant export	kWh/Tonne Fuel	Tonnes Fuel required per hour	per day	per month
4 MW	244	16.39	393	11,803
8 MW	281	28.47	68	20,498

3.0
FIELD EQUIPMENT

The field equipment to be used includes the following:

a) Side delivery rakes, to align the cane tops and leaves into windrows in the fields after the cane harvest and loading operations are completed, and after the tops and leaves have been sun-dried to a moisture content below 30% mcwb;

b) Round balers, which pick up the windrowed tops and leaves to form cylindrical bales which weigh approximately 0.4 tonne each. These balers are PTO (Power Take-Off) driven and pulled by standard tractors with 60 hp rating;

c) Rectangular balers with a bale chamber size of 16 by 18 inches, PTO driven with windrow pickups. These machines are an alternative to the large round balers, making bales weighing less than 50 kg each that can thus be moved and loaded manually. The smaller bale size permits more flexibility in handling, but does not provide the feature of weather-resistant outdoor storage which the large round bales have;

d) Bale movers and mechanical bale loaders for the big round bales. Loaders are locally available for use with tractor hydraulic lifts;

e) Trucks for transporting bales from field to mill. Dimensions of standard care trucks are 4.5 m x 2.5 m x 3. high; and

f) Equipment for fuel handling and preparation at the power plant. Bales can be disintegrated using a tub grinder that prepares the tops and leaves in a form ready for conveying into the boiler. Tractor-mounted hydraulic front-end loaders can be used to lift bales off the trucks and into the tub grinder.

The Machinery requirements for the field collection of tops and leaves can be calculated as follows:

Baler capacity	= 9 to 14 tonnes/hr
Field efficiency	70 %
Length of working day	8 hours
Availability	80%
Length of season	100 days
Daily output	40 to 63 tonnes/baler
Productivity	4,032 to 6,272 tonnes per Baler per season.

Area harvested per day, per baler:

Net recovery tonne/rai	Daily output tonnes/baler	Area harvested, rai/day
1.408	40	28.4
1.408	63	44.7
1.232	40	32.5
1.232	63	51.1
1.056	40	37.9
1.056	63	59.7

4.0
ACTION RECOMMENDATIONS

The following actions are required to implement the field operations for the collection, handling and transport of tops and leaves during the demonstration year.

4.1 Pre-season activities, July - November

Procure equipment and materials

Imported field machinery, rakes and balers need at least 90 days delivery time after receipt of order. Equipment to be imported include:

a) Side delivery rakes, PTO driven, for three-point hitch, rubber mounted teeth:
New Holland model 57 or similar
6 required.

b) Round balers, PTO driven:
New Holland model 848 or similar,
4 required.

c) Rectangular balers, PTO driven 16 x 18 inch bale chamber, twine tie:
New Holland model 426 or similar,
2 required.

Locally manufactured equipment items that need to be procured include:

a) Front-end loaders with hydraulic lift for handling round bales up to one tonne weight; and

b) Instrumentation and equipment for the data collection uring the field trials (described in Section 7.0).

Prepare a data collection plan for trial year activities.

a) Identify a local Thai institution to cooperate with data collection and analysis; and

b) Specify the information to be gathered from measurements, samples and observations taken during field and factory operations and describe the procedures for taking data and performing analyses.

It is recommended that a Thai university with Agricultural Engineering and Agricultural Economics capabilities be associated with the project.

Prepare an operational plan for managing field activities and transporting baled tops and leaves to the mill.

a) Identify the personnel at the mill who will schedule operations to gather cane tops and leaves in conjunction with the schedule for harvesting cane to be milled;

b) Develop a schedule for rake, baler, and loader operations and a staffing plan for tractor operations, field laborers and supervisor. Specify cane varieties, crop cycles (ratoon or replant fields), field locations, outdoor storage sites, and related details. Identify and brief cooperating farmers; and

c) Brief machinery distributors on trial year plans in order to ensure their participation and support during the field trails.

4.2 Activities during the cane harvest season, December - April

Implement the operational plan for raking, baling, handling and storage of tops and leaves. The day-to-day scheduling of specific fields for collecting tops and leaves will depend on the cane harvest schedule, weather conditions, machinery performance, labor availability and the availability of tractors for hire.

Take data on system performance and costs. The performance and productivity of all field machinery and labor must be observed and recorded. Samples of tops and leaves will be taken and analyzed for moisture content, ash content and yield (tonnes/rai) according to the data collection plan.

