REPORT
ON
GEOTHERMAL POWER PLANT COST
AND
COMPARATIVE COST
OF
GEOTHERMAL AND COAL FIRED
STEAM POWER PLANTS

Prepared for
UTAH POWER AND LIGHT COMPANY

By
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1.0

INTRODUCTION

Rogers Engineering was requested to prepare a cost estimate for a 55 MW (gross) geothermal power plant at Roosevelt Hot Springs based upon the Phillips Petroleum Company's discovery. The geothermal power plant cost in dollars per net kilowatt is to be compared with that for Utah Power and Light Company's Emery No. 1 400 MW (net) coal-fired steam power plant now under construction.

1.1

Purpose

This report is to be used by Utah Power and Light Company in making studies of geothermal power plants. The dollars per kilowatt comparison between a geothermal plant and a UP & L coal-fired plant is to be developed. Geothermal gathering system costs and return to owner are to be developed for information.

1.2

Scope

Prepare a detailed conceptual cost estimate for a 55 MW gross (52 MW net) geothermal power plant using Phillips Petroleum Company's resource characteristics.

Prepare preliminary process flow diagram to size major equipment for manufacturer letter quotations stating price, delivery, and terms of payment. Letter quotations on major items are included in Appendix B.

Provide an estimate of cash flow during the engineering and construction period.

1.3

Format and Parameters

The cost estimate detail is to follow U P & L's format for Emery No. 1: Man-hours, Material and Equipment, and Direct Labor costs. U P & L's most current labor rates are to be used in the geothermal power plant cost estimate. Environmental costs are to be shown separately.

Phillips provided the resource enthalpy and stated they could supply a 55 MW gross geothermal power plant with steam. The resource composition and characteristics used are those in ROGERS previous report for UP & L "Evaluation of Geothermal Fluids from Well No. 54-3" December 1975.

1.4

Two Unit Installations

In order to assess the economy inherent in constructing two units at one plant site, thus utilizing certain common facilities, cost estimates and comparisons are provided for a 2X 52 MW geothermal power plant and a 2X 400 MW coal fired plant.

2.0

SUMMARY

The information in this report is to aid Utah Power and Light in their economic studies related to geothermal electric power generation from the Roosevelt Hot Springs resource. The report includes development of the geothermal plant design basis, power plant cycle, process flow diagram, and the electrical power single line diagram on which the estimated capital cost is based. The coal plant data was furnished by Utah Power and Light for its Emery Plant, Unit No. 1, being constructed and due for operation in 1978.

2.1

Geothermal Power Plant Criteria

The Phillips Petroleum Company furnished the resource data at downhole conditions with enthalpy of 493.8 Btu per pound. The power plant design which maximizes the energy extraction per pound of resource is the double flash system. Resource conditions are favorable to the double flashed system which utilizes a turbine with two entry steam pressures.

Information available to date, indicates that the noncondensable gas content of the flashed steam has a low hydrogen sulfide content. The plant incorporates a minimum amount of hydrogen sulfide abatement. Added costs are specified in Section 3.3 if hydrogen sulfide abatement is necessary.

The plant as conceptually designed uses 3,926,600 pounds per hour (down hole basis) of the resource. 2,876,300 pounds per hour of the production fluids are to be reinjected. The power plant is rated 55,000 kW gross with an estimated 52,000 kW available after station power is subtracted.

The mechanical and electrical design criteria are discussed by major equipment items and overall characteristics. Special attention should be noted concerning equipment and material construction. The plant, in the future to hold a total of two units, is designed on a unit basis. The electrical single line and mechanical equipment are designed and selected accordingly. One transmission line from the network is assumed always available to supply plant start up power. A small diesel generator unit is supplied for light and emergency loads.

2.2

Geothermal Power Plant Cost Estimate

The power plant cost estimate is developed in Section 4. It is based upon a power plant building with an administration area. The building is laid out to accommodate a future additional 52 MW unit. It has been general practice to include only two units per plant to minimize transporting the geothermal fluids and steam great distances. If more units were installed in one plant the geothermal wells would probably be several miles from the power plant.

Utah Power and Light's subaccounts and the Federal Power Commission accounts were utilized in detailing the plant cost estimate. Major equipment cost and delivery time were solicited from vendors. Utah Power and Light's Emery No. 1 power plant labor rates were used in the cost estimate. The total construction cost including substation is estimated to be \$23,640,400 or 455 dollars per net kilowatt.

The engineering and construction time required is estimated to be 34 months based on similar plants. Section 4.5 contains a schedule for engineering and construction of a 52 MW geothermal power plant. This time excludes permit and utility commission times, if required, before engineering. The detailed estimate is provided by the subaccounts in Section 4.4.

2.3 Geothermal Power Plant Operating and Maintenance Requirements

The operation staffing and maintenance requirements are direct inputs to developing cost of energy sold. This report discusses staffing requirements for normal operation and maintenance. The plant is planned to be base loaded and operate three shifts per day. Operation and maintenance expenses are not shown in this report.

The plant is scheduled for maintenance approximately two weeks per year. The maintenance crew is listed in Section 5.2.

2.4 Cost Comparisons, Geothermal and Coal Fired Power Plants

The Emery No. 1 coal fired steam power plant was selected to be the comparison plant because the labor costs are the most recent. A summary by FPC account category is included in Section 6.2. These labor rates were used in the geothermal plant cost estimate. The Emery costs are from the May 1977 monthly cost forecast.

Summary comparisons of costs for a geothermal power plant and the referenced coal fired power plant follow. Both single unit and two unit plants are compared. Additional detail and backup for the figures given in these comparisons will be found in Tables 6-1, 6-2, C-2 and C-3.

Single Unit Plants

<u>Item</u>	<u>Geothermal</u>	<u>Coal Fired</u>
Total Cost (substation excluded)	\$22,482,700	\$252,000,000
Dollar per Net Kilowatt	432	630
Net Capacity	52,000 kW	400,000 kW
Engineering & Construction Time	34 months	60 months
Base Load	Yes	Yes

Two Unit Plants

<u>Item</u>	<u>Geothermal</u>	<u>Coal Fired</u>
Total Cost (substation excluded)	\$39,142,000	\$449,933,000
Dollars per Net Kilowatt	376	562
Net Capacity	104,000 kW	800,000 kW
Engineering and Construction Time	40 months	--
Base Load	Yes	Yes

2.5 Plant Capacity Factor

The geothermal plant capacity factor is estimated to be 85%.

2.6 Appendix Information

Four appendices are included with the report. The first (Appendix A) develops cost and investment return ranges for the geothermal resource production and reinjection system. The second (Appendix B) contains letters from manufacturers relating to cost and delivery of the major equipment pieces in the geothermal power plant. The geothermal cost estimate reflects these manufacturers' data. The third (Appendix C) gives estimated costs for two unit geothermal and coal fired plants. The fourth (Appendix D) includes back up information for calculations of cash flow and IDC.

3.0

GEOHERMAL POWER PLANT DESIGN CRITERIA

This Section presents the geothermal power plant design criteria and the operating conditions the design is based on. Main areas of discussion presented here are as follows:

- 1) Weather conditions
- 2) Geothermal well data
- 3) Power cycle
- 4) Site preparation and building construction
- 5) Mechanical design
- 6) Electrical design
- 7) Environmental protection considerations

3.1

Weather Data

Basis for design for cooling tower and ventilating and air conditioning design:

Summer: 96°F Dry Bulb
67°F Wet Bulb

Winter: -20°F Dry Bulb

Maximum Wind Velocity: 60 mph

Design wind loading:

Below 30 feet	- 15 lbs. per square foot
Above 30 and Below 50 feet	- 20 lbs. per square foot
Above 50 and Below 100 feet	- 25 lbs. per square foot

3.2

Geothermal Well Data

Downhole liquid temperature: 505°F
Downhole liquid enthalpy: 493.8 Btu/lb.
Noncondensable gas composition:

<u>Gas</u>	<u>Percent By Volume</u>
Helium	0.02
Methane	0.004
Hydrogen	0.75
Nitrogen	0.8
Carbon Dioxide	93.34
Carbon Monoxide	<10 ppm
Argon	0.1

Noncondensable gas quantity:

2% by weight in the first flashed steam

Chemical Content of Resource per Lab Report 0323-75

	<u>PPM</u>
Boron, B	31
Calcium, Ca	10
Magnesium, Mg	0.01
Potassium, K	470
Sodium, Na	2,200
Ammonium, NH ₄	145
Chloride, CL	3,900
Nitrate, NO ₃) Nitrite, NO ₂)	75.1
Silica, SiO ₂	520
Sulfate, SO ₄	211
Carbonate, CO ₃) Bicarbonate, HCO ₃)	173
pH	7.58

Gas Composition of Resoure per Well Data, Handwritten-Well 54-3
Sample #4 Gas From Wellhead 9/17/75

	<u>Vol. %</u>
H ₂	5.52
O ₂	0.23
N ₂	17.53
C ₁ (methane)	0.02
C ₂ (ethane)	0.005
CO ₂ (by difference)	76.67
NH ₃	1 ppm
H ₂ S	< 1 ppm
	100.0%

3.3

Power Cycle55 MW GENERATION UNIT (GROSS)CYCLE DATA

Resource Flow lb./hr. (Downhole Basis)	3,926,600
Flash Steam Flow lb./hr. (100% Steam Basis)	1,128,600
To Generator Turbine	1,056,000
To Auxiliaries	72,600
Flash Drum Steam Conditions	
First Flash Steam Pressure (psia)	125
Second Flash Steam Pressure (psia)	30.5
Turbine Steam Inlet Conditions	
1st Entry - Temperature, °F/Case Pressure, psia	335/110
Noncondensable Gas % Wt. of 1st Entry Steam	2
2nd Entry - Temperature, °F/Case Pressure, psia	240/25
Pressure	
Main Condenser Inlet, Inches Hg Absolute	3.5
Temperature	
Turbine Exhaust Saturation Temperature	120.6°F
Steam Enthalpy, Btu/lb.	
Inlet at Flange 1st/2nd	1189.9/1160.6
Turbine Drop 1st/2nd	200.5/128.5
Condenser Type:	Direct Contact
Condensing Water	
Flow lb./hr.	28,609,000
GPM (60°F)	57,200
Temperature °F/Pressure, psig	
Cold	80/Atmosphere
Return	114.7/45
Heat Transfer Duty, Btu/hr. (million)	1,050
Equivalent kW Values	
Turbine Power Gross at Generator Terminals	55,000
Cooling Water Circulation Pumps	1,520
Cooling Tower Fans	790
Miscellaneous Auxiliary Loads	690
TOTAL POWER PLANT AUXILIARY POWER	3,000
DESIGN NET GENERATION	52,000

3.4 Site Preparation and Building Construction

This Section describes the site and power plant building aspects of the project.

3.4.1 Site Preparation

Drawing B-04-101, included at the end of this Section, indicates the layout of the power plant site relative to the power plant building, cooling tower and substation. The future development of these three components for the additional second 52 MW unit are also shown. The substation is shown fully enclosed by a chain link fence and gates. The power plant building shows the main service access door central to the turbine units in the future arrangement. Front access to the administration area is shown in relationship to a proposed parking lot, landscaping and paved area, with direct roadway access.

For the initial phase (one 52 MW unit), the drawing shows the main transformer connected via a bus duct to the 13.8 kV switch-gear inside the power plant, and connected to the high voltage substation bus having three oil circuit breakers and associated disconnect switches; the first terminal point is for the main step-up transformer; 2nd and 3rd terminal points are for the 138 kV line takeoffs. Future arrangement provides for expansion of the ring bus to five (5) terminal points, i. e., two points for step-up transformers, and three points for 138 kV line take-offs.

3.4.2 Building Design Criteria

Structural Frame
Mezzanine Floor and Operating Floor

Roof Truss
Exterior Walls

Roofing

Foundation, Ground Floor Slab
Turbine Pedestal
Reinforcing Steel
Seismic Design
Structural Steel
Wind Load
Assumed Soil Pressure
Assumed Live Loads
Roof
Operating Floor
Mezzanine
Administrative Bay - Second and Third Floors

Steel columns and bracing
Steel frame, with concrete filled steel decking
Steel, long-span
Steel "Galbestos" panels
Insulated, with inside liner. Exterior and interior faces pre-finished. ("U" Value 0.13).
Steel "Galbestos" panels, as above.
3,000 psi concrete
4,000 psi concrete
ASTM A-615, 60,000 psi
Zone 3 - Importance Factor 1.5
ASTM A-36
Zone 20
3,000 psf

20 psf (snow load - 20)
125 psf
75 psf

75 psf

3.4.3 Building Types Considered:

- a) Poured in place reinforced concrete frame, exterior walls and floors (mezzanine and operating floors); a steel roof framing system with steel roof siding.
- b) A structural steel frame with steel bracing and steel wall siding; structural steel floor framing (mezzanine and operating floors) with concrete fill steel decking, a steel roof framing system with steel roof siding.

(Reinforced concrete foundations, ground floor slab and turbine pedestal would be common to both types a and b).

✚ Type b) was selected on the basis of suitability for architectural requirements and economy. The dimensions indicated for the power plant building provide for optimum operating efficiency in both the vertical and horizontal directions.

Long span trusses over the operating floor provide the clear span required for the flexibility of overall bridge crane operation.

All necessary doors for the performance of the operations are included to facilitate a logical flow to and from the building. The main service access to the power plant will be via a large rolling steel door, motor operated, planned central to the two 52 MW units (2nd 52 MW unit-future) and contiguous with the machine shop.

The main control room will be located on the third level of the administrative bay, level with the operating floor. By means of an observation window, the control room will have the visual control for the entire operating floor area.

3.4.4 Reference sketches of floor plans, building side elevation and cross section are shown on Drawing Nos. B-80-101, 102, 103 and 104, respectively, included at the end of Section 3.

3.5 Mechanical Design

3.5.1 General

The major items of mechanical equipment are shown on the process flow diagram B-02-101. The power plant from the mechanical viewpoint is considered to start at the plant, plot limit on the downstream side of the first and second stage separators and finish at the cooling tower and vent silencer discharges.

The first and second separators and the reinjection pumps are considered part of the gathering and reinjection system, and are not included in the power plant components.

3.5.2 Main Turbine

The main turbine is a double flow, mixed pressure condensing turbine. The high pressure stage inlet pressure is approximately 110 psia and the low pressure stage inlet pressure is approximately 25 psia with a rated gross output from the generator of 55 MW. The turbine output shaft is coupled directly to the generator shaft. The turbine exhausts into the condenser at a back pressure of 89 mm hg. (3.5 inches) absolute. The steam flow is controlled on the high pressure and low pressure inlet lines by means of control valves actuated through the hydraulic governor system on the turbine.

The material of construction of the turbine is as follows:

- a) Top and bottom outer shells are cast steel
- b) Steam path is stainless steel
- c) Blades and rotor are stainless steel.

3.5.3 Condenser

The main condenser is located immediately below the main turbine and accepts and condenses steam discharged from the turbine primary and secondary exhaust stages. The condenser is a direct contact spray condenser in which exhaust steam from the turbine is directly mixed with and condensed by the cooling water from the cooling towers. The condensate then becomes part of the make-up cooling water in the cooling tower. The condenser is constructed of a carbon steel outer shell clad with 316L stainless steel for the inner shell.

The condenser is operated at a vacuum of 89 mm (3.5 inches) Hg which is produced by the steam jet ejector system. The condensate is removed from the condenser by means of the hot well pumps and pumped directly to the cooling tower. Noncondensable gases are removed from a special gas cooling section in the condenser by means of a two stage steam jet ejector.

3.5.4 Hot Well Pumps

Each hot well pump is rated 1,000 horsepower. The hot well pumps are located adjacent to the condenser and are the "canned" type vertical centrifugal pumps. This type is used because of low net positive suction head available from the condenser. Each pump is sized to handle 55% of the total flow through the condenser. The flow to the cooling tower from the condenser via the hot well pumps is controlled by means of flow control valves which are integrated with the water level control system on the condenser.

3.5.5 Cooling Towers

The cooling tower is a mechanical induced draft type having single speed reversing electric motor driven fans. The cooling tower fans have the reversing capability to insure proper operation during winter conditions. The fans are operated to draw air through the towers thereby inducing the draft.

The cooling tower function is to cool the water returning from the condensers via the hot well pumps, and provide a cold water storage sufficient for the condenser and all water using equipment as well as providing a supply of water to the plant fire protection system.

Water is returned to the condenser from the cooling tower basin (cold well) via large diameter piping. The water is drawn into the condenser under the effect of a vacuum produced by the ejector system.

The cooling tower is constructed mainly from wooden members forming the superstructure and louver sides. The individual cells are separated by fire proof siding which is also used to cover the outside un-louvered areas.

3.5.6 Piping Systems

The piping is basically separated into two areas, one steam and the other water. The steam system piping is constructed from carbon steel pipe and the water system piping is constructed from stainless steel pipe. The distinction is made because of the corrosive nature of geothermal water. Geothermal steam does not exhibit the same tendencies as geothermal water to cause corrosion at an accelerated rate.

3.6 Electrical Design

3.6.1 General

The major electrical equipment for the proposed Utah Power and Light Geothermal Power Plant is shown on "Power Single Line Diagram", Drawing No. A-08-101, Rev. A, included at the end of Section 3, and includes the following:

- a) A steam turbine driven generator with a gross output of 55 megawatts at 0.9 power factor.
- b) Generator air circuit breaker switchgear with circuit breakers rated 13.8 kV and 1,000 MVA interrupting capacity.

