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UNIVERSITY OF UTAH
RESEARCH INSTITUTE
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raft river

five-megawatt
pilot power plant

EG&G Idaho

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

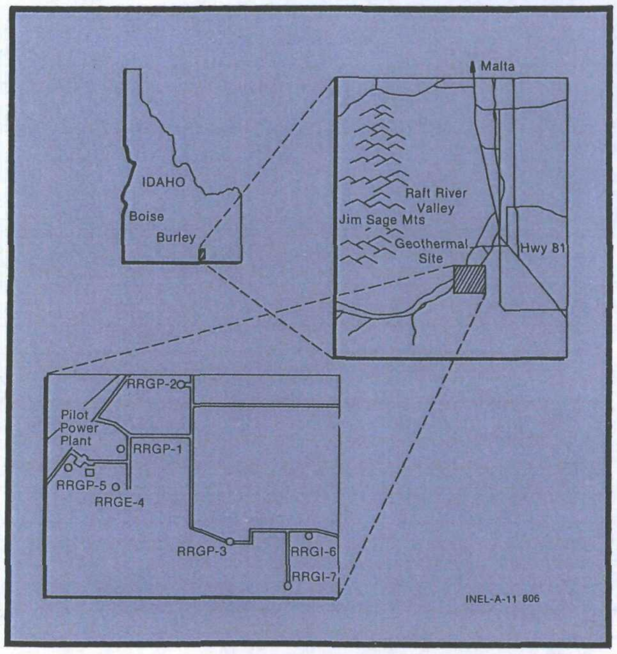
introduction

The Raft River 5-MW(e) geothermal pilot power plant is an integral part of the Department of Energy's plan for the commercial development of geothermal energy. The objective of the pilot plant is to demonstrate the technical feasibility and environmental acceptability of generating electric power from a 143°C (290°F) geothermal resource. An organic Rankine cycle in which an organic working fluid is heated, vaporized, expanded, and condensed much as in a conventional steam power plant is being tested.

The 5-MW pilot plant is a complete system, consisting of geothermal wells, a binary-cycle isobutane power plant, associated piping, and electrical switchgear. The environment and the geothermal reservoir are monitored to determine the effects of plant operation.

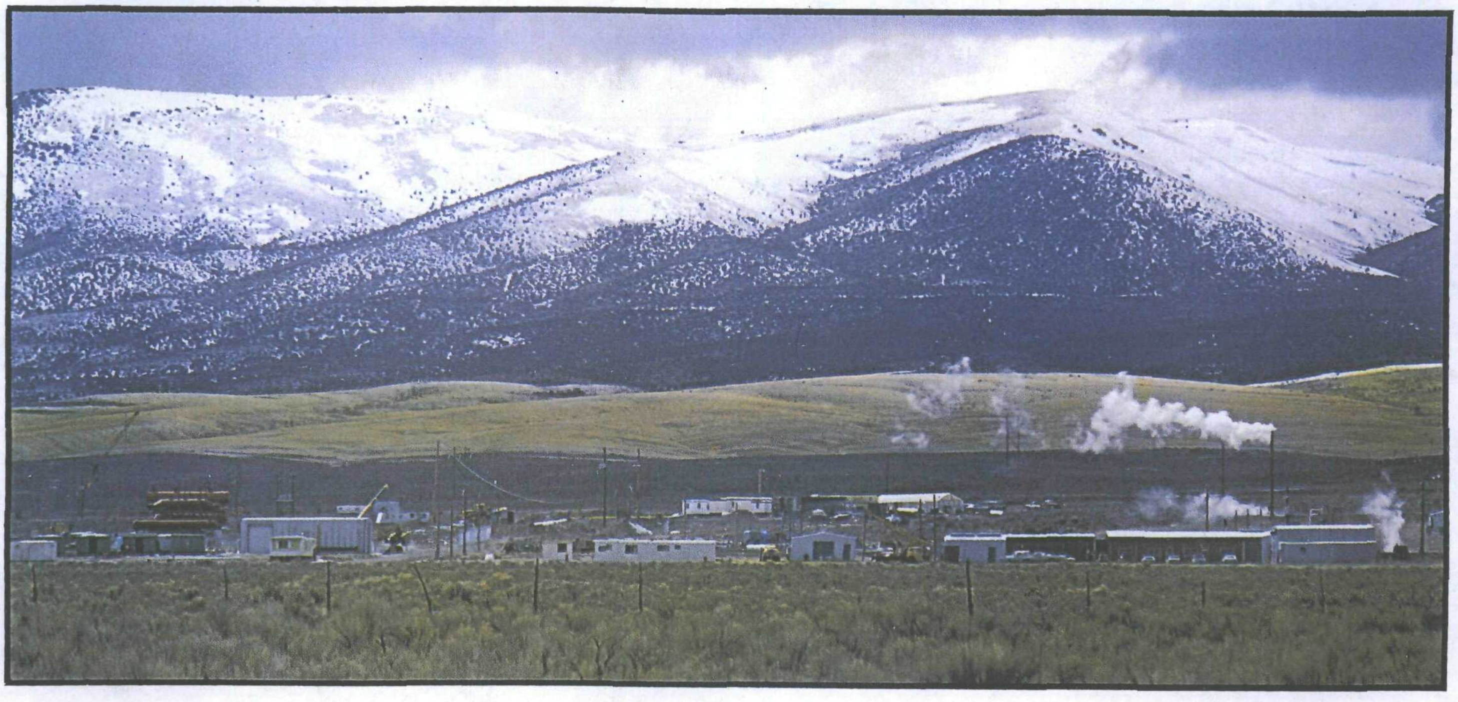
The plant is located in the Raft River valley in south-central Idaho. The pilot plant's completed fluid supply and injection system will use seven wells: three production wells, two injection wells, and a standby well of each type. The geothermal fluid travels more than one-half mile from the production wells to the plant, through 10- and 12-inch (25- and 30-cm) cement asbestos pipe.

