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NORTHERN CALIFORNIA POWER ASSOCIATION-SHELL OIL COMPANY GEOTHERMAL PROJECT NO. 2: ENERGY AND MATERIALS RESOURCES

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DISCLAIMER

FOREWORD

This report was prepared as part of a Joint Environmental Study prepared by the U.S. Department of Energy, the U.S. Geologic Survey, the U.S. Bureau of Land Management, and the California State Energy Resources Conservation and Development Commission.

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ABSTRACT

This report describes the potential environmental impact of the energy and material resources expended in site preparation, construction, operation, maintenance, and abandonment of all phases of the Northern California Power Association–Shell Geothermal Project in The Geysers–Calistoga Known Geothermal Resource Area. The impact of well field development, operation, and abandonment is insignificant, with the possible exception of geothermal resource depletion due to steam withdrawal from supply wells during operation. The amount of resource renewal that may be possible through reinjection is unknown because of uncertainties in the exact amount of heat available in the steam supply field. Material resources to be used in construction, operation, and abandonment of the power plant and transmission lines are described. Proposed measures to mitigate the environmental impacts from the use of these resources are included. Electric power supply and demand forecasts to the year 2005 are described for the area served by the NCPA.

WELL FIELD

The Northern California Power Association (NCPA)–Shell Geothermal Project steam supply field is located on federal land within parts of Sonoma and Lake Counties. This setting is a southeast extension of the proven Geysers steam field (Ref. 1, p. III-3). Although the terrain is rugged, selection of this area avoids the expense of fuel and material for exploration of geothermal resources of unknown economic potential.

Five wells have been completed within the NCPA–Shell steam supply field. Fifteen additional supply wells will be drilled before completion of the power plant. After these wells have been completed and tested, they will be shut in until construction of the generating unit is finished. Completed wells will be 4,500 to 10,000 ft deep.

The well sites are designed to balance cuts and fills, thus minimizing earthwork disturbance. Avoidance or stabilization of landslide areas, as well as preparation for proper drainage, will mitigate negative topographic impacts (Ref. 1, p. III-4). Existing roads will be used whenever possible, and necessary access roads will be constructed to use energy and material resources most efficiently and to minimize disruption to the environment.

Up to four wells will be drilled from each drilling pad site. This method will avoid the consumption of energy and material resources normally required to construct separate drilling pad sites for each well. Directional drilling methods will be used to reach the most favorable portion of the reservoir from the fewest surface positions. Drilling rigs are of modern design, of the type used in drilling for oil or gas. Materials required for a typical well casing are (Ref. 1, p. III-4)

- 20-in. conductor pipe, set and cemented to 150 ft,
- 13-3/8-in. water string, set and cemented to 2,500 ft,
- 9-5/8-in. casing string, set and cemented to 6,500 ft,
- 12-in. gate valve, 12-in. double-gate blowout preventer, and 12-in. Hydrill valves installed on the surface end of the 13-3/8-in. water string.

Completed wells may produce 75,000 to 350,000 lb/h of steam at about 125 psig wellhead pressure (Ref. 1, p. III-6). Underproducing wells will be used as injection wells. During protracted outages, wells are shut in and a small amount (less than 1% of the normal production rate) of steam is vented to prevent excessive condensation and to prevent thermal stresses in the metal and cement caused by the casing cooling down. After a well has been shut in, it is usually necessary to clean out the well by full-flow venting directly to the atmosphere. This venting may be required for up to 8 h, resulting in a necessary but irretrievable loss of steam energy. Full-flow venting also causes adverse environmental impacts, such as high noise levels and unabated hydrogen sulfide releases. Among the measures that will be used to minimize venting is a system of interconnecting steam lines that permit cross-over steam flow and well throttling, which can eliminate the necessity for full-flow venting after scheduled outages. Steel pipelines carrying steam from the wells to the power plant will be insulated with vinyl-asbestos-aluminum covers to reduce heat loss (Ref. 1, p. III-7). Preventive maintenance will be implemented and equipment will be monitored at all times to anticipate problems and to prevent unscheduled outages. When an emergency or unscheduled outage occurs, every effort will be made to correct the problem quickly to minimize venting.