- c) A step-up transformer from 13.8 kV to 138 kV served from the 13.8 kV generator switchgear by 3000A nonsegregated enclosed bus duct and connected on the line side to the 138 kV switchyard ring bus.
- d) Three 138 kV oil circuit breakers in a ring bus arrangement.
- e) A 13.8 kV to 4.16 kV transformer and associated draw-out motor starters to serve two 1000 H. P. hot well pumps and space for a future 4.16 kV bus tie circuit breaker.
- f) A 13.8 kV to 480 volt transformer and associated switchgear to serve the turbine-generator auxiliaries, cooling tower fans and general building service loads, including space for a future 480 V bus tie circuit breaker.
- g) An auxiliary diesel generator rated 200 kW at 0.8 power factor to serve emergency lighting and other essential loads under emergency conditions.

3.6.2 Main Turbine Generator

The generator supplied with the steam turbine will be totally enclosed for recirculating hydrogen cooling with hydrogen-to-water heat exchangers and brushless excitation. It will be rated 55 megawatts gross, 61.1 MVA continuous at 60 Hertz and 13.8 kV.

3.6.3 Generator Switchgear

The generator switchgear will be rated 13.8 kV with 1000 MVA interrupting capacity and will be of the metal-clad, drawout type, for location indoors, with a generator circuit breaker and two feeder circuit breakers to serve the 4.16 kV and 480 volt auxiliary transformers.

3.6.4 Step-up Transformer

The step-up transformer will be located outdoors in the 138 kV switchyard and will be oil-filled rated 37.5/50/62.5 MVA, OA/FA/FA, at 55°C rise and 42/56/70 MVA, OA/FA/FA, at 65°C rise, 13.8/138 kV, 3-phase, 60 Hertz. The transformer will be served from the 13.8 kV switchgear by 3000A nonsegregated enclosed bus duct. The transformer will have 138 kV high voltage bushings and lightning arresters for connection to the switchyard buses. The transformer will have the standard accessories for this class of transformer and will be equipped with standard high voltage taps: 2-2 1/2% above and 2-2 1/2% below normal, with a manual tap changer for de-energized operation.

3.6.5 Oil Circuit Breakers - 138 KV

The three oil circuit breakers for the ring bus will be rated 138 kV, 1200A, 5000 MVA interrupting capacity, and will each be provided with two gang-operated air disconnect switches for circuit breaker isolation.

3.6.6 Air Disconnect and Ground Switches - 138 kV

In addition to the circuit breaker isolation air disconnect switches, each line will be provided with a gang-operated air disconnect switch and ground switch, and a gang-operated air ground switch will be provided on the section of the 138 kV ring bus which is connected to the step-up transformer. Air disconnect switches will be rated 138 kV, 1200A.

3.6.7 138 kV Switchyard Arrangement

The ring bus arrangement of the 138 kV switchyard will facilitate the addition of a fourth oil circuit breaker in the ring bus in the future when the second turbine generator and step-up transformer are installed.

3.6.8 4.16 kV Transformer and Switchgear

The 4.16 kV transformer and associated switchgear will be located indoors. The transformer will be silicon-filled rated 2500/3125 kVA, 0A/FA, at 55°C rise and 2800/3500 kVA, 0A/FA, at 65°C rise, 13.8/4.16 kV, 3-phase, 60 Hertz. The 4.16 kV switchgear will be of the metal-clad drawout type and will include a drawout motor starter to serve each of the 1000 H. P. hot well pumps and space for a future 4.16 kV bus tie circuit breaker.

3.6.9 480 Volt Transformer and Switchgear

The 480 volt transformer and associated switchgear will be located indoors. The transformer will be silicon-filled rated 2500/3125 kVA, 0A/FA, at 55°C rise and 2800/3500 kVA, 0A/FA, at 65°C rise, 13.8 kV/480V, 3-phase, 60 Hertz. The 480 volt switchgear will be of the metal-clad drawout type and will include an air circuit breaker to serve each of the three plant auxiliary building service motor control centers and space for a future 480 volt bus tie circuit breaker. Air circuit breakers will have a minimum interrupting capacity of 65,000 amps. symmetrical.

3.6.10 Auxiliary Diesel Generator

The auxiliary diesel generator will provide emergency power upon failure of normal power to emergency lighting and other essential loads. The generator will be rated 200 kW, 250 kVA, 0.8 power

factor, 480 volts, 3-phase, 60 Hertz, and will supply power to the building service motor control center.

3.6.11 Plant Start-up

The plant design is based on connection to two incoming lines on a 138 kV grid system. With both or either line in service, the plant can be started by energizing the 13.8 kV switchgear bus from the line through the step-up transformer. This permits operation of all turbine/generator auxiliaries and the hot well pumps, and when the generator is up to speed and voltage, it can be synchronized with the 13.8 kV bus through the generator circuit breaker.

The minimum size of steam turbine/generator to provide cold starting of the plant independent of the 138 kV lines is 1,300 kW. The added expense of approximately \$7.00 per kW based on 52,000 kW net, or \$364,000, does not seem to be justified economically with power available from two incoming lines.

3.6.12 Corrosion Protection

There is an inherent hydrogen sulfide atmosphere in geothermal power plants which is corrosive to copper. Special attention must be given to the protection of all electrical facilities. Vulnerable copper connections and contacts are to be tinned or plated with a protective coating which will protect them against the harmful effects of the hydrogen sulfide. Since hydrogen sulfide does not affect aluminum, aluminum bus, tubing and cable will be used for application above ground throughout the outdoor substation.

For added protection from the hydrogen sulfide atmosphere, switchgear, motor control centers and main control boards will be located in charcoal filtered clean air pressurized rooms to prevent adverse effects on electrical contacts.

3.7 Environmental Protection Considerations

Information available to date, indicates that the noncondensable gas content of the flash steam has a low content of hydrogen sulfide. On this basis, plant design and costs include minimum facilities for hydrogen sulfide abatement. Should further information indicate hydrogen sulfide content increasing to values high enough to require major abatement facilities based on air quality requirements, the following plant design changes and equipment additions would be required:

- a) Change main turbine condenser design from direct contact to surface type.

- b) Change intercondenser design from direct contact to surface type. Intercondenser condensate to be separately collected and transferred to the sulfur recovery system.
- c) Add a Stretford type sulfur recovery unit to treat the exhaust gas from the turbine condenser vacuum system and the gas cooling and jet condensate.

Drawing A-02-102, included at the end of this section, indicates the sulfur recovery equipment required by the installation of the "Stretford Process" noncondensable gas purification system.

The increased cost for surface type heat exchangers for main steam condensing, gas cooling and intercondenser above that for a direct contact system is as follows:

Surface Condenser Installed Cost	\$ 800,000
Stretford Unit Installed Cost (Including Paid Up Royalties)	<u>\$2,000,000</u>
H ₂ S Abatement Total Estimated Additional Cost	<u><u>\$2,800,000</u></u>

3.8 Instrumentation and Control

Controls are to be provided for start up of the plant from local controls in the vicinity of the equipment. When the turbine-generator has reached synchronous speed, control will be turned over to operating personnel in the control room for synchronizing and loading. Emergency shut down can be actuated from the control room or the local control panel on the operating floor.

3.8.1 The control room will contain: (1) a control panel for the turbine-generator, (2) a control board for auxiliary station controls; and (3) a control panel for the 138 kV switchyard.

3.8.2 Operating features will include:

3.8.2.1 Steam Shutoff Valves

The main steam stop valves can be remote hand actuated. However, they are normally closed automatically in the event of an emergency turbine shutdown.

3.8.2.2 Condenser Level Control

The level in the main condenser is controlled by automatic operation of a valve in the discharge of the hot well pump. This con-

trol is supplemented by a bypass valve to return a portion of the discharge water from the hot well pump to the main condenser. The bypass valve operates during conditions of extreme low level in the condenser such as during plant start up.

3.8.2.3 Condenser Pressure Control

The pressure in the main condenser is regulated by a valve which controls the flow of cooling water to the sprays in the main condenser.

3.8.2.4 Noncondensable Gas Anti-Surge Control

Control is provided to admit ambient air to the suction side of the noncondensable gas ejectors to prevent surging during reduced load operation.

3.8.2.5 Lube Oil Warm Up System

Control is provided to turn off the cooling water to the lube oil heat exchanger to provide a fast warm up of lube oil after a cold start.

3.8.2.6 Compressed Air System

Compressed air is provided by two compressors. One of the compressors normally supplies instrument and control air and one compressor normally supplies utility air to the station.

The control air system draws air from the charcoal filtered air supply to the air conditioning system. A dryer is provided to provide air with a -45°C dewpoint. Instrument air is provided through a filter-regulator at each point of use.

In the event of the failure of the control air compressor, manual valves are provided so that air from the utility air compressor may be introduced to the control air system ahead of the dryers.

3.8.2.6 Fire Pump System

Pressure in the fire pump system is maintained by a jockey pump controlled by a pressure switch. In the event the pressure continues to drop with the jockey pump running, a second contact of the pressure switch will start the main fire pump and open the automatic discharge valve. A continued drop in pressure will operate a third pressure switch contact to start the No. 2 main fire pump and open its discharge valve. As the pressure in the system is restored, the pumps will be stopped in the reverse order.

3.8.3 Alarms

Alarms are provided to the control room annunciator to alert the operator to imminent problems. The most important of these include:

- 3.8.3.1 Main condenser low level
- 3.8.3.2 Main condenser high pressure
- 3.8.3.3 Main condenser low pressure
- 3.8.3.4 Intercondenser high pressure
- 3.8.3.5 Intercondenser high level
- 3.8.3.6 Low fire water pressure
- 3.8.3.7 Lube oil centrifuge breakover
- 3.8.3.8 Low control air pressure
- 3.8.3.9 Hotwell pump low flow alarm
- 3.8.3.10 Cooling Tower Overflow Sump Level Control

A pump with a float switch is provided in the sump of the cooling tower to pump the excess condensate to the blowdown area.

3.8.3.11 Air Compressor Cooling System Surge Tank

A low level control is provided in the air compressor cooling system surge tank to make up for losses by admitting water from the domestic water system.

UTAH POWER & LIGHT 55MW GEOTHERMAL PROJECT

PROCESS FLOW DIAGRAM
POWER PLANT

DRAWING No.	REV.
B-02-101	A

REV. NO.	JOB NO.	BY	DATE
A	S-74002-02	BF	7/77

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

REV
DATE

REVISION DETAILS

EN'S.

APPR.

A
6/27/77

	BY DATE	ROGERS ENGINEERING CO., INC. ENGINEERS & ARCHITECTS 111 PINE STREET SAN FRANCISCO, CALIF. 94111	UTAH POWER & LIGHT 55 MW GEOTHERMAL PROJECT PLOT PLAN	DRAWING NO.	REV.
A	FEASIBILITY STUDY BY DATE 7/24/77			B-04-101	A
REV. NO.	JOB NO. S-74002-02

MEZZANINE FLOOR PLAN

TO SUB STATION

GROUND FLOOR PLAN

NOT TO SCALE

REV	DATE	REVISION DETAILS	ENG.	APPR.

Rogers

UTAH POWER & LIGHT 55 MW GEOTHERMAL PROJECT

GROUND & MEZZANINE FLOOR PLANS

JOB NO 5-74002-02

REV

B-80-101

A

OPERATING FLOOR

NOT TO SCALE

REV	DATE	REVISION DETAILS		ENG.	APPR.
Rogers		UTAH POWER & LIGHT 55 MW GEOTHERMAL PROJECT		JOB NO. 5-74002-02	REV
		OPERATING FLOOR PLAN		B-80-102	A

NOT TO SCALE

REV	DATE	REVISION DETAILS	ENG.	APPR.

Rogers

UTAH POWER & LIGHT 55 MW GEOTHERMAL PROJECT

SIDE ELEVATION

JOB NO. S-74002-02

REV

B. 80-103

A

SECTION

NOT TO SCALE

REV	DATE	REVISION DETAILS	ENG.	APPR.

Rogers

UTAH POWER & LIGHT 55 MW GEOTHERMAL PROJECT

CROSS SECTION

JOB NO.

B-80-104

REV

A

A	6/9/77	PRELIMINARY	H.L.	
REV	DATE	REVISION DETAILS	ENG.	APPR.
<div> <div>Rogers</div></div> <div>UTAH POWER & LIGHT 55MW GEOTHERMAL PROJECT</div> <div>POWER SINGLE LINE DIAGRAM</div> <div><div>JOB NO. S74002-02</div><div>A-08-101</div></div> <div><div>REV</div><div>A</div></div>				

4.0 GEOTHERMAL POWER PLANT COST ESTIMATE

The cost estimate is based upon the criteria, features and ratings of the equipment in Section 3. The site and architectural features of the cost estimate are discussed in this section.

The cost estimate was developed using the Federal Power Commission (FPC) "Electric Plant Accounts" with the Utah Power and Light applicable Emery No. 1 sub-account numbering and descriptions. The geothermal plant cost estimate is presented in Section 4.4 in accordance with the above accounts.

4.1 Building

This section describes the power plant building aspects of the project with particular emphasis on the size and relationship parameters needed to prepare the conceptual cost estimate.

4.1.1 Power Plant Building

The cost estimate for the proposed building represents a design of the following components:

A power plant building to house one 52 MW unit, with appropriate administration and ancillary services to effect a complete self-contained operation. The degree of administrative and ancillary services included in the initial phase will be sufficient to serve a future second 52 MW unit.

The initial building, 158 feet X 78 feet, will consist of six bays at 22 feet, 8 inches each for a total dimension of 136 feet in the power plant proper, with an additional bay of 22 feet, 8 inches to accommodate administrative and ancillary services, for an overall length of 158 feet. Eave height in the power plant will be approximately 75 feet above the ground floor.

The power plant will have three (3) floors, namely, ground floor, mezzanine floor, and operating floor. The vertical heights between the respective floors will be approximately 14 feet - 0 inches.

The administrative and ancillary service areas comprising three (3) floors in a lower level connected structure will contain the following:

4.1.1.1	Entrance and Reception	340 sq. ft.
4.1.1.2	Plant Superintendent	100 sq. ft.

4.1.1.3	Change and Locker Room	400 sq. ft.
4.1.1.4	Electrical Shop	520 sq. ft.
4.1.1.5	Instrument Shop	500 sq. ft.
4.1.1.6	Chemical Laboratory	425 sq. ft.
4.1.1.7	General Office, Including Mechanical and Electrical Supervisors	360 sq. ft.
4.1.1.8	Machine Shop with crane and parts storage, (will occupy an area in the power plant, ground floor level)	1,500 sq. ft.

A 50-ton bridge crane, operable throughout the power plant, will be mounted approximately 35 feet above the operating floor level.

4.2 Mechanical

The estimate was prepared on the basis of construction man-hours, and equipment and material estimated costs.

4.2.1 The basis of the cost estimate for mechanical equipment and materials comes from two sources.

- a) Prices quoted by manufacturers to a written summary specification.
- b) Prices established by current or previous projects of the same nature and size.

4.2.2 The mechanical equipment duties shown on the Process Flow diagram B-02-101, Rev. A, are the basis for the cost estimate. The equipment items for which quotations were obtained are as follows:

- 1) Turbine Generator Package
- 2) Condensers
- 3) Hot Well Pumps
- 4) Cooling Tower
- 5) Main Bridge Crane

4.2.3 The installation manhours are based on a combination of (a) previous actual manhours for this type of project (b) Richardson's Estimating Data Book information and (c) in-house experience in estimating manhours in similar type installations.

4.3 Electrical

4.3.1 Electrical Equipment Ratings

The Power Single Line Drawing A-08-101, Rev. A, shows the major electrical equipment elements and ratings. Electrical equipment based on the single line equipment and the electrical design criteria in Section 3.5.

4.3.2 Electrical Equipment and Material Costs

The electrical equipment and material costs in the estimate are current, June 1977.

4.3.3 Electrical Construction Man-hours

The electrical construction man-hours in the construction cost estimate are based, in general, on Richardson Engineering Services, Inc. - "General Construction Estimating Standards - Mechanical and Electrical" - 1976-77 Edition.

Labor man-hours not included in the above Estimating Standards are based on man-hours for similar work from experience on previous power plant installations.

4.4 Cost Estimate By Accounts

The geothermal power plant cost estimate is presented by Utah Power and Light's accounts and subaccounts. In preparing the estimate, a major factor in its presentation was keeping it similar in format to other UP & L power plant projects for ease in comparing costs.

The summary cost estimate for the 55 MW gross geothermal power plant is presented in Table 4-1 in this Section. Succeeding the summary table is a detailed listing by Utah Power and Light accounts and subaccounts of the geothermal plant cost estimate details.

All equipment and material purchases for the project are under Material and Equipment. The man-hours are the estimated construction man-hours required. The labor rates used are those given in the UP & L January 1977 report on Emery No. 1 costs escalated to June 1977. These construction labor rates are assumed to be the average at the middle of a 40 month construction period per recommendation of the UP & L engineering department. The middle of construction was taken as October 1976 and therefore 7 months of escalation (0.05264 at 8% labor per year Utah Power and Light figure) is applied to the Emery rates to get those used in the geothermal estimate, Table 4.1.

The geothermal power plant total construction cost including substation is estimated to be \$23,640,400 or \$455 per net kilowatt.

4.5 Engineering-Construction Schedule

The engineering and construction schedule is graphically represented by Drawing E-07-101, Rev. A. This schedule is the result of past experience by Rogers in implementing geothermal power plant design, procurement of all major equipment, and construction management of the plant.