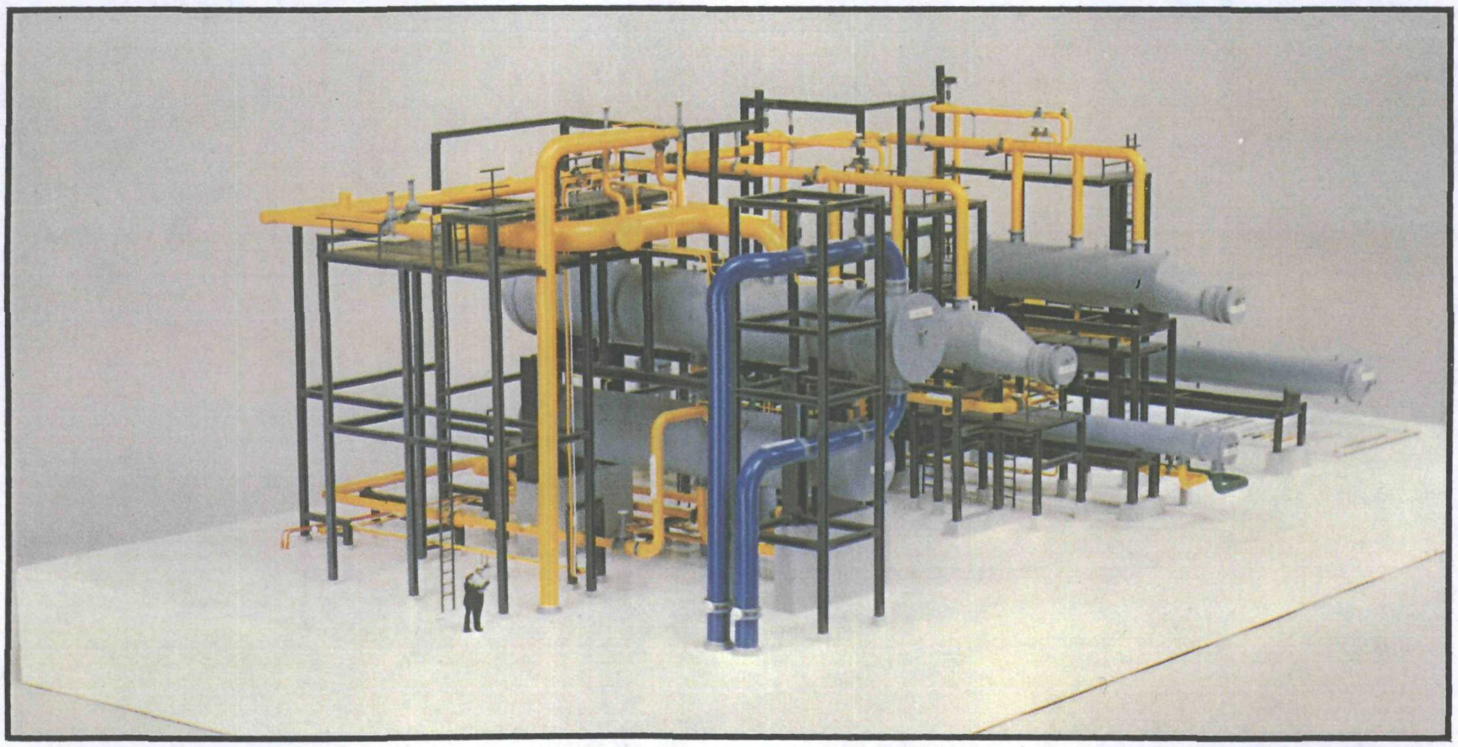
The plant power cycle will use 2250 gpm (142 l/s) of geothermal water. Cooling-tower makeup water will be extracted from the cooled plant geothermal fluid at a rate of up to 450 gpm (28 l/s). An average cooling-tower blowdown flow of 145 gpm (9 l/s) will be treated to remove chromates, then mixed with the geothermal water leaving the plant for injection.



