PROPOSAL
GEOTHERMAL POWER PLANT
NICARAGUA

ROGERS ENGINEERING CO., INC.
ENGINEERS & ARCHITECTS
111 PINE STREET
SAN FRANCISCO, CALIF. 94111

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ROGERS ENGINEERING CO., INC.
ENGINEERS & ARCHITECTS
111 PINE STREET
SAN FRANCISCO, CALIF. 94111, TEL. (415) 986-6546

In reply refer to: Z-75003-36

15 June 1976

Energeticos, S. A.
Apartado 4903
Managua, Nicaragua

Attention: Mr. Enrique Chamorro C.
General Manager

Subject: Proposal: Geothermal Power Plant Nicaragua

Gentlemen:

Rogers Engineering Company, Inc. is pleased to submit this proposal to Energeticos, S. A. for execution of the Momotombo Geothermal Power Plant Project.

The proposal is valid for 60 days from this date and provides for Rogers to serve as the principal engineering consultant to Energeticos, S. A. who in turn, will be the prime contractor to ENALUF for construction of the power plant, resource gathering system, and waste water reinjection on a turnkey basis.

We believe the proposal presents a strong technical program in terms of power plant design and methodology for development, and an attractive financial plan for financing the project on a turnkey basis.

Rogers Engineering Company, Inc. offers an exceptionally appropriate combination of technical excellence in geothermal installations teamed with mature management, skilled in cost effectiveness.

This expertise should place us in a unique position to provide professional engineering services for the fulfillment of the project.

We look forward to working with Energeticos, S. A. on the Momotombo Geothermal Power Plant Project.

Very truly yours,

ROGERS ENGINEERING COMPANY, INC.

H. Rogers, Jr.
President

HR,Jr.:lp

10 MW GEOTHERMAL POWER PLANT
NICARAGUA

2-75005-86 511/2

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QUALIFICATIONS

Rogers

1.0

PROJECT DESCRIPTION

Rogers Engineering Co., Inc. proposes to assist Energeticos, S.A. to design, procure equipment and materials, and construct a modular 10 MW geothermal power plant at Momotombo, Nicaragua.

The project scope will include the design and installation of a well gathering piping system, flash steam separation facilities, power generating plant, a substation for connection to transmission lines, and a waste water disposal piping system connecting to reinjection wells.

The drilling of production and reinjection wells, well testing, reservoir assessment and other activity relating to resource development will be by others.

ROGERS wishes to note that it has selected General Electric Company to provide the major hardware equipment for the project because of the firm's reputation and detailed knowledge of the special geothermal requirements. Financial arrangements underway with the Export-Import Bank require purchases of United States services and equipment. General Electric Company is the most qualified source in the United States able to provide this equipment.

Finally, ROGERS would like to underscore its understanding that ENERGETICOS will be the prime contractor and that our firm will be participating with them as their engineers. ROGERS will

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provide all services of the design, procurement, equipment specifications and prepare construction contracts. ROGERS will manage all construction activity, including the modular skid fabrication and assembly and plant site work.

Project specifics are described herein.

1.1 Proposal Design Basis

1.1.1 Site

The following site conditions have been assumed for this proposal:

Elevation:	100 M. (approximate)
Site :	Leveled
Access Roads:	Good for 40 Metric Ton Loads
Atmospheric Conditions:	26° C Wet Bulb 31.6° C Dry Bulb
Wind Velocity:	5-10 Knots, Gusts to 50
Wind Direction:	Northwest
Seismic:	Zone 3 (USA)

	<u>Mean Relative Humidity %</u>	<u>Rainfall in Millimeters</u>
January	69	2.03
February	63	12.70
March	61	5.08
April	59	3.30
May	66	77.72
June	82	209.04
July	81	92.71
August	84	130.81
September	84	172.97
October	80	160.53
November	75	31.50
December	70	8.38

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1.1.2 Resource Conditions

We understand the following are indicative of the available resources:

1.1.2.1 The water resource temperature is between 260°C and 287°C.

1.1.2.2 The average fluid composition of wells MT-2 and MT-3 - All values in ppm for cooled production well water (gas free).