The schedule presumes the resource is sufficiently defined to be able to proceed with the plant design based on the resource characteristics and well locations. This schedule includes an allowance for bids for all major equipment to be requested and evaluated according to detail specifications. The construction is separated into major areas: site, civil/structural, mechanical, etc. to show the allowed times and major interrelationships. The longest delivery item, the Turbine-Generator package, is the item which governs delivery and construction schedules. Delivery to the site is quoted by manufacturer to be 20 months. With delivery time of the turbine-generator package being 20 months, the shortest design and construction schedule achievable is 34 months. This schedule is based upon the increased time of delivery schedules recently proposed by manufacturers of turbine-generator packages.

The engineering includes all design engineering of construction drawings inside the power plant boundary fence, procurement of all equipment and major construction contracts, and on-site supervision by engineers as the construction progresses. Close coordination of the manufacturers' and construction personnel is maintained by the design engineering group.

Permits for building the power plant or acquiring permits for site construction and transmission line rights-of-way have not been included in the schedule. The schedule represents only engineering, procurement and construction since the Stearns-Roger construction schedule, as provided by Utah Power and Light Company for the 400 MW coal fired plant, does not provide for acquisition of plant permits or transmission line rights-of-way. A comparison of the geothermal schedule with a coal plant schedule is included in Section 6.3.

4.6

Estimated Cash Flow

An estimated cash flow for the engineering and construction period, taken as 34 months, has been prepared at the request of UP & L (see PCN No. 21 of July 15, 1977), and is shown in Table 4-2. Back up information may be found in Appendix D.

The flow has been prepared on a quarterly basis, and for the computation of IDC, monthly expenditures have been assumed uniform throughout each quarter.

TABLE 4-1

SUMMARY
55 MW (GROSS) GEOTHERMAL POWER PLANT
COST ESTIMATE
JUNE 1977

<u>Account Number</u>	<u>Description</u>	<u>Materials and Equipment</u>	<u>Labor Cost</u>	<u>Man-hours</u>
311	Structures and Improvements	\$ 1,186,000	\$ 597,400	29,800
312	Boiler (Steam Piping Only)	171,000	92,400	4,300
314	Turbogenerators	7,850,000	1,091,900	73,200
315	Accessory Electrical Equipment	740,000	198,900	12,700
316	Miscellaneous Power Plant Equipment	443,000	258,500	17,600
353	Substation	738,000	255,200	9,900
-	Refund Taxes	-	-	-
	Sub Totals	<u>\$11,128,000</u>	<u>\$2,493,400</u>	<u>147,500</u>
310	Land	\$ 8,000		
399	Contractor Overhead and Profit	<u>2,100,000</u>		
	Plant Installed	\$15,729,400		
399	UP & L Charges	475,000		
399	Engineering	2,000,000		
399	Interest During Construction	<u>2,352,500</u>		
	Sub Total	\$20,556,900		
	Contingency	<u>3,083,500</u>		
	TOTAL CONSTRUCTION COST	<u>\$23,640,400</u>		
-	Power Plant Construction Cost (\$/Net kW)	\$ 455		

TABLE 4-1 (Cont'd)

55 MW (GROSS) GEOTHERMAL POWER PLANT
COST ESTIMATE
JUNE 1977

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
310	<u>LAND AND LAND RIGHTS</u>			
310.1	Water Rights			
310.2	Land and Easements			
	SUB TOTAL DIRECT			
311	<u>STRUCTURES AND IMPROVEMENTS</u>			
311.1	Improvements to Site	-	-	
311.12	Plant Site	5,799	216,430	186,058
311.14	Sewage Treatment Facilities	438	8,732	5,552
311.15	Domestic Water System	266	22,823	3,405
311.3	Power Building	-	-	-
311.31	Substructure	8,092	111,057	90,120
311.32	Superstructures	12,190	726,805	263,404
311.33	Building Services	2,700	86,340	42,746
311.5	Fuel Oil System	-	-	-
311.51	Fuel Oil Tanks (Including Foundations)	250	10,000	4,916
311.52	Fuel Oil Piping (Yard Only - Building 312.191)	61	3,493	1,199
311.7	Administration Building and Main Warehouse and Shop	Included in Account 311.3		
311.8	Other Structures	None		
	Sub Total	29,796	1,185,680	597,400
	Use As	<u>29,800</u>	<u>1,186,000</u>	<u>597,400</u>
312	<u>BOILER PLANT EQUIPMENT</u>			
312.5	Boiler Plant Piping			
312.51	Steam Piping	2,349	85,374	32,540
312.56	Miscellaneous Process Piping	250	3,480	3,684
312.57	Piping Insulation (Lump All Insulation Here)	1,008	53,060	46,624
312.59	Piping & Valve Suspense (Material Only)	646	28,530	9,552
	Sub Total	4,253	170,444	92,400
	Use As	<u>4,300</u>	<u>171,000</u>	<u>92,400</u>

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
314	<u>TURBO-GENERATOR UNIT</u>			
314.1	Turbine - Generator			
314.11	Turbine Pedestal	8,671	125,145	91,457
314.12	Turbine	17,000	4,479,000	290,792
314.13	Generator	Included in Account 314.12		
314.14	Turning Gear			
314.15	Governing Control System			
314.16	Control and Stop Valve			
314.17	Gland Seal and Piping			
314.18	Supervisory Instrumentation (Local Front Standard)			
314.19	(Lump All Process Instrumentation Here)	4,800	154,500	82,106
314.2	Miscellaneous Turbine-Generator Equipment (Supplied by Turbine-Generator Package)	Included in Account 314.12		
314.3	Condenser and Auxiliaries			
314.31	Main Condenser (Surface Type Including Intercondensers)	11,000	900,000	162,686
314.33	Ejectors	Included in Acct. 314.31		
314.34	Condensate Pumps (Surface Type Cond)	2,300	500,000	34,016
314.35	Circulating Water Pumps	185	30,215	2,737
314.36	Circulating Water Pipe (Within Building)	4,706	146,811	69,600
314.4	Cooling Tower and Equipment			
314.41	Cooling Tower Basin and Foundations	2,355	32,434	38,425
314.42	Cooling Tower	7,000	1,000,000	98,222
314.43	Circulating Water Pump Structure	NONE		
314.45	Circulating Water Piping (Outside Building)	7,384	261,114	109,595
314.46	Water Treating System (For Circulating Water)	NONE		
314.47	Cathodic Protection (C. W. Piping)	Included in Acct. No. 314.45		
314.6	Lube Oil System (Including all equipment which is not furnished as an integral part of other equipment)			

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
314.61	Tanks, Pumps and Equipment	614	56,790	9,048
314.62	Lube Oil Piping	5,841	63,321	86,079
314.7	H ₂ and CO ₂ System (Only equipment which is not furnished as an integral part of other equipment)	730	81,200	10,758
314.9	Auxiliary Generator			
314.91	Diesel Engine Driven Generator	346	20,630	5,463
	Sub Total	73,190	7,851,160	1,091,000
	Use As	<u>73,200</u>	<u>7,850,000</u>	<u>1,091,000</u>

315 ACCESSORY ELECTRICAL EQUIPMENT

315.1	Main Power Control Equipment (13.8 kV)			
315.11	Cubicles	240	127,397	3,790
315.14	Load Frequency Control	Included in Account 315.41		
315.15	13,800 Volt Bus Duct and Terminals	180	58,812	2,842
315.16	Cooling Tower Control Equipment			
315.2	Start-up Power			
315.22	Start-up Switchgear	30	3,576	474
315.3	Other Station Service Control Equipment - 4160 Volt			
315.31	Cubicles	250	40,808	4,158
315.32	Local Control Stations and Receptacles	Included in Account 315.42		
315.34	4160 Volt Transformers	160	35,878	2,526
315.35	4160 Volt Bus Duct (1200 A)	80	6,969	1,263
315.4	Other Station Service Control			
315.41	Electrical Control Board & Supervisory Control	1,200	67,417	18,063
315.42	Local Control Stations and Receptacles	470	10,000	7,075
315.43	Motor Control Centers	200	68,000	3,011

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
315.44	Load Centers	420	80,000	6,322
315.5	Other Station Service Control Equipment - 120-208 Volt			
315.52	Distribution Panel	400	8,000	6,316
315.53	Transformer 480-120/208 Volt	40	2,000	632
315.6	Station Service DC Equipment			
315.61	DC Cubicles	Included in Account 315.64		
315.62	Distribution Panels	Included in Account 315.52		
315.63	Local Control Stations and Receptacles	Included in Account 315.42		
315.64	Battery	50	20,000	803
315.65	Battery Charger and Regulator	50	2,000	803
315.7	Other Control Wiring, Connections and Supports			
315.71	Conduit	3,080	37,000	48,632
315.72	Cable Tray	1,460	18,000	23,053
315.73	Wire and Cable	3,250	95,000	50,821
315.74	Grounding System	1,160	59,000	18,316
315.75	Annunciators and Alarms	Included in Account 315.41		
315.8	Freeze Protection	NONE		
	Sub Total	12,720	739,857	198,900
	Use As	<u>12,700</u>	<u>740,000</u>	<u>198,900</u>

316 MISCELLANEOUS POWER PLANT EQUIPMENT

316.2	Station Air System			
316.21	Compressors and Auxiliaries	372	51,477	5,475
316.22	Air Piping	4,614	20,154	67,899
316.3	General Plant Equipment			
316.31	Shop Equipment	86	112,748	1,267
316.32	Laboratory Equipment	-	65,000	-
316.33	Fire Extinguishing Equipment (Portable)	20	2,000	295
316.34	Office Equipment	-	3,400	-
316.35	General Service Equipment	-	25,000	-

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
316.36	Warehouse Shelves, Bins and Equipment (Including Gasoline and Diesel Pumps)	12,456	163,000	183,564
316.4	Intrasite Communication System (Including Gate TV)	NONE		
316.5	Weather and Monitoring Stations Remote from Plant	NONE		
	Sub Total	17,548	442,779	258,479
	Use As	<u>17,600</u>	<u>443,000</u>	<u>258,500</u>
352	<u>STRUCTURES AND IMPROVEMENTS</u>			
352.10	Clearing and Grading)	Included in Account 311		
352.20	Buildings)			
352.30	Roads, Walks and Fences)			
352.40	Yard Lighting)			
352.50	Water Supply System)			
352.60	Storm Drain System)			
352.70	Intrasite Communication System)			
353	<u>SUBSTATION EQUIPMENT</u>			
353.0	Common Wiring & Connections	-	-	-
353.06	Conduit, Wire and Cable	2,099	29,100	33,142
353.07	Yard Controls	1,600	88,000	25,263
353.10	Main Step-up Transformers	586	261,223	9,253
353.4	Switchyard			
353.40	Structures, Structure Lighting, Conductor Insulators and Hardware	2,953	49,818	46,627
353.41	Oil Circuit Breakers and Switchyard Grounding	1,280	167,000	119,685
353.42	Switches	1,140	65,000	18,000
353.44	Potential Transformers	200	78,000	3,158
	Sub Total	9,858	738,141	255,128
	Use As	<u>9,900</u>	<u>738,000</u>	<u>255,200</u>
	TOTAL PLANT INSTALLED	146,369	11,128,061	2,493,400
	USE AS	<u>147,500</u>	<u>11,128,000</u>	<u>2,493,400</u>

TABLE 4-2
CASH FLOW ESTIMATE
55 MW (GROSS) GEOTHERMAL POWER PLANT
JUNE 1977

1	2	3	4	5	6	7	8	9	10
End of Month No.	Material and Equipment	Direct Labor Charges	Contractor Overhead & Profit	Land	Engineering	UP & L Charges	Interest During Construction	Contingency	Total
3	\$1,177,500			\$8,000	\$ 150,000	\$ 40,000	\$ 15,500	\$ 209,700	\$ 1,600,700
6	706,500				150,000	40,000	41,000	141,800	1,079,300
9	1,892,500	\$ 66,400	\$ 55,900		200,000	45,000	76,600	351,500	2,687,900
12	706,500	99,500	83,800		200,000	45,000	114,700	188,100	1,437,600
15	824,300	99,500	83,800		250,000	60,000	142,300	218,900	1,678,800
18	1,978,700	99,500	83,800		250,000	60,000	185,000	397,800	3,054,800
21	2,743,000	99,500	83,800		200,000	50,000	248,500	511,900	3,936,700
24	942,000	407,000	342,800		200,000	45,000	306,000	336,100	2,578,900
27		561,000	472,500		200,000	45,000	342,200	243,600	1,864,300
30		561,000	472,500		100,000	25,000	370,500	228,200	1,757,200
34	157,000	500,000	421,100		100,000	20,000	510,200	255,900	1,964,200
	\$11,128,000	\$2,493,400	\$2,100,000	\$8,000	\$2,000,000	\$475,000	\$2,352,500	\$3,083,500	\$23,640,400

5.0

GEOTHERMAL POWER PLANT OPERATION AND MAINTENANCE

Personnel experienced in power plants will have the capability to operate and maintain large pumps and motors, process controls, heat exchangers, condensers, and cooling water systems.

Thus it is economic and practical to staff the power plant for routine maintenance with a minimum daily staff and utilize contract maintenance or a pool of plant maintenance crews for turnaround maintenance and repairs. The fixed operating costs must be calculated on this basis with an allowance for travel and subsistence for the power plant maintenance crews.

It is assumed the regular power plant supervisory staff will be present during weekday shifts and be available on short notice at all other times to assist with urgent matters regarding plant maintenance and operation.

5.1

Operations Staff

	<u># of Shifts Per Day</u>	<u>Total Operating Staff Per Day</u>
Supervisory		
Plant Supt.	1	1
Chief Operator	1	1
Maint. Foreman	1	1
Operating		
Shift Foreman	3	4
Shift Operator	3	4
Operator Helper	1	1
Maintenance, Regular	(50 Weeks)	
Electrician	1	1
Electrician Helper	1	1
Pipe Fitter/Mechanic	1	1
Pipe Fitter Helper	1	1
Instrument Technician	1	1

The power plant must be supplied with maintenance facilities and equipment sufficient to keep the power plant properly maintained. The plant will contain an instrument room, an electric shop, a machine shop and a chemical laboratory.

5.2

Maintenance Requirements

Geothermal Power Plant Maintenance - Yearly Turnaround Personnel

Maintenance, Turnaround Per Year
2 Weeks, 7 Days/Week, 3 Shifts

	<u>#/Shift</u>
Electrician	2
Electrician Helper	2
Pipe Fitter/Boiler Maker	4
Pipe Fitter Helper	4
Millwright	2
Millwright Helper	2
Instrument Technician	1
Instrument Technican Helper	1

5.3 Expected Plant Availability and Maintenance Schedule

5.3.1 Expected Plant Availability

The power plant is expected to operate 7,500 hours per year resulting in a plant capacity factor of approximately 85%.

5.3.2 Maintenance Schedule

5.3.2.1 The turbine-generator unit can be expected to be shut down approximately once per year for general maintenance procedures and repairs as necessary to ensure proper operation of the power plant equipment for its expected life.

5.3.2.2 During maintenance periods the covers are pulled off the turbine and generator units. Due to the inherent impurities carried by geothermal steam from the wells, the turbine blades and the entire steam flow path are subject to scaling. The turbine rotor is removed during the annual shutdown, any scaling is removed and the tips of the blades are checked closely for signs of erosion. Other elements in the steam flow path are also inspected, cleaned and repaired as necessary.

The main bearings are removed and cleaned and checked for any signs of wear due to vibration.

5.3.2.3 The generator rotor should be removed at this time and all the windings inspected. The excitation equipment should also be inspected at the same time.

5.3.2.4 General protective devices and systems that show any signs of operational problems are checked and maintained at this time.

5.3.2.5 Other major equipment such as the condenser, hotwell pumps and cooling towers, is also inspected during the annual maintenance period.

6.0 UTAH POWER AND LIGHT COMPANY COAL FIRED PLANT

At the present time, Utah Power and Light is constructing base load coal fired steam power plants. A geothermal base load plant will be compared with these coal plants.

6.1 Description and Basis

The coal fired power plant Emery No. 1 was selected to be compared with the geothermal plant. Emery No. 1 equipment was purchased after the rapid inflation of 1974 and both the material and labor costs provide the most up-to-date data available for comparison.

6.2 Coal Plant Costs by Account

The Emery Unit 1 cost data were furnished to Rogers by Utah Power and Light. The major document is titled "Subaccount Cost Forecast for Month Ending May 1977 Emery #1".

The coal fired plant cost is summarized by FPC accounts in Table 6-1. Column 1 relates to major material orders, all field purchases and rentals, and Utah Power and Light direct contracts as shown in the Utah Power and Light forecast. Column 2 is Contractor Direct Labor and Column 3 is Contractor Subcontracts, also shown in the UP & L forecast.

The above columns are sub totaled to give the Direct Costs. The contractor overhead and profit is derived from Acct. 399. The plant installed subtotal includes the contractor overhead and profit, equipment and material costs, and all installation labor costs. To develop total constructed cost, Utah Power and Light overheads, engineering and interest during construction, and all other 399 accounts not previously included are added to Plant Installed Cost. In the 399 account is a 1.0% contingency on total constructed cost.

The coal fired plant cost per net kW is \$630 as of May 1977.

The Emery plant accounts as discussed above form the basis for the geothermal power plant cost estimate presentation.

6.3 Cost Comparisons, Geothermal and Coal Fired Power Plants

The geothermal power plant as estimated includes one 52 MW unit with the planned expansion capability of one more 52 MW unit. The coal fired plant is also the first of two units at the Emery location.

The geothermal vs coal fired cost estimate comparison is summarized by FPC account number and indirect charges. The geothermal plant total cost in this Section 6.3 is reduced by the cost of the substation since no substation cost was available for the coal fired plant. The full geothermal cost summary and detail is in Section 4.4 of this report.

