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NEWMAN UNIT I SOLAR REPOWERING

Final Report, Volume 2

July 1980

Work Performed Under Contract No. AC03-79SF10740

El Paso Electric Company
El Paso, Texas

U.S. Department of Energy

Solar Energy

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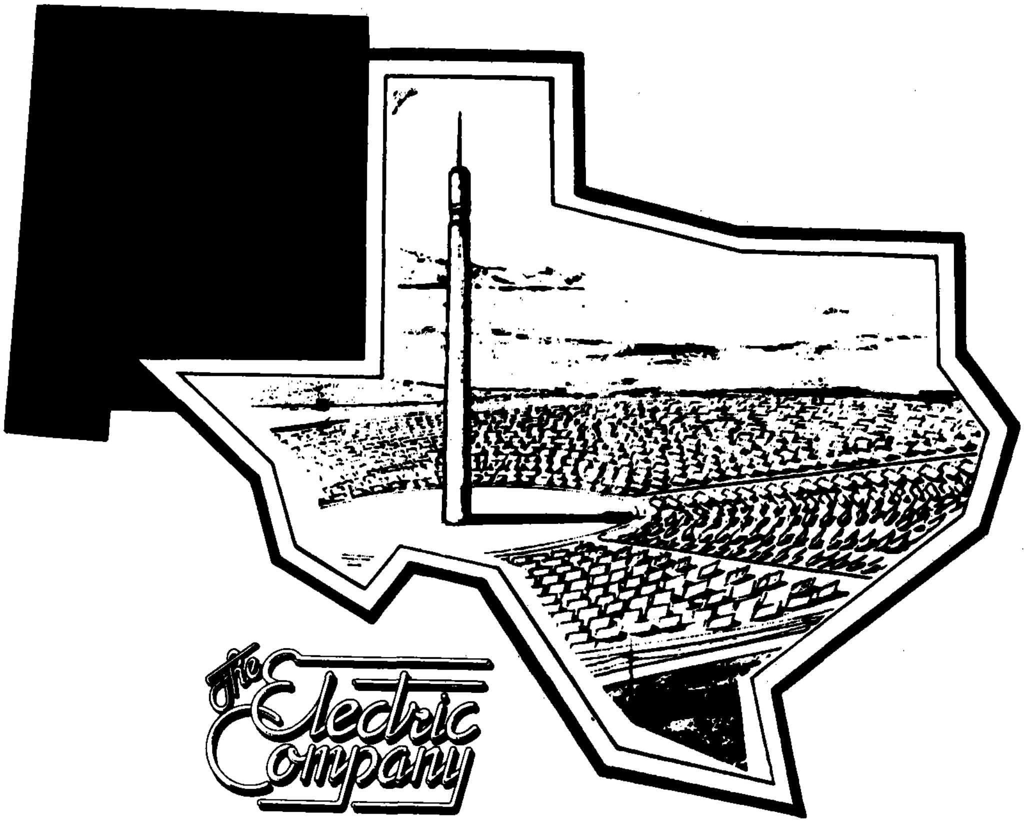

EL PASO ELECTRIC COMPANY

Newman Unit I Solar Repowering

Final Report Volume II

prepared for
Department of Energy as part of
Contract No. DE-AC03-79SF10740

July 1980

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1.0 GENERAL

1.1 SCOPE

This specification defines the system and subsystem characteristics, design requirements, and system environmental requirements for solar repowering of Newman Unit 1 which is operating on the El Paso Electric Company (EPE) system. This unit has a reheat steam turbine rated to produce 82 MWe with a 10.1 Pa/538°C (1450 psig/1000°F) main steam conditions and a 2.93 MPa/538°C (410 psig/1000°F) reheat steam conditions. The solar subsystem will be designed to supply steam in sufficient quantity and quality to generate 50 percent of the rated electrical power at the design point of noon summer solstice. It will operate in parallel with the present gas/oil fired boiler.

In general, the level of detail presented in this specification is consistent with the conceptual design phase of a large power plant project. Engineering information is developed to the extent necessary to support the development of a conceptual plant cost estimate and the determination of technical and economic feasibility of the project.

1.2 SYSTEM DESCRIPTION

The system for solar repowering of Newman Unit 1 will consist of the following major elements, which are described in the following sections.

- Site
- Site Facilities
- Collector Subsystem
- Receiver Subsystem
- Master Control Subsystem
- Fossil Boiler Subsystem
- Electric Power Generating Subsystem
- Specialized Equipment

The repowering system will be designed for a 30 year life.

1.2.1 SITE

Newman Station is located at the north end of the city of El Paso, 24 km (150 miles) northeast of the downtown area, and 19.3 km (12 miles) from the El Paso SOLMET station. The site is near the New Mexico border on the east side of the Franklin Mountains.

The Newman site is nearly flat with a downward slope of approximately one percent from west to east. A road to the west provides storm drainage, although some minor natural runoff gulleys (arroyos) exist northwest of the existing station. The site is in the Tularosa Basin, bounded by fault block mountains to the east and west, with 305 to 610 meters (1000 to 2000 feet) of underlying sediments. Approximately 14.2 km^2 (3500 acres) of public land around the site are available.

Newman Station is surrounded by land owned by El Paso Water Utilities Public Service Board, with one residential and no commercial buildings within a 3.2 km (2 mi) radius. The site is accessible by road from all directions.

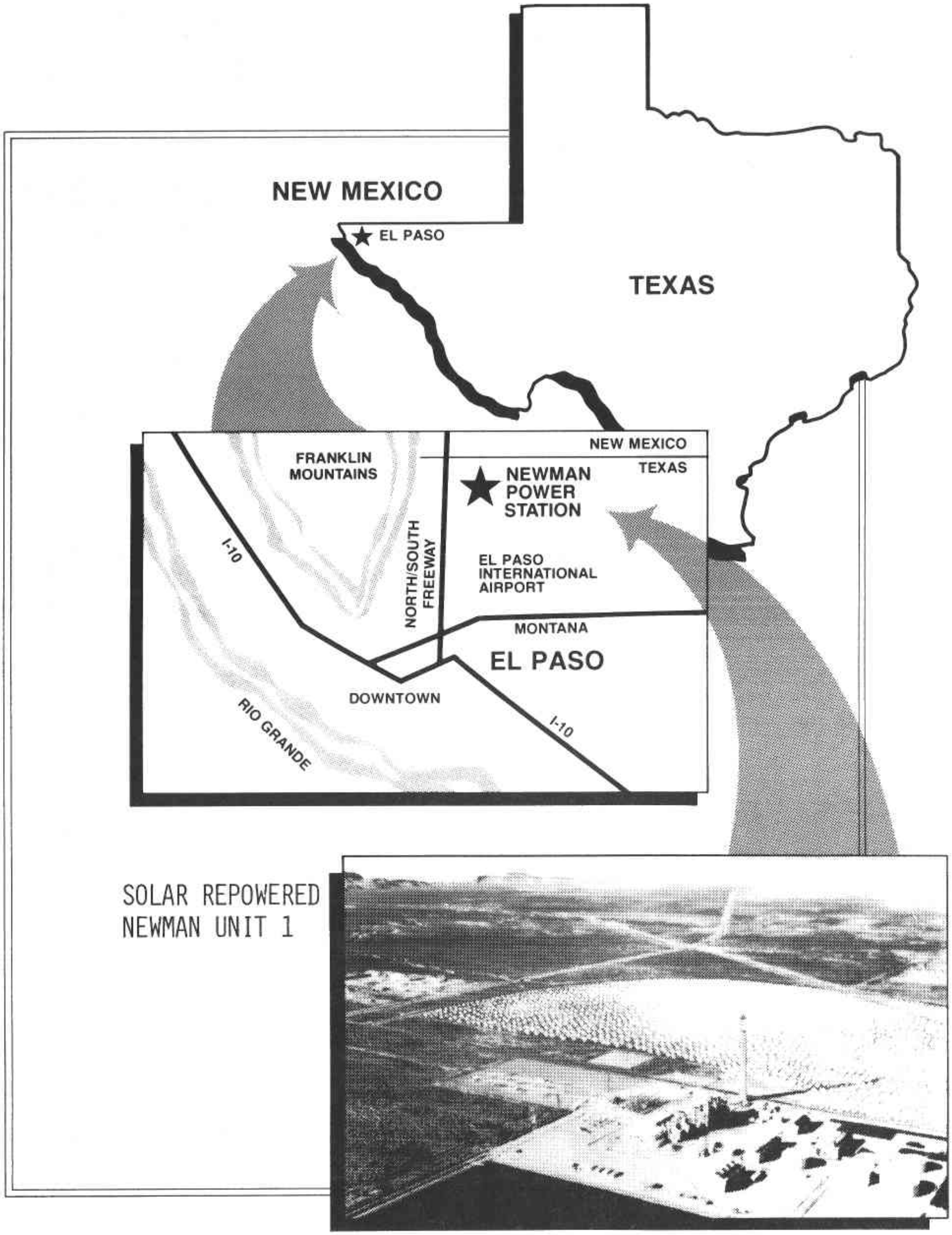
Figure 1-1 illustrates the location of the site relative to El Paso, Texas. Figure 1-2 shows the arrangement of the Newman Station's major existing facilities. Newman Station consists of four oil and gas-fired units capable of generating 498 MWe. Newman Unit 1 is located at the northern end of the Station.

Figure 1-3 describes the proposed site arrangement for Solar Repowering Newman Unit 1. The concrete tower supporting the primary and reheat receivers will be located adjacent to the Newman Unit 1 turbine building, with a 160^o north heliostat field. The approximate land area that will be utilized by the heliostat field is 1.50 km^2 (370 acres).

Site preparation activities for repowering Newman Unit 1 will include primary grading, surface preparation, and construction of roads. The collector field will be graded and covered with crushed stone and will include north-south drainage trenches to channel rainwater from the site. The natural arroyo at the northwestern part of the field will be diverted north of the field perimeter to preclude erosion of the graded surfaces. The main entrance to the Newman Station will be from an existing highway west of the site and an asphalt paved road will surround the field to provide access to the heliostats. A 61 m (200 ft) exclusion zone is provided outside this perimeter road. The solar main and reheat receivers will be mounted on a tower accessible from the main entrance road. Exclusion areas will be provided to avoid interferences with the inspection and maintenance of existing equipment and piping situated in the heliostat field area.

1.2.2 SITE FACILITIES

New structures and facilities associated with Solar Repowered Newman Unit 1 will include an addition to the existing control room, a solar feedwater pump house, and an addition to the existing maintenance building. The control room and maintenance building additions and the solar feed water pump house will be metal sided enclosures. The control room additions will house the Master Control Subsystem, collector and receiver controls, operator control panels, beam characterization system, and data acquisition system. The rooms will be air conditioned to maintain the correct temperature for the electronic equipment.



The Electric Company
El Paso Electric

Figure 1-1. Solar Repowered Newman Unit 1

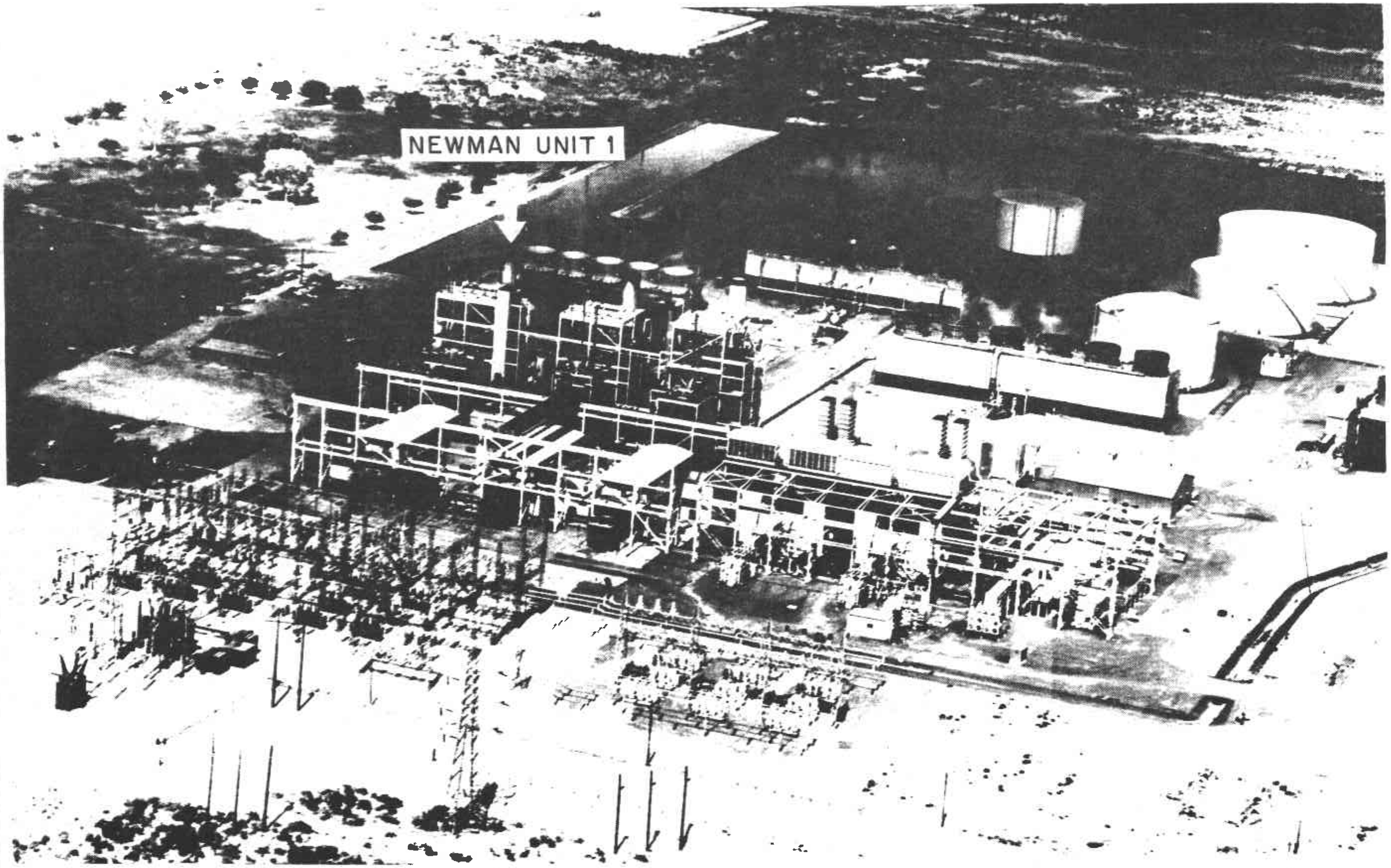


Figure 1-2. Newman Unit 1 Facility

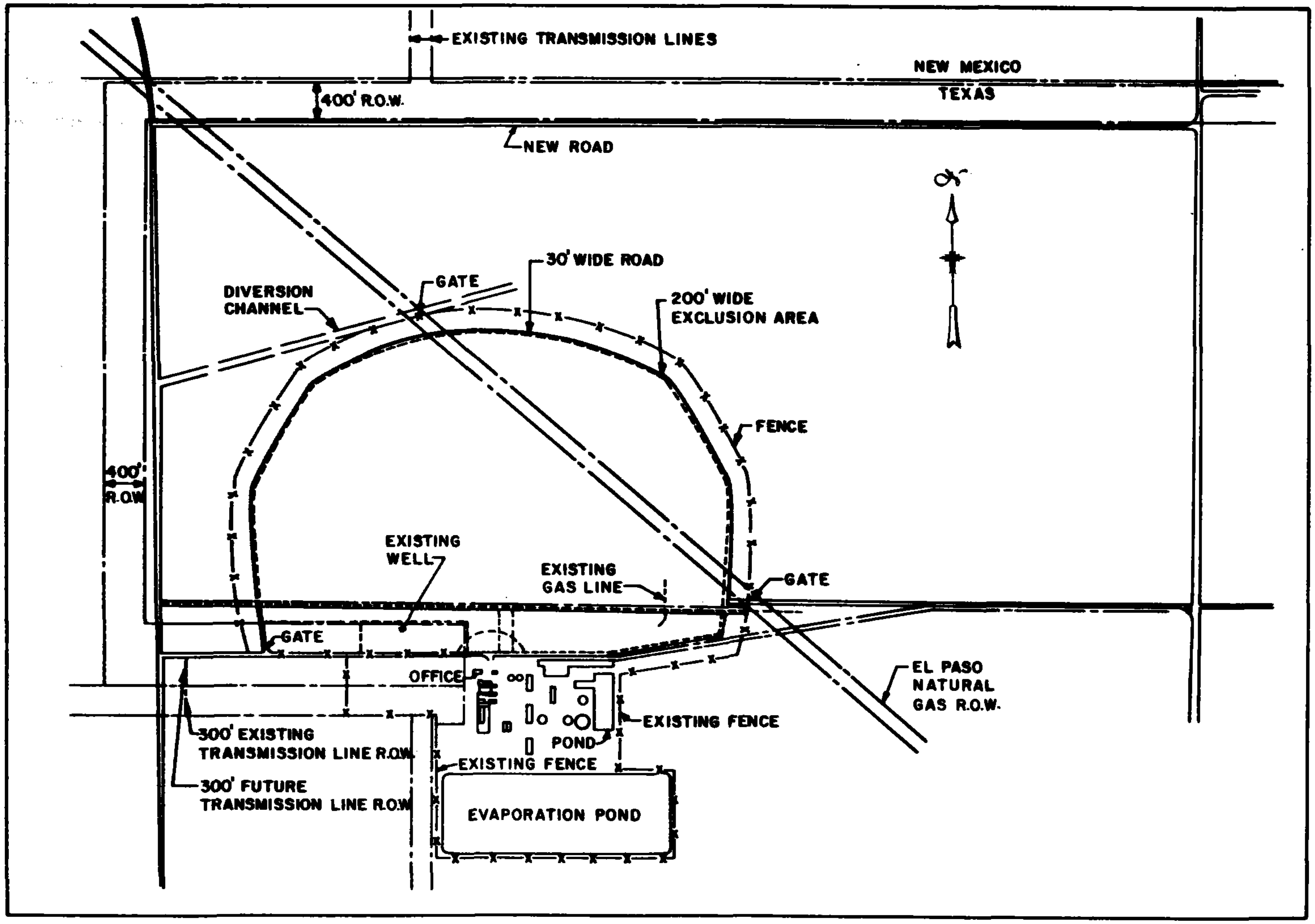


Figure 1-3. Proposed Site Arrangement for Solar Repowering Newman Unit 1

Evaporative cooling of the maintenance building addition and the solar feed water pump house will be provided by propeller type fans which will draw the outside air into the enclosures through inlet louvers and air filters. The existing fire protection system will be extended to provide suitable protection to the enclosures. Hydrants and hose stations will be located at strategic points in the collector field; a fire water booster pump and hose stations will be located inside the solar receiver tower. Lighting will be provided along the perimeter road surrounding the heliostat field and at the tower operating levels.

