Geothermal Resources Council, TRANSACTIONS, Vol. 8, August 1984

ROOSEVELT HOT SPRINGS UNIT DEVELOPMENT
A CASE HISTORY

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Abstract

The Roosevelt Hot Springs Unit (RHSU) was unitized in April 1976 and was the first geothermal unit approved by the United States Department of Interior. At the time, Phillips Petroleum Company was named unit operator. In the fall of 1980, after an extensive reservoir testing and marketing effort, a contract with Utah Power and Light (UP&L) was executed for the sale of steam to produce 120 MW of electricity. Design of the first 20 MW geothermal power plant began immediately and construction ensued in August of 1982. The startup of the 20 MW geothermal power plant occurred in April 1984. The following RHSU case history presentation includes a geological description, exploration review, testing and data collection, resource and reservoir evaluation, and the 20 MW geothermal power plant.

Introduction

RHSU is located in Beaver County, Utah, (Reference Figure 1) approximately 165 miles south of Salt Lake City and 12 miles northeast of the town of Milford. The Federal unit is 8 miles long (north-south) and 6 miles wide (east-west), and is situated between the western foothills of the Mineral Range Mountains and the northeastern edge of the Escalante Valley. The Federal unit consists of some 25,946 acres of Federal, State and fee leases currently held by Phillips Petroleum Company; O'Brien Resources; Milford Resources, Inc.; Graywes Resources, Inc.; Steam Reserve Corporation; VTN Consolidated, Inc.; and Union Oil Company.

Development of RHSU began in 1975 with the drilling of discovery well RHSU 3-1. To date 13 wells have been drilled by the Unit Partners and over 20 separate flow tests, ranging in duration from 1 hour to 9 months, have been conducted. Currently, the 20 MW single flash power plant is fed by three of four production wells. Two of three injection wells are used to dispose of the brine.

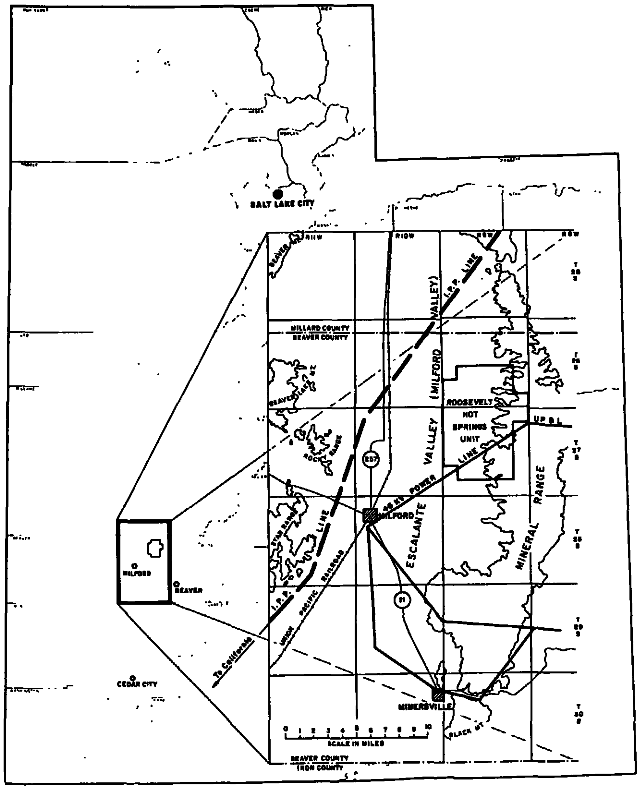

Figure 1 RHSU Field Location Map

Geology

The northern portion of the Escalante Valley, commonly referred to as Milford Valley, is a Basin and Range structure. The mountain range containing RHSU is approximately 30 miles long (north-south) and 12 miles wide (east-west). A sequence of normal Basin and Range faults marks the transition between Milford Valley and the Mineral Range.

In the thermal area, rocks beneath the thin veneer of alluvium are either igneous intrusive rocks from a granitic pluton of late Cenozoic age or metamorphic rocks of Pre-Cambrian age. Since these rocks have almost no intergranular porosity or permeability, production from the geothermal reservoir depends on interconnected fractures.

A cap formed by precipitation of silica and carbonate minerals in the fractures confines the reservoir. The geothermal resource represents a moderate-to-high temperature (500°F), low salinity (8,000 TDS), liquid-dominated type reservoir.

Development

Between April 1975, when RHSU 3-1 was drilled, and the fall of 1980, when the contract was signed with UP&L, extensive resource and reservoir evaluation was conducted. A geological model of the resource was developed using geochemical data, temperature and pressure surveys, and aerial mapping of the faults. A reservoir computer model was developed using the geological model and data gained from production tests of the various wells. The production tests consisted of flowing a producer to a pit or injection well and monitoring the other wells for pressure drawdown and buildup response.

Production well RHSU 54-3 has been tested the most, with over ten separate tests. In 1977 a separator was installed with an injection pipeline built between RHSU 54-3 and injection well RHSU 82-33. Two long-term tests of 3 and 9 months duration provided reservoir interference data used to define and modify the reservoir computer model. The current estimate of reservoir volume is 19 billion barrels.

Wellhead Facilities and Power Plant Design

Typically each production well is capable of producing 1.0 MM lbm/hr of geothermal fluid to the surface at wellhead pressures and temperatures approaching 380 psig and 440°F, respectively. The two-phase fluid is separated at approximately 118 psig in the tangential entry wellhead separators. Each of the wellhead separator facilities is controlled from a centralized control panel. Minimal operating labor is required because of the use of a distributed type of control system.