There are significant differences in magnitude of the two projects when comparing total cost, cost per kilowatt capacity and schedule. They are listed below:

<u>Item</u>	<u>Geothermal</u>	<u>Coal Fired</u>
Total Cost (substations excluded)	\$22,482,700	\$252,000,000
Dollars per Net Kilowatt	432	630
Net Capacity	52,000 kW	400,000 kW
Engineering and Construction	34 months	60 months
Base Load	Yes	Yes

Study of the direct cost elements by FPC accounts as a percentage of the direct cost total is beneficial in recognizing some physical differences.

<u>Item</u>	<u>Geothermal</u>	<u>Coal Fired</u>
310 Land	Nil	1
311 Structures & Improvements	14	28
312 Boiler (Piping)	2	52
314 Turbine-Generator	71	12
315 Electrical Equipment	7	6
316 Miscellaneous Equipment	6	1
Direct Cost %	100	100

The structures and improvements are twice the percentage of total cost in a coal fired plant vs geothermal plant. The boiler in the coal fired plant is 52 percent of the total plant cost and in geothermal is nonexistent, except for some piping. The turbine-generator is only 12 percent of a coal fired plant cost where it is 71 percent of the total plant cost in geothermal. The geothermal turbine is relatively larger for its capacity rating because of the lower pressure and temperature steam.

The accounts 315 and 316 do not show significant differences.

The indirect account charges Acct. 399 show some differences due to the size of the project. All the numbers are percentages of the direct costs line item in Table 6-2.

<u>Item</u>	<u>Geothermal</u>	<u>Coal</u>
Contractor Overhead and Profit	15	12
Utah Power and Light Charges	4	4
Engineering	16	7
Interest During Construction	19	14
Contingency	24	1

It is reasonable to expect the overheads, profits, and engineering fees to be a higher percentage of direct costs for smaller projects. Smaller projects require much of the same supervision and detail hence the higher percent of cost. Also in geothermal, more attention must be paid to the materials of manufacture, resulting in more engineering and procurement time. The contingency is larger due to the fact no preliminary design or major equipment purchases have been completed. All in all the indirect account charge differences between the two projects appear in line.

The overall data for the coal fired and geothermal power plants show that the geothermal plant can be constructed for the following percents of the coal fired plant cost.

<u>Item</u>	<u>Percent</u>
Dollars per Kilowatt	69
Time	57

Capacity factor is an important parameter when converting dollars per kilowatt to mills per kilowatthour. The geothermal power plant capacity factor is estimated to be 85 percent.

Figures 6.4-1 and 6.4.-2 represent the Engineering and Construction Schedules for a 400 megawatt coal-fired power plant and a 52 megawatt geothermal power plant, respectively. Details of the engineering tasks for each case have not been shown. The block periods of time required for the power plant engineering required before construction have been indicated.

The reference used for the 400 MW coal-fired power plant data was the Stearns-Roger Engineering and Construction Schedule for the Utah Power and Light Company as supplied to Rogers Engineering Company by Utah Power & Light Company (Emery Power Plant). These data were condensed to Figure 6.4.1 to show the installation schedule of one 400 MW unit. Figure 6.4.2 is based upon Rogers Engineering Company's own proposed Engineering and Construction Schedule shown in Section 3.5 for a 52 megawatt geothermal power plant.

TABLE 6-1

400 MW COAL FIRED STEAM POWER PLANT
EMERY #1 ESTIMATE
MAY 1977

<u>Account Number</u>	<u>Description</u>	<u>1 Materials and Equipment</u>	<u>2 Labor</u>	<u>3 Subs</u>
311	Structures and Improvements	\$ 30,170,990	\$10,706,022	\$11,685,494
312	Boiler	75,687,739	15,538,936	5,445,913
314	Turbogenerators	18,760,091	2,139,214	657,949
315	Accessory Electrical Equipment	8,357,014	2,508,100	-
316	Miscellaneous Power Plant Equipment	1,647,847	205,000	-
353	Substation	-	-	-
		<u>\$134,623,681</u>	<u>\$31,097,272</u>	<u>\$17,789,356</u>
310	Land, Easements and Water Rights	\$ 1,949,133		
399	Contractor Overhead and Profit	<u>\$ 21,822,558</u>		
	Plant Installed Sub Total	\$207,282,000		
399	UP & L Charges	6,509,000		
399	Engineering	12,710,000		
399	Interest and Taxes During Construction	<u>25,499,000</u>		
	CONSTRUCTION COST	\$252,000,000		
--	Power Plant Construction Cost (\$/Net kW)	\$ 630		

TABLE 6-2

GEOHERMAL VS COAL
COST ESTIMATE COMPARISON
SUBSTATIONS EXCLUDED

<u>Acct.</u>	<u>Item</u>	<u>52 MW Net Geothermal</u>	<u>400 MW Net Coal</u>
310	Land	\$ 8,000	\$ 1,949,133
311	Structures and Improvements	1,783,400	52,562,506
312	Boiler	263,400	96,672,588
314	Turbogenerators	8,941,000	21,557,254
315	Accessory Electrical Equipment	938,900	10,865,114
316	Miscellaneous Power Plant Equipment	701,500	1,852,847
353	Substation	-*	-
	Direct Costs Sub Total	\$12,636,200	\$185,459,442
399	Contractor Overhead and Profit	<u>1,935,500</u>	<u>21,822,558</u>
	Plant Installed Subtotal	\$14,571,700	\$207,282,000
399	Utah Power and Light Charges	475,000	6,509,000
399	Engineering	2,000,000	12,710,000
399	Interest During Construction	2,352,500	25,499,000
399	Contingency	<u>3,083,500</u>	<u>-</u>
	Construction Cost Total	<u>\$ 22,482,700*</u>	<u>\$252,000,000</u>
	Power Plant Construction Cost (\$/Net kW)	432	630

*Substation cost excluded for comparison.
Geothermal full cost Section 4.4

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ENGINEERING & CONSTRUCTION SCHEDULE FOR 400 MW COAL FIRED PLANT

FIGURE 6.4-1
S-74002-02
10 JUNE '77

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ENGINEERING AND CONSTRUCTION SCHEDULE

55 MW GEOTHERMAL PLANT

SITE PREPARATION

CIVIL / STRUCTURAL

COOLING TOWER

PIPING & MECHANICAL INCLUDING
T/G UNIT

ELECTRICAL

INSTRUMENTATION

START UP SERVICES

ENGINEERING BEFORE CONSTRUCTION

FIGURE 6.4-2
S-74002-02
10 June '77

OPERATING FLOOR

GROUND FLOOR PLAN

NOT TO SCALE

REV. NO.	JOB NO. 5-74002-02 FEASIBILITY STUDY BY [Signature] DATE 7/20/77	ROGERS ENGINEERING CO., INC. ENGINEERS & ARCHITECTS 111 PINE STREET SAN FRANCISCO, CALIF. 94111	UTAH POWER & LIGHT 2-55 MW GEOTHERMAL POWER PLANT <u>FLOOR PLANS</u>	DRAWING NO. B-80-105	REV. A
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APPENDIX A

A-1 Steam Gathering and Waste Water Reinjection System Description

Prior studies have determined that for a double flash system, a network of field-located high pressure satellite steam separators to separate the high pressure steam and low pressure steam, usually results in the lowest cost gathering system. Each field satellite may collect the two phase production flow from one to four wells. The satellite steam and remaining unflashed resource fluid flows are collected in separate piping networks and run into the high pressure steam condensate separator and the low pressure flash drum respectively. The two steam sources are then piped through the steam strainers and control valves to their respective inlets on the turbine casing.

The residual resource from the low pressure steam drum is sent to the booster pumps and then is pumped to the reinjection wells via a pipeline.

A-2 Steam Gathering and Water Reinjection Systems Cost Estimate

An average cost of approximately \$300,000 per well is expected for the gathering and reinjection system facilities. The cost is based on the well cost, plus piping costs derived from assumed well separation and reinjection well distances.

Varying numbers of production wells are reflected in the economic analyses. Three well flow rates were used to demonstrate the effects of this variation. A minimum spare capacity equal to the flow of one new well is required at all times. Production wells are assumed to decay in flow with time according to Figure A-1, thus additional production wells are required from time to time.

Figure A-2 shows the computer input used to determine the required number of production wells. This example uses 500,000 lbs. per hour brine flow from each well. The power plant (55 MW gross) required steam is produced from 4,080,000 lbs. per hour brine flow. A spare capacity of 500,000 lbs. per hour is stipulated. The table indicates the well flow characteristics with time as used in this example.

Figure A-3 is the computer calculated number of wells and available flow per project year. This example assumed start of production in fifth project year. Ten wells are required initially and others are required as stated to maintain the proper flow for the power plant plus spare capacity. It is assumed one reinjection well is required for each two production wells and the same well drilling cost is used for production and reinjection wells.

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FIGURE A-1

POUNDS PER HOUR WELL= 500000,
POUNDS PER HOUR POWER PLANT= 4080000,
POUNDS PER HOUR SPARE CAPACITY= 500000,

Figure A-2

YEAR	WELL FLOW
1	1.00
2	.80
3	.70
4	.64
5	.60
6	.57
7	.54
8	.52
9	.51
10	.50
11	.50
12	.50
13	.50
14	.50
15	.50
16	.50
17	.50
18	.50
19	.50
20	.50
21	.50
22	.50
23	.50
24	.50
25	.50
26	.50
27	.50
28	.50
29	.50
30	.50

ROGERS ENGINEERING WELL PROGRAM

500,000

PROJECT YEAR

NUMBER OF WELLS

AVAILABLE FLOW

FIGURE A-3

1	0	0.
2	0	0.
3	0	0.
4	0	0.
5	10	5000000.
6	2	5000000.
7	1	4800000.
8	1	4800000.
9	1	4890000.
10	1	5020000.
11	0	4640000.
12	1	4895000.
13	0	4645000.
14	1	4975000.
15	0	4790000.
16	0	4685000.
17	0	4620000.
18	1	5075000.
19	0	4945000.
20	0	4875000.
21	0	4830000.
22	0	4805000.
23	0	4785000.
24	0	4770000.
25	0	4760000.
26	0	4755000.
27	0	4750000.
28	0	4750000.
29	0	4750000.
30	0	4750000.
31	0	4750000.
32	0	4750000.
33	0	4750000.
34	0	4750000.

A-3 Gathering and ReInjection System Economics

Several cases are presented to show economic characteristics of the gathering and reinjection system. The studies are not derived from specifics of the Phillips wells at Roosevelt Hot Springs. However, they are for a 500°F bottom hole resource.

A series of thirteen cases have been run to demonstrate the economic parameters. Rogers' computer program develops cash flow for all project years. It calculates expenses, taxes and royalties as described in the input data. Annual operation expenses, well costs and gathering system capital are accounted for when spent. Figure A-4 is a typical set of input parameters and Figure A-5 is a Cash Flow Table. The rate of return is calculated on a present worth basis. The project rate of return is that rate at which the sum of present worth's of the annual amounts of capital exactly equals the sum of the present worth's of the available funds. The available funds for any given year is the sum of the depreciation and the profit. These studies have been made assuming the capital was equity. Each data point on the plotted curves is the result of a cash flow table.

The cases are:

Case 1	Base Case No Escalation of Capital
Case 2	Case 1 with 8% escalation of Capital for 10 Years
Case 3	Case 2 with 750,000 #/hr. Flow Rate
Case 4	Case 2 with 250,000 #/hr. Flow Rate
Case 5	Case 2 with Well Cost \$300,000 Each
Case 6	Case 2 with Well Cost \$700,000 Each
Case 7	Case 2 with Well Expense of Capital 70%
Case 8	Case 2 with Royalty 15% of Revenue
Case 9	Case 2 with Depletion Allowance 17.5% of Revenue
Case 10	Case 2 with Power Plant Capacity Factor 70%
Case 11	Case 2 with Power Plant Capacity Factor 90%
Case 12	Case 2 with Investment Tax Credit 12.5% of Tax
Case 13	Case 2 with Revenue Escalated at 3% Per Year
Case 14	Case 2 with Cost of Capital at 8% Interest on
80 percent Project Borrowed Funds
Case 16	Case 2 with Case 9, 12 and 13.

Case 2 input data is Figure A-4 and Figure A-5 with the cash flow table for revenue at 5 mills per kWh.

The economic graphs all are plotted with Case 2 which uses values for the various parameters that are bracketed by those values used in the other cases.

Figure A-6 shows the base case (Case 1) with 1977 prices and no escalation plotted with Case 2 with 8% escalation for the first 10 years only. This shows that if the resource producer required a 15 percent return he would sell the steam for 12.5 mills per kWh in Case 1 and 19.5 mills per kWh in Case 2. The 8 percent escalation increases by 56 percent the selling price of the steam to maintain the same 15 percent rate of return.

LOGS ENG 574002-02 -- UTAH POWER AND LIGHT STUDY -- CASE2

WELL FLOW	500000.	ROYALTY	.10
TEMPERATURE	500.	DEPLETION	0.00
PLANT OUTPUT NET KW	52000.	COST OF CAPITAL	0.000
CAPACITY FACTOR	.80	GROSS REVENUE TAX	0.00
UPPER PLANT COST	0.	TAX ON INCOME	.51
PP OPER + MAINT EXP	0.	INVESTMENT TAX CREDIT	0.000
YEARS IN STUDY	34	DEP WELL LIFE	20.
YEAR START GEN	5	DEP SRFC FCLT LIFE	20.
ESCAL CAPITAL	.000	ESCAL REVENUE	0.000
ESCAL YEARS	10	COST PER WELL	500000.

LR---EXP1-----EXP2-----WELLS-----SRF FACIL-----PWR FLT

1	0.	0.	1080000.	0.	0.	Well expense of Cap. 30%
2	0.	0.	1166400.	0.	0.	
3	0.	0.	1889566.	0.	0.	
4	0.	0.	2720978.	0.	0.	
5	185135.	0.	2932656.	6611976.	0.	
6	199946.	0.	2380311.	1428187.	0.	
7	215942.	0.	1713824.	1028295.	0.	
8	233217.	0.	925465.	555279.	0.	
9	251875.	0.	1999005.	1199403.	0.	
10	272025.	0.	1079462.	647677.	0.	
11	272025.	0.	0.	0.	0.	
12	272025.	0.	2158925.	1295355.	0.	
13	272025.	0.	0.	0.	0.	
14	272025.	0.	1079462.	647677.	0.	
15	272025.	0.	0.	0.	0.	
16	272025.	0.	0.	0.	0.	
17	272025.	0.	0.	0.	0.	
18	272025.	0.	2158925.	1295355.	0.	
19	272025.	0.	0.	0.	0.	
20	272025.	0.	0.	0.	0.	
21	272025.	0.	0.	0.	0.	
22	272025.	0.	0.	0.	0.	
23	272025.	0.	0.	0.	0.	
24	272025.	0.	0.	0.	0.	
25	272025.	0.	0.	0.	0.	
26	272025.	0.	0.	0.	0.	
27	272025.	0.	0.	0.	0.	
28	272025.	0.	0.	0.	0.	
29	272025.	0.	0.	0.	0.	
30	272025.	0.	0.	0.	0.	
31	272025.	0.	0.	0.	0.	
32	272025.	0.	0.	0.	0.	
33	272025.	0.	0.	0.	0.	
34	272025.	0.	0.	0.	0.	

FIGURE A-4

YEAR	CAPITAL	REVENUE	EXPENSE	ROYALTY	DEPRCTN	INTEREST	ACCUM CASH	AFT TAX	AVLBL	YEAR
-DPLT GRT-				-UNRC CP-----REQMT-----P OR L-----FUNDS						
1	756.	0.	324.	0.	38.	0.	1080.	-362.	-38.	1
2	816.	0.	350.	0.	79.	0.	2246.	-429.	-79.	2
3	1323.	0.	567.	0.	145.	0.	4136.	-712.	-145.	3
4	1905.	0.	816.	0.	240.	0.	6857.	-1056.	-240.	4
5	8669.	1822.	1067.	182.	673.	0.	14953.	-100.	573.	5
6	3094.	3644.	914.	364.	828.	0.	15682.	1558.	2366.	6
7	2228.	3644.	730.	364.	940.	0.	15609.	1361.	2300.	7
8	1203.	3644.	511.	364.	1000.	0.	14946.	867.	1867.	8
9	2599.	3644.	652.	364.	1130.	0.	15779.	636.	1766.	9
10	1403.	3644.	596.	364.	1200.	0.	15255.	727.	1927.	10
11	0.	3644.	272.	364.	1200.	0.	13159.	886.	2086.	11
12	2807.	3644.	970.	364.	1380.	0.	14136.	500.	1840.	12
13	0.	3644.	272.	364.	1340.	0.	11979.	817.	2157.	13
14	1403.	3644.	596.	364.	1410.	0.	11348.	624.	2034.	14
15	0.	3644.	272.	364.	1410.	0.	9155.	783.	2193.	15
16	0.	3644.	272.	364.	1410.	0.	6961.	783.	2193.	16
17	0.	3644.	272.	364.	1410.	0.	4768.	783.	2193.	17
18	2807.	3644.	920.	364.	1551.	0.	5628.	397.	1947.	18
19	0.	3644.	272.	364.	1551.	0.	3363.	714.	2265.	19
20	0.	3644.	272.	364.	1551.	0.	1099.	714.	2265.	20
21	0.	3644.	272.	364.	1551.	0.	0.	714.	2265.	21
22	0.	3644.	272.	364.	1513.	0.	0.	732.	2245.	22
23	0.	3644.	272.	364.	1472.	0.	0.	752.	2225.	23
24	0.	3644.	272.	364.	1406.	0.	0.	785.	2191.	24
25	0.	3644.	272.	364.	1311.	0.	0.	832.	2142.	25
26	0.	3644.	272.	364.	877.	0.	0.	1044.	1921.	26
27	0.	3644.	272.	364.	722.	0.	0.	1120.	1842.	27
28	0.	3644.	272.	364.	611.	0.	0.	1174.	1785.	28
29	0.	3644.	272.	364.	551.	0.	0.	1204.	1755.	29
30	0.	3644.	272.	364.	421.	0.	0.	1267.	1688.	30
31	0.	3644.	272.	364.	351.	0.	0.	1302.	1653.	31
32	0.	3644.	272.	364.	351.	0.	0.	1302.	1653.	32
33	0.	3644.	272.	364.	210.	0.	0.	1371.	1581.	33
34	0.	3644.	272.	364.	210.	0.	0.	1371.	1581.	34
PROJECT RATE OF RETURN .063 21130301. .010										

Figure A-7 shows Cases 2, 3 and 4 plotted together. This figure shows how the average flow rate per well changes the selling price. Using a constant 10 percent return required the selling price for:

Case 3	750,000 #/hr.	10 mills per kWh
Case 2	500,000 #/hr.	14 mills per kWh
Case 4	250,000 #/hr.	24.8 mills per kWh

Using 14 mills as 1.0 base the price varies 105 percent between the lowest and highest for a constant rate of return and varying average well flow rates.