1.2.3 COLLECTOR SUBSYSTEM

The Collector Subsystem will be composed of an array of heliostats and supporting power and control elements which interact with the Master Control Subsystem. The heliostat array will be arranged in a 2.79 radian (160) fan shaped configuration north of the single receiver tower (Figure 1-3). The heliostat array will reflect solar radiation onto the elevated absorbers (boiler, superheater and reheater) of the receiver subsystem in a manner which will satisfy the receiver incident flux requirements. The Collector Subsystem is sized for a solar multiple of 1.0. The Collector Subsystem components will include the following:

a. 2776 heliostats, including reflective surface, structural support, drive units, control sensors, pedestals, foundations, cabling, and cable array installations.

b. Electromechanical and electrical controllers, including individual heliostat, heliostat field and heliostat array controllers, control system interface electronics, power supplies, and beam characterization system components.

The Collector Subsystem Description is based on the characterisitics of the Westinghouse Second Generation Heliostat. The design description, performance characteristics, and cost data for this heliostat are incorporated in the specification as representative of the class of heliostat configurations that will be available for Solar Repowering Newman Unit 1.

1.2.4 RECEIVER SUBSYSTEM

The Receiver Subsystem provides a means of transferring the incident radiant flux energy from the Collector Subsystem into superheated steam. The receiver fluid is water/steam. The Receiver Subsystem will consist of primary and reheat receivers to intercept the radiant flux reflected from the Collector Subsystem, a single tower structure to support the two receivers, receiver header piping and riser and down comer piping for the primary receiver.

The receivers will be of external panel type configuration with a forced recirculation boiler. The Receiver Subsystem will include the pumps, valves and control system within the tower structure necessary to regulate the flow, temperature and pressure; and the required control system components necessary for safe and efficient operation, startup, shutdown and standby. Also included in this subsystem will be an elevator, crane system, platforms, stairs etc. to provide for observation and maintenance.

1.2.5 MASTER CONTROL SUBSYSTEM

The Master Control Subsystem (MCS) is used to sense, detect, monitor and control all system and subsystem parameters necessary to ensure safe and proper operation of the entire integrated repowered plant. Specifically, this subsystem will provide for stable plant operation during startup, steady-state, shutdown, transient, or emergency conditions in the fossil only, solar only, or combined operating modes. It will provide for an effective operator/plant interface, allow for automatic or manual control, and permit comprehensive plant performance evaluation. This subsystem will consist of a central computer, computer peripheral equipment, time code generator, control and display consoles, and solar/non-solar electric power control interfaces and software.

1.2.6 FOSSIL BOILER SUBSYSTEM

The Fossil Boiler Subsystem provides a fossil energy source which is used to enhance performance and/or maintain normal plant operation during periods of reduced or no insolation. The Fossil Boiler Subsystem consists of the existing Newman Unit 1 fuel handling, boiler and related equipment. It also consists of the control system necessary to regulate the steam flow, temperature, and pressure; and the required control necessary for safe and efficient operation, startup, shutdown, and standby of the Fossil Boiler Subsystem. Essentially all of the existing Newman Unit 1 boiler equipment will remain after being retrofitted with a solar steam supply system, although most of the existing pneumatic control system will be replaced with electronic combustion and feedwater controls.

1.2.7 ELECTRICAL POWER GENERATING SUBSYSTEM

The Electrical Power Generating Subsystem (EPGS) provides the means for converting to electrical power the thermal output from the Receivers and/or the Fossil Boiler Subsystem. The output from the EPGS will be regulated for integration into El Paso Electric Company system network. The EPGS consists of the existing balance-of-plant equipment at Newman Unit 1.

1.2.8 SPECIALIZED EQUIPMENT

No specialized equipment required to service, maintain, repair, clean or overhaul any of the solar repowered plant equipment has been identified during the conceptual design effort.

1.3 DEFINITIONS OF TERMS

Beam Pointing Error
The angular difference between the aim point and measured beam centroid for any tracking aim point (on target or at standby) under the specified operating conditions.

Capacity Factor, Annual - Non-Solar
Annual non-solar MWh divided by the product of 8760h and plant or unit rating in MW.

Capacity Factor, Annual - Overall
Annual solar and non-solar MWh divided by the product of 8760h and plant or unit rating in MW.

Capacity Factor - Solar
Annual solar MWh divided by the product of 8760h and plant or unit rating in MW.

Conversion Efficiency (Gross)
The gross output provided by a conversion device divided by the total input power at specified conditions.

Conversion Efficiency (Net)
The actual net output (after deducting parasitics) provided by a conversion device divided by the required input power at specified conditions.

Demand
The power versus time profile of the energy required to satisfy the energy needs of the final consumer or end use consuming process.

Design Point
The time and day of year at which the system is sized with reference direct insolation, wind speed, temperature, humidity, dew point, and sun angles.

Direct Insolation
The non-scattered solar flux falling on a surface of given orientation (W/m^2).

Fluid, Receiver
The fluid used to cool the solar receiver and distribute the absorbed solar energy to other parts of the system; heat transport fluid of the receiver.

Fluid, Working
The fluid used in the turbine or other prime mover.

Hybrid System
A combination of solar and non-solar technology to provide a single plant system that is capable of continuous operation.

Levelized Busbar Energy Cost
That cost per unit of energy which, if held constant throughout the life of the system would represent the total required life cycle costs, assuming that all cash flow interim requirements or excesses are borrowed or invested at the utility's internal rate of return.

Nameplate Rating
The full-load continuous rating of a generator, prime mover, or other electrical equipment under specified conditions as designated by the manufacturer.

Present Value
The present value of capital and operating costs (or annual savings, brought over a given time period such as the life of the plant) represents a single payment at a reference year that would yield the necessary cash flow at a given interest rate.

Receiver Efficiency
The ratio of thermal power absorbed by the fluid flowing through the receiver to the solar power incident upon the receiver.

Repowered Plant
A plant that uses central receiver technology and solar energy to partially displace non-renewable (fossil) fuels.

Repowering Percent - Design Point
The percentage of the unit's rated net electrical power output produced as a result of the steam generated by the solar receivers at the design point.

Solar Flux
The rate of solar thermal radiation per unit area (w/m^2).

Solar Fraction (Annual)
The annual average fraction of thermal energy to the turbine delivered by the solar steam supply system.

Solar Fraction (Design Point)
The fraction of thermal energy to the turbine delivered by the solar steam supply system at the design point.

Storage Capacity
The amount of net energy which can be delivered from a fully charged storage subsystem (MWhe or MWht).

Thermal Power, Fossil Boiler Output
Thermal power in steam generated by the fossil boiler after stack and miscellaneous losses.

Thermal Power, Turbine
Thermal power input required by the turbine at the design point.

Thermal Power, Receiver Output
The thermal power in steam generated by the receiver measured at the receiver outlet.

2.0 REFERENCES

The following references will provide the guidelines for development of the conceptual designs that are presented in this specification. These references will influence the design and selection of vessels, heat-transfer equipment, mechanical equipment, structures, civil work, piping, instrumentation, and electrical items that are used in the utility industry.

2.1 STANDARDS AND CODES

The latest revisions of each of the following codes in effect during final design will be used.

Uniform Building Code - 1976 Edition by International Conference of Building Officials

OSHA Regulations

- OSHA Title 29, Part 1910 - Occupational Safety and Health Standards

ASME Boiler and Pressure Vessel Code

- Section I - Power Boilers, including: ANSI B31.1-1977 Power Piping
- Section II - Materials Specifications
- Section VIII - Unfired Pressure Vessels

NRC Regulatory Guides 1.60 and 1.61.

Institute of Electrical and Electronic Engineers (IEEE) Codes, as applicable.

National Fire Protection Association (NFPA) National Fire Codes

Human Engineering Design Criteria

- MIL-STD-810C
- MIL-STD-1472

Design, Construction and Fabrication Standards

- Standards of AISC (American Institute of Steel Construction)
- Standards of ACI (American Concrete Institute)
- Standards of TEMA (Tub. Exchanger Manufacturer's Association)
- ANSI A58.1 - Building Code Requirements for Minimum Design Loads in Buildings and Other Structures

2.2 OTHER PUBLICATIONS AND DOCUMENTS

National Energy Conservation Policy Act of 1978
Power Plant and Industrial Fuel Use Act of 1978
Public Utilities Regulatory Policy Act
Natural Gas Policy Act of 1978
Energy Tax Act of 1978
Environmental Legislation

- National Environmental Policy Act (NEPA)

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2.3 PERMITS AND LICENSES REQUIRED

Construction Permit
Waste Water Discharge Permit (NPDES)
SPCC (Spill Prevention Containment Countermeasure)
Air Navigation Approval (FAA)
Elevator Permit/Certificate
State (Highway Connector)
Local (land use, general construction, private road
construction and use)

2.4 APPLICABLE LAWS AND REGULATIONS

Texas Clean Air Act of 1973 (Air Control Board)
Texas Water Quality Act of 1977 (Dept of Water Resources)
Federal Aviation Regulation, Part 77 (FAA)
El Paso Building Law
Department of Transportation, State Highway Dept Regs
El Paso Zoning Laws; Building Laws; Texas Regulation, Control of
Air Pollution from Visible Emissions of 1975

3.0 REQUIREMENTS

The Solar Repowered Newman Unit 1 shall be designed to meet the requirements of this section. The solar steam generating system shall be sized to produce steam at conditions necessary to generate 50 percent of the rated net electrical output, 82 MWe, at the design point solar conditions corresponding to noon summer solstice. The solar mutiple at the design point is 1.0. The design lifetime shall be 30 years. The repowering system shall include both a primary and reheat receiver mounted on a single tower which will supply 10.1 MPa/538^{o}C (1450 psig/ 1000^{o}F) steam to the high pressure turbine inlet and 2.93 MPa/538^{o}C (410 psig/ 1000^{o}F) reheat steam to the intermediate pressure turbine inlet of Newman Unit 1. The solar repowered steam generator system will operate in parallel with the existing gas/oil fired boiler to meet the total daily electrical demand requiremets. The performance and operating requirements of the solar retrofit subsystems are defined below:

3.1 SITE

The collector field and other facilities associated with Solar Repowering Newman Unit 1 will require approximately 1.50 km^2 (370 acres) of land. Site preparation will include minor grading and surface preparation with crushed rock. A state highway and a transmission line that currently transect the site will be rerouted. A new access road to the Newman Station and a perimeter road around the heliostat field will be provided to support vehicular traffic.

Heliostats shall be excluded from portions of the collector field where existing equipment and piping rights-of-way are required, and where future tranmission line rights-of-way will be located.

Drainage ditches are required to channel rainwater from the solar collector field to minimize erosion of the graded surfaces and protect foundation integrity. The solar repowering site shall include paved roads and fences to provide access to the solar collectors and receivers and protect against unauthorized entry to the site.

The characteristics of the Newman Station site shall satisfies all the necessary siting requirements for a successful repowering application.

3.2 SITE FACILITIES

New site facilities will require additions to the existing control room and maintenance building, and a new solar feed water pump house.

The control room will require a second level to house the solar repowering electronic equipment. The extended control room areas shall be air conditioned to maintain the correct ambient temperature for the new computers and associated equipment. The second level will require new toilet facilities. An addition to the maintenance building will be required to enable plant personnel to repair and test complete heliostat assemblies. Additional evaporative coolers will be required to circulate fresh air through the maintenance area.

A solar feed water pump house will be required for the solar feed pumps and the solar repowering equipment switchgear.

The existing fire protection system must be extended to protect the new site facilities. Hydrants and hose stations will be necessary for the heliostat field and around the solar field water pump house and maintenance area. Hose stations shall be provided at the various levels inside the solar receivers tower.

Outdoor lighting shall be provided along the solar collector field perimeter road and at the base and upper levels of the tower.

3.3 COLLECTOR SUBSYSTEM

The Collector Subsystem shall reflect solar radiation onto the Receiver Subsystem in a manner which satisfies receiver incident heat flux requirements specified in Section 3.4.2. In addition, the Collector Subsystem shall respond to commands from the Master Control Subsystem for emergency defocusing of the reflected energy or to protect the heliostat array against environmental extremes. The heliostats shall be properly positioned for repair or maintenance in response to either master control or manual commands. Heliostat design shall provide for a stored or safe position at night, during periodic maintenance and during adverse weather conditions. The Collector Subsystem shall be designed to match the receiver design and provide energy to the receiver working fluid consistent with the input energy requirements of the existing turbine.

Meteorological and insolation data corresponding to the Typical Meteorological Year for El Paso as supplied on the SOLMET Weather Tapes shall be used as a design basis for the subsystem. The design point basis shall be noon summer solstice.

3.3.1 COLLECTOR FIELD

The collector field shall be designed so that 105 MWt of the redirected solar energy will impinge on the primary receiver and 25 MWt will impinge on the reheat receiver at noon summer solstice with a direct normal insolation value of 950 W/m^2.

The Collector Field design shall provide the optimum heliostat layout considering the following:

a. Heliostat capital cost
b. Operating and maintenance cost
c. Field wiring cost
d. Land availability
e. Land cost
f. Heliostat performance
g. Receiver size
h. Receiver tower height
i. Plant Availability
j. Shading and blocking
k. Atmospheric attenuation
l. Sun position
m. Piping cost
n. Foundation Requirements

The Collector Subsystem shall function as appropriate for all steady-state modes of plant operation. This shall include the capability of controlling the number of heliostats in tracking mode so as to vary the redirected flux to either receiver between zero and the maximum achievable level with step changes no larger than ten percent of the total collector field output.

Drive systems must be capable of positioning a heliostat to stowage, stand by, cleaning, or maintenance orientation from any operational orientation within 15 minutes of a command signal.

Elevation and azimuth drives shall not drift from last commanded positions due to environmental conditions.

The drive system shall provide for cost effective stowage of the reflective surface to minimize reflected beam safety hazards and dust or dirt build-up on the mirrors. Heliostat orientation shall be available to the Master Control Subsystem at all times. Calculated gimbal angles are acceptable, orientation sensors are not required.

Heliostat control shall be by computer. Control functions shall be accomplished as follows:

Heliostat Array Controller (HAC) shall:
  Initiate operational mode commands to HFC
  Address commands to HFC groups or individual HC
  Respond to MCS commands and requests
  Interface with beam characterization system
  Provide time base

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Heliostat Field Controller (HFC) shall:
- Determine sun vector
- Transmit sun vector to HC
- Transmit status and data to HAC
- Initiate safe stowage command
- Control groups of HCs

Heliostat Controller (HC) shall:
- Determine heliostat azimuth and elevation position requirements
- Control drive motors
- Provide heliostat axis position data to HFC

The Collector Subsystem shall be capable of emergency defocusing upon command to reduce peak incident radiation on the receiver to less than 3% of initial value within 120 seconds.

Heat fluxes on tower and normally unirradiated portions of the Receiver Subsystem are limited to 25 kW/m^2 (7880 BTU/FT^2 hr).

Beam control strategy and equipment will protect personnel and property within and outside the plant facility including air space.

3.3.2 HELIOSTATS

In order to attain overall plant field performance such that 95% of the redirected energy approaching the receivers will impinge on the receivers with an incident angle of less than 60 , the following requirements have been established for designing and evaluating individual heliostats.

a. Maximum beam pointing error (tracking accuracy) shall be limited to 1.5 mrad standard deviation for each gimbal axis under the following conditions:

- Wind - none
- Temperature -0 to 50^{o}C (32 to 122^{o}F)
- Gravity effects - at all elevation and azimuth angles that could occur in a heliostat field
- Azimuth angles - at all angles except during stow
- Sun location - at least 0.26 rad above horizon, any time of year
- Heliostat location - any position in the field

Pointing error is defined as the difference between the aim point and measured beam centroid for all of the above conditions for any tracking aim point (on target or at standby).

b. Beam quality shall be such that a minimum of 90% of the reflected energy at target slant range shall fall within the area defined by the theoretical beam shape plus a 1.4 mrad fringe width. Heliostat beam quality shall be maintained for 60 days without realignment. Beam quality requirements are applicable under the following conditions:

- Wind - none
- Temperature - 0 to 50°C (32° to 12°F)
- Gravity effects - at all elevation and azimuth angles that could occur in a heliostat field
- Sun location - at least 0.26 rad above horizon, any time of year
- Heliostat location - any position in the field and any slant range
- Operating mode - tracking on a BCS calibration target
- Facet alignment - as planned for the plant
- Theoretical beam shape - the theoretical beam contour, determined by HELIOS, is the isoflux contour that contains 90% of the total power. This isoflux contour will be increased by 1.4 mrad fringe. The HELIOS computer code is available through Sandia Laboratories.

c. Overall structural support shall limit reflective surface static deflections to an effective 1.7 mrad standard deviation for a field of heliostats in a 12 m/s (27 mph) wind.