Raft River Geothermal Site and Location of Wells

Raft River Site





Raft River 5-MW Pilot Power Plant
Process Facilities

pilot power plant

The power plant itself is the main element of a complex comprising various buildings and structures. An office/control building contains the power-plant control room, a water-chemistry laboratory, and administrative office space. A maintenance building provides space for servicing plant equipment.

The accompanying illustration of a facility model shows - beginning in the foreground and proceeding in a clockwise direction - the maintenance building, office/control building, cooling-water pump house, cooling tower, substation, power plant area, flare pit, holding ponds, water storage tank, and fire water pump house.

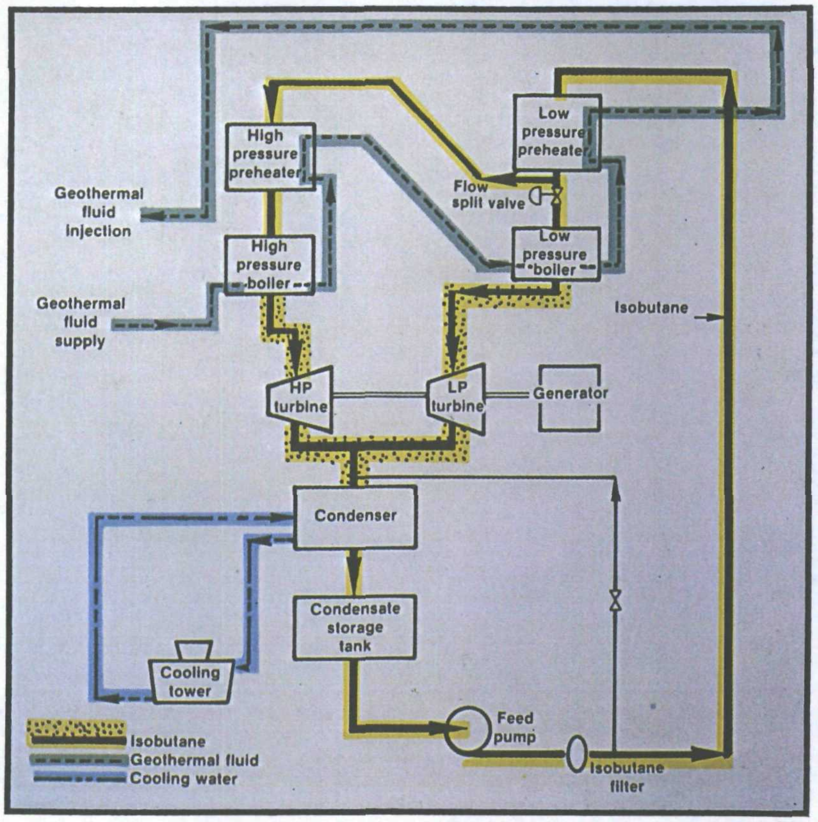
A schematic diagram of the pilot power plant cycle is shown at the upper right. Tracing the loop in a counterclockwise direction, starting at the bottom of the figure, the cycle operates as follows. The feed pumps take suction from the liquid accumulated in the condensate storage tank. They operate in parallel, raising the pressure of the isobutane to overcome hydraulic losses and boiler pressure. A pump-bypass valve controls the flow rate. The isobutane is piped from the pump discharge to the shell side of the low-pressure preheater, where the total process flow is first heated by geothermal fluid.

The process flow is divided when it leaves the low-pressure preheater. Control valves allow about 34% of the isobutane liquid to flow into the low-pressure boiler. The remaining 66% of the flow passes into the shell side of the high-pressure preheater for additional heating by the geothermal fluid. This larger flow then enters the high-pressure boiler. The isobutane is vaporized by geothermal heating in both boilers.