Figure A-8 shows Cases 2, 5 and 6. This combination varies the cost of wells. Using 15 percent required return the following relationships exist:

Case 5	\$300,000/Well	15. mills per kWh
Case 2	\$500,000/Well	19.5 mills per kWh
Case 6	\$700,000/Well	24. mills per kWh

Using 19.5 mills as 1.0 base the price varies 46 percent between the lowest and highest for a constant rate of return varying the average well cost.

Figure A-9 shows Case 2 and 7. This set demonstrates the difference when the percent of well capital, to be expensed in the year of occurrence, varies. Case 2 uses 30 percent. Case 7 uses 70 percent. At 15 percent return Case 7 gives 14.5 mills per kWh and Case 2 gives 19.5 mills per kWh. This is 26 percent difference in cost of steam to the power plant.

Figure A-10 shows Cases 2, 8, 9, 12 and 13. Case 2 and 8 show the difference when the royalty is increased from 10% to 15%. Case 2 and 9 show the effect when the Internal Revenue Service allows 17.5% depletion allowance. Case 2 and 12 show the effect of the 12.5% investment tax credit. Case 2 and 13 show the effect of escalating the revenue received from the sale of steam by 3 percent per year.

Figure A-11 shows cases 2, 10 and 11. This set presents the effects due to changing the power plant capacity factor. Again assuming 15 percent return is required the cost of steam varies like this:

Case 10	70% Capacity Factor	27.2 mills per kWh
Case 2	80% Capacity Factor	19.5 mills per kWh
Case 11	90% Capacity Factor	17.2 mills per kWh

Using 19.5 mills as 1.0 base there is a 26 percent difference in steam selling price between the lowest and highest.

Figure A-12 shows Case 2 plotted with 14 and 16. In Case 14 the variation is return or selling price of steam when the project is financed 50 per-

cent with borrowed money earning 8 percent annual interest and 50 percent with equity money earning zero interest. Case 16 combines Case 9, Depletion Allowance, Case 12 Investment Tax Credit and Case 13 Escalated Revenue with the assumptions and parameters of Case 2. Something approximating Case 16 would probably be the result if the resource supplier achieved optimum conditions from contract negotiations and favorable rulings from the Internal Revenue Service. Many other cases than those presented are possible; however, it is significant to recognize when putting the parameters together they add considerably to the returns of Case 2, when holding the selling price constant.

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CAPITAL COST ESCALATION vs. FLAT COST

FIGURE A-6
S-74002-02
10 JUNE, '77

Rogers

WELL FLOW RATE VARIATION

FIGURE A-7
S-74002-02
10 JUNE, '77

Rogers

COST OF WELLS VARIATION

FIGURE A-8
S-74002-02
10 JUNE, '77

Rogers

TAX TREATMENT EXPENSE PERCENT OF WELL COST

FIGURE A-9
S-74002-02
10 JUNE, '77

Rogers

ROYALTY, DEPLETION ALLOWANCE, INVESTMENT
TAX CREDIT, AND REVENUE ESCALATION

FIGURE A-10
S-74002-02
10 JUNE, '77

Rogers

POWER PLANT CAPACITY FACTOR VARIATION

FIGURE A-11
S-74002-02
10 JUNE, '77

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COST OF CAPITAL vs BASE CASE (14 & 2)
COMPOSITE SITUATION vs BASE CASE (16 & 2)

FIGURE A-12
5-74002-02
10 JUNE, '77

APPENDIX B

B-1 Major Equipment Quotations

Letter quotations were received from manufacturers for many of the major equipment items which make up the geothermal power plant. Quotes which were responsive to Material Requisitions are included herein. Material Requisition numbers for the major equipment quoted upon are as follows:

<u>MR Number</u>	<u>Item</u>
MR-12-101	Condensing Equipment
MR-12-102	Cooling Tower
MR-14-101	Hotwell Pumps
MR-17-101	Turbine-Generator
MR-17-102	138 - 13.8 kV Step-up Transformer
MR-19-101	Bridge Crane

Quotations responsive to the Material Requisitions shown under the appropriate MR number with its corresponding quoted price are itemized below.

MR-12-101	Condensing Equipment		
	Toshiba	\$1,278,000	
	MHI	\$ 966,545	
	Ecolaire Condenser	\$ 850,000	
	Graham Manufacturing Co.	\$1,000,000	
	- Budget Figure Used in Estimate		\$ 900,000
MR-12-102	Cooling Tower		
	Marley Cooling Tower Company	\$1,275,000	
	Ecodyne-Cooling Products Division	\$ 908,300	
	- Budget Figure Used in Estimate		\$1,000,000
MR-14-101	Hotwell Pumps		
	Peerless	\$ 488,090	
	MHI	\$ 779,272	
	Toshiba	\$2,205,000	
	- Budget Figure Used in Estimate		\$ 500,000
MR-17-101	Turbine-Generator Unit		
	MHI	\$4,479,000	
	General Electric	\$6,500,000	
	Toshiba	\$5,250,000	
	- Budget Figure Used in Estimate		\$4,479,000

MR-17-102

138 - 13.8 kV Step-up
Transformer

General Electric	\$ 311,000
Westinghouse	\$ 260,000

- Budget Figure Used in Estimate \$ 260,000

MR-19-101

Bridge Crane

P & H (Harnischfeger)	\$ 225,000
Sierra Crane & Hoist	\$ 148,000

- Budget Figure Used in Estimate \$ 225,000

MATHESON - DOHERTY Co.

191 BEACON ST., SOUTH SAN FRANCISCO, CALIFORNIA
PHONE (415) 583-6161 94080

June 15, 1977

Rogers Engineering Company, Inc.
111 Pine Street
San Francisco, California 94111

Attention: Mr. R. G. Brindle

RE: Your Request for Quote Job No. S-74002-02

Gentlemen:

We are pleased to attached our quotation to cover a Twin Element Two Stage System as per your above request.

Please note that this is for components only and you will note from the attached sketch that there would be some valving and elbows required beyond what we are offering. The proposal is based on F.O.B. Cornwells Heights, Pennsylvania.

We appreciate the opportunity of working with you on this project. Should you have any questions, do not hesitate to contact us.

Yours very truly,

MATHESON-DOHERTY COMPANY, Representing
AMETEK/SCHUTTE & KOERTING DIVISION

BOB BURNS

BB:sm

enc: Proposal - Job No. J-15030F
Sketch

MR 12-101
H.I. ROGERS
574002-02

METEK

SCHUTTE & KOERTING COMPANY • CORNWELLS HEIGHTS, PENNSYLVANIA 19020

TELEPHONE: (215) 639-0900

TELEX: 84-5283

J-15030F

Roger Engineering Co., Inc.

Engineers & Architects

111 Pine Street

San Francisco, CA 94111

In Reply Refer to File No.

Attention: R. G. Brindle, Purch. Mgr.

Reference: Job #S-74002-02, Spec S-12-101

Twin Element Two Stage Air Ejector with

D/C Intercondenser

for Utah Power & Light Co.

June 13, 1977

Quan.	Article	Net Price Each	Total
	<i>We Quote as Follows /</i>		
	S&K Twin Element Two Stage Air Ejector with Direct Contact Intercondenser (Ref Sketch #1). All fabrication is S/S Type 316L (nozzles are 316 S/S) (S&K quoting components only at this time with interconnecting piping and isolating valves supplied by others)		
2	22" T4S3 First Stage Ejectors - Each to handle 2,300 PPH W/V 11,000 PPH gas (NC) MW=40 300 PPH air Suction pressure @ 3.0" HgAbs. Steam consumption is 26200 PPH each @ 100 PSIG		
	108" dia. Type 598 Barometric Intercondenser - uses 3520 GPM 80° water in, 105°F out (designed to handle both first stage ejectors operating - water flow cannot be throttled since this is spray type condenser) 15 PSI differential required at water inlet operating pressure design is 14.3" HgA		
2	8" S-3 Second Stage Ejectors - Each to handle 5000 PPH gas (MW-40) plus 300 PPH air and associated water vapor using 6600 PPH steam @ 100 PSIG and discharging to 1/2 PSIG.		
	NET PRICE F.O.B. CORNWELLS HEIGHTS, PA.....	\$124,000.00	
1	S&K Size 5" (6" suction x 6" discharge) S8 gland ejector having S/S 316 body and diffuser using 930 PPH steam @ 100 PSIG handling minimum 2600 PPH (considered steam) @ 28" Hg.Abs and discharging to 1/2 PSIG		
	NET PRICE F.O.B. CORNWELLS HEIGHTS, PA.....	\$ 4,900.00	
	DELIVERY: 24-26 weeks after approval of drawings. 4-6 weeks for preparation of drawings.		

30 days net from date of invoice f.o.b. shipping point.

Yours Respectfully

SCHUTTE AND KOERTING COMPANY

per Howard Agnew
Assistant Sales Manager

This contract shall be subject to
and include all the provisions
printed on the reverse side hereof.

PLS SUBMIT FLWG ESTIMATE TO ROGERS:

A. PRICE (ON FOB JAPANESE PORT BASIS)

$275Y = 1\$$
unofficial

1) TURBINE-GENERATOR AND ACCESSORIES:

55MW TURBINE, LUBRICATING OIL SYSTEM, GLAND SEAL EJECTOR,
SAFETY DEVICE, 61, 111 MVA H2 COOLED GENERATOR WITH
BRUSHLESS EXCITOR INCLUDING GAS AND OIL CONTROL PANEL.

FOB JAPAN YEN 1,231,740,000. (1,231,740,000.)

4,479,000 81.44 \$/kw

2) ALTERNATE:

-DITTO BUT GENERATOR IS AIR COOLED FOB JAPAN YEN 1,066,740,000.

(1,066,740,000.) 3,879,054 70.5 \$/kw

3) CONDENSER, STEAM JET GAS EJECTOR SYSTEM

FOB JAPAN YEN 265,800,000. (265,800,000.)

966 EAS 17.57 \$/kw

4) HOTWELL PUMP AND MOTOR

FOB JAPAN YEN 214,300,000. (214,300,000.)

779 272 14.17 \$/kw

GRAND TOTAL

IN CASE H2 COOLED

FOB JAPAN YEN 1,711,840,000

6,224,872

GENERATOR ADOPTED

(1,711,840,000.)

113 \$/kw

(1)/(3)/(4)

IN CASE AIR COOLED

FOB JAPAN YEN 1,546,840,000.

5,624,872

GENERATOR ADOPTED

(1,546,840,000.)

102 \$/kw

(2)/(3)/(4)

B.B. TERMS OF PAYMENT: ABOVE PRICES IS BASED ON 100 PCT UPON

SHIPMENT

C. TIME OF DELIVERY: FOB 18 MONTHS AFTER SIGNING OF CONTRACT

NOTE: DESPITE ROGERS REQUEST OF QUOT ON FOB SALT LAKE CITY

DUE TO LACK OF TIME ABOVE PRICE IS ON FOB JAPANESE PORT

BASIS HWVR WE ARE NOW PREPARING TO CALUCULATE OCEAN FRT/

MARINE INS TO SFC OR LOS

GRAHAM MANUFACTURING CO., INC.

SALES HEADQUARTERS: 170 GREAT NECK ROAD • GREAT NECK, NEW YORK 11021

TELEPHONE: 482-5200 • AREA CODE 516

TWX: 510-223-0808 • TELEX: 12-5070

June 23, 1977

PLEASE REPLY TO:

THE CUTINO COMPANY
P.O. BOX 146
PINOLE, CA 94564
(415) 223-5554

cc HIR
JTK
JB.
BF.
RGG
Job File

Mr. R. G. Brindle
Purchasing Manager
Rogers Engineering Company, Inc.
111 Pine Street
San Francisco, California 94111

Subject: Rogers Job No. S-74002-02
Graham Reference EG 92-SF-77
Utah Power and Light

H. I. Rogers

S-74002-02

MR-12-101

Dear Mr. Brindle:

Thank you for your inquiry regarding the direct contact condensers and gas removal equipment on the subject job.

The following preliminary vacuum system consists of a main condenser and two-stage steam jet system which includes a barometric intercondenser. The main condenser has been selected on the basis that the steam turbine will have a quantity of eight steam outlets arranged in parallel, four to each side of the turbine. These connections are 4 ft. high x 8 ft. wide each and are spaced equally along the side of the main turbine. We are quoting two main condensers to be arranged in parallel with four steam inlets per condenser. Each main condenser will be approximately 10 ft. wide x 12 ft. high x 48 ft. long. Each condenser requires 28,500 GPM of cooling water.

One two-stage single element ejector set to serve both condensers will be required using a total of 55,000 lb/hr of steam at 100 psig and 2,000 GPM of cooling water in at 80°F. Material of construction is 10% Type 316L stainless steel clad steel plate.

We estimate the budget price for these components only as \$1,000,000.00, F.O.B. factory, Batavia, New York. The total weight is approximately 250,000 lb.

Mr. R. G. Brindle

-2-

GRAHAM MANUFACTURING CO., INC.
June 23, 1977

The first-stage ejector is Graham Size 4400B. The barometric intercondenser is Graham Size 66MM. The second-stage ejector is Graham Size 1100C.

These selections are preliminary and pricing is based on Graham General Conditions of Sale, enclosed.

If we can be of any further assistance regarding this selection, please do not hesitate to call on us.

Sincerely yours,

GRAHAM MANUFACTURING COMPANY, INC.

Thomas P. Cutino

TPC:dh
Encl.

ECOLAIRE CONDENSER

INCORPORATED

P.O. BOX 2327, LEHIGH VALLEY, PA. 18001

PHONE: 215-866-9500 TELEX: 84-7330 ECOLAIRE BETM

San Francisco Branch
101 Howard Street, Suite 2A
San Francisco, California 94105
Phone (415) 433-1450

June 16, 1977

RECEIVED
JUN 18 1977
Rogers Engineering Co., Inc.
SAN FRANCISCO

Rogers Engineering Company
111 Pine Street
San Francisco, California 94111

PROJ. MGR. *HIR*

Attention: Mr. R. G. Brindle, Purchasing Manager

S74002-02
MR-12-101

Subject: Material Requisition
Direct Contact Condensers & Related Auxiliaries
Utah Power & Light Company

Your Reference: S-74002-02
Our Reference: SF-1000

Gentlemen:

In accordance with your Material Requisition No. MR-12-101, we are pleased to offer our quotation for the condensing equipment. Please note that we have offered a close estimated price at this time, due to the fact that several of the variables that would be required to determine a final selling price have not been fully determined. By this we are referring to the type and characteristics of the steam turbine; the foundation details, including the pedestal width and height; the economic factors that will affect the tube diameter, length, and gage; and the breakdown of the non-condensable gases that will determine the actual ejector and inter and after condenser sizes. Until these items are known the condenser cannot be finality designed and priced.

We would be pleased to work with you to design the optimum condenser for this application.

If there are any questions, please contact me.

Very truly yours,
ECOLAIRE CONDENSER, INC.

T. Pullen
T. K. Pullen
Regional Manager

TKP:mh

Ecolaire Condenser, Inc.
SF-1000

June 16, 1977

PRICING

One (1) lot of condensing equipment consisting of a direct contact main condenser with direct contact inter and after condenser and first and second stage ejectors. The material of construction for the main condenser shell wall shall be carbon steel with a 316L stainless steel cladding. The internal plates shall be solid 316L stainless steel. The ejectors shall be 316L stainless steel materials.

Estimated Price: \$850,000.00 net total

Estimated Time of Delivery: 18-24 months from approval of drawings with release to manufacturer.

Preferred Method of Payment: Progress Terms of Payment with 60% of the contract due in 6 equal monthly payments, beginning 6 months prior to shipment. 20% at time of shipment. 15% - 30 days from shipment. 5% - 180 days from shipment.

This price can be considered as F.O.B. Salt Lake City, Utah with freight included from our factory in Easton, Pennsylvania.

THE MARLEY COOLING TOWER COMPANY

P.O. Box 547/Millbrae, California 94030/Telephone: (415) 697-6612/Telex 34-9300

June 16, 1977

Rogers Engineering Co., Inc.
111 Pine Street
San Francisco, California 94111

Mr. R. G. Brindle, Purchasing Manager

Cost Estimate To Quotation
Rogers Engineering Job S-74002-02
Utah Power & Light Company

*HI Rogers
S74002-02
MR-12-102*

Gentlemen:

For your preliminary cost estimate for Utah Power & Light Company, we have selected a model 6615-4-07 for your design performance of cooling 62,600 gpm from 114.7F hot water to 80F cold water at a 67F design wet bulb.