Upon abandonment of the steam field, the steam supplier is required to fill each well with concrete plugs; to remove wellhead equipment and casing below grade; to cap the well casing and backfill to grade; to remove all steam lines, separators, mufflers, and other surface equipment; and to regrade drilling pads, roadways, and drilling fluid sumps, reseeding where required (Ref. 1, p. III-8). These measures, undertaken in conformance with regulations of the California State Division of Oil and Gas and the Geothermal Supervisor of the U.S. Geologic Survey, will restore the site to its original condition, insofar as possible.

POWER PLANT

The plant site is located along Ridge Road, the main divide of the Mayacmas Mountains (Ref. 1, p. IV-1). This site, located about 700 ft southwest of the Lake County border in Sonoma County, was chosen after careful study of contour, geology, and soil maps coordinated with field evaluation. A major advantage to this site from the standpoint of energy conservation is its central location within the steam supply fields and its proximity to the steam supply wells. This location minimizes heat loss because pressure and temperature decrease as steam is transported over long distances.

Moderately steep slopes at the site will require cutting and filling. Potential soil erosion and sedimentation will be controlled through properly designed drainage and planting of cut areas. These measures will comply with standard specifications of the State of California, with applicable county standards, and with the requirements of the Regional Water Quality Control Board. An estimated 200,000 yd^3 of earth will be moved during site preparation. All ground cover will be removed from an area of about 10 acres to create a 7-acre pad area (Ref. 1, p VI-1). Conventional heavy earth-moving equipment will be used for grading. About 3,000,000 gal of water will be used during the 26-33 months of construction. In addition, 400,000 gal of water will be required to fill the cooling tower basin prior to startup.

Table 1 lists the construction equipment estimated to be required for site preparation, excavation of foundations, and power plant erection. Most of these vehicles use diesel fuel. The environmental impact from this fuel consumption will be insignificant.

TABLE 1. Estimated equipment needed for plant construction.

Phase of plant construction			
Site preparation	Excavation	Plant erection	General
Lowboy with tractor	Drill rigs	Pickup truck	Pickup trucks
Earthmovers	Backhoe	Tractor-trailer rig	Office trailers
Water trucks	Bulldozers	10- to 15-ton crane	Vans for tools and storage
Compactor		Dump trucks	
Graders		Large crane	
		Transit mixers	
		Flatbed truck	

Major structures and the kinds of materials required in the power-generating facility include:

- Powerhouse building and switchyard (steel frame with corrugated metal siding on a concrete foundation),
- Cooling tower (fiberglass panels for wall casings and air inlet louvers, polyvinyl chloride for cooling tower fill material, reinforced concrete base),
- Hydrogen sulfide abatement unit (Stretford Unit, surrounded by a paved area with a sump and an impermeable concrete barrier).

The powerhouse building will contain two turbine-generator units, surface condensers, switchgear, and most of the auxiliaries (Ref. 1, pp. V-1 through V-6). Adjacent to the power plant will be a substation for stepping up the voltage for transmission. Excess condensate not required for cooling tower make-up, estimated at 250 tons/h, will be disposed of in reinjection wells. The condensate and circulating water systems include a 10- to 12-cell mechanical-draft cooling tower, noncondensable gas remover, and associated pumps. Miscellaneous systems include fire protection, domestic water and sanitary waste, instrument, and utility air compressor systems. An 8-ft chain-link fence will enclose the yard area around the plant. The yard will be covered with blacktop and is to be lighted. Electrical power for construction equipment will probably be supplied by a 21-kV distribution line.