Wind deflections of the foundation, pedestal, drive mechanism, torque tube, and mirror support members shall be included, but not the slope errors due to gravity and temperature effects. Wind deflection limits apply to the mirror normal (not reflected beam) for each axis fixed in the reflector plane. Both beam quality and beam pointing are affected.

To assure that the net slope errors of a field of heliostats is less than 1.7 mrad, the rms value of the slope errors taken over the entire reflective surface of an individual heliostat, computed under the worst conditions of wind and heliostat orientation (but excluding foundation deflection), shall be limited to 3.6 mrad for a single heliostat. This limit represents a 3-sigma value for the field derived by subtracting foundation deflection (see 3.2.1.d) from the total surface slope error (1.7 - 0.5 = 1.2 mrad standard deviation x 3 = 3.6 mrad, 3-sigma). The conditions under which this requirement applies are:

- Wind, including gusts 12 m/s (27 mph) at 10 m (33 ft) elevation
- Temperature 0 to 50°C (32 to 122°F)
- Heliostat location - any position in the field at any time of the year
- Gravity effects - not included
- Mirror module waviness - none
- Facet alignment error - none

d. The allowable tilt and/or torsional rotation of a heliostat foundation shall not exceed ± 1.5 mrad total angular deflection per axis, when the heliostat is subjected to a 12 m/s (27 mph) operational wind load. This total deflection shall, in addition to elastic response, include the amount of plastic or permanent deflection, including any wobble (looseness) resulting from a prior 22 m/s (50 mph) wind experience. The allowable plastic or permanent deflection of the foundation resulting from a 22 m/s (50 mph) wind load shall not exceed ± 0.45 mrad.

Both deflection allowances are 3-sigma limits expressed for a single heliostat/foundation field position, and are computed under the worst condition of wind and heliostat orientation. For a full field of heliostat foundations, the effective limits will result in a standard deviation of 1/3 of the deflection allowances specified for a single foundation.

The deflections specified are applicable at the foundation-to-heliostat interface located on a plane parallel to and approximately 50.8 mm (2 inches) above the pier concrete surface, which is represented by the underside of the heliostat pedestal mounting flange.

3.4 RECEIVER SUBSYSTEM

The Receiver Subsystem shall include a primary receiver and a reheat receiver mounted on a single tower and shall provide a means of transferring the incident radiant flux energy from the Collector Subsystem into superheated steam and transport of the steam to the high pressure 10.1 MPa/538°C (1450 psig/1000° F) turbine and the intermediate 2.93 MPa/538°C (410 psig/1000°F) turbine.

3.4.1 STRUCTURAL DESIGN

The receiver and tower shall be designed to provide access for maintenance and inspection of tower structure, receiver, working fluid, instruments and controls, cranes, hydraulic equipment, etc. Consideration shall be given to ease of maintenance. Adequate provisions shall be made to ensure crew safety at all times for required operations, inspection, maintenance and repair. The receiver design shall be consistent with Section 1 of the ASME Boiler Codes and appropriate sections of the construction codes. The design lifetime shall be 30 years. Seismic criteria will be based on a peak ground acceleration of 0.125g combined with the response spectrum given by NRC Regulatory Guide 1.60 and the operating basis earthquakes in NRC Reg. Guide 1.6.1.

3.4.2 RECEIVER

The Primary Receiver shall be an external panel configuration with a forced recirculation boiler and shall face a 160° north field of heliostats. The primary receiver shall be capable of operating safely and reliably for 30 years with heat flux levels not exceeding 0.60 MW/m^2 for water-cooled tubes and 0.3 MW/m^2 for the superheater tubes at noon winter solstice with an incident power level of 117 MWt. The corresponding heat flux distribution is shown in Figure 3-1.

At noon summer solstice, the primary receiver shall be capable of absorbing 92 MWt into steam with a receiver incident power level of 105 MWt and the incident heat flux distribution indicated in Figure 3-2. Steam shall be generated at the rate of 129,000 kg/h (284,000 lbs/hour) (including losses and attemperation) with outlet conditions of 10.8 MPa (1550 psig) and 549°C (1020°F). The corresponding inlet temperature shall be 238°C (46°F) and the maximum allowable pressure drop (inlet to outlet) shall be 1.72 MPa (250 psig).

The Reheat Receiver shall be an external panel configuration and shall be capable of operating safely and reliably with an absorption heat flux level not exceeding 0.14 MW/m^2 at noon winter solstice with an incident power level of 28 MWt. The corresponding heat flux distribution is shown in Figure 3-3. At noon summer solstice, the reheat receiver shall be capable of absorbing 13 MWt into steam with a receiver incident power level of 25 MWt and the incident heat flux distribution indicated in Figure 3-4. Steam shall be generated at the rate of 115,400 kg/h (254,500 lbs/hour) (including attemperation) with outlet conditions of 2.97 MPa (416 psig) and 549°C (1020°F). The corresponding inlet temperature will be 380°C (720°F), and the maximum allowable pressure drop shall be 172 kPa (25 psi).

The receivers shall be designed to be subjected to 10,000 start up/shutdown cycles and 50,000 cloud transient cycles. The Receiver Subsystem shall include a control system to maintain the HP at IP turbine inlet conditions within tolerances to be set by plant operators and equipment manufactures while being subjected to fluctuations in solar heat fluxes due to normal daily/hourly variances and partial cloud transients. At those times when the solar system is not capable of meeting turbine inlet requirements, the receivers shall be maintained in standby mode.

ANGLE FROM NORTH

-180 -135 -90 -45 0 45 90 135 180

15.7	.0008	.0375	.1526	.1860	.2159	.1463	.0282	0.0000
13.7	.0015	.0651	.2843	.4283	.3844	.2592	.0589	.0032
11.8	.0015	.0715	.3519	.5125	.5399	.3395	.0650	.0015
9.8	.0039	.0879	.3755	.5407	.5934	.3885	.0769	.0015
7.9	.0015	.0824	.4062	.5706	.5714	.3764	.0730	.0039
5.9	.0024	.0793	.3420	.4909	.5291	.3662	.0754	.0032
3.9	0.0000	.0408	.2379	.3954	.3728	.2692	.0558	0.0000
2	.0008	.0236	.1014	.1611	.1721	.1117	.0173	0.0000
0								

Figure 3-1. Incident Heat Flux Distribution on the Primary Receiver at Noon Winter Solstice

ANGLE FROM NORTH

Height (m)	−180		−135		−90		−45		0		45		90		135		180
15.7		0.0000		.0346		.1182		.1780		.1620		.1182		.0279		.0014	
13.7		.0040		.0600		.2139		.3508		.3826		.2352		.0638		.0026	
11.8		.0026		.0757		.3441		.5009		.4624		.3402		.0877		.0014	
9.8		.0040		.0638		.3282		.4916		.4730		.3641		.0811		.0026	
7.9		.0014		.0625		.3760		.4996		.4836		.3601		.0851		.0053	
5.9		.0040		.0757		.3336		.4464		.4624		.3269		.0625		.0040	
3.9		0.0000		.0439		.2564		.2843		.2950		.2113		.0452		.0014	
2		0.0000		.0119		.0903		.1595		.1462		.0891		.0266		.0014	
0																	

Height (m)

Figure 3-2. Indicent Heat Flux Distribution on the Primary Receiver at Noon Summer Solstice

ANGLE FROM NORTH

−180 −135 −90 −45 0 45 90 135 180

15.7	0.0000	.0047	.0233	.0259	.0255	.0235	.0060	0.0000
13.7	0.0000	.0109	.0823	.1112	.1117	.0822	.0090	0.0000
11.8	0.0000	.0085	.0868	.1251	.1257	.0899	.0087	0.0000
9.8	0.0000	.0123	.0993	.1352	.1284	.0996	.0115	0.0000
7.9	0.0000	.0085	.0875	.1285	.1253	.0886	.0085	0.0000
5.9	0.0000	.0105	.0947	.1263	.1322	.0907	.0115	0.0000
3.9	0.0000	.0045	.0668	.1041	.1075	.0666	.0050	0.0000
2	0.0000	.0008	.0130	.0176	.0183	.0150	.0001	0.0000
0								
Height								

Figure 3-3. Incident Heat Flux Distribution on the Reheat Receiver at Noon Winter Solstice

ANGLE FROM NORTH

−180 −135 −90 −45 0 45 90 135 180

15.7	.0002	.0055	.0163	.0230	.0242	.0158	.0044	0.0000
13.7	0.0000	.0153	.0805	.1134	.1162	.0795	.0128	0.0000
11.8	0.0000	.0108	.0823	.1178	.1131	.0847	.0141	0.0000
9.8	0.0000	.0166	.0877	.1366	.1314	.0840	.0148	0.0000
7.9	.0002	.0136	.0808	.1252	.1223	.0800	.0150	0.0000
5.9	0.0000	.0188	.0847	.1147	.1198	.0867	.0133	0.0000
3.9	0.0000	.0081	.0711	.0887	.0988	.0727	.0074	0.0000
2	0.0000	.0002	.0082	.0129	.0092	.0081	.0003	0.0000
0								

Height (m)

Figure 3-4. Incident Heat Flux Distribution on the Reheat Receiver at Noon Summer Solstice

3.4.3 WORKING FLUID

The Working Fluid shall be water/steam for the primary receiver and superheated steam for the reheat receiver. Specifications and quality for the Working Fluid are as follows:

Solar Main Steam

TDS	270 ppb.
Na	30 ppb.
SiO_2	8.5 ppb.

Solar Feedwater

pH	8.7
Conductivity	2.6 mmhos.
SiO_2	048 ppm.

3.4.4 RECEIVER TOWER

The Receiver Tower must support the main and reheat receivers, piping and other elements of the receiver subsystem. Tower design will require the following:

a. Tower height-130.5 m

b. Elevation of primary receiver centerline-155.0 m

c. Elevation of reheat receiver centerline-139.2 m

d. Weight of primary and reheat receivers including support structure-1.1 x 10^6 kg

e. Design wind load-35.8 m/s (80 mph)

f. Seismic Zone category-UBC Zone 1

g. Deflection Limitations (TBD)

h. Soil conditions (See Section 5.1.1)

Structural design will include an analysis of dynamic wind stresses (vortex shedding) to determine the critical wind velocity.

The tower will be required to support feedwater, main steam, reheat and auxiliary piping and associated controls and provide access for maintenance and repair. In addition to internal ladders, platforms and walkways the design of the tower shall include an elevator having a capacity of approximately 409 kg (900 lbs).

3.5 MASTER CONTROL SUBSYSTEM (MCS)

3.5.1 GENERAL DESIGN REQUIREMENTS

The Newman Unit 1 control system and existing power plant equipment shall be modified to provide daily cycling of the unit and utilize fossil and solar energy for generation of electrical power. The MCS shall control the solar steam supply system and the existing plant equipment in a safe and reliable condition under all modes of operation.

The MCS shall permit the operator to select one of three plant operating modes: a fossil mode, solar mode or combined solar/fossil mode.

The MCS shall operate the unit under all conditions including start-up, shutdown, transient, steady state, and emergency operation.

3.5.2 DESIGN CRITERIA

In order to satisfy the general design requirements the MCS shall meet the following design criteria:

a. High Availability

- High component/circuit reliability employing the latest solid state technology and conservative designs.
- Major control systems and components shall have full redundant backup.
- Modular architecture to enhance fault detection and maintenance.
- Self-diagonostic capability wherever possible.

b. Redundancy

The MCS will include full system redundancy where feasible. A failure of one computer processing unit CPU will not cause a reduction in control, monitoring, display or other required plant control functions.

c. Comprehensive Operator/Plant Interface

- CRT displays are provided for the following.
  - process monitoring
  - trouble identification
  - operator guidance
  - interactive communications
  - status information
  - historical review

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- Main Control Board with conventional analog displays, control stations, alarms, etc. providing the operator with a familiar operation/process interface.

d. Flexibility

All control logic functions and control algorithms are implemented in comprehensive direct digital control (DDC) software. The system is programmed in a basic language which allows changes to be made simply and quickly.

e. System Modifications

Existing control systems will be modified only where necessary. The following criteria will determine which controls are changed:

- Direct interface with MCS.
- Significant enhancement of the repowered unit's ability to meet the design requirements.
- Ability of the equipment to function properly for the required 30-yr lifetime.

In general, all the instrumentation that will be replaced meets two or more of the above criteria.

3.5.3 OPERATING MODES

3.5.3.1 FOSSIL MODE

When the fossil mode has been selected, the solar repowering system shall be isolated from the existing fossil fueled power plant. In this mode, the control system shall permit the unit to be placed in either boiler following, or turbine following control.

3.5.3.2 SOLAR ONLY MODE

With clear day insolation available, the operator will select a solar only mode of operation. The fossil boiler will be shutdown and isolated and the solar repowering system will be operated with the turbine placed in turbine following control. The solar Primary Receiver, solar Reheat Receiver and the Collector Subsystem shall be automatically controlled to maximize thermal energy output from the solar steam supply system. The turbine inlet control valves will be automatically positioned to maintain stable steam conditions to the turbine inlets.

3.5.3.3 COMBINED SOLAR/FOSSIL MODE

When intermittent cloud conditions prevail or when it is economical to operate the unit at high load, the Master Control System shall control the plant in a solar/fossil mode. In the solar/fossil mode, the steam from the solar receivers and the fossil boiler shall be combined prior to being admitted to the turbine. The control system shall operate the solar steam supply system to maximize solar thermal output and uses the fossil boiler to supplement steam to meet the unit's load demand. In this mode the turbine can be operated in either turbine following or boiler following control depending on the needs of the grid.

3.6 FOSSIL BOILER SUBSYSTEM

The Fossil Boiler Subsystem of Newman Unit 1 shall interface with the solar steam supply system according to the following boiler performance requirements:

a. Minimum automatic operation - 28% load (36% rated steam flow)

b. Maximum boiler ramp rate - 11%/min
(change in boiler thermal output)

c. Energy required from cold startup to 28% load -
1.06×10^{11} J (100 MBtu) over 4 hours

d. Energy required from hot standby to 28% load -
1.58×10^{10} J (15 MBtu)

e. Boiler efficiency - 84.4%

f. Ability to maintain superheat and reheat temperature of
538°C (1000°F), to minimum load

3.7 ELECTRIC POWER GENERATING SUBSYSTEM

The Electric Power Generating Subsystem (EPGS) will be required to accept steam from either or both the solar or fossil steam supply systems.

Operating constraints imposed by the existing EPGS are as follows:

a.	Maximum gross electric output	85.8 MW_e
b.	Rated main steam flow for guaranteed output	257,000 kg/h (567,000 lb/h)
c.	Main steam rated temperature	538 C (1000°F)
d.	Reheat steam rated temperature	538 C (1000°F)
e.	Main steam rated pressure	10.1 MPa (1450 psig)
f.	Rated reheat pressure drop	255 kPa (37 psi)

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g. Steam temperature limitations (at turbine main stop valve)
   1. average over 12 months not to exceed 538°C (1000°F)
   2. 552°C (1025°F) for not more than 400 hrs for 12 months
   3. 566°C (1050°F) for up to 15 minutes: not more than 80 hrs/yr

h. Steam pressure limitations
   1. 10.1 MPa (1450 psig) at rated output
   2. 10.6 MPa (1523 psig) as turbine approaches zero output
   3. 13.0 MPa (1885 psig) momentarily, not exceeding 12 hr/yr

i. Load limitations

   Rate of load change is limited by metal temperatures in critical areas of turbine. Normal turbine load change rates are limited to about 5 MW_e/min. Faster load changes will require monitoring of turbine rotor and casing metal temperatures.

3.8 SERVICE LIFE

The system shall be designed for a 30 year service life.

3.9 PLANT AVAILABILITY AND RELIABILITY

Consideration shall be given in the design to achieving high reliability by providing design and operating margins and utilizing sound engineering design practices.

3.10 MAINTAINABILITY

The solar repowered plant modifications and new installations shall be designed to be compatible with existing plant maintainability characteristics and practices. Potential maintenance locations shall be easily reached and components, such as electronic units, motors, drivers, etc., readily replaced. Elements subject to wear and damage such as supporting wheels, gears, etc., shall be easily serviced or replaced. The plant shall be capable of being serviced with a minimum of specialized equipment or tools.

4.0 ENVIRONMENTAL CRITERIA

This section addresses plant environmental design requirements and environmental standards.

4.1 DESIGN REQUIREMENTS

The system shall be capable of operating in and surviving appropriate combinations of the following environments:

a. Temperature: The plant shall be able to operate in the ambient air temperature range from -22 to +48.9°C (-8°F to 120°F). Performance requirements shall be met throughout an ambient air temperature range selected to be consistent with efficient plant operation.

b. Wind: The plant shall be capable of operating given the following approximate wind profile as a frequency of function of height above ground level.

   Performance requirements shall be met for the most adverse combination of wind and temperature conditions selected to be consistent with efficient plant operation. Wind analyses shall satisfy the requirements of ANSI A58.1-1972.

c. Earthquake: This peak ground accelerations as presented below will be combined with the response spectrum given by NRC Reg. Guide 1.60 and the damping values given for the operating bases earthquake in NRC Reg. Guide 1.61.

   Peak Ground Acceleration Average or Firm Conditions = 0.125 g

The system shall be capable of surviving appropriate combinations of the environments specified below:

a. Wind: The plant shall survive winds with a maximum speed, including gusts of 35.8 m/s (80 mph), without damage. A local wind vector variation of +10 degrees from the horizontal shall be assumed for the survival condition.

b. Snow: The plant shall survive a static snow load of 250 Pa (5 lb/ft^2) and a snow deposition rate of 0/3 m (1 ft) in 24 hours.

c. Rain: The plant shall survive the following rainfall conditions at a maximum 24-hr rate of 75 mm (3 in)

d. Ice: The plant shall survive freezing rain and ice deposits in a layer 50 mm (2 in) thick.

e. Earthquake: The peak ground accelerations as presented below will be combined with the response spectrum given by NRC Reg. Guide 1.60 and the damping values given for the operating bases earthquake in NRC Reg. Guide 1.61.