We enclose with this letter a copy of your cooling tower data sheet DS-12-001 and also motor data sheet DS-12-002. These data sheets have been filled in with the requested information.

A lump-sum price for furnishing, delivering, and erecting this cooling tower would be \$1,275,000. This is based on today's prices and would be escalated from the current date.

We would invoice on the following basis:

Materials: Net 30 days progressively as materials are shipped.
Labor: 85 percent monthly as work progresses with the 15 percent balance due 30 days after completion.

This is offered on the basis of typical materials that we would furnish on a geothermal job.

Please let us know if we can provide any further detailed information.

Very truly yours,
THE MARLEY COOLING TOWER COMPANY

Ward L. Clark
Ward L. Clark

A MARLEY COMPANY

Ecodyne Cooling
Products Division

P. O. Box 1267
Santa Rosa, California 95403
707/544 5833

HIR
RCB

File S-74002-02

June 14, 1977

Rogers Engineering Company, Incorporated
Engineers and Architects
111 Pine Street
San Francisco, California 94111

Attention: Mr. R. G. Brindle
Purchasing Manager

REFERENCE: Utah Power and Light Company
Cost Estimate Quotation
Rogers Job No. S-74002-02
ECPD Proposal No. SR-E-7353

Gentlemen:

Please find attached Ecodyne's budget estimate for one crossflow mechanical draft cooling tower as per your Material Requisition and letter of June 1, 1977. The estimate is for ECPD's Model No. 670-5-6916 and is not a firm price.

Our estimated materials price is \$674,600 with a delivery time of 270 days after award of contract. Time of construction is equal to four months, or 120 days. Ecodyne's preferred method of payment is listed on Page 1 of the attachments. Separate prices for supervision and erection appear on Page 2.

Our Santa Rosa Office will deal directly with the Rogers Engineering Company rather than Eckels-Spaulding Company. Thank you for your request.

Very truly yours,

James V. Bennardo
James V. Bennardo
Project Coordinator

JVB/pjk

Attachments

H I Rogers
S-74002-02
MR-12-102

ECODYNE

Ecodyne Cooling
Products Division

PRICING, F.O.B. POINT AND TERMS OF PAYMENT

Date June 14, 1977

Proposal SR-E-7353

PRICING AND F.O.B. POINT

Materials price F.O.B. shipping points, with full freight allowed to jobsite with:

*Unload and Haul by ECPD

Anchor Bolts by OTHERS

Supervision by OTHERS

Motors by ECPD

Erection and Labor by OTHERS

Motor Control and Wiring by OTHERS

Taxes by ECPD

Riser Piping and Pump by OTHERS

Basin by OTHERS Performance Test by OTHERS

*Note: ECPD—Ecodyne Cooling Products Division

TOTAL NET PRICE: \$674,600*

*Budget Estimate Only; Not a Firm Price

Prices quoted are for acceptance within 30 days from above date. Price is contingent on shipment of materials on or before 270 Days and completion of erection on or before 120 Days After Delivery

PAYMENT TERMS

Materials and Freight

90% - Upon Shipment

10% - 60 Days After Completion of Construction

Supervision and Erection

100% Monthly

Presented by

James V. Bennardo
James V. Bennardo
Project Coordinator

For: Ecodyne Cooling Products Division

Ecodyne® Corporation
Ecodyne Cooling Products Division

DESCRIPTION AND PRICING OF OPTIONAL EQUIPMENT

Date June 14, 1977

Proposal No. SR-E-7353

OPTIONAL PRICING*

1. For supervision by ECPD
(\$250/5-day week for 16 weeks.)	-Add \$4,000 + Travel
2. For erection and labor by ECPD
(Estimated Manhours = 9,600)	-Add \$230,300

*Budget Estimate Only; Not Firm Prices.

Peerless Pump

An Indian Head Company

1043 Stuart Street, Suite 5B
Box 635
Lafayette, CA 94549
Telephone (415) 284-5990

Rogers Engineering Co., Inc.
SAN FRANCISCO
RECEIVED

June 16, 1977

JUN 17 1977

Rogers Engineering Co., Inc.
111 Pine St.
San Francisco, CA 94111

PROJ. MGR. H I Rogers
JOB NO. S-74002-02

Attention: Mr. R. G. Brindle

Subject: Cost Estimate Quotation - S-74002-02, MR #14-101, Rev. 0
Our File SQ-9459

Gentlemen:

For conditions of 34,800 GPM at 105' TDH, we recommend our 42HXB-1 stage can pump as further illustrated and described on the attached drawing, performance curve and data sheets.

The unit would be constructed in the unusual configuration as shown on drawing #DS-14-002, Rev. 0, and would be driven by a 1250 HP, 705 RPM, 4,000 volt, 3 phase, 60 Hz. motor.

Price of the pump and motor, F.O.B. factory with freight allowed to Salt Lake City will be.....\$244,045.00 each.

The above price is for a motor with a standard shaft arrangement; for a double extended shaft, please add.....\$ 6,000.00 each to the above price.

We estimate weight as approximately 30,000# each and shipment will take 36 weeks from receipt of your order and all necessary data, including approved drawings.

The unusual design of the suction connection shown on drawing #DS-14-002, Rev. 0 has added to the cost of the pump. In accordance with Your Mr. H. I. Rogers request, we have asked our Proposal Engineering group at the factory to refigure the job based upon the more standard configuration for the suction nozzle. Hopefully, we will have this information within the next few days and pass it on to you.

Very truly yours,

R. B. Bentley
R. B. Bentley
Field Engineer
RBB:has

Letter forthcoming on deduct of 5000 if suction can be installed higher in head and straight in rather than at angle as shown. This is for pump.

Enclosures

CC HIR
JB.
R6B M/O
Job file

MR

GENERAL ELECTRIC

J.B.
JW/ELK
R.C.B.
File S-74002-02
POWER SYSTEMS

SALES OPERATION

GENERAL ELECTRIC COMPANY, 55 HAWTHORNE STREET, P. O. BOX 3736
SAN FRANCISCO, CALIF. 94119, Phone (415) 546-4211

June 14, 1977

Mr. R. G. Brindle
Purchasing Manager
Rogers Engineering Co., Inc.
111 Pine Street
San Francisco, California 94111

Subject: Utah Power & Light/Rogers Engineering
55 MW Geothermal Turbine-Generator

Dear Mr. Brindle:

In response to your May 27, 1977 request for a preliminary cost estimate, we offer the following estimate in accordance with your preliminary specification:

One (1) 55,000 KW, 61,100 KVA, 3600 RPM double flow, dual flash steam turbine-generator unit with 23" last stage buckets designed for throttle steam conditions of 115 psia, 1189.6 Btu/lb and admission steam conditions of 25 psia, 1160.6 Btu/lb, while exhausting to 3.5" HgA.

Estimated net price for one (1) unit \$6,500,000

Estimated shipment is twenty (20) months from the date of engineering and manufacture release.

With regard to method of payment, please refer to General Electric Handbook Section 4721, page #4 (copy attached). Should you desire shipment within the 20 months referred to above then those charges that would normally be incurred from the 24th through the 20th month would be equally dispersed from the 20th month through 13th month.

As your project progresses and as further questions arise please feel free to contact me.

Very truly yours,

G. D. Squires
G. D. Squires

GDS:na
encl.

PROJ. ... H1 Rogers
S-74002-02

Conditions of Sale

statements shall be calculated on the nearest 1/10th of 1%. For purposes of this Price Adjustment clause, the date of shipment is defined as the date of lading is signed by the carrier covering the last shipped following turbine-generator bearing standards, outer turbine shells, exhaust hoods and generator stator.

PAYMENT

The contract price shall be paid in cash as follows:

Purchaser shall make cash payment to the Company in accordance with the following schedule: the contract price as advanced each of the first six months after release for engineering.

the contract price as advanced each of the 24th through the 36th month prior to scheduled shipment.

of the contract price as advanced each of the 12th through the 24th month prior to scheduled shipment.

the contract price as advanced each of the 6th through the 12th month prior to scheduled shipment.

the contract price as advanced all unpaid adjustments shall be paid in cash in the month of scheduled shipment.

If above payments shall be payable on the 15th day of the month in which due.

the contract price as advanced shall be paid 60 days from shipment.

the contract price as advanced and all remaining unpaid amounts shall be paid one year after shipment.

Amount of any adjustment in price shall be paid in accordance with the Price Adjustment clause when payments thereon are made.

When the parties agree to a date later than that set forth in the clause entitled Release for Engineering and Manufacture, Purchaser shall make uniform payments from the date of release through the 13th month after shipment so as to conform to the above schedule.

8) In the event the parties agree to advance the scheduled shipment, the Purchaser shall make concurrent payments as mutually agreed upon so as to maintain the above schedule.

For the purposes of terms of payment, the date of shipment is defined as the date the bill of lading is signed by the carrier covering the last shipped of the following turbine-generator parts: bearing standards, outer and inner turbine shells, exhaust hoods and generator stator.

MODIFICATION OF TERMS OF PAYMENT

There will be no reduction in price for payment schedules or amounts which are more favorable to the Company than those stated in the Company's standard method of payment as set forth in the clause entitled "Terms of Payment."

When the Purchaser specifies, at the time of order, terms of payment less favorable to the Company than the above standard method of payment and when such proposed terms are acceptable to the Company, a price increase will be charged based on interest at 15 per cent per annum on the difference between the amounts and dates of the Company's standard Terms of Payment and the amounts and dates specified by the Purchaser and agreed to by the Company. In no event will any payment due prior to scheduled shipment be delayed beyond shipment nor more than six (6) months beyond that specified in the Company's standard Terms of Payment.

If the Purchaser does not specify amounts or due dates for payment at the time of order, then the Company's standard method of payment as set forth in the clause entitled "Terms of Payment" shall apply.

PAYMENTS

Payments will be made by the Purchaser pursuant to the Terms of Payment provision without any right of set-off.

If Purchaser's financial condition at any time does not justify continuance of the work to be performed by the Company hereunder, on the agreed terms of payment, Company may require full or partial payment in ad-

vance or shall be entitled to cancel this order and shall receive reasonable and proper cancellation charges. In the event of Purchaser's bankruptcy, or insolvency or in the event any proceeding is brought against the Purchaser, voluntarily or involuntarily, under the bankruptcy or any insolvency laws, the Company shall be entitled to cancel any order then outstanding at any time during the period allowed for filing claims against the estate and shall receive reimbursement for its reasonable and proper cancellation charges.

CHANGES

The Purchaser has the right to make mutually agreeable changes to the turbine-generator type, rating, or steam conditions, and to add or delete any accessories with the assurance that any such changes will be in accordance with the Terms and Conditions as provided herein. This right may be exercised any time, provided that if such changes are made after release for engineering the price addition for the change may include expenses incurred by the Company for re-engineering and/or manufacturing rework required by such change.

COMPLIANCE WITH LAWS

The equipment to be furnished and the work to be performed hereunder shall comply with applicable Federal, State, and local, laws, rules, and regulations except to the extent that they pertain to conditions wholly or partly within the control of the Purchaser or as otherwise provided in this clause. The prices set forth for the equipment described herein, however, are based upon the Company's design, manufacture and delivery of the equipment pursuant to its design criteria, manufacturing processes and procedures and quality assurance program in effect on the date of the order.

Therefore, in the event that compliance requires any changes in the Company's design criteria, manufacturing processes and procedures and quality assurance program (except changes required by applicable Federal laws or rules or regulations promulgated thereunder in effect and as interpreted on the date of order), the price will be adjusted equitably to reflect the added cost and expense to the Company of

GENERAL ELECTRIC

POWER SYSTEMS

SALES OPERATION

GENERAL ELECTRIC COMPANY, 55 HAWTHORNE STREET, P. O. BOX 3736
SAN FRANCISCO, CALIF. 94119, Phone (415) 546-4211

June 7, 1977

Rogers Engineering Company
111 Pine Street
San Francisco, California 94111

Attention: Mr. R. G. Brindle
Purchasing Manager

Subject: Material Requisition
Cost Estimate
Rogers Job #S-74002-02

Gentlemen:

Your inquiry of June 1, 1977 was referred to me by Glen Wimer since your client is a utility.

We estimate that the transformer described in your inquiry would cost \$311,000 net. Delivery could be effected in 50 weeks. Preferred method of payment is 100% net 30 days from shipment. Preferred shipping terms are F.O.B. factory, freight allowed.

Please let me know if I can be of further assistance to you.

Very truly yours,

Joe T. Lamb
Joe T. Lamb, Sales Engineer
Power Systems Sales & Service Operation

JTL:mb

RECEIVED
JUN 14 1977
POWER SYSTEMS

HIR
JUL 10 1977
574002-02
MR # 17-102-0

RGB
orig to HIE

Westinghouse
Electric Corporation

One Maritime Plaza
San Francisco California 94111

June 9, 1977.

Mr. R. G. Brindle
Purchasing Manager
Rogers Engineering Co., Inc.
111 Pine Street
San Francisco, California 94111

Subject: Utah Power and Light Co.
138 KV Step-Up Transformer
Requisition 17-102, Rev. 0
Price Estimate

Dear Mr. Brindle:

This is in reply to your letter of June 1, 1977, and confirms and supplements our recent phone conversation.

For estimating purposes only, we quote \$260,000 net for the 37.5/56/70 MVA main step-up transformer, 138 KV to 13.8 KV, 3-phase, 60 Hertz, as described in your preliminary specification.

Shipment is estimated at 60 weeks after receipt of order with complete information.

As indicated above, this price is for estimating purposes only.

Should you desire any further information, please let us know.

Yours truly,

R. W. Beckwith
Sales Engineer

By: C. D. Green

/k

RECEIVED
JUN 14 1977
Rogers Engineering Co., Inc.

H.T. Rogers
5.74002-02

of P&H construction and mining equipment - industrial
es, hoists & material handling systems - electrical products
415, 303 hegenberger road, p.o. box 2399
ind, california 94621 - (415) 635-4742

nischfeger

R66

File orig. S-74002-02

Rogers Engineering Co., Inc.
San Francisco
RECEIVED

PROJ. NO. H1. Rogers
JOB NO. S-74002-02
MR-19-101

June 10, 1977

ROGERS ENGINEERING COMPANY, INC.
111 Pine Street
San Francisco, California 94111

Attention: Mr. R. G. Brindle
Purchasing Manager

Reference: Utah Power & Light Project
Your Job S-74002-02
45/15 Ton Overhead Crane
P&H Proposal SF1396

Gentlemen:

In accordance with your Material Requisition 19-101 Revision 0, we are pleased to present our proposal with approximate pricing covering the subject 45/15 ton crane. You will see we are generally in accordance with your specification except for some areas which we feel are more suitable for your application, and in line with previous equipment we have furnished Utah Power & Light.

Referring to your specification under Item 2.0 - You will see we are quoting standard U.S. capacity of 45 ton for the main and 15 ton for the auxiliary.

Reference Your Item 2.0 b), c), d), e) & f) - In lieu of the slow speed at full load and high speed at light load you described, which is essentially a system using a direct current motor, we are quoting speeds more in line with your faster speeds using an AC stepless control which is speed regulated and capable of very slow creep speeds. This control is a lot simpler than using a motor generator set or a DC variable voltage control which costs more and is more difficult to maintain.

Lischfeger

ROGERS ENGINEERING COMPANY, INC.

Mr. R. G. Brindle

June 10, 1977

Page Two (2)

Reference Your Item 2.0 i) & j) - We are quoting slightly faster bridge and trolley speeds, which again with the stepless control described in our Bulletin 562 still allows you very slow creep speeds. Please refer to the speed load curves submitted with that control. We believe for your construction particularly the faster speeds we have quoted would be very advantageous.

Reference Your Item 2.2 o) - We believe you are requesting a festoon mainline system which we have included. You would have to furnish an I-beam near your runway beam for us to run our trolleys carrying this system. This system would be very similar to the festoon span conductor system we are using which is described in our literature.

Reference Your Item 2.0 q) - We are using 60 minute TENV motors and we have no exposed copper, therefore we have not included epoxy to protect the motors from the H_2S .

In respect to your induction motor data sheet, we believe you will find all the specific information on the motors in our proposal and we particularly refer you to our Bulletin 501.05(1) which describes these motors.

We are taking the liberty of enclosing a standard specification No. 5-100 which describes this type of crane in more detail. Also enclosed is one (1) copy of CMAA #70 which you may find useful.

We hope to be of service.

Very truly yours,

HARNISCHFEGGER CORPORATION

J. B. Fischenich

J. B. Fischenich
District Manager
Industrial Products Group

JBF/jp
Encl.

Harnischfeger

P&H Industrial Duty, Stock Component
Overhead Cranes
FEATURBILT-TYPE CI

Milwaukee, Wisconsin U.S.A.

PROPOSAL

To: ROGERS ENGINEERING CO., INC.

Proposal No. SF1396

111 Pine Street

Date: June 10, 1977

San Francisco, California 94111

For: Utah Power & Light

We propose to furnish you:

One P&H STANDARD INDUSTRIAL DUTY STOCK COMPONENT TYPE CI double girder overhead traveling crane (s) fully described on the attached data form. Addenda, Clearance Drawing and general descriptive bulletins are made part of the complete proposal. Description of crane is as follows:

Capacity 45 tons; Span 72.16 Ft.; ☐ 3 Motion ☒ 4 Motion (w/Auxiliary) ☐ 5 Motion (Double Trolley).

Maximum Lift: 35 . Crane to be:

☐ A. Floor operated from traveling pendant station with induction type PB elements.

☒ B. Cab operated from shelf mounted SIR master switches, induction type.