Take data on the agronomic effects of field trash removal particularly soil compaction and moisture, weed growth and cane regrowth in accordance with the research plan.

4.3 Activities during the off-season, April - October

1) Schedule the transport of bales from storage to the power plant. Performance and cost data will be gathered during these operations.

2) Continue monitoring of agronomic effects. This involves observations of weed control and cane growth, and analysis of previously gathered data.

3) Monitor bale quality in storage. Moisture content changes, bale damage and bale degradation should be observed and recorded.

4) Analyze data on system performance and report results.

5) Develop plans for future seasons.

6) Perform preventive maintenance on field machinery.

5.0
COSTS

Field, transport and handling machinery costs for a demonstration project for using up to 24,000 tonnes of tops and leaves at 25% mcwb are calculated as follows:

5.1 Capital costs, US Dollars:

Rakes: Ford New Holland Model 7 mounted rake, or equivalent, 3 point hitch, C.I.F. Bangkok
$3,309 (6 required) 19,854

Balers: Ford New Holland Model 848 Round Baler or equivalent, 3 point hitch, C.I.F. Bangkok
$16,903 (4 required) 67,612

Ford New Holland Model 426 Twine Baler, or similar, C.I.F. Bangkok
$21,076 (2 required) 42,152

Round bale attachment for front-end hydraulic loaders, estimated.
$3,333 (6 required) 20,000

Total 149,618

5.2 Local costs, Baht:

Tractor hire, rakes: 80 days x 6 rakes x 1 tractor 1 rake
= 480 working days at
1,200 Baht/day tractor
120 Baht/day driver

Fuel, 0.1 gal/hp-hr x 40 hp x 8 hr/day
= 32 gal/day per tractor
3.85 l/gal = 123 l/day
at 6.5 Baht/l = 800 Baht/day

Total daily tractor cost 2,120 Baht

$$2{,}120 \frac{\text{Baht}}{\text{tractor-day}} \times 480 \text{ tractor-days} = 1{,}017{,}600 \text{ Baht}$$

Tractor hire, balers:

60 hp required : Fuel costs
increase by 50 % to 1,200 Baht/day

$$2{,}520 \frac{\text{Baht}}{\text{tractor-day}} \times 480 \text{ tractor-day} = 1{,}209{,}900 \text{ Baht}$$

Tractor hire, loaders:

During the harvest season, loaders are required to move bales from the fields to outdoor storage.

6 loaders required: 4 in the fields, 2 at storage sites.

2,500 $\frac{\text{Baht}}{\text{tractor-day}}$ x 480 days	=	1,209,600 Baht

During the off-season, 2 loaders will be required to load bales from outdoor storage onto trucks, and 2 for unloading trucks and lifting bales into the tub grinder.

16,000 tonnes/393 tonnes/day	=	40 days
2,500 $\frac{\text{Baht}}{\text{tractor-day}}$ x 160 tractor days	=	403,200 Baht

Transport by trucks, from storage site to power plant:

70 Baht/tonnes 20,650 tonnes	=	1,445,900 Baht

Labor for handling small bales in the field:

8,000 tonnes/40 kg per bale	=	200,000 Baht

Assume:	250 bales/man-day to get		800 man-days
	Labor rates 100 Baht/day:		80,000 Baht
	Loading and stocking, 400 man-days	=	40,000 Baht
	Loading from storage for transport to the power plant, 400 man-days	=	40,000 Baht
	Subtotal for bale handling		160,000 Baht

Truck hire for gathering bales from the fields:

60 days, 1,500 Baht/day	=	240,000 Baht

Materials:

Baler twine, lubricants	875,000 Baht
Spare parts for rakes and balers (belts, rake teeth, spare tires, PYO shafts)	20,000 Baht
Procurement, one man-month	25,000 Baht
Labor for helpers for balers: 480 days at 75 Baht/day	36,000 Baht

5.3 Summary of Costs:

Field machinery purchases				US$ 149,618
Procurement	Baht	25,000		
Tractor hire		3,810,000		
Trucks, hauling		1,920,000		
Materials		800,000		
Labor for handling bales		160,000		
Labor for balers' helpers		36,000		
Spare parts		20,000		
Subtotal, local cost	Baht	6,801,000	=	US$ 272,040
TOTAL				US$ 421,658

NOTES:

Tractor hire costs include the labor cost of the drivers:

	172,800	Baht in season	
	19,680	Baht out of season	
Total	192,480	Baht	
Other labor costs as listed above.	196,000	Baht	
Total field labor	388,480	Baht	(US$ 15,539)
Transport labors, est. (truck drivers)	480,000	Baht	
Labor total for tops and leaves	868,480	Baht	(US$ 34,739)

5.4 Tractor Purchase Alternative:

Purchasing tractors may be a lower cost alternative, instead of using a tractor hire rate.