   Maximum Survival Ground Accelerations (Peak Ground Acceleration Average or Firm Conditions) = 0.125 g

f. Hail: The plant shall survive hail impact up to the following limits:

Diameter	25 mm (1 in)
Specific Gravity	0.9
Terminal Velocity	23 m/s (75 fps)
Temperature	-6.7°C (20°F)

g. Sandstorm Environment: The plant shall survive after being exposed to flowing dust comparable to the conditions described by Methods 510 of MIL-STD-810B.

The plant shall be provided with a lightning protection system for the tower and receivers.

4.2 ENVIRONMENTAL STANDARDS

Federal, state, and local regulations applicable to solar repowering Newman Unit 1 are presented in Sections 2.4.

5.0 CONCEPTUAL DESIGN DATA

5.1 PLANT CHARACTERISTICS AND PERFORMANCE DATA

Key design and operational characteristics of solar repowering Newman Unit 1 are summarized in Table 5-1.

5.1.1 SITE

The Newman site is nearly flat with a downward slope of approximately one degree from west to east. The solar collector field is graded and covered with 5.10cm (2 in) of crushed stone. Access to the heliostats for inspection and maintenance is from a 9.1 m (30 ft) wide asphalt paved perimeter road. A 2.4 m (8 ft) high fence along the perimeter road is provided to discourage unauthorized access to the heliostats. A new 3.2 Km (2 mile) long highway (Farm To Market Road 2529) is provided to reroute traffic north of the solar collector field location.

Arroyos ranging from surface erosion near the center of the site to 91.9 m (6 ft) wash near the War Road (Farm To Market Road 3255) west of the site are diverted north of the collector field. The diversion channel extends east across a 36.6 m (120 ft) wide natural gas line right-of-way (ROW). Rainfall in the field will be channeled by several north-south shallow ditches, 0.6 m (2 ft) deep with a 3.0 m (10 ft) bottom width. The shallow ditches discharge into collection ditches of 0.9 m (3 ft) deep and 6.1 m (20 ft) bottom width along the field's east-west perimeter road. Ten culverts are provided under the perimeter road to drain water away from the field area.

Exclusion areas in the collector field allow access to existing piping. A 36.6 m (120 ft) wide ROW located in the eastern part of the field is provided for underground natural gas lines. A 12.2 m (40 ft) wide ROW running in the east-west direction is provided for the water and gas lines at the Newman Station. In addition, a 61 m (200 ft) wide exclusion area is provided on the east, north and west sides of the heliostat field, to provide room for turning trucks and reduce the likelihood of vandalism.

Existing transmission lines in the proposed field location will be rerouted and future transmission line ROWs are provided to meet El Paso Electric Company expansion plans. Rerouted and future transmission rights-of-way will occupy the adjacent area at the north end of the planned 345 kV switchyard additon (See Figure 1-3).

TABLE 5-1: SOLAR REPOWERED NEWMAN UNIT 1 CHARACTERISTICS OF PREFERRED CONFIGURATION

● Unit Type	Reheat Steam Turbine
● Unit Rating	82 MWe
● Solar Repowering Percentage*	50 Percent
● Plant Operating Scenario	Maximize Solar Benefit Fossil Operation only on Cloudy Days Economic Dispatch Fossil Energy
● Collector Subsystem	
- Field Configuraton	North Field (160° Array)
- Field Area	1,500,000m^2
- Heliostat Area (Gross)	227,000m^2
- Heliostat Area (Effective)	211,000m^2
- Number of Heliostats	2776
● Receiver/Tower Subsystem	
- Primary Receiver Type	External (Forced, Recirculation Boiler/Screened Tube Concept)
- Primary Receiver Size	12.6m Dia. x 15.7m Long x 4.2 Rad Arc
● Reheat Receiver	
- Type	External
- Size	12.6m Dia. x 15.7m Long x 3.7 Rad Arc
● Tower	
- Height w/ Receiver	172.7m
- Height w/o receiver	127m
- Number of Towers	1
- Primary Receiver C/L Height	155m
- Reheat Receiver C/L Height	139m
● Electric Power Generation Subsystem	
- Cycle	Steam Rankine (Reheat)
- Net Unit Efficiency (Solar/Fossil)	40/40
- Turbine Inlet	10.1 MPa/538 C/538 C
- Heat Rejection	Wet Cooling Tower
● Fossil Boiler	
- Type	Gas/Oil
- Rated Load Efficiency	84.4%
- Minimum Automatic Operation	28% Minimum load
- Startup Energy	1.06×10^{11} J
- Warm Standby	1.58×10^{10} J

* Based on an Insolation Level of 950 W/m^2, noon summer solstice

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5.1.2 SITE FACILITIES

An addition to the existing Newman Station Control Room will extend approximately 2.3 m (7.5 ft) north to permit placing the solar repowering operator's panel adjacent to the Newman Unit 1 boiler control panel. An air conditioned second level, approximately 17.1 m (56 ft) by 11.0 m (36 ft), is provided above the existing control room. The new room is sectioned off to house the computer equipment, relay equipment, battery inverters and associated consoles for the operators and programmers. The second level also includes an engineering office and personnel toilet facilities.

The solar feed water pump house is a 11.0 m (36 ft) by 15.2 m (50 ft) sheet metal enclosure located next to the solar receiver tower. The pump house includes two half-capacity solar feed pumps/motors with associated equipment and a switchgear area for the solar repowering electrical equipment.

A 12.2 m (40 ft) by 18.3 m (60 ft) maintenance area is connected to the existing warehouse. The new maintenance area has adequate space to assemble and test a heliostat unit prior to field installation. Existing fire protection underground mains are extended to cover new fire protection requirements for the solar repowering facilities. Hydrants and hose stations will be located at strategic points in the solar collector field, around the maintenance area and solar feed water pump house. A fire water booster pump will be located at the base of the solar receiver tower and hose stations will be provided at the tower upper levels.

5.1.3 COLLECTOR SUBSYSTEM

The Collector Subsystem will have the following design and operating characteristics:

5.1.3.1 DESIGN CHARACTERISTICS

Figure 5-1 shows the conceptual layout of the heliostat field for Newman Unit 1 for 50% repowering. The receiver tower is located as close as possible to the turbine building to minimize feedwater and steam piping distances. The heliostat array is a 2.79 radian (160) north field on a radial stagger arrangement. Heliostats are not placed on the rights-of-way for transmission lines and water and gas pipelines. The heliostat array consists of 2776 Westinghouse Second Generation Heliostats. The design characteristics of the Westinghouse Second Generation Heliostat are given in Figure 5-2.

5.1.3.2 OPERATING CHARACTERISTICS

- Operating Modes
  - Startup
  - Shutdown (normal and emergency)
  - Track
  - Standby (normal and emergency)
  - Align
  - Manual
  - Stow (normal and emergency)
  - Communication

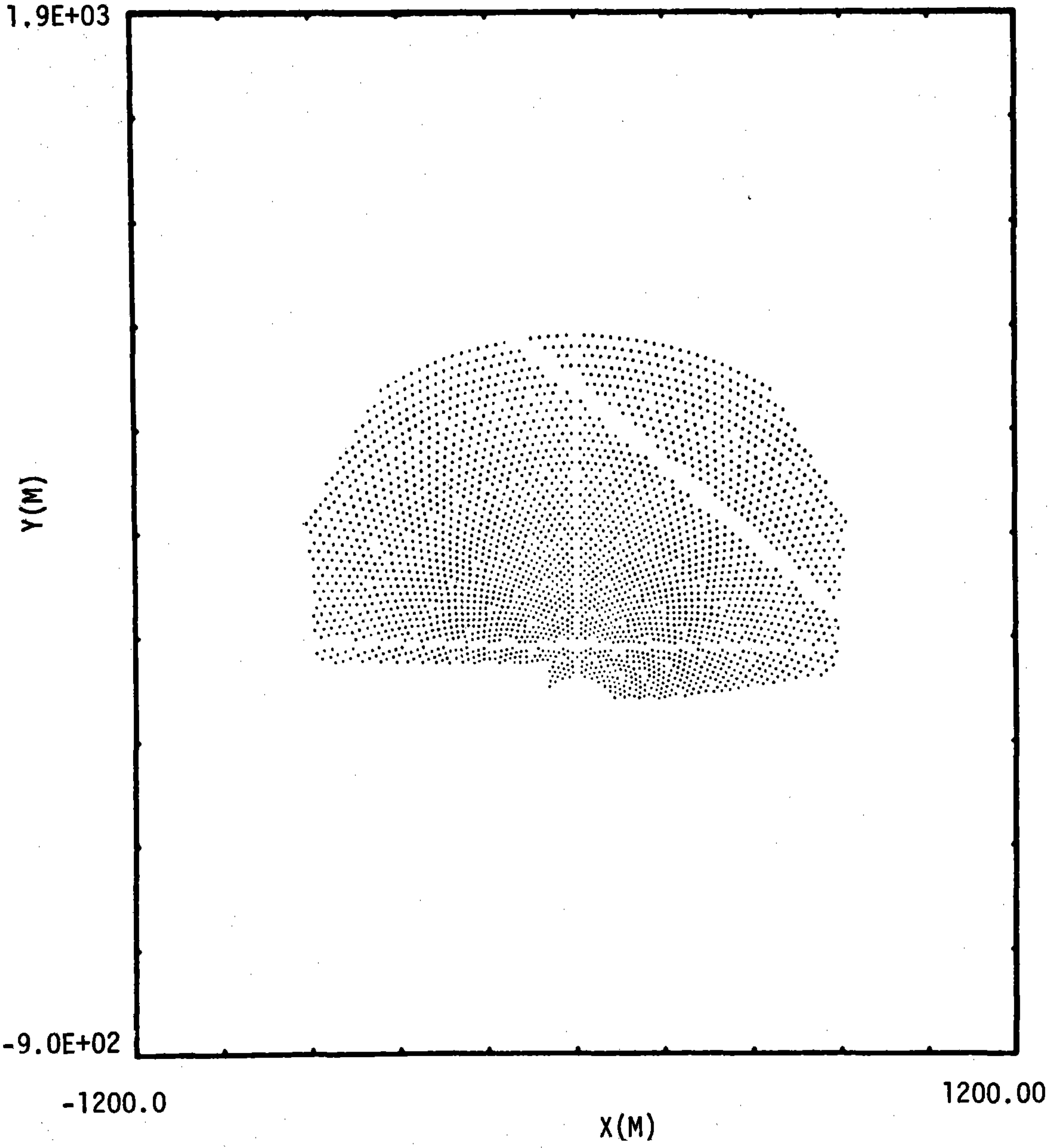
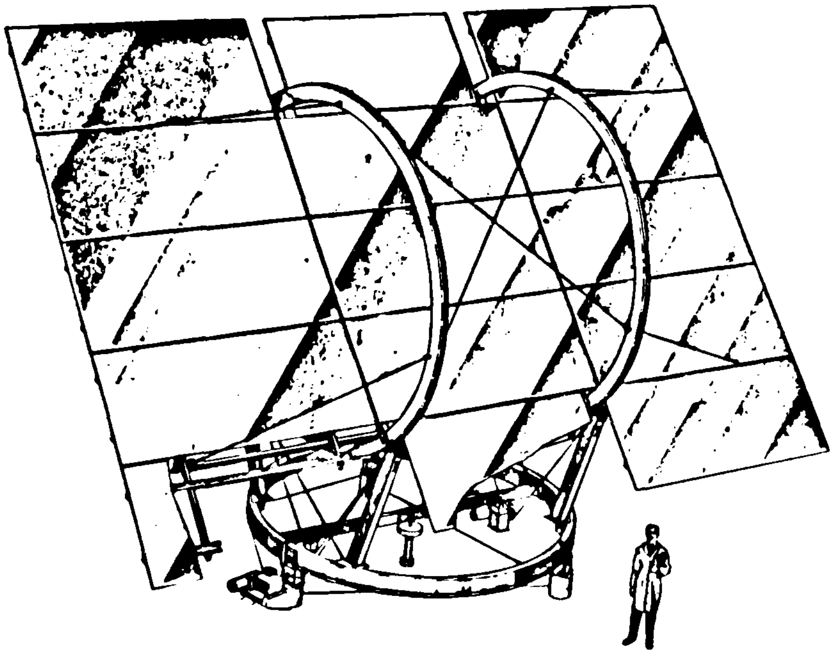


Figure 5-1. Newman Unit 1 Collector Field Layout



HELIOSTAT CHARACTERISTICS

Aspect Ratio	1.5:1 (7.6m x 11.0m)
Mirror Area	81.8m^2
Mirror Panel	Laminated Glass Panels
Elevation Wheels	4.9m Dia.
Azimuth Ring	4.57m Dia.
Weight	3725Kg

Figure 5-2. Heliostat Concept

- Allowed Mode Transitions
    - Startup
        - Stow
        - Communication
        - Standby
        - Track
    - Normal Shutdown
        - Track
        - Standby
        - Stow
    - Emergency Shutdown
        - Track
        - Standby (emergency - azimuthal movement only)
        - Stow (emergency - mirror face up)

- Power Requirements for Each Mode

Communication	160 kW
Track (with Align and Manual)	270 kW
Standby (with Align and Manual)	270 kW
Stow	160 kW

- Peak Power Requirements for Mode Transition

Stow to Standby	1440 kW
Standby to Track	670 kW
Track to Standby (emergency)	1440 kW
Standby to Stow (emergency)	1440 kW
Track to Stow (emergency)	1440 kW

5.1.3.3 CONTROL SYSTEM CHARACTERISTICS

The control functions are accomplished through a computer system. The heliostat array control system is composed of a Heliostat Array Controller (HAC) (backed up by the BCS computer), 104 Heliostat Field Controllers (HFC) and 2776 Heliostat Controllers (HC).

The Collector Subsystem meets performance requirements for the following conditions.

Environment	Level
Wind, including gusts	12 m/s maximum (27 mph)
Temperature	0 to 50°C (32 to 122°F)
Gravity	All elevation angles

The heliostats will continue to track the target with wind speeds up to 16 m/s (35 mph). Between 12 m/s (27 mph) and 16 m/s (35 mph) the heliostats will continue to track the target but with degraded performance. The heliostat will maintain structural integrity in a non-operational state in a 22 m/s (50 mph) wind in any orientation and will also maintain structure integrity in the stowed position in wind gusts up to 55 m/s (125 mph).

To achieve morning operational position or evening stow position, the heliostat will be required to function with ambient temperatures down to -9^{o}C (16^{o}F) at component temperatures that are colder or hotter than ambient temperatures duu to thermal lag and/or absorption of direct insolation.

The heliostat, in any orientation, will survive 19 mm (0.75 inch) diameter, 0.9 specific gravity, hail impacting at 20 m/s (65 ft/s).

Heliostats may be in stowed position to survive hail conditions cited in Section 4.0, Environmental Criteria.

The Collector Subsystem shall have lightning protection consistent with the following guidelines:

Direct Hit	Total destruction of a single heliostat and its controller subjected to a direct lightning strike is acceptable.
Adjacent Strike	Damage to a heliostat adjacent to a direct lightning strike should be minimized within appropriate cost risk limits.
Controllers	The HACs, HFSs, and HCs adjacent to a direct lightning strike must be protected.

For design purposes, the maximum current in a lightning strike shall be limited to 200,000 amperes.

5.1.4 RECEIVER SUBSYSTEM

The Receiver Subsystem including the primary and reheat receivers shall have the following design and operating characteristics:

5.1.4.1 DESIGN CHARACTERISTICS

- Primary Receiver
  - External Configuration
  - Water/Steam Working Fluid
  - Forced Recirculation Boiler (Recirculation Ratio = 3.5))
  - Vertical Tube Panels with Screened Superheater Tubes (16 Panels)
  - Three superheater passes with 2 attemperation stages (attemperation capacity = 10% at design flow)
  - Superheater panel inlets valved for secondary control
  - Receiver Size
    - Length 15.7 m
    - Diameter 12.6 m
  - Receiver enclosed angle 4.2 rad (240°)
  - Single Drum
  - Superheater Material Alloy 800 H
  - Tube Diameters
    - Superheater 1.9 cm (0.75 in)
    - Boiler 4.4 cm (1.75 in)
  - Tube Absorptivity = 0.95 (Pyromark or equivalent)
  - Mean Design Wind Speed 5.5 m/s at receiver surface
  - Shroudless
  - Design Life
    - 30 years
    - 10,000 startup shutdown cycles
    - 50,000 cloud transients

- Reheat Receiver
  - External Configuration
  - Superheated Steam Working Fluid
  - Horizontal Tube Panels
  - 16 Panels
  - Receiver size
    - Length 15.7 m
    - Diameter 12.6 m
  - Receiver enclosed angle 3.7 rad(210°)
  - Single stage attemperation at inlet to reheat panels (attemperation capacity = 4% of design flow)
  - Tube diameter 3.8 cm (1.5 in)
  - Absorptivity = 0.95 (Pyromark or equivalent)
  - Shroudless
  - Mean design wind speed 5.5 m/sec at receiver surface
  - Design Life
    - 30 years
    - 10,000 startup/shutdown cycles
    - 50,000 cloud transients
- Receiver Support Structure - Steel Girder Network

- Tower

- Reinforced Concrete structure	
- Height	127 m (417 ft)
- Base Diameter	18.3 m (60 ft)
- Top Diameter	10.7 m (35 ft)
- Feedwater Pipes	20.3 cm (8 in) OD CL 901 CS matl
- Primary Steam Downcomer	30.5 cm (12 in) OD CL 2505 CR/MO matl
- Reheat Steam Pipes	35.6 cm (14 in) OD and 61.0 cm (24 in) OD
Low Temperature -	CL 601 CS matl;
High Temperature -	CL 601C CR/MO matl

- Total Receiver Weight 1,100,000 kg (2,420,000 lbs)
  (Includes receivers, structure, cranes, etc at top of concrete tower)

5.1.4.2 PERFORMANCE CHARACTERISTICS (DESIGN POINT)

- Primary Receiver

Incident Power	105 MW$_t$	
Absorbed Power	92 MW$_t$	
Flow Rate	129,000 kg/hr	(284,000 lbs/hr)
Outlet Pressure	10.8 MPa	(1550 psig)
Outlet Temperature	549°C	(1020°F)
Peak Heat Flux (water/steam)	0.60/0.3 MW/m^2	
Allowable Pressure Drop	1.72 MPa	(250 psi)

- Reheat Receiver

Incident Power	25 MW$_t$	
Absorbed Power	13 MW$_t$	
Flow Rate	115,400 kg/hr	(254,500 lb/hr)
Outlet Pressure	2.97 MPa	(416 psig)
Outlet Temperature	549°	(1020°C)
Peak Heat Flux	0.135 MW/m^2	
Allowable Pressure Drop	172 kPa	(25 psi)

5.1.4.3 OPERATING CHARACTERISTICS

- Feedwater
  Feedwater controlled by 3 element flow control valves in both solar and fossil boiler feedwater systems.