<u>Components</u>	<u>MT-2</u> <u>ppm (wt.)</u>	<u>MT-3</u> <u>ppm (wt.)</u>
Na	2025	2375
K	396	442
Ca	62	90
Mg	Trace	Trace
Cl	3495	4165
B	41	50
HCO ₃	192	64
SO ₄	21	25
SiO ₂	667	242
<hr/>		
Na/K	9	9
Na/Ca	57	46
Cl/B	26	26
Cl/SO ₄	448	457
CL/MCO ₃	31	112

1.1.2.3 The chemical composition of non-condensable gases from Well MT-2:

<u>Constituents</u>		<u>Volume % (Dry Basis)</u>
CO ₂ + H ₂ S	=	95.29%
H ₂	=	0.25%
N ₂ + Ar	=	4.46%
		<u>100.00%</u>

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Concentrations in the flash steam:

CO₂ 507 millimols/100 mols

H₂S 10.03 millimols/100 mols

This corresponds to 1.26% by weight of the non-condensable gases at a separation pressure of 3.9 Kg/cm²_g.

1.1.3

Wells

The drilling of production and reinjection wells, well flow testing and resource definition and evaluation will be supplied by others. The scope of services for this proposal includes all facilities between the wellhead valve flanges of the production and reinjection wells. The number of wells committed to the power plant will include:

3 Production Wells, Including One Spare

2 Reinjection Wells, Including One Spare

Typical well analysis as stated in 1.1.2.

Each production well is assumed to have a flow capacity of 210,000 Kg per hour, measured at a wellhead pressure of 9.15 Kg/cm²_a.

1.2

Resource Gathering System

Production wells will be manually regulated to produce the required well flow to supply flashed steam for the power plant. An automatic pressure controlled bypass valve and vent line will be provided to safely vent the steam from the turbine to the silencer in the event there is a sudden load change and decrease in steam demand.

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The piping system required to bring the resource to the power plant from each well is assumed to be not longer than 500 meters. The piping system will be designed for two-phase flow from the wellhead to the flash steam separator. There will be two steam separators, assumed to be located at the power plant, but final location may change depending on the relative elevation difference between the wells and power plant.

1.3

Power Plant

The proposed power plant incorporates special design considerations which reduce plant costs and provide flexibility. The turbine and generator units are shipped skid mounted to minimize field erection time and costs. The skids are portable and can be moved with minimum problems. The heaviest skid unit is approximately 40 metric tons and will measure 10 meters long, four meters wide and four meters high. The electric control equipment and relay are mounted in a van. The barometric condenser structure and the cooling tower are the main pieces of equipment to be erected at the site. Other power plant facilities include miscellaneous equipment concrete pads, a canopied building over the turbine generator unit and a shop area.

1.3.1

The Power Cycle Flow Diagram Drawing E-02-001 indicates the principal heat and material balance flows and the major equipment included in the power plant facilities. There are two steam

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flash drum separators provided for separating the flash steam from the water prior to entry into the single 10 MW turbine unit. A steam purifier is installed between the flash drums and the turbine, to assure complete removal of any entrainment or steam condensate from the steam before the steam enters the turbine. The turbine skid includes the lubrication and governor oil system, and ejector gland seal systems.

The steam from the turbine is exhausted to a barometric condenser. Spray water for condensation is provided from the cooling tower basin. The non-condensable gases from the barometric condenser are removed by two stage steam ejectors with intercondensing. The non-condensable gases saturated with steam are then vented to the atmosphere through a silencer.

The condensate cooling water mixture from the barometric condensers discharges into seal tanks, thence to a hot water collection sump from which the water is pumped and returned to the top of the cooling tower.

The proposed design indicates an excess of water (approximately 17,600 kg per hour) available for blowdown from the cooling tower basin. Therefore makeup cooling water is not required.

The power plant includes an instrument air supply system and an auxiliary startup diesel generator.