Standard control to be P&H Bulletin 562/563 Static Stepless, Secondary Reactor with Magnetorque® Brake on hoist as described in the addenda attached. Crane to be arranged for operation on 460 volts, AC, 3 phase, 60 cycle — three (3) wire power supply.

☐ C. Combination cab and floor control as above.

For: Thermal Power Plant application. ☒ Indoor service. ☐ Outdoor service.

Clearance Sketch No. 45CI72

Estimated net weight 95,000 lbs.; Estimated shipping weight 100,000 lbs.

Base price: (F.O.B. Cars) Milwaukee, Wisconsin Approximate 19.77. Cost \$ 216,000.00

Price additions for equipment and services not included in base price: (Note: Base price includes service checkout of crane after erection per addenda item 28.)

Approximate Freight 5,000.00

For Festooned Mainline (I-beam by others) ADD 4,000.00

Total Price (F.O.B.) APPROXIMATE \$ 225,000.00

Terms: 80% cash upon receipt of invoice and B/L; balance, 20% cash within 30 days from date of shipment. See letter of transmittal for supplementary information.

Shipment: 20-24 Weeks from receipt of approved clearances and relevant data; subject to verification by factory at time order is received in Milwaukee, Wisconsin

The Conditions of Proposal and attached Addenda Descriptive Sheets are integral parts of this proposal.

CONDITIONS OF PROPOSAL

Harnischfeger

Milwaukee, Wisconsin 53201

414 671-4400
CABLE "HARNCO"
TELEX 02-6837

Page 2

1. This Proposal expires thirty (30) days from date hereof unless previously accepted by Buyer or withdrawn by Seller upon written notice to Buyer.

2. Seller will use all reasonable means to make delivery within the time specified, but Seller shall not be liable for loss or damage arising from late delivery or failure to perform due to causes beyond the reasonable control of Seller or its sources of supply, including without limitation, material shortages, labor difficulties, accidents, transportation delays and force majeure.

3. Prices quoted are subject to adjustment to include increased costs of the equipment between the date of Proposal and the date of delivery. Prices quoted by Seller do not include sales, excise or other taxes imposed upon the sale or use of the equipment, and Buyer agrees to reimburse Seller for any such tax which Seller is required to pay, unless otherwise stated.

4. Seller warrants the equipment to be free from defects in material and workmanship, under normal use and service, for one (1) year after shipment or 2,000 hours of operation, whichever expires first. No warranty is made for motors, control, cable reels, air conditioners, buckets and accessories made by others when such items are warranted by their respective manufacturers. Installation or operation of the equipment in any manner other than recommended by Seller shall void the warranty.

Seller's liability under its foregoing warranty shall be fully discharged by furnishing without charge, F.O.B. Seller's factory, any part as shall appear to Seller, upon inspection, to have been defective under normal use within the warranty period. Where claims for defects are made, the defective part or parts shall be delivered to the company prepaid at Milwaukee, Wisconsin, for inspection. Seller shall not be responsible for the cost of repairs, alterations, installation or replacement or expense connected therewith. In no event shall Seller be liable for special or consequential damages.

This warranty is expressly in lieu of any other warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose.

5. After acceptance hereof by Buyer, cancellation may be made only with Seller's consent in writing. In the event of cancellation or suspension of manufacture of the equipment at Buyer's request, Buyer agrees, as a cancellation charge, to reimburse Seller for all expenditures for materials used or appropriated, labor and engineering services, a proportionate share of indirect manufacturing, engineering, selling, and general and administrative expenses incurred in connection with such manufacturer so far as it has been completed, plus the contemplated normal profit on this Proposal.

6. Unless otherwise stated, a supervisor of erection is not included in the price quoted. Seller agrees to provide experienced personnel to supervise unloading, assembly and installation or to service the equipment at Seller's standard charge for such personnel in effect at the time such services are performed. Seller's standard charge as of the date of this proposal is \$200. per 8 hour day, with time and one half for Saturday work or all hours worked in excess of an 8 hour day and double time for all Sunday or holiday work but Seller reserves the right to change such standard charge whenever Seller in its sole discretion deems it necessary to do so. In addition, Buyer will be charged for transportation and living expenses and the time charge for the supervisor enroute to Buyer's plant and back to Seller's plant in Milwaukee, Wisconsin, or to the district office where he may be stationed.

7. Seller agrees to give Buyer prompt notice of shipment. Demurrage charges or expenses of protecting and storing the equipment prior to installation shall be for Buyer's account.

8. Upon acceptance by Buyer, this Proposal shall become a binding contract between Buyer and Seller and shall be construed in accordance with the laws of the State of Wisconsin.

Proposal No. SF 1396

Date: June 10, 1977

Respectfully submitted, _____

HARNISCHFEGGER CORPORATION

By _____

J. B. Fischenich

ACCEPTED: _____

By _____

Date _____

14 June 1977 Job File

Rogers Engineering Co., Inc.
111 Pine Street
San Francisco, California, 94111

ATTENTION: Mr. R. G. Brindle
Purchasing Manager, Ref. S-74002-02

SUBJECT: Cost Estimate Quotation
Your Job # S-74002-02
Requisition #MR-19-101 *MR*
44 Ton Capacity Overhead Traveling Bridge Crane

GENTLEMEN:

The following cost estimate proposal is submitted for your review.

SCOPE: To design, manufacture and deliver (1) only, 44 ton/16.5-ton capacity bridge crane to the above mentioned power plant.

44-TON HOIST: The electric hoist will be of our design using the following equipment:

HOIST MOTOR AND CONTROLS: To be by General Electric, max. speed 320 static stepless with float control using 15 HP. 830 rpm D-C motor with a motor mounted disc brake at 150% torque. Hoist to be pendant controlled from an infinite speed push-button assembly. A second 150% electric A-C brake will be used with an adjustable off-delay.

MAIN HOIST REDUCER: To be 3 reduction helical geared speed reducer designed for crane and hoist service. All gearing operating in oil.

DRUM BEAR AND PINION: To be spur gear with sheet metal covers and drip pan enclosed for open gear lubrication.

HOIST DRUM: To be fabricated structural pipe (60,000 PSI TENSILE) with right and left machined grooves for true vertical lift.

HOIST REEVING: To be 6 P.D. for 30'-0" lift. Hoist rope to be 5/8" ϕ 6/25 IWRC EIPS flattened strand for extended service and strength. Load hook to be forged steel sister hook with 45 ton capacity safety anchor shackle and spring return safety gates.

HOISTING SPEED: 4.7 FPM Full Load
15 FPM (0-10% load)

LOAD BLOCK: Actuated up limit switch and geared limit for down direction.

RECEIVED

JUN 17 1977

PROJ. MGR. *H I Rogers*
JOB NO. *S-74002-02*

16.5-TON AUXILLIARY HOIST: To provide a 16.5 ton capacity auxilliary hoist drive assembly on the 44-ton trolley frame with the following operating characteristics:

Hoist motor control system to be General Electric Max-speed 320 drive with a 15 hp D-C drive motor and 20 hp A-C/D-C motor generator.

Hoist drive to be equipped with two (2) electric operated motor brakes each at 150% minimum drive motor torque capacity.

Operating speed to be 42 FPM no load and 12 FPM capacity load.

Hoist to be reeved 4 P.D. - 1/2" ϕ cable for 30'-0" lift.

Limit switches provided for upper and lower hook positions.

TROLLEY ASSEMBLY: The trolley structural frame will be welded construction designed for stiffness at capacity load. Earthquake brackets are to be furnished on trolley frame assembly.

TROLLEY MOTOR DRIVE: will be Eaton Adjusto Speed - 2 hp - 1800 rpm A-C motor with a D-6 eddy current coupling for infinite speed control. Travel speed - 1.3 fpm -- 40 fpm regulated speed ~~and~~ regardless of hook loads. CONTROL

Motor to be NEMA D Crane and Hoist Duty.

TROLLEY DRIVE REDUCER: will be double reduction helical gearing in oil, with a reducer mounted, motor brake at 75% torque.

WHEELS: to be pinion driven with gearing enclosed by gear covers for open gear lubrication. Wheels to be 14 ϕ forged steel mounted on Timken bearings. Drive wheel treads to be tapered for straight tracking.

TROLLEY TRAVEL LIMIT SWITCHES: will be provided.

TROLLEY: to have bumpers to cushion impact at ravel end stops.

BRIDGE: The bridge structure will be designed in accordance with CMAA No. 70.

Bridge girder to be welded box girder construction with necessary full depth and intermittent diaphragm plates. Girders are proportioned to give necessary vertical and lateral stiffness.

Earthquake brackets will be furnished on bridge end trucks to prevent bridge from leaving rail in event of earthquake.

BRIDGE MOTOR DRIVE: will be Eaton Ajusto Speed - 5 ^{HP} ~~HP~~ --1800 rpm
A-C motor with a D-C eddy current coupling for infinite speed control.
Travel speed - 1.8 fpm - 50 fpm regulated speed range regardless of
hook loads.

Motor to be NEMA D Crane and Hoist Duty.

BRIDGE DRIVE REDUCER: will be double reduction helical gearing in
oil, with a reducer mounted - motor brake at 75% torque.

WHEELS: to be pinion driven with gearing enclosed by gear covers for
open gear lubrication. Wheels to be 21" ϕ forged steel mounted on
Timken bearings. Drive wheel treads to be tapered for straight
tracking.

BRIDGE TRAVEL LIMIT SWITCH: will be provided.

BRIDGE: to have bumpers to cushion impact at travel end stops.

BRIDGE CONDUCTOR: will be multi-conductor cords mounted on plain
trolleys which will be mounted on a monorail type beam running
full length of bridge span. The cords will be mounted on large
loops to avoid excess bending of the conductors. A pusher-puller
bar will be mounted to the trolley hoist and attached to the load
conductor trolley to provide movement of the conductor system when
the trolley hoist is moved on the bridge.

MAINLINE CONDUCTOR SYSTEM: to be a spring driven power reel mounted
on the bridge for a 2-way payout (retrieve). Power source to be at
runway length mid-point. 100'-0"
Cable support tray or brackets by others.

POWER SUPPLY: to be 480 V- 3 ϕ 60 cy.

CRANE LIGHTS: (6 each) on each side of hook center line, will be
provided complete with lighting panel board."

PRKING: DELIVERED SQ SITE \$ 148000⁰⁰
BASED ON CURRENT PRKES.

Jack Stodd
6/17/77

TELEPHONE:
(415) 434-2340

JTK
JW/M.O'N.
R.G.B.
J.B.

Toshiba

TELEX:
W.U. 03-4484

TOSHIBA INTERNATIONAL CORPORATION

465 CALIFORNIA STREET, SUITE 430
SAN FRANCISCO, CALIFORNIA 94104

June 21, 1977

Rogers Engineering Co., Inc.
111 Pine Street
San Francisco CA 94111

Attention: Mr. R. J. Brindle
Purchasing Manager

Subject: Furnishing and Delivering
55MW Geothermal Turbine-Generator
Your Job No. S-74002-02

RECEIVED
JUN 23 1977

PROJ. H.I. Rogers
S-74002-02
MR 12-401
" 14-101
" 17-101

Gentlemen:

In reply to your letter dated June 1, 1977, we are pleased to submit our proposal for the furnishing and delivering of the referenced equipment in accordance with Rogers Engineering's preliminary material requisition.

Following is our preliminary cost estimation based on C.I.F. Salt Lake City. Our prices are subject to change depending on your actual specifications and delivery date.

1. Price:

- 1 Unit, 55MW nominal turbine-generator and auxiliaries: \$5,250,000
- 1 Unit, direct contact condensers & gas removal equipment: \$1,278,000
- 2 Units, hot well pumps: \$2,205,000

2. Delivery:

20 months after receiving your firm order

3. Terms of Payment:

10 percent of the contract amount shall be paid at the time of completion of engineering.

80 percent of the contract amount shall be paid upon completion of shipment.

TOSHIBA INTERNATIONAL CORPORATION

-2-

The remaining 10 percent of the contract amount shall be paid after acceptance of equipment or one year after shipment, whichever is earlier.

This quotation is based on your specification and our Preliminary Specification No. Q/#NAB-0066 which is enclosed.

We look forward to participating in this project. If you have any questions regarding the above, please feel free to contact me.

Sincerely,

Shinichi Kato
District Manager

SK:ms
encl.

RECEIVED
JAN 11 1977

FILE NO. _____
JOB NO. _____

APPENDIX C

C-1 Introduction

Project Conference Note No. 7 of May 16, 1977 records an indication by Phillips Petroleum that Phillips will be able to supply steam for a two unit (55 MW gross each) geothermal plant. Hence this appendix has been prepared to show estimated construction costs for a two unit plant. At the request of UP & L (See PCN No. 19 of July 8, 1977) an estimate for a two unit coal fired plant has also been included as well as a comparison of costs for the geothermal and coal fired plants. This appendix concludes with a Cash Flow Estimate for the two unit geothermal plant.

C-2 Two Unit Geothermal Power Plant Estimate

Table 4-1, 55 MW (gross) Geothermal Power Plant Cost Estimate (single unit plant) was used as a basis for the Two Unit Geothermal Power Plant Estimate which follows in Table C-1. Each sub-account line item was assessed to determine what percentage of the cost for one unit should be added in developing the estimate for two units. For some items, such as the turbine-generator package, condenser and condensate pumps, it was assumed the cost would be equal for each unit; i. e., two unit costs are twice those for one unit. In taking this approach, it was recognized some small price advantage might accrue when two units are ordered essentially simultaneously, but, due to the budgetary nature of the estimate, no attempt was made to incorporate this degree of accuracy. Several items were considered as designed for two units, and no additional costs were included in the two unit estimate. In the remaining cases, experience acquired from other two unit plants was applied in developing the percentage adder.

Contractor overhead and profit was computed on the same basis as for one unit. Interest during construction is based upon the two unit cash flow as it was for one unit, and contingency was left at 15% of the immediately preceding sub total. Engineering is based upon previous experience and UP & L charges were increased by approximately the same percentage as engineering.

C-3 Two Unit Coal Fired Power Plant Estimate

Included in information furnished to Rogers by UP & L were cost estimates for Units 1 and 2 of the Emery Station. The following procedure was used to develop the two unit coal fired power plant estimate given in Table C-2.

1. Probable costs for Emery No. 1 as of May 31, 1977 (furnished by UP & L) were grouped into the same categories as used in the above mentioned estimates.

2. A ratio of probable cost to the original estimated cost was calculated for each category.
3. The above ratios were applied to the Unit 2 estimate figures in each category.
4. The updated Unit 2 figures were added to the May 31 probable costs for Unit 1 to arrive at totals for a two unit plant.

C-4 Cost Comparison, Geothermal vs Coal Fired

Table C-3 compares costs for a two unit, 104 MW net geothermal plant and a two unit, 400 MW net coal fired unit. Substations costs were excluded from the geothermal estimate and the contractor overhead and profit reduced accordingly. Contingency and IDC could have also been reduced slightly, thus making the geothermal plant appear in a more favorable light. This refinement was not, however, felt consistent with the order of accuracy of the estimate.

C-5 Cash Flow

Estimated cash flow for a two unit geothermal plant is given in Table C-4. It was computed on the basis of a 40 month engineering and construction schedule and is in the same format as the single unit cash flow estimate. Appendix D contains back up information.