- Main Steam
  Flow from solar and fossil fueled boiler recombined upstream of H.P. turbine.

- Low Temp Reheat
  Flow controlled to solar reheater using temperature control.
  Flow controlled to reheat section of fossil fueled boiler using flow control.

- High Temp Reheat
  Flow from solar reheater and reheat section of fossil fueled boiler recombined upstream of I.P. Turbine.

- Turbine Generator
  Digital Electro-hydraulic Turbine Control system provides flexibility to operate the unit in boiler following or turbine following modes and provides the capability of turbine automatic startup.

- Electrical
  Heliostat Power Supply will be provided by 4 - 2,400 V circuits, each feeding 4 - 225 kva transformers. Each 225 kva transformer will supply power to 174 heliostats.

5.1.5 MASTER CONTROL SUBSYSTEM

The Master Control System as defined for Solar Repowering Unit 1 shall encompass the following control subsystems:

a. Process Computer System
b. Collector Control System
c. Beam Characterization System (BCS)
d. Digital Electro-Hydraulic Turbine Control System (DEH)

The purpose of the Process Computer System (PCS) is to integrate, supervise and coordinate the operation of all major systems and subsystems of the hybrid power plant including:

a. Collector Subsystem
b. Beam Characteristics System
c. Receiver Subsystem
d. Fossil Boiler Subsystem
e. Electric Power Generating Subsystem
f. Balance of Plant

The PCS consists of two central processing units (CPU's). One CPU will be used for primary plant control, monitoring and display functions while the other CPU provides backup. The backup CPU will have complete software and active data base so that it can quickly take over plant control whenever the primary CPU is not operational.

5.1.5.1 PROCESS COMPUTER SYSTEM CAPABILITIES

The PCS shall have the capability to perform the following:

a. Direct Digital Control
b. Data acquisition, storage, analysis and retrieval
c. Comprehensive equipment and plant performance calculations
d. Displays, monitor, and alarm
e. Trend logs, trip logs, and operations journals
f. Contact sequential events recording and logging
g. Analog trending of points using trend pen recorders

5.1.5.2 PROCESS COMPUTER SYSTEM HARDWARE

The Process Computer System (PCS) hardware configuration is shown schematically in Figure 5-3. This configuration is typical of commerically available computer and support hardware process in numerous power plant applications.

The components of the PCS are as follows:

a. Two central processor units (256 K, 32 bit word, core memory)

b. One operator's console, with color graphic CRT and control functions keyboard.

c. One engineer's/programmer's console, with color graphic CRT and control functions keyboard.

d. A programmer's terminal with keyboard

e. Three medium speed printers associated with above consoles and terminal

f. One alarm printer, one line printer, and one general purpose printer

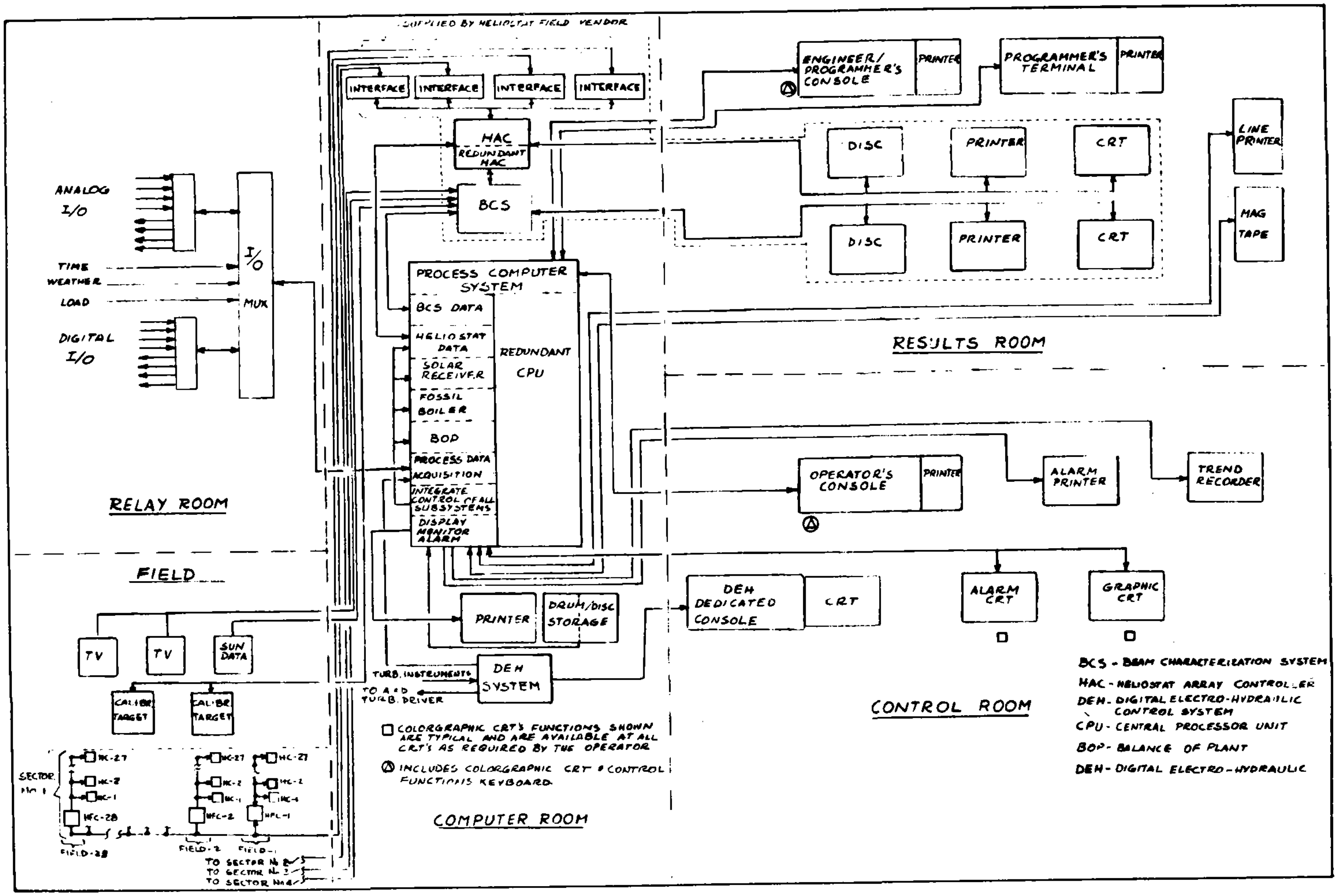
g. Computer driven trend strip chart recorders

h. Three color CRTs mounted on the Main Control Board for alarm, DEH control, graphic display, etc. Information displayed on any CRT is operator selectable.

i. Mag-tape unit for programming

j. Two drum/disc units for bulk storage

k. Analog and Digital I/O multiplex cabinet with all required hardware to read, condition, amplify, compensate, and digitize process signals such as flows, temperatures, pressures level and contact (power supplies included).



☐ COLORGRAPHIC CRT'S FUNCTIONS SHOWN ARE TYPICAL AND ARE AVAILABLE AT ALL CRT'S AS REQUIRED BY THE OPERATOR

Ⓐ INCLUDES COLORGRAPHIC CRT & CONTROL FUNCTIONS KEYBOARD

BCS - BEAM CHARACTERIZATION SYSTEM
HAC - HELIOSTAT ARRAY CONTROLLER
DEH - DIGITAL ELECTRO-HYDRAULIC CONTROL SYSTEM
CPU - CENTRAL PROCESSOR UNIT
BOP - BALANCE OF PLANT
DEH - DIGITAL ELECTRO-HYDRAULIC

Figure 5-3. Master Control System

l. Relay and logic cabinet to interface the PCS with the final control elements

m. Interface cabinets

5.1.5.3 PROCESS COMPUTER SYSTEM SOFTWARE

The PCS will include a process software package that has been used in many power plant applications. This software includes the following:

a. Operating System
b. Programming Support/Languages (i.e., Fortran, etc.)
c. Data Base Management
d. Data Acquisition and Validation
e. Real Time Variable Calculations
f. Data Analysis and Alarming
g. Operator/Engineer Communications
h. Color Graphic Display
i. Plant Operations Displays/Records

In addition to the above, the PCS will include a comprehensive Direct Digital Control (DDC) software system.

The DDC systems will perform conventional analog control algorithms as well as the more complex application programs necessary for supervisory control and plant integration. The system will also perform sequential control for burner management on the fossil boiler and other applications which previously utilized relay logic.

Control Levels

The plant can be operated at no less than three levels of control with the operator's responsibilities varying with each level.

a. Automatic

At this level the PCS is providing overall plant control and subsystem integration and coordination. The PCS optimizes the operation of the plant by evaluating many environmental, plant, system and component variables, characteristics, and responses.

The operator simply monitors the performance and status of the plant, systems and components.

b. Semi-Automatic

At this level the PCS automatically controls each subsystem with the operator providing the supervisory control and subsystem integration/coordination function input. He accomplishes this by adjusting the setpoints on subsystem master control stations or initiating control logic sequences associated with the individual subsystems.

c. Manual

In the unlikely event that both CPU's fail or during startup/shutdown the operator can operate the plant manually by directly positioning final control elements or starting/stopping components.

For critical variables the operator will be provided with hardwired indicators and annunciators (bypassing the PCS) to assist with plant shutdown.

That portion of the emergency trip and interlock system necessary for operating/equipment safety will employ solid state logic and will function automatically at all levels of control.

5.1.6 FOSSIL BOILER SUBSYSTEM

The Fossil Boiler Subsystem will include the existing fossil fueled boiler and associated boiler control system as described in Section 5.2.

The Fossil Boiler Subsystem will be modified to provide state-of-art control components which will improve the reliability and availability of the subsystem. The modifications will affect the combustion control system, feedwater control system, steam temperature control system, and burner controls.

5.1.6.1 COMBUSTION CONTROL SYSTEM

The existing Bailey Meter Company pneumatic combustion control system is performing satisfactorily at this time, however it has been decided to replace it for the following reasons:

a. The existing controls are 20 years old and are not expected to function properly for many of the 30 years for which the repowered unit is designed. Bailey Meter Company is no longer manufacturing this line of instrumentation.

b. The combustion controls have a major control and monitoring interface with the PCS.

c. In order to limit the effects of solar transients on the turbine-generator the fossil unit dynamic response must be as fast as possible within the design limitations of the existing unit.

The new combustion controls will employ new electronic components and state-of-the-art control concepts.

The new combustion control logic includes cross limiting of fuel/air, feet forward and other techniques that will provide improved dynamics response, stability and safety. This logic will be implemented in PCS software. This approach greatly simplifies the interface, improves response, and provides added control and monitoring capability.

The basic combustion control system consists of a three-element control system; 1) fuel flow, 2) steam pressure and 3) air flow. The final control elements for this unit are the gas valve which controls the fuel, and the FD fan damper which controls the air. All final control elements will be retained if they are working properly.

5.1.6.2 FEEDWATER CONTROL SYSTEM

The present Bailey Meter feedwater pneumatic control system employs a three-element feedwater control concept to maintain proper drum level.

Like the combustion control system, the feedwater controls instrumentation will be replaced by electronic equipment, but will retain the three-element control concept. The control logic will be implemented in the PCS.

Final control will be through two pneumatic control valves. Each will receive an electronic signal which is converted to a pneumatic signal through a current-to-pneumatic (I/P) converter.

5.1.6.3 STEAM TEMPERATURE CONTROL SYSTEM

The present three-element Bailey Meter pneumatic superheat and two-element reheat steam temperature control systems will be replaced by an electronic system. Although the control concept will be retained, the control logic will be implemented in the process computer system (PCS).

Better superheat steam temperature at low load will be obtained by interlocking the superheat control system with the new burner control system and bringing in additional burners when attemperation has reached its low limit.

Reheat steam temperature can also be maintained at low loads by diverting an excess portion of the cold reheat steam to the solar reheat receiver.

5.1.6.4 BURNER CONTROL SYSTEM

The present Forney Engineering Company Burner Control System is working properly. However, it requires a great deal of manual operation.

This burner control is of an old vintage and would require extensive work to upgrade the system to provide the response necessary to meet the repowered unit requirements. Therefore it will be necessary to provide a new Burner Management System.

The new Burner Management System will respond faster to unit transients, will increase fuel safety, and will operate automatically from the main control board under all operating conditions.

The new Burner Management System will consist of a panel insert on the new main control board with push buttons and switches to provide the operator interface and comply with the latest OSHA and NFPA-85B requirements.

The control logic and interlocks for burner operation, purge prelight, fuel safety, etc., will be implemented in the PCS software. In addition, sufficient hardwired solid state logics will be provided so the operator can safely shutdown the fossil boiler in the unlikely event that both PCS CPU's fail. Remote local controls will be provided to control individual burners whenever required.

5.1.7 ELECTRIC POWER GENERATING SUBSYSTEM

The design and operating characteristics of the existing Electric Power Generating Subsystem are described in section 5.2.

This subsystem will be modified to enable Newman Unit 1 to accept solar steam for generation of electric power. The design and operating characteristics of the additional equipment are as follows:

5.1.7.1 DESIGN CHARACTERISTICS

● Solar Feed Water Pump	2 Half Capacity
Rated flow	.027 m^3/S (430 gpm)
Rated head	2.95 MPa (1200 ft)
● Piping for Solar Repowering	
Solar Feed Water PP inlet	20.3 cm (8 in), sch 80, carbon steel
Solar Feed Water PP inlet	10.2 cm (4 in) & 15.2 cm (6 in), sch 120, carbon steel
Solar Main Steam	30.5 cm (12 in), sch 160, 2 1/4 cr/1 mo.
Solar Low Temp Reheat	35.6 cm (14 in) & 61.0 cm (24 in), sch 60, carbon steel
Solar High Temp Reheat	35.6 cm (14 in) & 61.0 cm (24 in), sch 60, 2 1/4 cr/1 mo.
● Motor Operated Gate Valves	To isolate fossil fueled boiler from solar main and reheat receivers.
● Control Valves	
Solar Feed Water	3 element feed water control
Existing Feed Water	3 element feed water control
● Control Valves	
Solar Low Temp Reheat	Temperature Control
Existing Low Temp Reheat	Flow Control
● Turbine Generator	
Control System	Change existing mechanical control system to a digital electro-hydraulic control system

- Transformers

Solar Auxiliary Transformer No. 1	3,750 kva, Oa/Future FA 13.8 - 2.4 kv, 3-Phase, 60 HZ
Solar Auxiliary Transformer No. 2	750 kva, AA, 2,400/480 V 3-Phase, 60 HZ

- Unit 1 Station Battery

Distribution Panel	125 V D-C

5.1.7.2 TURBINE CONTROL

The present Newman Unit 1 Allis-Chalmers turbine will require some engineering redesign of the existing Mechanical-Hydraulic system to allow the controls of the turbine to operate in a turbine-following mode. In addtion a Digital Electro-Hydraulics (DEH) control system will be implemented.

Due to the expected cyclic operation of the fossil/solar hybrid plant it is important to avoid excessive thermal stresses during rapid transients and at the same time reduce start-up times under all operating conditions. The implementation of a DEH control system will greatly facilitate operator interface and minimize the margin for error.

Some of the important benefits from implementing a DEH are as follows:

a. Automatic Turbine Startup (ATS) from turning gear to synchronous speed.
b. Measure shaft eccentricity, vibration, and metal temperatures.
c. Calculate rotor stresses and adjust turbine speed accordingly.
d. Self diagonistic features to evaluate the validity of control information.
e. Execute load runback based on command from the control system.

The ATS normally has two operating modes:

- Automatic
- Supervisory

In the automatic mode an ATS program automatically adjusts turbine speed and acceleration via control signals at the digital reference of the electro-hydraulic control system.

In the supervision mode, guide messages inform the operator to adjust turbine speed and acceleration manually.

The turbine DEH system is composed of a dedicated digital computer located in the computer room which receives analog and digital information from different turbine sensors and transmits control signals to the electro hydraulic system that controls the turbine throttle valves.

The DEH is interfaced with the Process Computer System through a data link. The process computer system will coordinate turbine operation to match loading requirements for Newman Unit 1 under the Fossil only, Solar/Fossil, or Solar Only modes.

Communication between the operator and the DEH system is normally through a dedicated console with its corresponding keyboard and dedicated CRT colorgraphic display and program status, however, whenever operator coordination as mentioned above is required, communication is through the operator's console.