Balers and loaders require tractors in the 75 - 90 hp range; rakes in the 40 hp range.

12 tractors at	$16,000	=	$192,000
6 tractors at	12,000	=	72,000
			264,000
Depreciated over 5 years		=	52,800
Convert to Baht			1,320,000 Baht
Fuel and labor costs			2,122,080 Baht
Total tractor costs/year			3,442,080 Baht

Compared to tractor hire, this represents a saving of 408,000 Baht.

6.0
LABOR REQUIREMENTS FOR TRIAL YEAR

Tractor hire costs include labor costs of the drivers:

	172,800	Baht in season
	19,680	Baht out of season
Total	192,480	(approx. 1,604 days)

Labor costs for handling bales	160,000	Baht
Labor for baler's helpers	36,000	Baht

Truck hire (transport costs) include drivers wages, Baht 5,000/month wage rate.

Approximately	480,000	Baht

Total labor costs for demonstration year.

868,480 Baht, farm and transport labor

7.0
EQUIPMENT REQUIRED FOR FIELD PLOT MEASUREMENTS AND SAMPLING

1) One portable chopper for preparing samples

2) Star model FC 13 B or similar with 5 hp gasoline engine.

3) Measuring tape, 10 m

4) Weighing scale, pull type, 100 kg capacity

5) Tripods and beam for supporting the scales.

6) Slings for weighing cane and tops and leaves.

7) Plastic drop sheet, 3 m x 3 m or larger, 4 required.

8) Burlap bags for catching chopped tops and leaves for transporting samples, one dozen required.

9) Balance for weighing 500 g samples to the nearest 100 mg.

10) Sample bags, two liter capacity, 1,000 required

11) Clip boards, two required.

12) Permanent markers, four required.

13) Gas can, for chopper.

14) Water can, for crew.

15) Laboratory instruments available from the sugar mill laboratory:

    a) Convection oven, for moisture content determinations.

    b) Muffle furnace, for ash determinations.

    c) Analytic balance.

8.0
STORAGE REQUIREMENTS

Assume that six balers are used (or six "sets" of field machinery) with a capacity of 4,000 tonnes per season, then 24,000 tonnes per year will be harvested.

For a power plant demonstration at the level of 4,000 kw net steam plant export, there will be enough fuel available for 61 days (2 months) of operation.

This fuel in the form of bales, will be 60,000 bales weighing 400 kg each. For outdoor storage, the required area is approximately 8.8 ft^2/ bale or 528,000 ft^2 total. (5.24 ha = 33 rai required).

Selecting a combination of four big round balers and two rectangular balers, will yield 40,000 big round bales weighing 400 kg. each. These bales will require 8.8 ft^2 each for outdoor storage area, a total of 352,000 ft^2.
3.5 ha = 22 rai.

Rectangular bales, totaling 8,000 tonnes, number 200,000 at 40 kg each. (0.1,696 m^3) (Density 236 kg/m^3) total storage volume would be 34,000 m^3 at 4.24 m^3/tonne.

It is recommended that specific farmers and fields be identified and selected early, in preparation for the trial season. These fields should be located relatively close to the mill, or otherwise concentrated to facilitate management of the machinery operations. Outdoor storage sites should also be selected in advance. Well drained locations, close to good roads, with arrangements for keeping watch or protecting the bales from pillerage.

9.0
TECHNICAL SPECIFICATIONS AND PROCUREMENT DOCUMENTS FOR FIELD MACHINERY

9.1 General Technical Specifications

Service conditions

All equipment shall be designed and manufactured for satisfactory operation at ambient temperature of 45°C and 98% maximum relative humidity.

Applicable standards

Except as provided in the specifications, all materials, equipment, and fabrication and testing thereof shall conform to the latest applicable standards continued in the following list or other approved equivalent standards.

ASAE	American Society of Agricultural Engineers
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ISO	International Organization for Standardization
SAE	Society of Automatic Engineers

References to standards or to materials and equipment of a particular manufacturer shall be regarded as followed by the words "equivalent".