TABLE C-1

SUMMARY
2X 55 MW (GROSS) GEOTHERMAL POWER PLANT
COST ESTIMATE
JUNE 1977

<u>Account Number</u>	<u>Description</u>	<u>Materials and Equipment</u>	<u>Labor Cost</u>	<u>Man-hours</u>
311	Structures and Improvements	\$ 1,829,000	\$ 884,000	46,700
312	Boiler (Steam Piping Only)	263,000	142,000	6,600
314	Turbogenerators	15,661,000	2,174,000	145,300
315	Accessory Electrical Equipment	1,355,000	334,000	21,400
316	Miscellaneous Power Plant Equipment	512,000	291,000	19,800
353	Substation	1,202,000	375,000	14,900
-	Refund Taxes	-	-	-
	Sub Totals	<u>\$20,822,000</u> ✓	<u>\$4,200,000</u> ✓	<u>254,700</u>
310	Land	\$ 8,000		
399	Contractor Overhead and Profit	<u>3,665,000</u> ✓		30.62
	Plant Installed	\$28,695,000		
399	UP & L Charges	625,000		
399	Engineering	2,600,000		
399	Interest During Construction	<u>3,703,000</u>		
	Sub Total	\$35,623,000		
	Contingency	<u>5,344,000</u> ✓		
	TOTAL CONSTRUCTION COST	<u>\$40,967,000</u> ✓		
-	Power Plant Construction Cost (\$/Net kW)	\$ 394		

TABLE C-1 (Cont'd)
2X 55 MW (GROSS) GEOTHERMAL POWER PLANT
COST ESTIMATE
JUNE 1977

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Total Cost</u>	<u>Labor Dollars</u>
310	<u>LAND AND LAND RIGHTS</u>			
310.1	Water Rights			
310.2	Land and Easements			
	SUB TOTAL DIRECT			
311	<u>STRUCTURES AND IMPROVEMENTS</u>			
311.1	Improvements to Site	-	-	
311.12	Plant Site	5,799	216,430	186,058
311.14	Sewage Treatment Facilities	438	8,732	5,552
311.15	Domestic Water System	266	22,823	3,405
311.3	Power Building	-	-	-
311.31	Substructure	14,566	199,903	162,216
311.32	Superstructures	20,723	1,235,569	447,787
311.33	Building Services	4,585	132,340	72,589
311.5	Fuel Oil System	-	-	-
311.51	Fuel Oil Tanks (Including Foundations)	250	10,000	4,916
311.52	Fuel Oil Piping (Yard Only - Building 312.191)	61	3,493	1,199
311.7	Administration Building and Main Warehouse and Shop	Included in Account 311.3		
311.8	Other Structures	None		
	Sub Total	46,688	1,829,290	883,722
	Use As	<u>46,700</u>	<u>1,829,000</u>	<u>884,000</u>
312	<u>BOILER PLANT EQUIPMENT</u>			
312.5	Boiler Plant Piping			
312.51	Steam Piping	3,289	119,524	45,556
312.56	Miscellaneous Process Piping	500	6,960	7,368
312.57	Piping Insulation (Lump All Insulation Here)	1,512	79,590	69,936
312.59	Piping & Valve Suspense (Material Only)	1,292	57,060	19,104
	Sub Total	6,593	263,134	141,964
	Use As	<u>6,600</u>	<u>263,000</u>	<u>142,000</u>

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
314	<u>TURBO-GENERATOR UNIT</u>			
314.1	Turbine - Generator			
314.11	Turbine Pedestal	17,342	250,290	182,914
314.12	Turbine	34,000	8,958,000	581,584
314.13	Generator)	Included in Account 314.12		
314.14	Turning Gear)			
314.15	Governing Control System)			
314.16	Control and Stop Valve)			
314.17	Gland Seal and Piping)			
314.18	Supervisory Instrumenta-) tion (Local Front) Standard)			
314.19	(Lump All Process Instru- mentation Here)	9,600	309,000	164,212
314.2	Miscellaneous Turbine- Generator Equipment (Supplied by Turbine- Generator Package)	Included in Account 314.12		
314.3	Condenser and Auxili- aries			
314.31	Main Condenser (Sur- face Type Including intercondensers)	22,000	1,800,000	325,372
314.33	Ejectors	Included in Acct. 314.31		
314.34	Condensate Pumps (Surface Type Cond)	4,600	1,000,000	68,032
314.35	Circulating Water Pumps	370	60,430	5,474
314.36	Circulating Water Pipe (Within Building)	9,412	293,622	139,200
314.4	Cooling Tower and Equipment			
314.41	Cooling Tower Basin and Foundations	4,710	64,868	76,850
314.42	Cooling Tower	14,000	2,000,000	196,444
314.43	Circulating Water Pump Structure	NONE		
314.45	Circulating Water Piping (Outside Building)	14,768	522,228	219,190
314.46	Water Treating System (For Circulating Water)	NONE		
314.47	Cathodic Protection (C. W. Piping)	Included in Acct. No. 314.45		
314.6	Lube Oil System (Including all equipment which is not furnished as an integral part of other equipment			

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
314.61	Tanks, Pumps and Equipment	1,228	113,580	18,096
314.62	Lube Oil Piping	11,682	126,642	172,158
314.7	H ₂ and CO ₂ System (Only equipment which is not furnished as an integral part of other equipment)	1,278	142,100	18,827
314.9	Auxiliary Generator			
314.91	Diesel Engine Driven Generator	346	20,630	5,463
	Sub Total	145,336	15,661,390	2,173,816
	Use As	<u>145,300</u>	<u>15,661,000</u>	<u>2,174,000</u>

315 ACCESSORY ELECTRICAL EQUIPMENT

315.1	Main Power Control Equipment (13.8 kV)			
315.11	Cubicles	480	254,794	7,580
315.14	Load Frequency Control	Included in Account 315.41		
315.15	13,800 Volt Bus Duct and Terminals	360	117,624	5,684
315.16	Cooling Tower Control Equipment			
315.2	Start-up Power			
315.22	Start-up Switchgear	60	7,152	948
315.3	Other Station Service Control Equipment - 4160 Volt			
315.31	Cubicles	520	90,000	8,649
315.32	Local Control Stations and Receptacles	Included in Account 315.42		
315.34	4160 Volt Transformers	320	71,756	5,052
315.35	4160 Volt Bus Duct (1200 A)	160	13,938	2,526
315.4	Other Station Service Control			
315.41	Electrical Control Board & Supervisory Control	2,400	134,834	36,126
315.42	Local Control Stations and Receptacles	705	15,000	10,613
315.43	Motor Control Centers	300	102,000	4,517

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
315.44	Load Centers	840	160,000	12,644
315.5	Other Station Service Control Equipment - 120-208 Volt			
315.52	Distribution Panel	800	16,000	12,632
315.53	Transformer 480-120/208 Volt	80	4,000	1,264
315.6	Station Service DC Equipment			
315.61	DC Cubicles	Included in Account 315.64		
315.62	Distribution Panels	Included in Account 315.52		
315.63	Local Control Stations and Receptacles	Included in Account 315.42		
315.64	Battery	100	40,000	1,606
315.65	Battery Charger and Regulator	100	4,000	1,606
315.7	Other Control Wiring, Connections and Supports			
315.71	Conduit	4,620	56,000	72,948
315.72	Cable Tray	2,920	36,000	46,106
315.73	Wire and Cable	4,870	143,000	76,232
315.74	Grounding System	1,740	89,000	27,474
315.75	Annunciators and Alarms	Included in Account 315.41		
315.8	Freeze Protection	NONE		
	Sub Total	21,375	1,355,098	334,207
	Use As	<u>21,400</u>	<u>1,355,000</u>	<u>334,000</u>

316 MISCELLANEOUS POWER PLANT EQUIPMENT

316.2	Station Air System			
316.21	Compressors and Aux- liaries	744	102,954	10,950
316.22	Air Piping	6,460	28,216	95,059
316.3	General Plant Equipment			
316.31	Shop Equipment	86	112,748	1,267
316.32	Laboratory Equipment	-	65,000	-
316.33	Fire Extinguishing Equipment (Portable)	40	4,000	590
316.34	Office Equipment	-	3,400	-
316.35	General Service Equip- ment	-	32,500	-

<u>Account Number</u>	<u>Description</u>	<u>Man-hours</u>	<u>Material & Equipment</u>	<u>Labor Dollars</u>
316.36	Warehouse Shelves, Bins and Equipment (In- cluding Gasoline and Diesel Pumps)	12,456	163,000	183,564
316.4	Intrasite Communication System (Including Gate TV)	NONE		
316.5	Weather and Monitoring Stations Remote from Plant	NONE		
	Sub Total	19,786	511,818	291,430
	Use As	<u>19,800</u>	<u>512,000</u>	<u>291,000</u>
352	<u>STRUCTURES AND IMPROVEMENTS</u>			
352.10	Clearing and Grading)	Included in Account 311		
352.20	Buildings)			
352.30	Roads, Walks and Fences)			
352.40	Yard Lighting)			
352.50	Water Supply System)			
352.60	Storm Drain System)			
352.70	Intrasite Communication) System)			
353	<u>SUBSTATION EQUIPMENT</u>			
353.0	Common Wiring & Connections	-	-	-
353.06	Conduit, Wire and Cable	2,850	43,500	43,875
353.07	Yard Controls	3,200	176,000	50,526
353.10	Main Step-up Transformers	1,000	523,000	15,789
353.4	Switchyard			
353.40	Structures, Structure Light- ing, Conductor Insulators and Hardware	4,220	64,370	65,981
353.41	Oil Circuit Breakers and Switchyard Grounding	1,820	226,000	170,307
353.42	Switches	1,600	91,000	25,200
353.44	Potential Transformers	200	78,000	3,158
	Sub Total	14,890	1,201,870	374,836
	Use As	<u>14,900</u>	<u>1,202,000</u>	<u>375,000</u>
	TOTAL PLANT INSTALLED	254,668	20,822,600	4,199,975
	USE AS	<u>254,700</u>	<u>20,822,000</u>	<u>4,200,000</u>

TABLE C-2

2X 400 MW COAL FIRED STEAM POWER PLANT
EMERY #1 AND #2 ESTIMATE
MAY 1977

<u>Account Number</u>	<u>Description</u>	<u>1 Materials and Equipment</u>
311	Structures and Improvements	\$ 75,944,000
312	Boiler	184,693,000
314	Turbogenerators	43,576,000
315	All Electrical Equipment	19,929,000
316	Miscellaneous Power Plant Equipment	2,729,000
353	Substation	
		<u>\$326,871,000</u>
310	Land, Easements and Water Rights	\$ 1,949,000
399	Contractor Overhead and Profit	<u>42,255,000</u>
	Plant Installed Sub Total	\$371,075,000
399	UP & L Charges	11,682,000
399	Engineering	20,626,000
399	Interest and Taxes During Construction	<u>46,550,000</u>
	CONSTRUCTION COST	<u>\$449,933,000</u>
--	Power Plant Construction Cost (\$/Net kW)	\$ 562

TABLE C-3
2X 52 MW GEOTHERMAL
VS
2X 400 MW COAL FIRED
COST ESTIMATE COMPARISON
SUBSTATIONS EXCLUDED

<u>Acct.</u>	<u>Item</u>	<u>104 MW Net Geothermal</u>	<u>800 MW Net Coal</u>
310	Land	\$ 8,000	\$ 1,949,000
311	Structures and Improvements	2,713,000	75,944,000
312	Boiler	405,000	184,693,000
314	Turbogenerators	17,835,000	43,576,000
315	Accessory Electrical Equipment	1,689,000	19,929,000
316	Miscellaneous Power Plant Equipment	803,000	2,729,000
353	Substation	-*	-
	Direct Costs Sub Total	<u>\$23,453,000</u>	<u>\$328,820,000</u>
399	Contractor Overhead and Profit	<u>3,417,000</u>	<u>42,255,000</u>
	Plant Installed Subtotal	\$26,870,000	\$371,075,000
399	Utah Power and Light Charges	625,000	11,682,000
399	Engineering	2,600,000	20,626,000
399	Interest During Construction	3,703,000	46,550,000
399	Contingency	<u>5,344,000</u>	<u>-</u>
	Construction Cost Total	<u>\$39,142,000*</u>	<u>\$449,933,000</u>
	Power Plant Construction Cost (\$/Net kW)	376	562

*Substation cost excluded for comparison.
Refer to Table C-1 for cost including
substation.

TABLE C-4
CASH FLOW ESTIMATE
2X 55 MW (GROSS) GEOTHERMAL POWER PLANT
JUNE 1977

1	2	3	4	5	6	7	8	9	10
End of Month No.	Material and Equipment	Direct Labor Charges	Contractor Overhead & Profit	Land	Engineering	UP & L Charges	Interest During Construction	Contingency	Total
3	\$1,177,500			\$8,000	\$ 150,000	\$ 65,000	\$ 15,800	\$ 212,700	\$ 1,629,000
6	706,500				150,000	65,000	41,900	144,300	1,107,700
9	3,707,200	\$ 104,300	\$ 90,600		250,000	55,000	47,300	635,900	4,890,300
12	1,409,500	156,300	135,800		250,000	55,000	169,400	325,900	2,501,900
15	1,545,200	156,300	135,800		300,000	70,000	216,900	363,400	2,787,600
18	3,145,700	156,300	135,800		350,000	70,000	285,100	619,800	4,762,700
21	4,247,200	156,300	135,800		300,000	60,000	383,600	790,900	6,073,800
24	2,244,700	463,800	394,800		300,000	55,000	477,600	590,400	4,526,300
27	1,406,000	766,000	660,500		200,000	45,000	551,200	587,700	4,216,400
30	919,300	840,000	728,400		100,000	25,000	585,800	476,100	3,674,600
33		279,000	677,000		50,000	20,000	656,100	251,100	1,933,200
36	157,000	779,000	255,900		150,000	20,000	236,100	240,500	1,838,500
40	156,200	342,700	314,600		50,000	20,000	36,200	105,300	1,025,000
	\$20,822,000	\$4,200,000	\$3,665,000	\$8,000	\$2,600,000	\$625,000	\$3,703,000	\$5,344,000	\$40,967,000

APPENDIX D

D-1 Appendix D provides back up data for preparation of the cash flow estimates, Tables 4-2 and C-4 which are estimated cash flows for a single unit - 52 MW geothermal power plant and a two unit 104 MW geothermal power plant respectively.

D-2 The back up data sheets included hereinafter are as follows:

1. Equipment and Material Cash Flow - This sheet provides cash flows for the 52 MW power plant and the 104 MW power plant with expenditures for the 52 MW unit shown on the lower portion of the diagram and the expenditures for the second 52 MW unit shown on the upper portion. The numbers directly above and below the horizontal line indicating time periods are percentage progress payments for the major equipment which includes the turbine-generator units, condensers and hotwell pumps along with other miscellaneous payments for equipment in FPC account 314. Required payments for all equipment are indicated along with the FPC account number.
2. Contractor Direct Labor, Overhead and Profit Cash Flow - This diagram shows Unit 1 expenditures and Unit 2 expenditures similar to the equipment and material diagram with Unit 1 on the bottom and Unit 2 on the top. Unit 1 and 2 combined totals for labor and overhead & profit are shown at the top and bottom of the vertical lines on the diagram, respectively.
3. Engineering Cash Flow - This diagram indicates Unit 1 and Unit 2 expenditures and the combined Unit 1 and 2 expenditures in a format similar to the two previous diagrams.
4. Utah Power and Light Charges Cash Flow - These are the progressive charges to be incurred by Utah Power and Light.
5. Interest During Construction, Unit 1 - These costs are based upon cash flow per period and accumulated cash flow as determined by totaling columns 2 through 7 of Table 4-2, Cash Flow Estimate, 55 MW (gross) Geothermal Power Plant. The interest rate used is 9% per annum.
6. Interest During Construction, Units 1 and 2 - These costs are based upon the combined cash flow required by the construction of Units 1 and 2 of a 110 MW Power Plant as determined by cash flow per period and the accumulated cash flow shown in columns 2 through 7 of Table C-4, Cash Flow Estimate, 2X 55 MW Geothermal Power Plant.

D-3 The project contingency has been dispersed throughout the engineering and construction periods based upon the totals of Column 2 through 8 for both Tables 4-2 and C-4.

TOTAL
UNIT
1 1/2

T/G(1) (#314)
T/G(2)

T/G(1) (#314)
T/G(2)

STRUCTURES &
IMPROVEMENTS
1,186,000

PUMP (#312)
171,000
ELECT. EQ. (#315)
749,000
ELECT. EQ. (#316)
221,000
ELECT. EQ. (#353)
369,000

Rogers

SUBJECT

WATERWORKS & LINES

UTAH POWER & LIGHT

EQUIP. MAINT. CASH FLOW - CHKD. BY

SHEET NO. 374002-02
OF 02
JOB NO. 374002-02
DATE 7/1/87
DATE 7/1/87

D-2-1

SHEET NO. OF
JOB NO. 574002-02
BY: MAN DATE 2/1/79
CHKD. BY: DATE
D-2-3

TOTAL
UNIT 1
\$2

UNIT 2

UNIT 1

UNIT 1 UP & L CHARGES - \$475,000

UNIT 2 UP & L CHARGES - \$625,000

Rogers

SUBJECT

UP & L

UP & L CHARGES,

CASH FLOW

SHEET NO. ... OF ...
 JOB NO. 374002-02
 BY M.A. DATE 7/19/77
 CHKD BY DATE
 D-2-4

Rogers

SUBJECT U.S. & L.
ID. UNIT 1 entry

SHEET NO. 274-22-03 OF 2
JOB NO. 274-22-03
BY M. R. R. DATE 7/19/77
CHKD. BY DATE

D-2-5

$I = 9\% \text{ PER ANNUM}$

$I / \text{QUARTER} = .09 / 4 \times \frac{1}{2} = 0.0125 = K_1$

$K_2 = 2K_1 = 0.025$; $K_3 = \frac{4}{3} K_2 = 0.03$

MTH	(1) CASH FLOW (PER PERIOD)	(2) ACCUMULATED CASH FLOW	INTEREST (EACH PERIOD)	ACCUMULATED INTEREST
3	\$ 1,375,500	1,375,500	$(1) \times K_1$	115,474
6	896,500	2,272,000	$(1) \times K_1 + \frac{1}{2}[(2)-(1)]K_2$	41,034
9	2,259,800	4,531,800		76,543
12	1,134,800	5,666,600		114,732
15	1,317,550	6,984,150		142,321
18	2,472,050	9,456,200		184,954
21	3,176,300	12,632,500		249,498
24	1,936,800	14,569,300		306,020
27	1,278,500	15,847,800		342,192
30	1,158,500	17,045,900		370,500
33				
34	1,198,100	18,204,400	$[(2)-(1)] K_3$	510,189
				2,352,457

Rogers

SUBJECT UP & L
 ID UNITS 1 & 2

SHEET NO. 57400202 OF 2
 BY M.O.N. DATE 7/29/77
 CHKD. BY D-2-6 DATE 7/29/77

$$K_4 = \frac{1}{3} K_2 = 0.0075$$

MTH	CASH FLOW (PER PERIOD)	ACCUMULATED CASH FLOW	INTEREST (EACH PERIOD)	ACCUM. INTEREST
3	1,400,500	1,400,500	(1) K_1	15,756
6	921,500	2,322,000	(1) $K_1 + [(2)-(1)]K_2$	57,634
9	4,207,050	6,529,050		104,963
12	2,006,590	8,535,640		274,441
15	2,207,340	10,742,980		491,325
18	3,857,840	14,600,820		776,443
21	4,899,255	19,500,075		1,160,078
24	3,458,305	22,958,380		1,637,736
27	3,077,480	26,035,860		2,188,921
30	2,612,720	28,648,580		2,774,728
33	1,026,000	29,674,580		3,430,864
34	157,000	29,831,580	$[(2)-(1)]K_4$	3,653,423
36	1,204,900	1,204,900	(1) K_1	3,666,978
40	883,520	2,088,420	(2)-(1) K_3	3,703,125