5.2 EXISTING PLANT DESCRIPTION

5.2.1 GENERAL

● Location	9.66 Km (6 mi) W of Newman, Texas 24.1 Km (15 mi) N of downtown El Paso
● Elevation	1,239 m (4,065 ft)
● Turbine-Generator	75,000 Kw tandem-compound
● Steam Generator	253,970 kg/hr (560,000 lb/hr)
● Throttle Steam Conditions	538°C (1000°F) 10.1 x MPa (1450 psig)
● Reheat Steam Conditions	538°C (1000 F) 2.93 MPa (425 psig)
● Fuel	Natural Gas
● Alternative Fuel	Fuel Oil
● Extraction Steam	4 Closed Feed Water Heaters 1 Open Deaerating heater
● Condenser Cooling	5 Cell Induced Draft Cooling Tower
● Make Up Water	Evaporation of Zeolite Softened Well Water
● Electrical Output	96,000 kva
● Fundamental Flow Diagram	(See Figure 5-4)
● Heat Balances	
- Maximum net unit output	82.3 MWe
- Design net unit output	79.6 MWe
- Maximum gross generation	86 MWe
- Design gross generation	83.1 MWe

(See Figures 5-5 and 5-6 for heat balances at 83 MWe and 41 MWe)

- Unit Heat Rate
  - Heat Rate vs. Load (See Table 5-2)
  - Heat rate increases significantly at loads of 52 MW and below
  - Heat Rate and Unit Output vs. Steam Temperature and Reheat Pressure Drop (See Table 5-3)

This section describes the design and operating characteristics of the existing boiler, turbine-generator and related control systems.

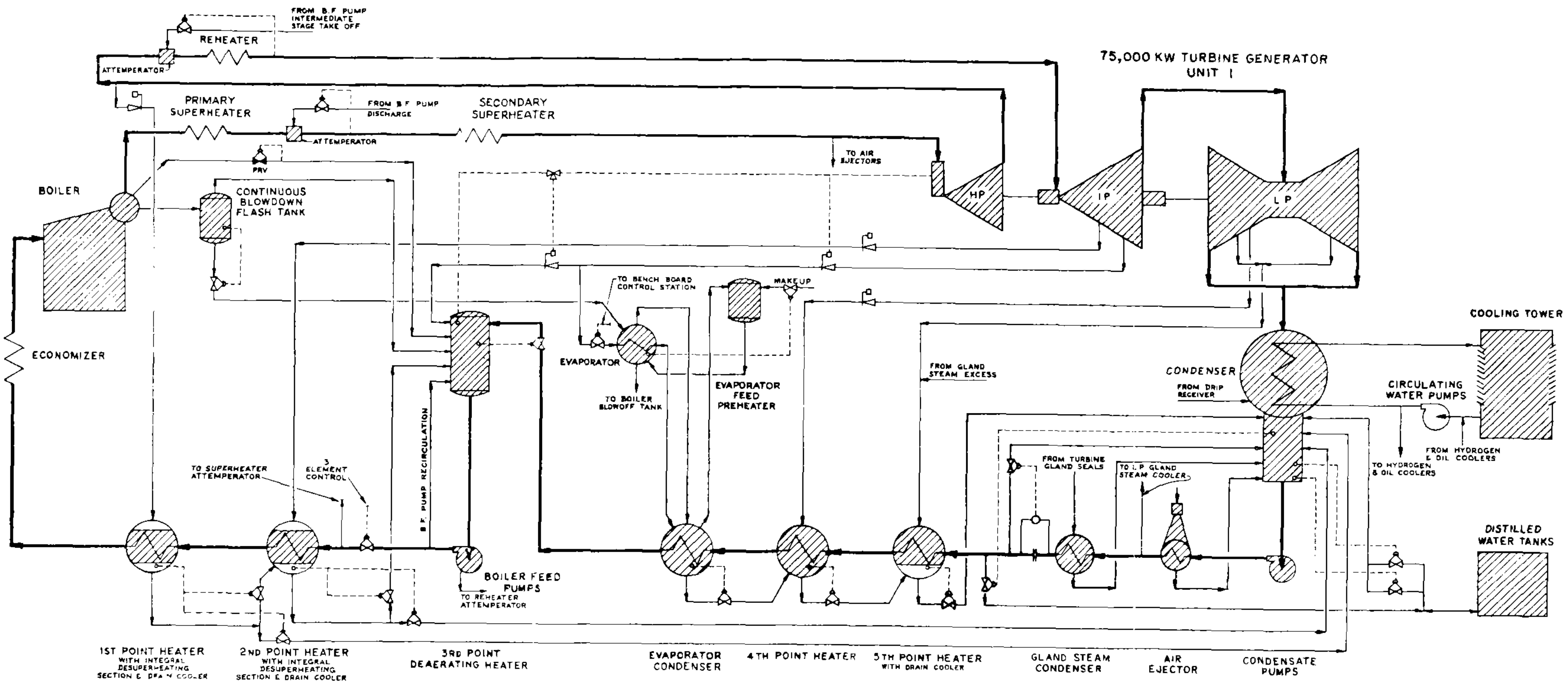
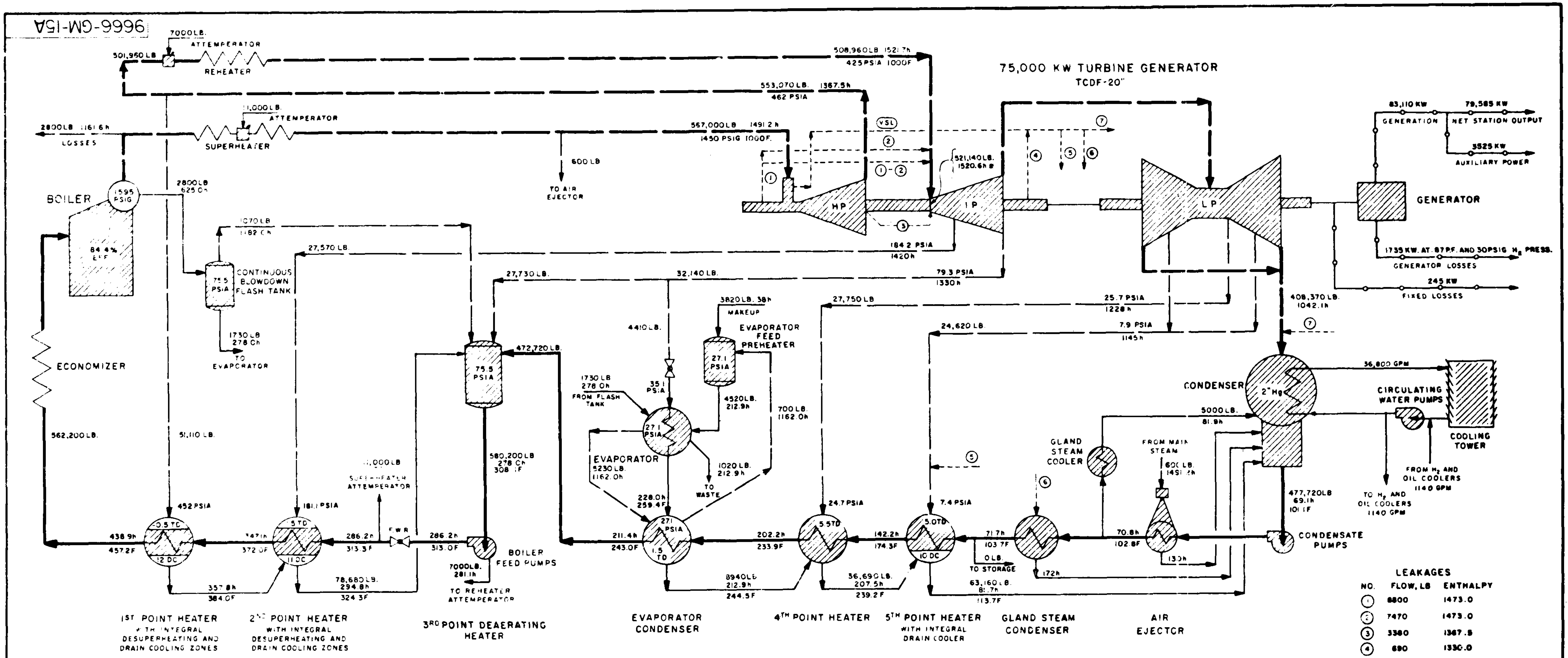


Figure 5-4. Fundamental Flow Diagram



LEAKAGES

NO.	FLOW, LB	ENTHALPY
①	8800	1473.0
②	7470	1473.0
③	3380	1367.5
④	690	1330.0
⑤	1650	1445.6
⑥	360	1352.0
⑦	230	1352.0
VSL	1750	1491.2

BASIS OF HEAT BALANCE CALCULATIONS

ELEVATION: PLANT IS APPROXIMATELY 4065 FEET ABOVE SEA LEVEL

AIR TEMPERATURE: AVERAGE ANNUAL AMBIENT AIR TEMPERATURE IS 63.3F

FUEL: NATURAL GAS

STEAM LOSSES: 2800 LB, CONSTANT AT ALL LOADS

BOILER BLOWDOWN: 0.5% STEAM GENERATION

BOILER EFFICIENCY: ADJUSTED FOR ACTUAL INLET AIR TEMPERATURE AT 73.8

SUPERHEATER, REHEATER, MAIN AND REHEAT STEAM LINE PRESSURE DROPS CALCULATED AT ALL LOADS. REHEAT SYSTEM PRESSURE DROP EXPRESSED AS 8.0 PERCENT OF HIGH PRESSURE TURBINE EXHAUST PRESSURE AT THIS LOAD.

EXTRACTION LINE PRESSURE DROPS CALCULATED AT MAXIMUM LOAD AND EXPRESSED AS THE FOLLOWING PER CENT OF THE FLANGE ABSOLUTE PRESSURES FOR USE AT ALL LOADS

EXTRACTION LINE	1	2	3	4	5
PER CENT	2.2	1.7	4.8	4.0	6.4

EXTRACTION PRESSURES SHOWN AT OR NEAR THE TURBINE SYMBOL ARE TURBINE EXTRACTION FLANGE PRESSURES. PRESSURES SHOWN NEAR HEATER SYMBOLS ARE HEATER ENTRANCE PRESSURES

EVAPORATOR SYSTEM IS OPERATED TO REPLACE ESTIMATED STEAM AND WATER LOSSES FROM THE CYCLE BY THROTTLING COIL STEAM SUPPLY PRESSURE AS REQUIRED, WITH SURFACE 50% CLEAN. EVAPORATOR BLOWDOWN QUANTITY BASED ON SOLIDS CONCENTRATIONS AS FOLLOWS: EVAPORATOR SHELL, 3500 PPM; BOILER BLOWDOWN, 3.5 PPM; MAKEUP, 780 PPM

WET BULB TEMPERATURES SHOWN ARE REQUIRED TO PRODUCE CORRESPONDING BACK PRESSURES WITH 36,800 GPM OF CIRCULATING WATER.

BASE HEAT BALANCE COMPUTED FOR 2" Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED FOR OTHER BACK PRESSURES, EXCEPT AS FOLLOWS: VALUES SHOWN IN TABLE, ENTHALPY AND TEMPERATURE OF CONDENSATE TO THE AIR EJECTOR, GLAND STEAM CONDENSER AND 5TH POINT HEATER, ENTHALPY AND TEMPERATURE OF DRAINS FROM 5TH POINT HEATER.

* INLET ENTHALPY OF I.P. TURBINE DETERMINED BY TURBINE MANUFACTURER'S PROCEDURE FOR HANDLING LEAKAGE ②

AUXILIARY POWER REQUIREMENTS ARE CALCULATED FOR ALL EQUIPMENT. THE MAJOR EQUIPMENT CONSIDERED IS AS FOLLOWS:

REQUIREMENTS VARIABLE WITH CHANGE IN LOAD ON UNIT

EQUIPMENT	NUMBER OPERATING
2 BOILER FEED PUMPS	2
2 CONDENSATE PUMPS	2
1 FORCED DRAFT FAN	1
STATION SERVICE TRANSFORMER LOSS	

AVERAGE DAILY REQUIREMENTS, CONSIDERED CONSTANT AT ALL LOADS

EQUIPMENT	NUMBER OPERATING
1 INSTRUMENT AIR COMPRESSOR	1
1 SERVICE AIR COMPRESSOR	1
1 DEEP WELL PUMP	1
2 CIRCULATING WATER PUMPS	2
5 COOLING TOWER FANS	5

$$\text{TURBINE HEAT RATE} = \frac{3412.75(83,110+1735+245)+408,370(1042.1-69.1)+63,160(81.7-69.1)+5000(81.9-69.1)+230(1352-69.1)}{83,110} = 8290 \text{ BTU PER KWH}$$

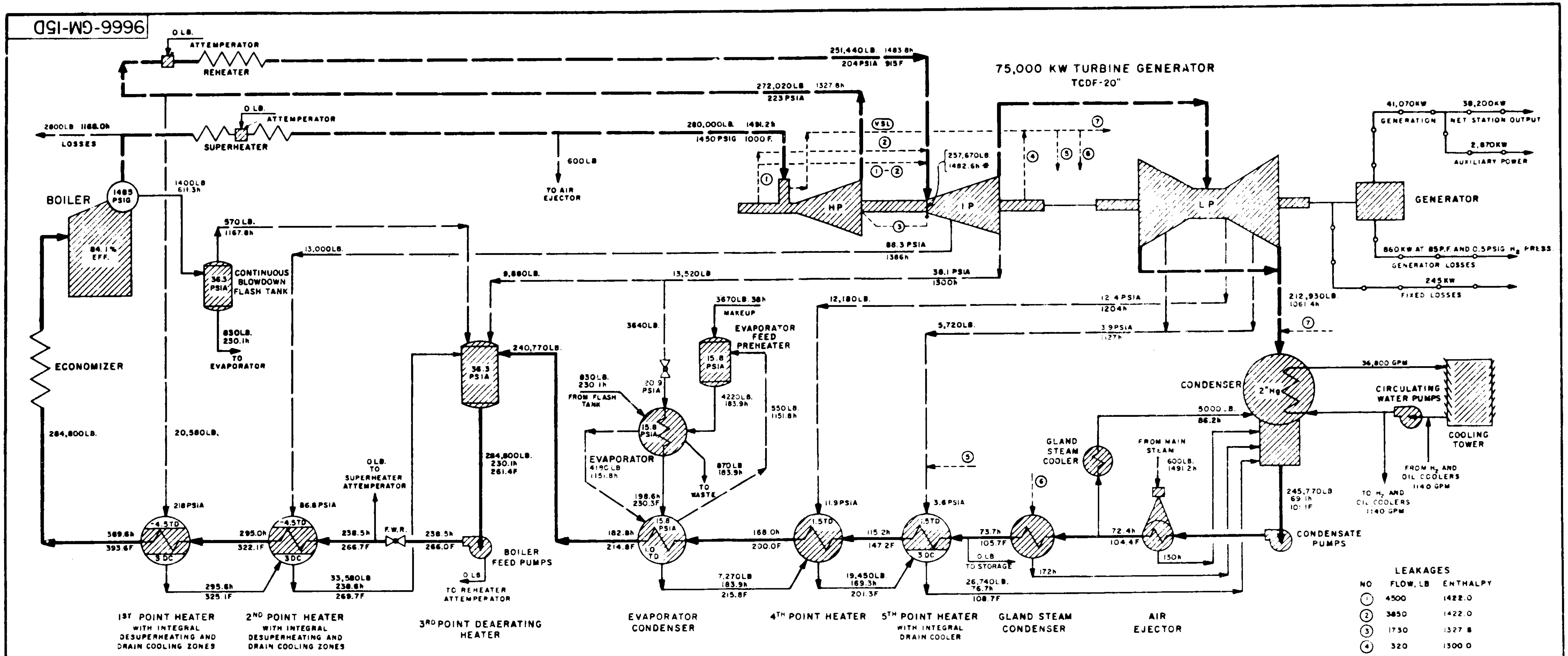
$$\text{STATION HEAT RATE} = \frac{556,600(1491.2-438.9)+11,000(1491.2-286.2)+2800(1161.6-438.9)+2800(625.0-438.9)+501,960(1521.7-1367.5)+7000(1521.7-281.1)}{.844 \times 79,585} = 10,235 \text{ BTU PER KWH}$$

CONDENSER BACK PRESSURE "Hg	5TH POINT EXTRACTION FLOW LB	TURBINE EXHAUST FLOW LB	L.P.T. END POINT ENTHALPY h	TURBINE EXHAUST ENTHALPY h	GENERATION KW	NET STATION OUTPUT KW	TURBINE HEAT RATE BTU/KWH	STATION HEAT RATE BTU/KWH	CIRC. WATER TEMP. F	WET BULB TEMP. F
2.5	21,680	411,310	1042.5	1049.6	82,295	78,770	8370	10,340	80.5	65.5
2.0	24,620	408,370	1032.0	1042.1	83,110	79,585	8290	10,235	72.5	51.5
1.5	28,210	404,780	1018.5	1035.3	83,805	80,280	8220	10,150	62.0	—
1.0	32,930	400,060	1000.0	1029.2	84,370	80,845	8165	10,075	47.5	—

LEGEND

— —	STEAM
——	WATER
—o—	POWER, KW
LB	FLOW, POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR
TD	TERMINAL DIFFERENCE
DC	TERM. DIFF. DRAIN COOLER
KW	KILOWATTS
FWR	FEED WATER REGULATOR
Hg	PRESSURE, IN. OF MERCURY, ABS.
PSIA	PRESSURE, LB PER SQUARE IN., ABS
PSIG	PRESSURE, LB PER SQUARE IN. GAGE

Figure 5-5. Heat Balance Diagram - 83 MW Load



LEAKAGES

NO	FLOW, LB	ENTHALPY
①	4500	1422.0
②	3850	1422.0
③	1730	1327.8
④	320	1300.0
⑤	1570	1461.8
⑥	280	1324.0
⑦	220	1324.0
VSL	1750	1491.2

BASIS OF HEAT BALANCE CALCULATIONS

ELEVATION: PLANT IS APPROXIMATELY 4065 FEET ABOVE SEA LEVEL

AIR TEMPERATURE. AVERAGE ANNUAL AMBIENT AIR TEMPERATURE IS 63.3F

FUEL: NATURAL GAS

STEAM LOSSES 2800 LB, CONSTANT AT ALL LOADS

BOILER BLOWDOWN: 0.5% STEAM GENERATION

BOILER EFFICIENCY ADJUSTED FOR ACTUAL INLET AIR TEMPERATURE AT 75.0

SUPERHEATER, REHEATER, MAIN AND REHEAT STEAM LINE PRESSURE DROPS CALCULATED AT ALL LOADS. REHEAT SYSTEM PRESSURE DROP EXPRESSED AS 8.5 PERCENT OF HIGH PRESSURE TURBINE EXHAUST PRESSURE AT THIS LOAD.