Plant reliability is a major consideration for energy conservation as well as for safety and economics. To improve plant reliability, NCPA plans to install duplicate equipment, interconnecting piping, and circuitry to provide 100% redundancy of the following auxiliaries (Ref. 1, Appendix C, p. 9-9):

- Condensate pumps,
- Reinjection water pumps,
- Circulating water pumps (except main circulating water pumps),
- Instrument air compressor,
- Turbine-generator unit lube oil coolers,
- Turbine-generator unit lube oil pumps,
- Generator seal oil pumps,
- Condensate spill pumps,
- All Stretford system pumps.

Only one auxiliary unit will be used in normal operation; the duplicate will start automatically if the operating unit fails. Each turbine generator unit will have auxiliary transformers, electrical equipment, and circuitry capable of handling all the station requirements. Either or both of the duplicate equipment may be used. The resulting redundancy will enhance the reliability of the electrical system.

TRANSMISSION SYSTEM

The transmission system, as planned by NCPA, will be located in Shell right-of-way, running 21 mi west of the plant, intersecting the existing 230-kV PG&E line running to the Fulton substation (Ref. 1, p. V-1). NCPA is negotiating with PG&E to wheel the power over the PG&E transmission system (Ref. 1, p. V-12; Ref. 2, p. 15-3) to NCPA members. This would save substantial duplication of transmission facilities construction, operation, and maintenance.

Nine towers will be built, occupying approximately 0.25 acres each (Ref. 2, p. 79; Ref. 3, p. 5). Existing access roads offer access to half the towers

TABLE 2. Estimated typical equipment for construction of transmission line.

Phase of construction			
Laying foundations	Erecting structures	Conductor stringing and temporary work	Cleanup
2 1/2-ton pickups	2 1/2-ton pickups	2 1/2-ton pickups	1 1/2-ton pickup
3 4×4 crew cab power wagons	2 4×4 crew cab power wagons	6 4×4 crew cab power wagons	1 Mobile office
2 5-ton trucks	2 10-ton trucks	2 10-ton trucks	1 Tool van
1 Truck-mounted auger	2 5-ton trucks	1 Rope puller	1 Crew cab pickup
1 250-cfm compressor	1 2-ton truck	1 Conductor tensioner	1 2-ton pickup
3 Concrete mixer trucks	1 20-ton trailer	6 HRD reel dollies	1 Crawler tractor
1 20-ton trailer	1 30-ton mobile crane	1 Pole dolly	1 Motor grader
1 Tiltbed trailer	1 Tool van	3 Crawler tractors	
1 Tool van	1 Mobile office	1 Lowbed trailer	
1 Mobile office		1 Highway tractor	
		2 Tool vans	
		2 Fire suppression trailers	
		1 4×4 line truck	
		1 4×4 boom truck	

(Ref. 1, p. V-15; Ref. 3, p. 5-8); new access roads will be built for the remainder in accordance with acceptable engineering practice and applicable standards.

Towers will be steel lattice design, 110 ft in height, square based, with concrete footers designed to carry the 230-kV double-circuit transmission system. The conductors will be 61-strand nonreflective aluminum. Ground clearance will be a minimum of 30 ft (Ref. 2, p. 15-3). Electric power will be stepped up from the generated 13.8 kV to 230 kV for economic transmission. The right-of-way will probably be 120 ft wide (Ref. 2, p. 76); it will be returned to a natural condition after the plant is abandoned and the facilities are removed (Ref. 1, p. V-23).

Table 2 lists equipment to be used in construction of the transmission system (Ref. 2, p. 83-84).

ELECTRIC POWER SUPPLY, DEMAND, AND CONSERVATION

The NCPA has 11 incorporated cities and one rural electric cooperative (Ref. 1, p. II-1). Tables 3 and 4 show the estimated annual capacity and total power requirements, respectively, in its service area (Ref. 1, Appendix C, pp. 1-13 to 1-18).