The design for the production/injection system utilizes existing wells that are distributed along a stretch of approximately 3½ miles (Reference Figure 2). Brine and steam are supplied from four production wells, with three wells required for maximum electrical generation and one well available for maintenance. Two of the three injection wells are required to be in service for the disposal of brine during maximum electrical generation. The system is designed for maximum operational flexibility, i.e., various combinations of production and injection wells can be in service at one time. This operational flexibility prevents well shut ins from impacting power plant electric generation availability. To achieve a high degree of operational flexibility, two stages of brine injection pumps are required along with a centralized brine surge vessel. This arrangement is required due to the large differences in well injection pressures and to prevent surging due to long piping sections and different wellhead elevations. Small brine booster pumps, at each wellhead separator, transfer the brine to a centralized surge vessel. The electrical brine injection pumps transmit the fluid from the surge vessels to the injection wells.

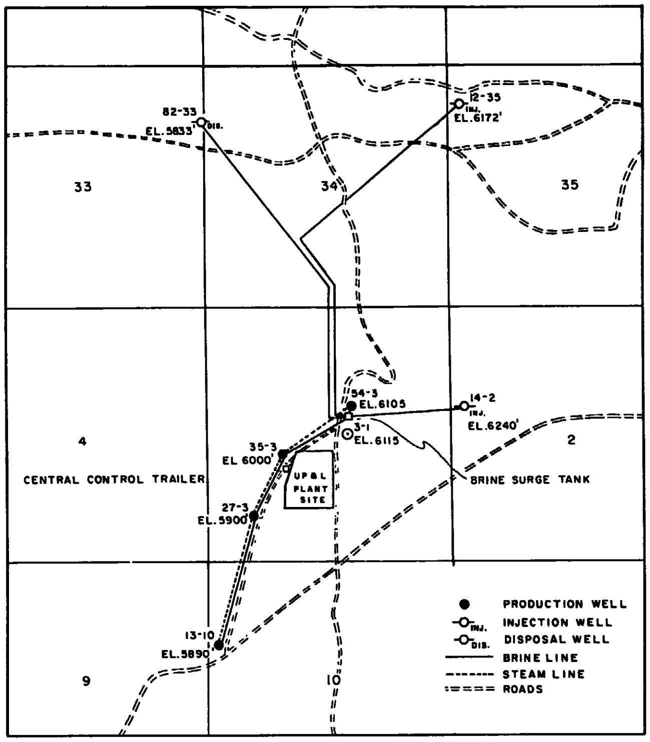

Figure 2 RHSU Well Location Map

The production/injection system is relatively expensive in comparison to some other geothermal power plants due to the dispersed locations of the wells and the requirements for maximum operational flexibility. Approximately 4½ miles of brine piping and 1 mile of steam piping are required.

At the wellhead separation facilities, UP&L takes custody of the steam and brine. The steam is piped to the power plant and the brine is repressurized at a centralized injection pad area and delivered to Phillips at the injection well for disposal (Reference Figure 3). UP&L owns all of the piping and pumping facilities. The power plant generates 20 MW (net) of electricity from the 2.25 MM lbm/hr of geothermal fluids. Of the total produced fluids the 400 M lbm/hr of steam is diverted to the power plant turbine and the remaining 1.85 MM lbm/hr of brine is reinjected.

At the power plant, the steam is expanded through a General Electric multistage steam turbine, producing mechanical energy to drive the direct-coupled electric generator. Power is generated at 12.5 KV for in-plant auxiliary equipment and for transmission to the 46 KV grid. Waste heat in the steam is rejected to the atmosphere through a direct contact condenser and evaporative cross-flow forced mechanical draft cooling tower.

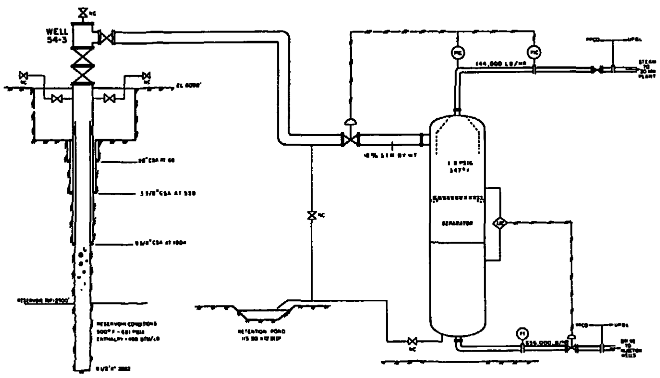

Figure 3 RHSU Wellhead Facility Schematic

Cooling system water losses are offset by the condensed steam. Steam-jet-air-ejectors are used for the removal from the condenser of non-condensible gases that are present in the steam. The power plant occupies an area of about 6 acres. Major structures within the plant site are the auxiliary building, cooling tower, and the turbine generator building which houses the power generation equipment and plant offices.

Current operations are geared toward evaluating the 20 MW geothermal power plant, wellhead facilities and the reservoir. The long range plans call for continual development at RHSU with the addition of another 100 MW of electrical generating capacity through two 50 MW geothermal power plants or wellhead electrical generating units. The Unit Partners and UP&L are working together in an effort to see that the geothermal resource is developed to its maximum potential.