The Contractor or Supplier may propose alternative standards, materials, or equipment which shall be equal to those specificied. If the Contractor or Supplier for any reason proposes alternatives to or deviations from the above standards, or desires to use equipment or materials not covered by the above standards, he shall state the exact nature of and the reason for making the change with his bid. The Contractor or Supplier shall submit to USAID for approval, a comparison of applicable clauses of the proposed standards with the specified standard and relevant specifications of the materials and equipment.

All threaded parts shall conform to the Standard of the International Organization for Standardization (ISO).

9.2 Rakes:

Number required: Six

Type: 3-point hitch, tractor mounted, side delivery.

Characteristics:

Swath width	8 1/2 ft., left delivery
Drive	540 RPM, PTO
Teeth	Steel, rubber mounted
Number of bars	four or more
Operating speed	Up to six miles per hour
Lubrication	Grease packed bearings
Tractor requirements	Less than 40 hp

Tests: The Supplier's representative will be present after delivery for first operation to insure that all adjustments and settings are complete and correct.

Owners manuals: Two (2) each supplied in English and Thai languages.

9.3 Round Balers:

Number required: Four

Type: Big round pickup forage baler

Characteristics and Construction:

Bale size	4 ft. wide x 4 1/2 diameter (1.2 m x 1.4 m)
Bale weight	up to 850 lb (386 kg)
Drive	540 RPM, PTO
Tractor requirement	40 - 60 hp (29.8 - 44.7 kw)
Main Apron	Replaceable slat, steel chain construction
Floor roll	Steel slatted
Pickup Steel	teeth, 56 inch (1.4 m) width
Tires	6 ply pneumatic
Bale counter	4 digit
Wrapping system	Automatic with microprocessor
Twine box	4 balls capacity
Twine	Plastic or sisal
Chain oiler	Automatic
Special features	Bale kicker
	Reverse drive
	Full - bale alarm
Warranty	5,000 bale chain replacement warranty.

Tests: (Same as 2.4)

Owner's manuals: (Same as 2.5)

9.4 Square balers:

Number required: Two

Type: Pickup automatic baler.

Characteristics and Construction:

Bale size	16 in x 18 in bale chamber, (406 mm x 457 mm) adjustable length up to 5 in (1,321 mm)
Plunger speed	Up to 93 strokes per minute
Plunger mounting	Sealed ball bearing rollers.
Drive	540 RPM, PTO
Hitch	Clevis type, adjustable drawbar height
Tongue	Swing type. One transport, one field position
Tractor requirements	45-65 hp (34-48 kw)
Twine	Sisal or plastic, two stands per bale
Pickup	64-3/4 in (16.45 mm) width, floating windguard, sealed ball bearings, semi-pneumatic wheel.
Tires	Pneumatic, 6 - ply
Bale chute	Flat type
Tests:	(same as 2.4)
Owner's manuals:	(same as 2.5)

9.5 Loaders:

Number required: Six

Type: Front-end, hydraulic left, tractor mounted.

Characteristics and Construction:

Capacity	1,000 kg
Vertical lift	Up to 5 m
Tractor requirements	82 hp new DIN
Loader type	Bale fork for big round bales,interchangeable
Features	Tractor hydraulic system modification kit for front-end loaders mounting.

Tests: The Supplier's representative will be present after delivery for first operation to insure that all adjustments and settings are complete and correct.

Owners manuals: Two (2) each supplied in English and Thai languages.

9.6 Spare parts and supplies:

Spare parts:

V - belts	Two (2) of each size
Tires	Two (2) of each size
Chains	One (1) of each set
Teeth, pickup	One (1) complete set
Teeth, rake	One (1) complete set
PTO shafts	One (1) of each type
Hydraulic lines	One (1) of each set

Supplies:

Baler twine	1,000 balls, 5.9 kg each 1,947 m length, plastic
Hydraulic fluid	Sufficient for 1,000 hours of operation of each machine.
Lubricants	Sufficient for 1,000 h operation of each machine.

APPENDIX C

MEMORANDUM OF UNDERSTANDING

(Proposed)

MEMORANDUM OF UNDERSTANDING

Trial Year
Electricity From Sugarcane Residues

Introduction

In early 1986, the Ministry of Industry, the Electricity Generating Authority of Thailand (EGAT), and USAID worked with the sugar industry of Thailand to examine the costs and benefits of having the sugar industry generate and sell electricity produced from sugarcane residues to EGAT. The study published in September 1986 found this option attractive and described in detail national benefits as well as benefits to EGAT, sugar millers, and sugar farmers.