Project No. 2 will contribute significantly to the overall NCPA power requirements, particularly to baseload power in the early years of its introduction. The plant will also reduce consumption of fossil fuels; it would take 1,000,000 bbl of oil annually to fire an equivalent plant. Even if conservation reduces power demand growth, substitution of geothermal for fossil fuel in baseload power will preserve nonrenewable fuels and save money (Ref. 2, Appendix G, p. 1-1).

Although, with current technology, the thermodynamic efficiency of geothermal energy is lower than that of alternative fuels, the resource is apparently partially renewable.[4] Some of the reinjected fluid is reheated in the formation and is reextracted. (Much of the steam condensate is evaporated and thus not reinjected.)

NCPA energy consumption had been growing at a compounded annual rate of 10% from 1925 to 1975 (Ref. 1, p. II-2) because there were no restrictions on fuel use, on development of power-consuming appliances, or on commercial, residential, agricultural, or industrial development in the member areas. Lower growth rates have been assumed in the future as a

TABLE 3. Estimated annual electric power capacity in NCPA service area.[a]

	1975	1980	1985	1990	1995	2000	2005
NCPA annual noncoincident peakload forecast, MW[a]	581[b]	789	987	1204	1440	1694	2041[c]
Estimated reserve requirements, MW[d]	67[e]	87	116	158	205	256	390
Estimated total capacity requirements, MW (Noncoincident peakload forecast + estimated reserve requirements)	648	876	1103	1362	1645	1950	2431
Power contributed by NCPA Geothermal Project No. 2, MW			105[f]	105	105	105	105
Percent of total capacity contributed by NCPA Geothermal Project No. 2			9.5	7.7	6.4	5.4	4.3

[a]Assumes 4.3% compounded annual growth rate; other Notice of Intention projections assume higher rates (Ref. 1, p. II-3).

[b]Actual data, (Ref. 1, p. II-3).

[c]LLL estimate assuming growth rate from 2000 to 2005 equals the composite growth rate for 1985-1995 (Ref. 1, Appendix C, p. 1-16).

[d]See Ref. 1, Appendix C, p. 1-18, for reserve requirement calculation.

[e]Ref. 1, p. II-3.

[f]NCPA Geothermal Project No. 2 is scheduled to be on line 1981-82.

TABLE 4. Total estimated annual energy requirements in NCPA service area.[a]

	1975	1980	1985	1990	1995	2000	2005
Total estimated annual energy requirement, GW·h	2991[b]	3994	5025	6154	7382	8710	10,546[c]
Energy contributed by NCPA Geothermal Project No. 2, GW·h			771[d]	771	771	771	771
Percent of total energy requirement contributed by NCPA Geothermal Project No. 2			15.3	12.5	10.4	8.9	7.3

[a]Assumes 4.4% compounded annual growth rate and 58% load factor. Other Notice of Intention forecasts assume higher rates (Ref. 1, p. II-4).

[b]Actual data, Ref. 1, p. II-4.

[c]LLL estimate assuming growth rate from 2000 to 2005 equals the composite growth rate for 1985-1995 (Ref. 1, Appendix C, p. 1-16).

[d]NCPA Geothermal Project No. 2 is scheduled to be on line 1981-82. See Ref. 1, Appendix C, p. 1-7 for annual geothermal power production calculation.

result of energy conservation measures, power availability, growth of alternative energy sources, and decline in commercial, residential, agricultural, and industrial development in the larger cities in the NCPA service area. The average annual compounded growth rate assumed for peak load varies from 1.8% (Alameda) to 7.9% (Healdsburg); total energy demand varies similarly. The NCPA growth rates used (Ref. 1, Appendix C, p. I-16) are consistent with PG&E recommended rates and are generally between the CERCDC "adopted" and "high" rates. Some of the NCPA service area cities are expected to grow more rapidly than other areas in the state.

Even at these growth rates, geothermal energy will permit reduced reliance on and consumption of fossil fuels, will encourage development of an alternative energy source that is at least partially renewable, and will possibly provide the base for direct use of spent geothermal fluid (from electric generation). Future development of reinjection, heat exchange, and turbine technology will affect the net rate of depletion of the geothermal resource.