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1.3.1.1

Pumps

The auxiliary cooling water pump is provided with a 100% spare with automatic startup because this is regarded as a critical service.

The hot water return and main cooling water circulating pumps are each 50% capacity pumps. On failure of any one of these pumps, the plant will shed load to 50% capacity, and continue operating.

The waste water pump is on intermittent demand service only.

Therefore a spare pump is not considered necessary.

1.3.1.2

Cooling Water

The cooling tower is designed specifically for geothermal plant operation in that all hardware will be provided to resist corrosion from H_2S attack, which will be present in the condensate/cooling water mixture returned to the top of the cooling tower.

1.3.1.3

Cooling Tower Design Conditions

Duty:	Approximately 50×10^6 Kcal/hr.	Wet Bulb:	26.1
Range:	16.7° C	Approach:	8.3° C

Two cell units are provided for isolating a cell for maintenance when the other unit is operating.

The above design considerations allow the unit to operate with maximum flexibility. Except for major turbine or generator problems, the unit will sustain at least 50% capacity.

A summary of the design basis for the proposed plant power cycle is included.

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SUMMARY

PROPOSED PLANT DESIGN BASIS

10,700 KW GENERATION UNIT (GROSS)

Cycle Data

Flash Steam Flow Kg/Hr (100% steam basis)	95,750
To Generator Turbine	90,740
To Auxiliaries	5,010

Flash Steam Condition	
Temperature, °C.	168
Flash Drum, Kg/Cm ² A (120 psia)	8.44
Pressure Throttle, Kg/cm ² A (110 psia)	7.44
Non-condensable Gas, % Wt.	1.24

Pressure	
Main Condenser, mm Hg Absolute (4.1" HgA)	104

Enthalpy, Kcal/Kg	<u>Kcal/Kg</u>
Throttle Inlet	660.5
Turbine Drop	101.5

Condensing Water	
Flow Kg/Hr	3,025,000
M ³ /Hr (60%)	3,025

Temperature, °C	
Cold	34.4
Return	51.1
Air to Tower wet bulb	26.1

Pressure, Kg/cm ² a	
Cold	3.1
Return	3.1

Equivalent KW Values

Turbine Power Gross at Generator Terminals	10,700
Cooling Water Circulation Pumps	640
Cooling Tower Fans	200
Miscellaneous Auxiliary Loads	<u>60</u>

SUBTOTAL TO STATION	900
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DESIGN NET GENERATION	9,800
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1.3.2

The electrical output to the transmission or distribution line will be approximately 9,800 kW net to the line. The generator voltage will be 13.8 kV at 60 hertz. Power will be routed from the generator through the 15 kV cable to the main oil filled step-up transformer. The transformer will be connected to the 69 kV transmission line through an oil circuit breaker and a disconnect switch.

Station power will be derived through a dry type transformer at 480 volts. All station power loads will be supplied from a motor control center. The motor control center will have a split bus. One section of the bus will supply the large motors (50 horsepower or larger), and the other section will supply all small loads including the lighting and those loads needed for cold start-up of the plant.

Differential relay protection will be provided for the main generator and step-up transformer. The generator will be protected from reverse power over current, over frequency, under and over voltage, negative phase sequence, vibration, winding over temperature, air cooler over temperature and ground faults and liquid leaks. The transformer will be protected from phase over current and ground faults.

69 KV LINE
DEADEND
STRUCTURE
DISCONNECT
SWITCH
OIL
CIRCUIT
BREAKER
MAIN STEP-UP
TRANSFORMER
OIL INSULATED
10/12.5 MVA
69 Y/33.0-13.8 KV