EXTRACTION LINE PRESSURE DROPS CALCULATED AT MAXIMUM LOAD AND EXPRESSED AS THE FOLLOWING PER CENT OF THE FLANGE ABSOLUTE PRESSURES FOR USE AT ALL LOADS

EXTRACTION LINE	1	2	3	4	5
PER CENT	2.2	1.7	4.8	4.0	6.4

EXTRACTION PRESSURES SHOWN AT OR NEAR THE TURBINE SYMBOL ARE TURBINE EXTRACTION FLANGE PRESSURES. PRESSURES SHOWN NEAR HEATER SYMBOLS ARE HEATER ENTRANCE PRESSURES

EVAPORATOR SYSTEM IS OPERATED TO REPLACE ESTIMATED STEAM AND WATER LOSSES FROM THE CYCLE BY THROTTLING COIL STEAM SUPPLY PRESSURE AS REQUIRED, WITH SURFACE 50% CLEAN. EVAPORATOR BLOWDOWN QUANTITY BASED ON SOLIDS CONCENTRATIONS AS FOLLOWS EVAPORATOR SHELL, 3800 PPM, BOILER BLOWDOWN, 325 PPM; MAKEUP, 780 PPM.

WET BULB TEMPERATURES SHOWN ARE REQUIRED TO PRODUCE CORRESPONDING BACK PRESSURES WITH 36,800 GPM OF CIRCULATING WATER.

BASE HEAT BALANCE COMPUTED FOR 2"Hg BACK PRESSURE. ALL FLOWS, PRESSURES, TEMPERATURES AND ENTHALPIES REMAIN UNCHANGED FOR OTHER BACK PRESSURES, EXCEPT AS FOLLOWS: VALUES SHOWN IN TABLE, ENTHALPY AND TEMPERATURE OF CONDENSATE TO THE AIR EJECTOR, GLAND STEAM CONDENSER AND 5TH POINT HEATER, ENTHALPY AND TEMPERATURE OF DRAINS FROM 5TH POINT HEATER.

* INLET ENTHALPY OF IP TURBINE DETERMINED BY TURBINE MANUFACTURER'S PROCEDURE FOR HANDLING LEAKAGE ②.

AUXILIARY POWER REQUIREMENTS ARE CALCULATED FOR ALL EQUIPMENT. THE MAJOR EQUIPMENT CONSIDERED IS AS FOLLOWS.

REQUIREMENTS VARIABLE WITH CHANGE IN LOAD ON UNIT

EQUIPMENT	NUMBER OPERATING
2 BOILER FEED PUMPS	2
2 CONDENSATE PUMPS	1
1 FORCED DRAFT FAN	1
STATION SERVICE TRANSFORMER LOSS	

AVERAGE DAILY REQUIREMENTS, CONSIDERED CONSTANT AT ALL LOADS

EQUIPMENT	NUMBER OPERATING
1 INSTRUMENT AIR COMPRESSOR	1
1 SERVICE AIR COMPRESSOR	1
1 DEEP WELL PUMP	1
2 CIRCULATING WATER PUMPS	2
5 COOLING TOWER FANS	5

$$\text{TURBINE HEAT RATE} = \frac{3412.75(41{,}070+860+245)+212{,}930(1061.4-69.1)+26{,}740(76.7-69.1)+5000(86.2-69.1)+220(1324.0-69.1)}{41{,}070} = 8{,}665\ \text{BTU PER KWH}$$

$$\text{STATION HEAT RATE} = \frac{280{,}600(1491.2-369.6)+2800(1168.0-369.6)+1400(611.3-369.6)+251{,}440(1483.8-1327.8)}{.841 \times 38{,}200} = 11{,}095\ \text{BTU PER KWH}$$

CONDENSER BACK PRESSURE	5TH POINT EXTRACTION FLOW	TURBINE EXHAUST FLOW	LPT END POINT ENTHALPY	TURBINE EXHAUST ENTHALPY	GENERATION	NET STATION OUTPUT	TURBINE HEAT RATE	STATION HEAT RATE	CIRC WATER TEMP	WET BULB TEMP
"Hg	LB	LB	h	h	KW	KW	BTU/KWH	BTU/KWH	F	F
2.5	4,160	214,490	1064.5	1073.5	40,345	37,475	8820	11,310	94.0	—
2.0	5,720	212,930	1054.0	1061.4	41,070	38,200	8665	11,095	86.0	80.5
1.5	7,620	211,030	1040.0	1046.6	41,940	39,070	8485	10,850	77.0	69.0
1.0	10,110	208,540	1021.0	1030.9	42,830	39,960	8305	10,610	63.5	50.5

LEGEND

— —	STEAM
——	WATER
—○—	POWER, KW
LB	FLOW POUNDS PER HOUR
h	ENTHALPY, BTU PER POUND
F	TEMPERATURE, DEGREES FAHR
TD	TERMINAL DIFFERENCE
DC	TERM DIFF DRAIN COOLER
KW	KILOWATTS
FWR	FEED WATER REGULATOR
Hg	PRESSURE, IN OF MERCURY, ABS
PSIA	PRESSURE, LB PER SQUARE IN, ABS
PSIG	PRESSURE, LB PER SQUARE IN, GAGE

Figure 5-6. Heat Balance Diagram - 41 MW Load

TABLE 5-2: VARIATION OF UNIT HEAT RATE AND BOILER EFFICIENCY AS A FUNCTION OF LOAD

Gross Generation MW	Net Unit Output MW	Net Unit Heat Rate KJ/kWh	Boiler Efficiency %	Superheat Temp °C (°F)	Reheat Temp °C (°F)
83.1	79.6	10,800	84.4	538 (1000)	538 (1000)
79.2	75.7	10,780	84.4	538 (1000)	538 (1000)
55.2	52.1	11,110	84.1	538 (1000)	538 (1000)
41.1	38.2	11,710	84.1	538 (1000)	491 (915)
22.7	20.4	13,740	84.2	477 (890)	413 (775)

Basis: Gas Firing

6800 Pa. (2.0" Hg) condenser back pressure

TABLE 5-3: EFFECT OF STEAM TEMPERATURE AND REHEAT PRESSURE DROP VARIATION ON UNIT HEAT RATE

Main Steam Temperature °C	(°F)	Reheat Steam Temperature °C	(°F)	Reheat Pressure Drop KPa	(psi)	Decrease In Net Unit Output (MW)	Increase in Net Unit Heat Rate KJ/kWh: Solar Operation (100% Boiler Efficiency)	Increase in Net Unit Heat Rate KJ/kWh: Fossil Operation (84.4% Boiler Efficiency)
538	(1000)	538	(1000)	255.	(37)	0	0	0
				345.	(50)	0.59	24	28
				414.	(60)	1.03	43	52
				483.	(70)	1.47	61	74
510	(950)	510	(950)	255.	(37)	3.42	142	169
				345.	(50)	3.98	168	199
				414.	(60)	4.41	186	223
				483.	(70)	4.83	206	245
482	(900)	482	(900)	255.	(37)	6.83	296	352
				345.	(50)	7.38	323	383
				414.	(60)	7.79	343	406
				483.	(70)	8.20	363	430

Basis: All other operating conditions consistent with full load operation shown on Heat Balance for 83 MW (see Figure 5-5).

5 2.2 FOSSIL BOILER (See Figure 5-7)

● Furnace	Pressurized Water-Cooled, Radiant
● Superheater	Two-stage, Drainable
● Reheater	Drainable
● Manufacturer	Babcock & Wilcox
● Fuels	Natural Gas, No. 6 Oil (Limited)
● Circulation	Natural
● Superheater Steam (Nominal Full Load)	254,000 kg/hr (560,000 lb/hr) 10.4 MPa (1510 psig) 538°C (1000°F)
● Reheat Steam	538°C (1000°F)
● Superheat Surface	1230m^2 (13,205 ft^2)
● Superheat Temperature Control	Water Spray (Attemperation at High Loads) and Burner Selection
● Reheat Surface	644m^2 (6,930 ft^2)
● Reheat Temperature Contol	Excess Air and Water Spray Attemperation (High Loads)
● Economizer Surface	1520m^2 (16,350 ft^2)
● Steam Outlet Temperature	
Design Superheat	538°C (1000°F) to 50% Load 510°C (950°F) to 41% Load 482°C (900°F) to 26% Load
Design Reheat	538°C (1000°F) to 67% Load 510°C (950°F) to 55% Load
Actual Superheat (Increased Excess Air)	538°C (1000°F) to 30 MW
● Steam Pressure	
Set Point (At Turbine Steam Throttle Valves)	10.1 MPa (1450 psig)
Control	Pneumatically Operated Combustion Control
Superheat Safety Valve	
Blow-Off	11.1 MPa (1590 psig)
Reseat	10.8 MPa (1545 psig)
Reheat Safety Valves	
Blow-Off	3.7 MPa (517 psig)
Reseat	3.5 MPa (500 psig)
● Load Change Capability (10-20 times/yr)	11%/min. (9 MWe/min)
● Maximum (Above minimum 25 MWe) Turndown	25 MWe 88,900 kg/hr (196,000 lb/hr steam)
● Cold Startup to 25 MWe	2,830 scm @ 15.6°C (100,000 SCF Gas) over 4 Hrs
● Overnight Banking (Warm Standby)	316-371°C (600-700°F)
● Overnight Banking (Hot Standby)	427-482°C (800-900°F)
● Boiler Efficiency vs. Load	(See Table 5-2)

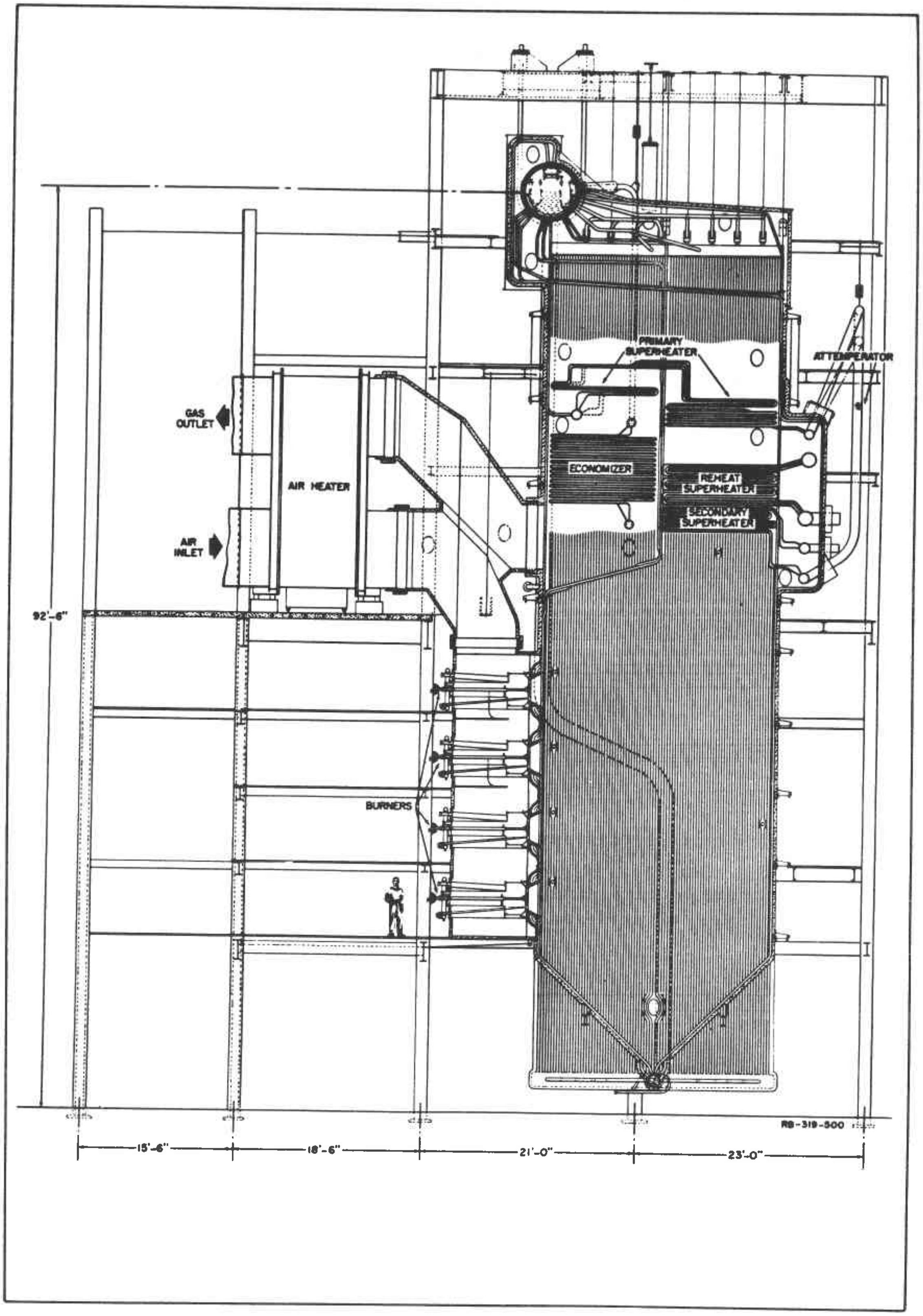


Figure 5-7. Boiler Design

5.2.3 TURBINE-GENERATOR (See Figure 5-8)

● Nomial Output	175 MWe
● Design Output	81 MWe @ 3600 RPM
● Construction	Tandem-compound, Double Flow
● Design Steam Conditions	10.1 MPa/538°C (1450 psig, 1000°F)
Reheat	538°C (1000°F)
Back Pressure	5.1 kPa (1.5 in. Hq.)
● Extraction Steam	5 Points
● Generator Data	96,000 KVA 0.85 P.F. (lagging) 13,800 V., 3 Phase, 60 Hz 3600 RPM, 4017 amp per Phase @ 308 kPa (30 psi) Hydrogen Pressure
● Generator Efficiency	(See Table 5-4)
● Turbine Temperature Restrictions	
Annual Average	Not to Exceed 538°C (1000°F)
Normal Upper Limit	546°C (1015°F)
Abnormal Upper Limit	552°C (1025°F) (No more than 400 Hr/yr)
● Turbine Pressure Restrictions	
At Rated Output	10.1 MPa (1450 psig)
At Near-Zero Output	10.6 MPa (1523 psig)
Abnormal Upper Limit	13.1 MPa (1885 psig)(No more than 12 hr/yr)

5.2.4 CONTROL SYSTEM

● Philosophy	Boiler-Following Control Mode (Figure 5-9)
● Turbine Control System	
- Governing System	Main Governor Load Dump Anticipator
- Turbine Steam Valves	Main Steam Stop Valves Reheat Intercept Valves Reheat Stop Valves
- Turbine Trip System	Manual Trip Buttons - Control Room - On Turbine Automatic Trips - Low Condensor Vacuum - Solenoid Valve - Overspeed Governor
- Load Limit Control and Speed Changer	Control Oil Flow Regulator to Inlet Valves
● Boiler Control System	
- Functions	Maintain Steam Pressure Control Superheat Temperature Control Reheat Temperature Control Feedwater Flow