REFERENCES

1. *Notice of Intention, NCPA Geothermal Project No. 2,* submitted to the California Energy Resources Conservation and Development Commission, prepared by SAI Engineers, Santa Clara, CA (1978).
2. *Notice of Intention, The Geysers Unit 17,* submitted to the California Energy Resources Conservation and Development Commission, prepared by PG&E, San Francisco, CA (1978).
3. *Preliminary Report on the Notice of Intention, NCPA Geothermal Project No. 2,* submitted to the California Energy Resources Conservation and Development Commission (1978).
4. M. S. Gulati, S. C. Lipman, and C. J. Strobel, "Tritium Tracer Survey at The Geysers," *Transactions, Geothermal Resources Council* **2,** 237 (1978).

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APPENDIX A: IMPACT IDENTIFICATION MATRIX

Project: NCPA–Shell
By: ____________
Date: ____________

Environmental category: Energy and material resources

Potential impact	Significance	Source
Well field		
Use of resources and energy associated with construction of well field and waste fluid disposal facilities, and with well field abandonment	Insignificant	Mitigating measures: Ref. 1, p. III-4, III-8. The impacts are insignificant; in addition, mitigating measures are proposed (Ref. 1, pp. III-4 to 8).
Energy use associated with operation and maintenance of well field and waste fluid disposal facilities	Insignificant	
Power plant		
Use of resources and energy in the preparation of the site and construction of the various facilities including the generating plant	Insignificant	The energy and materials used in site preparation, equipment, building, and facility construction, operation, and maintenance, and eventual abandonment are concentrated and are considerable but are not significant in terms of construction throughout the state or in the energy industry (Ref. 1, pp. V-1 to 17).
Depletion of the geothermal resource for power generation	Unresolved	The degree of significance of the resource depletion is unresolved because, although studies show that some of the fluid injected into a geothermal well will be vaporized and produced as steam, the exact rate of recycling is unknown (Ref. 4).
Resource and energy uses associated with project facilities including the generating, service water, and waste heat dissipating systems (e.g., coolant pumps, cooling tower blowers) plus other internal uses	Insignificant	
Use of chemicals, materials, fuel, and electricity for facilities operation and maintenance	Insignificant	
Energy and resources used in maintenance of turbines	Insignificant	Ref. 1, pp. V-1 to 17.
Transmission lines		
Use of resources and energy associated with construction of electrical transmission system, including transformer stations, etc.	Insignificant	Energy and materials resources consumed in transmission system site preparation, construction, operation, maintenance, and abandonment are not significant in comparison with California energy industry-wide capital investment. (Ref. 1, pp. V-12 to 15, 17, IX-3; Appendix C, pp. 15-1 to 10)

Environmental category: Energy and material resources (continued)

Potential impact	Significance	Source
Transmission lines (continued)		
Use of resources and energy associated with transmission facilities—transmission lines, transformer stations, switchyard, etc.	Insignificant	
Energy used in transmitting, transforming, switching, and regulating electrical energy (transmission lines, terminal equipment (transformers, converters, switchgear), and control and metering systems)	Insignificant	
Fuel, chemicals, materials, and electricity used for transmission facilities operation and maintenance	Insignificant	
Electrical power supply, demand, and conservation	Unresolved	The NCPA Project No. 2 will significantly contribute to the NCPA service area baseload electric power production. It will reduce the consumption of fossil fuels, regardless of electric energy demand growth (Ref. 2, Appendix G, p. 1-1; Ref. 1, Appendix C, pp. 1-13 to 1-18). The provision of this baseload capacity will not stimulate increased energy consumption; it will replace fossil fuel baseload capacity and provide capacity for normal growth in the NCPA service area (Ref. 1, pp. II-1, 2). The steam resource is partially renewable (Ref. 4) and may become the basis for a direct use cascade.