TURBINE GENERATOR
10.73 MVA
13.8Y/8.0

GROUNDING
TRANSFORMER

GROUNDING
RESISTOR

STATION POWER TRANSFORMER
1500 KVA OIL INSULATED
13,800-480Y/277V

MOTOR CONTROL CENTER

REDUCED VOLTAGE
STARTER

COOLING WATER PUMPS

HOT WATER
RETURN PUMPS

REINJECTION WATER PUMP

COOLING TOWER FANS

DIESEL DRIVEN
AUX. GENERATOR
60 KW 480Y/277V

LUBE OIL CENTRIFUGE

AUX. LUBE OIL PUMP

TURBINE CASE DRAIN PUMP

AUX. COOLING WATER PUMP

AIR COMPRESSOR

STATIC GEN. EXCITER

LIGHTING PANEL BOARD

REFERENCE DRAWINGS	REV.	DATE	REVISION	BY	CHK.	APP.
	1		ISSUED WITH PROPOSAL	H.S.	JWS	

ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111
SCALE NONE DATE 5-21-76
DR. H.S. CHK. JWS ENG. JWS APPROVED

APPROVALS	DATE

ELECTRICAL SINGLE LINE DIAGRAM	
27500336	E-08-001

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1.3.3

The operating philosophy of the proposed design is as follows:
The plant can be started without any additional outside electrical power source. The design provides a condenser steam bypass valve, a vent, and a start-up auxiliary generator. The auxiliary generator only supplies essential power to permit the turbine to start up in a non-condensing mode of operation. In the non-condensing mode, the power plant will generate approximately 6 MW of electricity. After electricity has been put on the line, the larger motor loads associated with the cooling system can be started, and the plant operated in a condensing mode.

1.4

Waste Water Reinjection System

Twenty-three per cent of the water from production wells is utilized as flashed steam for operating the turbine. The remaining 77% as hot water and the cooling tower blow down must be disposed of. We have assumed in our design that disposal of these waste waters will be by reinjection wells. Experience indicates that reservoir permeabilities are sufficiently great that steam separator operating pressures are adequate for reinjection and no pump is required. Past experience also indicates that one reinjection well will be required for every two production wells. Accordingly, we are assuming that there will be two reinjection wells-- one operating and one spare -- provided by others. If maintenance work is required on the reinjection system, the design provides

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for temporary diversion of the waste water to a holding pond at the plant. The waste water booster pump can provide sufficient head to reinject the ponded water.

This proposal anticipates that the reinjection can be done without additional pumping; however, a pond is included near the plant so that there is a holding area. A booster pump from this pond is provided back to the reinjection gathering system piping. The reinjection system piping is included for two reinjection wells and approximately 500 meters of piping for each well. This piping stops at the reinjection well wellhead equipment.

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2.0 PROJECT ORGANIZATION

The three principal organizations implementing this project will be ENALUF, Energeticos, S.A. and Rogers Engineering Co., Inc.

2.1 Energeticos, S.A.

The prime contractor to ENALUF will be Energeticos, S.A. ENERGETICOS will assume overall responsibility for the total project, which will include the design, procurement, construction and financing of the geothermal power plant and gathering system.

2.2 Rogers Engineering Co., Inc.

Rogers Engineering Co., Inc. will be the principal consultant to ENERGETICOS. In this capacity, ROGERS will serve as the engineering arm of ENERGETICOS and will provide all engineering services associated with the design, procurement and construction management. Under ROGERS' management, all equipment manufacturers' drawings and specifications will be reviewed and invoices will be reviewed and approved for payment by ENERGETICOS. ROGERS will also arrange for financing the cost of the power plant, and gathering and reinjection systems.

2.3 Equipment Manufacturers

2.3.1 The General Electric Company has been selected as the equipment manufacturer of the turbine and the generator unit.

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2.3.2

All equipment will be purchased with performance specifications. The guarantees from all manufacturers of equipment will be provided to ENALUF on a "pass through" basis for the equipment installed in the power plant.

2.4

Construction Contractors

Rogers Engineering Co., Inc. will prepare plans and specifications for the shop fabricated equipment module skids. ROGERS will submit these to qualified shops for bids. ROGERS will review the bids and make selective recommendations to ENERGETICOS, who will approve and award the skid assembly contracts. ROGERS will inspect the shop assembled skids prior to shipment to Nicaragua.

Concurrently, ROGERS will prepare construction bid packages of plans and specifications to secure bids for site construction. ROGERS will select contractors for approval and award of contract by ENERGETICOS, S.A. ROGERS will provide construction management for site construction work on behalf of ENERGETICOS.