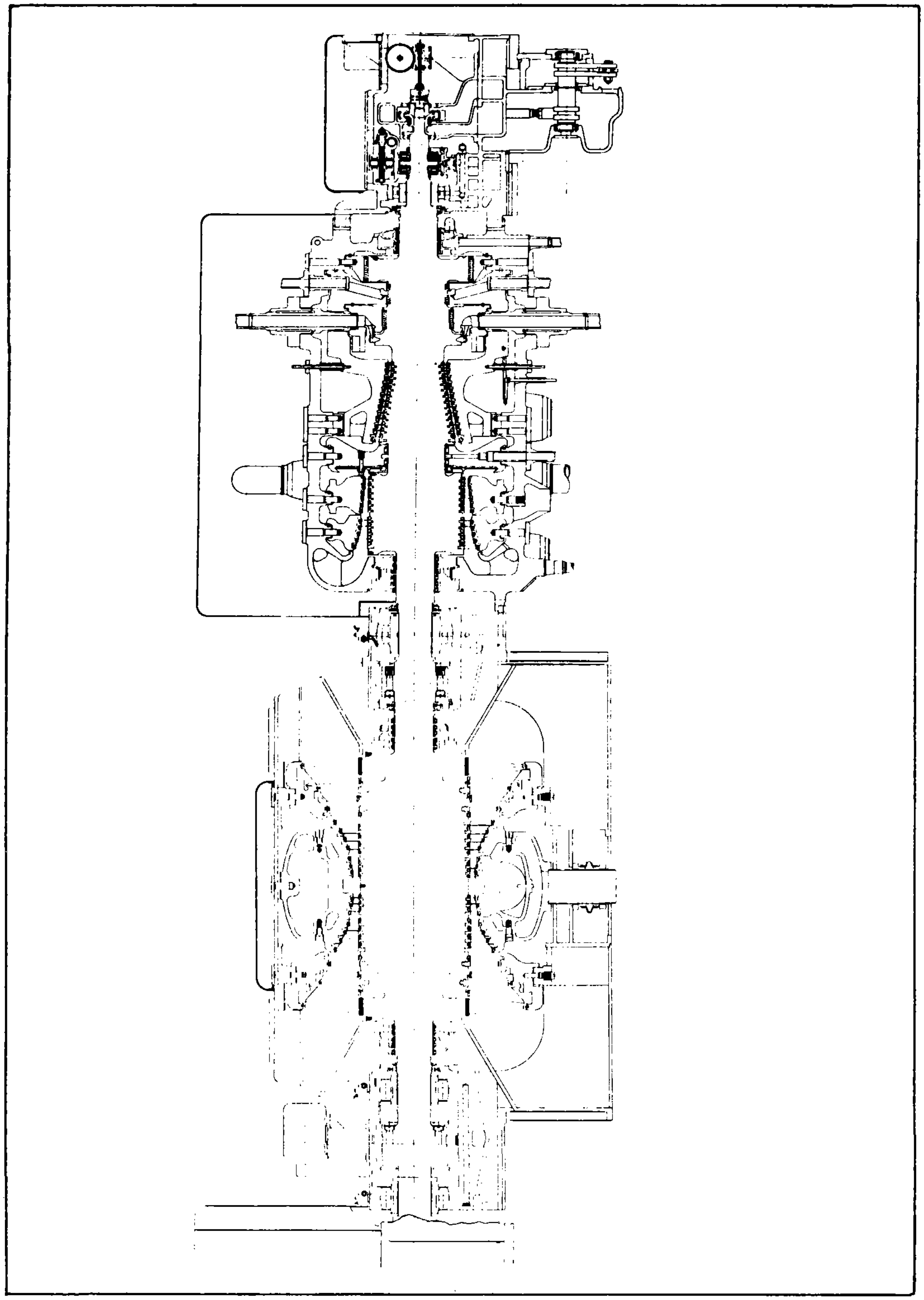


Figure 5-8. Turbine Generator

TABLE 5-4: OVERALL EFFICIENCY OF GENERATOR AND EXCITERS AS A FUNCTION OF LOAD

kPa	Hydrogen Pressure Psig	Kva	Kw	Pf (Lagging)	Per Cent Efficiency
105.	0.5	23,529	20,000	0.85	96.90
105.	0.5	47,059	40,000	0.85	97.91
105.	0.5	70,588	60,000	0.85	98.23
105.	0.5	76,800	65,280	0.85	98.31
105.	0.5	76,800	76,800	1.00	98.63
205.	15	88,320	75,072	0.85	98.12
308.	30	96,000	82,560	0.86	97.98

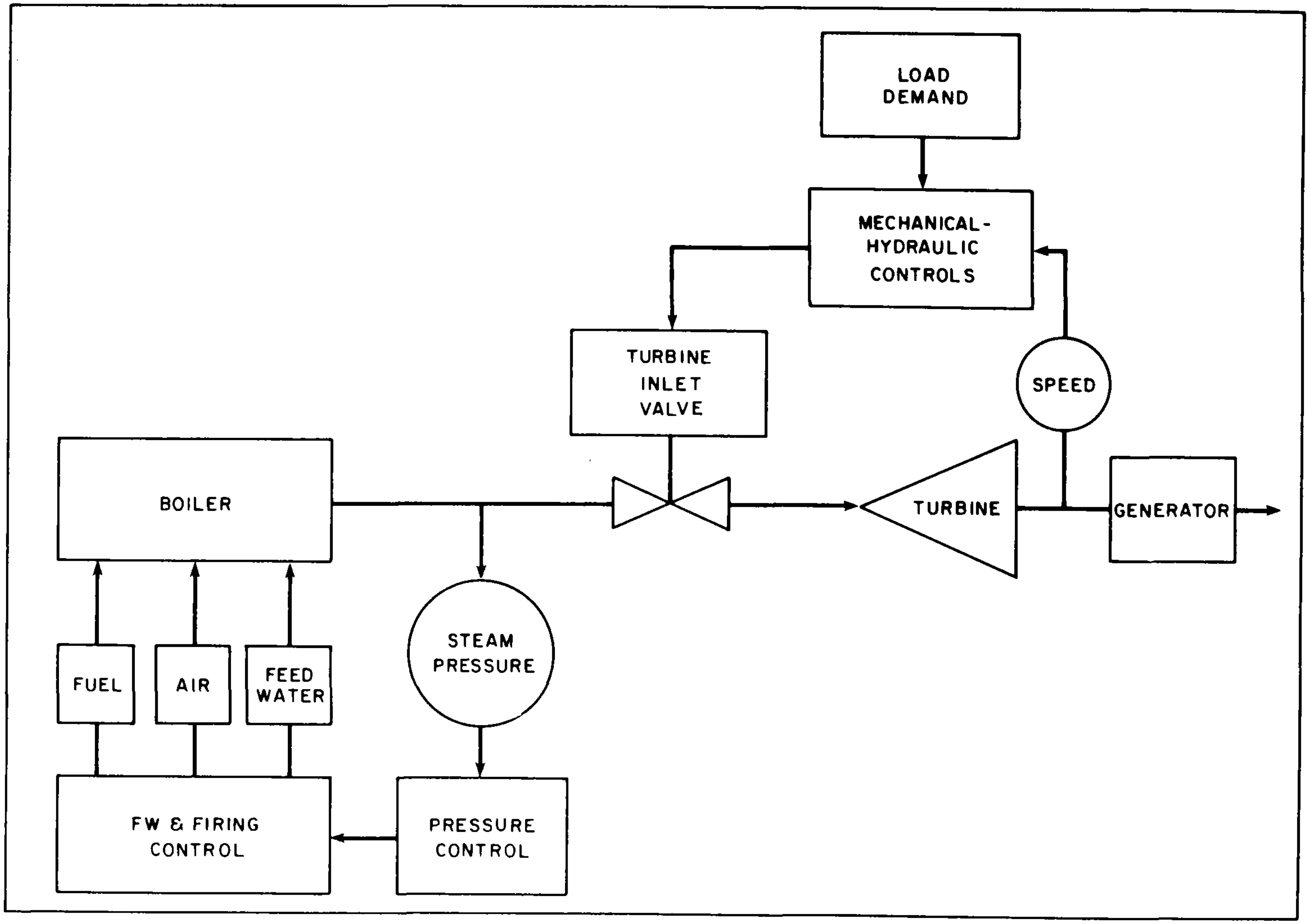


Figure 5-9. Boiler Flowing Unit Control Scheme, Newman Unit 1

- Mechanisms	Master Pressure Regulator Fuel-Air Ratio Control Fuel Flow Control Air Flow Control Burner Selection Attemperation Spray Three-Element Controller

5.3 PLANT COST DATA

Construction costs, owners costs, and operations and maintenance costs are presented in this section.

5.3.1 CONSTRUCTION COSTS

Assumptions utilized in developing the construction costs are summarized in

Table 5-5	Basis for Construction Cost Estimate
Table 5-7	Cross references cost accounts utilized for the Construction Cost Summary Sheet.

Construction costs are summarized in tables as follows:

Table 5-6	Construction Cost Summary
Table 5-8	Direct Cost Summary
Tables 5-9 through 5-14	Direct Cost Detail
Table 5-15	Owners Cost Summary

5.3.2 OPERATING AND MAINTENANCE COSTS

Operating and maintenance costs are summarized in Table 5-16. Plant operating and maintenance staff requirements are listed in Table 5-17. Staff requirements are based on the assumption that all heliostat washing is contracted to outside entities.

5.4 SIMULATION MODEL

The performance and economic models used for the evaluation of Newman Unit 1 were:

- Insolation - Solmet Weather Tape/Typical Meteorological Year Data for El Paso, Texas
- Heliostat Field - Mirval Computer Program/Preprocessor Programs
- Performance - TAF Computer Program/Steady State or Transient Response Program
- Heat Balances - Stone and Webster Heat Balance Program

TABLE 5-5: BASIS FOR CONSTRUCTION COST ESTIMATE

1. A/E performs as an engineer and constructor and is responsible for:

    Plant Design
    Quality Control
    Construction
    Subcontracting Construction
    Procuring Major Equipment
    Construction Management

2. Labor wage rates based on job location, 1980.
3. Labor manhours per U.S. Gulf Coast (Houston).
4. Adjustments for labor productivity from U.S. Gulf Coast (Houston, Texas) to El Paso, Texas.
5. Material priced to job location, 1980.
6. AFUDC (Allowance for Funds Used During Construction) is included.
7. Design and construction contingency is included in total construction costs to reflect the level of accuracy in conceptual design estimating.
8. Heliostat price based on \$230/m^2 including installation foundations and field wiring.
9. Receiver price based on preliminary estimate by Babcock and Wilcox.

TABLE 5-6: CONSTRUCTION COST ESTIMATE SUMMARY

CLIENT EL PASO ELECTRIC CO.
DESCRIPTION ____________

LOCATION Newman Station Unit 1
CONT. NO. ____________
MADE BY ____________

PROJECT Solar Repowering
APPROVED ____________

(Rounded to $100,000)

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST (In Thousands of $)			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil	64,676		1,900	1,200	3,100
B	Concrete	203,294		3,500	3,800	7,300
C	Structural Steel					
D	Buildings	12,118		300	200	500
E	Machinery & Equipment	304,107		7,100	39,900	47,000
F	Piping	65,636		1,400	1,500	2,900
G	Electrical	360,734		7,300	3,200	10,500
H	Instruments	95,531		2,000	3,700	5,700
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS	1,106,096		23,400	53,600	77,000
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense					
P	Craft Benefits, Payroll Burdens & Insurances					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					3,300
	TOTAL FIELD COSTS	1,106,096				80,300
R	Engineering					
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					11,400
	TOTAL FIELD & OFFICE COSTS	1,106,096				91,700
U	Labor Productivity (Houston&El Paso)	(55,305)				(1,100)
V	Contingency A for I	157,619				13,600
	Escalation					41,400
W	Fee					
	AFUDC					14,600
	Owners Costs					3,500
	TOTAL CONSTRUCTION COST	1,208,410				163,700

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TABLE 5-7: CROSS REFERENCE

DIRECT COST ACCOUNTS vs. SUMMARY ACCOUNTS
(by SANDIA FORMAT)

Sandia Account Table 5-6	Corresponding Direct Cost Accounts	Table
A. Excavation & Civil	5100 Site Improvements	5-9
B. Concrete	5330 Foundations	5-10
	5420 Tower	5-11
C. Structural Steel	N/A	
D. Buildings	5200 Site Facilities	5-12
E. Machinery & Equipment	5310 Heliostats	5-10
	5320 Installation	5-10
	5410 Receiver	5-11
	5810 T/G Modifications & Solar Feed Water Pumps	5-13
F. Piping	5820 Piping	5-13
G. Electrical	5340 Field Wiring	5-10
	5350 Peremeter Lighting	5-10
	5430 Receiver Electricals	5-11
	5830 Elec. Pwr. Gen. Subsystems - Electricals	5-13
H. Instruments	5810 DEH Control System	5-13
	5340 Beam Characterization System	5-10
	5510 Master Control System	5-14
	5520 Miscellaneous Instruments	5-14
J. Painting	N/A	
K. Insulation	N/A	

CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-8: CONSTRUCTION COSTS-DIRECT COST SUMMARY

BY ______ **CHKD.** ______ **APVD.** ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5100	Site Improvements				64676						1863	1264	3127
5200	Administrative Areas				12118						259	236	495
5300	Collector Subsystem				628196						12676	38281	50957
5400	Receiver Subsystem				246802						5292	8375	13667
5500	Control Subsystem				54885						1103	2578	3681
5800	Electrical Power Generating Subsystem				99453						2228	2894	5122
	Total				1106096						23421	53628	77049
	Use												77000

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CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-9: CONSTRUCTION COSTS-DETAIL

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5100												
	Site Improvements												
5110	Clearing and Grubbing	294	Acre		17640						529		529
5120	Diversion Channel and Drainage Ditches				8064						241	40	280
5130	2" Crushed Rock Surface	1,562	KSY		24992						715	734	1449
5140	Roads and Fencing				13980						379	489	868
5100	Total				64676						1863	1264	3127

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CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-10: CONSTRUCTION COSTS-DETAIL

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5300												
	Collector Subsystem												
5310	Heliostats	2780	EA									31692	31962
5320	Heliostat Installation				136009						3169		3169
5330	Foundations				124298						2113	3169	5282
5340	Field Wiring				327960						6592	1859	8451
5350	Perimeter Lighting				25004						502	861	1363
5360	Beam Characterization System				14925						300	700	1000
	Total				628196						12676	38281	50957

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CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

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TABLE 5-11: CONSTRUCTION COSTS-DETAIL

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5400 Receiver Subsystem												
5410	Receiver Subsystem				165230						3850	7650	11500
5420	Receiver Tower				79000						1390	680	2070
5430	Receiver Electrical				2572						52	45	97
	Total				246802						5292	8375	13667

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LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-12: CONSTRUCTION COSTS-DETAIL

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5200												
	Administrative Areas												
5210	Control Room Extension				4297						92	76	168
5220	Solar Feed Pump Building				2133						45	44	89
5230	Maintenance Building Extension				5688						122	116	238
	Total				12118						259	236	495

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CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-13: CONSTRUCTION COSTS-DETAIL

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5800												
	Electrical Power Generating Subsystem												
5810	Turb-Gen and D.E.H.				28219						657	690	1347
5820	Piping and Pumps				66036						1466	1750	3216
5830	Electrical				5198						105	454	559
	Total				99453						2228	2894	5122

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CLIENT DOE/El Paso Electric

LOCATION Newman Unit 1

PROJECT Solar Repowering

TABLE 5-14: CONSTRUCTION COSTS-DETAIL

BY ________ CHKD. ________ APVD. ________

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (In Thousands of $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
	Account 5500												
	Control Subsystem												
5510	Master Control System				30000						603	1996	2 599
5520	Miscellaneous Instruments				24855						500	582	1 082
	Total				54855						1103	2578	3 681

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TABLE 5-15: OWNER's COSTS

	$\$10^6$
TRANSMISSION RELOCATION	1.06
HIGHWAY RELOCATION	.89
ENVIRONMENTAL AND REGULATORY	.10
PUBLIC RELATIONS	.05
LAND	1.30
EMPLOYEE PARK (REPLACEMENT)	.10
TOTAL	3.50

TABLE 5-16: PLANT OPERATIONS AND MAINTENANCE COSTS
($1000's)

	Annual Costs in 1985$	
OM100 Operations		1670
OM110 Operating Personnel	1450	
OM120 Operating Consumables	120	
OM130 Fixed Charge Rate	100	
OM200 Maintenance Materials		970
OM210 Spare Parts	483	
OM211 Turbine and Electrical Plant	(60)	
OM212 Collector Equipment	(267)	
OM213 Receiver Equipment	(96)	
OM214 Thermal Storage Equipment	0	
OM215 Fossil Boiler Equipment	(60)	
OM220 Materials for Repairs	483	
OM230 Other	0	
OM300 Maintenance Labor		644
OM310 Scheduled Maintenance	322	
OM320 Corrective Maintenance	322	
		3,280

TABLE 5-17: PLANT OPERATING PERSONNEL

	Number of Full-Time Employees Assigned to Solar Repowered Newman 1	Existing Employees At Newman Unit 1
Station Superintendent	0.25	0.25
Supervisor of Operation	0.25	0.25
Supervisor of Maintenance	0.25	0.25
Plant Engineer	0.25	0.25
Maintenance Foreman	0.75	0.75
Operating Shift Supervisor	1.00	1.00
Control Operator	3.00	1.00
Assistant Control Operator	1.00	1.00
Plant Equipment Operator	1.00	1.00
Electrician	3.50	1.50
Boiler and Condenser Mechanic	5.00	3.00
Maintenance Helper	3.00	1.00
Utility Worker	1.00	1.00
Instrument Technician	3.00	1.00
Chemical Technician	0.5	0.50
Station Clerk	1.25	0.25
Janitor & Landscaping	1.0	1.0
	26	15

- Utility System - EPRI Report 869, "Methodology for Solar Thermal Plant Evaluation", March 1977.

5.5 ECONOMIC ASSUMPTIONS

Tables 5-18 and 5-19 summarize the economic assumptions used to evaluate the solar repowering of Newman Unit 1.

TABLE 5-18: ECONOMIC SCENARIOS (1985)

	EPE SCENARIOS		DOE SPECIFIED DATA
	A	B	
Present Worth Discount Rate	12%	12%	12%*
Carrying Charge Rate	16%	16%	16%*
Capital Cost, $/kWe (c-t/c-c/coal/nuc)	300/600/1400/1600	300/600/1400/1600	190/360/860/100
Fuel Cost ($MBTU) (Gas/Oil/Coal/Nuc)	4.5/12/1.5/1.0	4.5/12/1.5/1.0	2.50/4.00/1.25/0.85
Fuel Escalation Rate (%) (Gas/Oil/Coal/Nuc)	10/8/7/7	10/12/7/7	11/12/10/9
Capital Escalation Rate	7%	7%	7%*
O & M Escalation Rate	7%	7%	7%*

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*EPE Data used

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TABLE 5-19 ECONOMIC PARAMETERS

CAPITAL COST (1985 $)	163,514 M$
FIXED CHARGE RATE	16%/YR
FIXED O&M (1985)	3.3 M$/YR
O&M ESCALATION RATE	7%/YR
FORCED OUTAGE RATE	10%
SCHEDULED OUTAGE	3 WEEKS/YEAR
INSOLATION	EL PASO SOLMET TMY 7.26 AVG. kWh/m^2/DAY

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