In April 1987, USAID sponsored participation of representatives from EGAT, the Ministry of Industry, and the sugar industry at a meeting in Hawaii where representatives of the Hawaiian sugar industry and Hawaiian utilities described their experience with power generation from sugarcane residues in Hawaii. In June 1987, the Ministry of Industry decided to request USAID assistance to proceed with a trial year of electricity generation and sale at two mills. The results of the trial year will be shared with the rest of the Thailand sugar industry.

During July 1987, USAID provided a team of experts to assist in the design of trial year activities and the preparation of an implementation plan. The team proposes that trial year activities be carried out at Nong Yai Sugar Company. Attached is a summary of the proposed implementation plan.

The purpose of this Memorandum Of Understanding is to obtain the agreement of all parties that will be involved in trial year activities before committing further capital and management resources.

Objectives

The objectives of trial year activities are:

1. To demonstrate steady, controllable generation of electricity by the sugar industry both during and outside the processing season; and

2. To determine the costs of collection, storage, and transport of cane tops and leaves in Thailand and estimate the quantity which may be available as fuel.

It is expected that the Royal Thai Government will use the results of trial year activities to determine appropriate government policies with respect to generation and sale of electricity by the sugar industry.

Responsibilities

1. Nong Yai Sugar Factory

The Nong Yai Sugar Factory will be responsible to design, procure, install, and operate equipment necessary to allow the sugar mill to produce and export up to 4 MW of electricity during the off-season using surplus bagasse and baled cane tops and leaves. The major categories of equipment that are the responsibility of the mill are the boiler controls, the fuel preparation equipment, and the electrical meters and controls to be used in the Factory control room. The Factory will sell the electricity produced in excess of mill and refinery requirements to EGAT at a mutually agreed price.

The Nong Yai Sugar Factory will provide staff necessary to operate boilers, turbogenerator, and fuel preparation equipment. The Factory will also organize and schedule the delivery of baled cane tops and leaves from farmers to the mill and organize and schedule the delivery of purchased bagasse from other mills as necessary.

The Factory will be responsible to maintain data as described in the implementation plan. The Factory will retain ownership of all equipment purchased and installed during the trial year. USAID recommends the Factory contract with EGAT for design, procurement, and installation of necesssary electrical equipment.

2. EGAT

EGAT will be responsible to design, procure, install, and maintain equipment at the interface between the Factory and the utility not owned by the Factory. This equipment includes the protective relays and connections to be installed between the Factory and the utility, and the meters used by the utility to measure electricity characteristics and net export.

During the trial year, EGAT will provide a continuous contact point between the Factory and EGAT dispatch control. Such contact may be a load dispatcher who periodically calls the Factory power plant to request export information or issue instructions for power curtailment during system upsets.

EGAT will purchase up to 4 MW electricity during the trial year from Nong Yai Sugar Factory at a mutually agreed price. The price will be set so that the participants in the trial year program will not experience losses. If requested, EGAT will assist the Factory to identify an individual to manage power production at the Factory.

EGAT will retain ownership of all equipment it purchases for trial year activities.

3. Ministry of Industry Office of Cane and Sugar Board

The Ministry of Industry (MOI) Office of Cane and Sugar Board is responsible to assure that information obtained during the trial year is in a format acceptable for distribution to other interested sugar mills and interested sugar farmers. The Office of Cane and Sugar Board will publish and distribute information from the trial year as it deems appropriate.

The MOI will be the recipient of agricultural machinery provided under grant funds from USAID and will assist in the design of systems to collect, store, and transport cane tops and leaves. The MOI will coordinate a tax waiver with DTEC and will set the terms for use of the machines by the Nong Yai Sugar Factory. The MOI will retain ownership of the agricultural machinery after the trial year and can use it for demonstrations at other locations in Thailand.

4. USAID

USAID will provide funds for technical assistance and will procure the agricultural machinery to be used in the trial year. Technical assistance will include one manager resident in Thailand during the trial year and short term specialists to assist in the design of boiler modifications and control systems, field trials of systems to collect, store, and transport cane tops and leaves, and other areas as necessary.

The agricultural machinery will be procured using funds from USAID/Washington through a procurement agent in Thailand in time for use during the upcoming cane harvest season.

5. DTEC

DTEC will coordinate with the MOI and USAID to assure that requirements are satisfied for a waiver of taxes on the agricultural machinery imported into Thailand.

Agreement

The signatories of this Memorandum of Understanding agree to fulfill trial year responsibilities as defined above.

Ministry of Industry

EGAT

Nong Yai Sugar Factory

USAID

DTEC