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2.5

ORGANIZATION CHART

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3.0

Financial Plan

Rogers Engineering Co., Inc. proposes the following construction cost estimate and financing terms.

3.1

Construction Cost

The construction cost estimate is based upon the process flow sheet and the electrical single line diagram included herein. These documents will be refined and expanded in the preliminary engineering submittals to the financial institutions during the initial phase of the project. The cost estimate calculations are as of 1 June 1976.

The proposed construction cost estimate is as follows:

<u>Item</u>		<u>Dollars</u>
Equipment and Materials:		
Production Gathering System	\$ 446,000	
Waste Water Piping System	195,000	
Power Plant	3,523,000	
Substation	214,000	
Freight, Tax & Insurance	359,000	
Subtotal		\$4,737,000
Construction Contracts:		
Foreign (USA)	293,000	
Local (Nicaragua)	1,020,000	
Subtotal		1,313,000
Engineering:		350,000
Construction Management:		400,000
Prime Contractor Fee		300,000
TOTAL		\$7,100,000

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3.2

Financing

The project financing is with the Export-Import Bank of the United States in conjunction with Chemical Bank International, San Francisco. Both banks have expressed interest in this proposal and project and we hold a letter from Chemical Bank dated 26 May 1976 to this effect. The final application for loans and the necessary agreements will be finalized in the initial phase of the project.

The general terms of the seven year loans include:

Two year principal grace

Five year principal and interest repayment

The current Export-Import bank interest rate: 8.5%

The current Chemical Bank interest rate: 9.7%
(LIBO + 2.5%)

It is assumed ENALUF will be the borrower and the Central Bank of Nicaragua will be the Guarantor.

3.3

Financing Conditions

Additional conditions required by the banks are outlined below.

3.3.1

A Note Purchase Agreement or a Loan Agreement and all other documentation shall be entirely satisfactory to Chemical Bank.

3.3.2

Any legal fees arising with regard to the drafting of a Note Purchase Agreement or Loan Agreement will be for the account of the borrower.

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- 3.3.3 As the financing is predicated on an Ex-Im Bank project loan, it also will be subject to all of the conditions contained within that loan.
- 3.3.4 A commitment fee of 1/2% p.a. will be charged on the undisbursed balance of the loan to commence with Ex-Im Bank's commitment fee or the signing of the contract, whichever event occurs first.
- 3.3.5 A 1/2% management fee to be applied against the face value of the Commerical Bank's loan will be payable with the signing of Ex-Im Bank's loan agreement.
- 3.3.6 All guarantee fees as charged by Ex-Im Bank will be for the account of the borrower.
- 3.3.7 All principal, interest, and fees will be free and clear of any and all taxes and deductions.
- 3.4 Project Financial Summary
- Three elements summarize this proposed financial plan. The interest during construction, the semi-annual loan repayment amount, and the capitalized plant cost indicate the commitment. These are approximate numbers. The bank will prepare the actual

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payment and interest numbers during the initial phase of the project while preparing the loan agreements.

The banks as a matter of policy will not finance the interest during construction. Therefore, during the 18 month construction time, the interest during construction will have to be paid from funds not available from this proposal. It is estimated to be:

Interest During Construction: \$716,000

During the five year repayment portion of time the payment will approximate the semi-annual amount shown.

Semi-annual Repayment:

First six payments \$1,051,000

Last four payments \$ 603,000

In terms of energy generated from this plant at 85 percent capacity factor, the capitalized cost of the items in this proposal and the above financial assumptions for the first five years following the two year grace period is expressed in mils per kilowatt hour. Operation, resource development, well, and electric line costs are not included in this figure.

Capitalized Plant Cost:

First three years	28.8 Mils per kwh
Next two years	16.5 Mils per kwh
After three years	0.0 Mils per Kwh

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4.0

PROJECT IMPLEMENTATION

Rogers Engineering Co., Inc. has had notable success with on-time completions of geothermal power plants under difficult environmental conditions. For instance, the current Iceland project is on schedule despite an earthquake and a harsh Arctic winter. The "fast-tracking" or over-lapping phase completion system, commonly used, will be employed.

4.1

Proposal

ROGERS' proposal presents the concepts and parameters of the project, the financing, and credentials supporting ROGERS to complete the assignment. From the proposal presentation and discussions, we anticipate receiving a Letter of Intent signed by ENALUF to commence work.

4.2

Initial Phase

Rogers Engineering Co., Inc. will initiate preliminary designs and will collect field data after the Letter of Intent is signed. This preliminary design, schedule and field data will be necessary to complete the financial arrangements in the USA and Nicaragua for the financial plan. During the preliminary design phase, the quantities and sizes of major pieces of equipment will be finally determined and their specifications will be prepared for procurement pending completion of financial arrangements.

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General Electric Company will begin work on the design of the turbine and the generator upon signing of the Letter of Intent.

After the financing arrangements have been made, contracts between the appropriate parties will be signed to formalize the project and continue the effort beyond the Letter of Intent.

4.3

Design and Procurement Phase

This phase commences with the contract between ENERGETICOS and ROGERS to provide the design, procurement and construction management for the project. All procurement will be performed timely to allow the schedule to be met. Procurement and construction will proceed according to the design and construction drawings and specifications provided by ROGERS.

4.4

Construction Phase

The construction phase will be carried out under the ROGERS' construction management direction and coordination.

Nicaraguan contractors will be utilized both for construction at the site and for transportation from the Nicaraguan port to the site. Items such as cooling tower basin, building, equipment pads and the gathering systems will be field constructed, and the modular unit field connections made.

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The construction of equipment components module skids will be carried out in the USA under ROGERS' construction management.

4.5

Schedule

The above approach to the project was taken to facilitate a short time schedule and have a power plant as mobile as possible for the size. The attached schedule indicates the general approach to the project and the work time frame anticipated. A detailed schedule will be developed in the initial phase; however, the present schedule can be accomplished. Equipment deliveries have been checked to confirm the schedule times.

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SCHEDULE

PHASES

Letter of Intent

Initial

Finalize Financial Arrangements
Associated Preliminary Engineering
Contract Arrangements
Scheduling

Design and Procurement:

Finalize Project Parameters
Procure Long Lead Items
Construction Drawings and Specs
Equipment and Material Procurement
Construction Management

Construction:

Site Preparation
Gathering Systems
Power Plant Facilities
Turbine Generator At Site

Test

Operations

Overall Time To Operation

Critical Path: Turbine-Generator

Nicaragua Geothermal
Z75003-36
June 1976

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4.6

LETTER OF INTENT

Upon acceptance of the proposal by ENALUF, a Letter of Intent will be issued to Rogers Engineering Company, Inc. and General Electric Company. The Letter of Intent will authorize Rogers Engineering Company, Inc. to initiate preliminary engineering and to complete financial arrangements with the banks. The Letter of Intent also will authorize General Electric Company to proceed with the manufacturer's design of the turbine and the generator.

As soon as the US dollar loan is approved by the banks, ENALUF will enter into a contract with ENERGETICOS to proceed with the final design, procurement and construction. If for any reason a contract is not implemented, ROGERS and GENERAL ELECTRIC shall be reimbursed in US dollars for work completed under this Letter of Intent and the Initial Phase covered by Section 4.2.

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5.0

QUALIFICATIONS

Rogers Engineering Co., Inc. has pioneered geothermal projects throughout the world in such diverse climes as Iceland and the Philippines. The breadth of the firm's experience on geothermal projects during the past 15 years is described in the accompanying brochure, "Geothermal Resource Development and Utilization."

The firm's expertise in geothermal development is strengthened by 30 years of professional engineering services to industry and government agencies, here and abroad. A veteran staff of professionals are able to "team" into a project to provide preliminary reconnaissance, detailed design, financial reports, procurement and construction management services. The enclosed brochure "Engineering and Architecture" shows a representative cross-section of the company's capabilities.