Saturated isobutane vapor from the high-pressure boiler enters the high-pressure portion of the turbine, and saturated isobutane vapor from the low-pressure boiler is admitted to the low-pressure portion. The vapor expands in the turbine and exhausts to the condenser in a slightly superheated state.

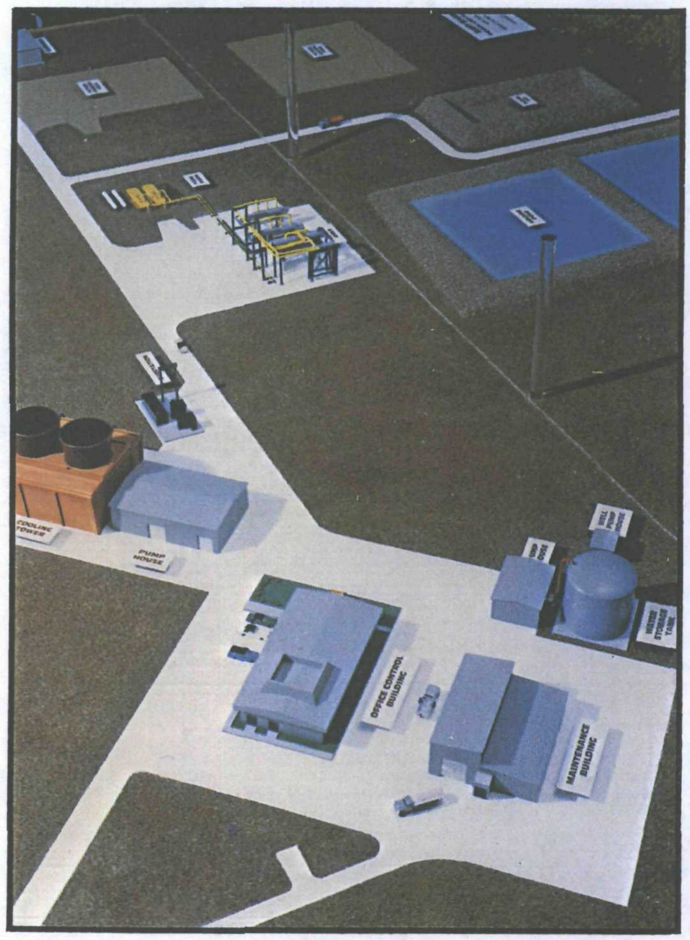
The exhaust vapor is condensed and slightly subcooled in the condenser. The condensate then flows by gravity to the condensate storage tank. The feed pumps take suction from this tank to complete the cycle.

Heat contained in the geothermal fluid pumped from supply wells provides the energy for driving the Rankine conversion cycle. Two pressure-boosting pumps operating in parallel increase the inlet pressure enough to maintain the required flow through the various heat exchangers to prevent the geothermal fluid from boiling (this would decrease efficiency and cause calcite to deposit on system components). The pressurized geothermal fluid flows in series through the tube side of each of the following (in order of temperature drop): (a) high-pressure boiler, (b) high-pressure preheater, (c) low-pressure boiler, (d) low-temperature preheater. The spent fluid is then piped to injection wells, where it is pumped back into the reservoir.



Raft River 5-MW(e) Geothermal Pilot Plant
Dual Boiling Cycle

Raft River 5-MW Facility



The work performed by the isobutane vapor expansion is mechanically coupled to a 60-Hz generator, which is connected to the Raft River Rural Electric Cooperative distribution system through appropriate transformers, switchgear, and protective devices. The plant is designed to generate 5-MW (gross) of electrical power, using heat extracted from geothermal fluid at the rate of 45 MW. The amount of power transmitted to the grid will depend on in-plant loads.

Heat is removed from the cycle when cooling water circulates through the tube side of the condenser. This heat is discharged to the atmosphere through a wet cooling tower. The cooling tower will be allowed to run at maximum capacity throughout the year in order to keep the condensing temperature as low as possible. The turbine back pressure will be allowed to "float" with condenser temperature, resulting in a predicted 20% increase in power output from the plant over a yearly cycle. (This increase is measured against the same plant with condensing temperature held constant.)

Geothermal water used for makeup is processed to remove most of the silica and is then treated to provide corrosion and biological protection to the cooling system components. Periodic blowdowns also add cooling water to the spent geothermal fluid exiting the plant for injection.

objectives

This pilot plant is the first R&D facility of its kind, and the specific technical objectives for the project are:

(1) To establish the actual performance of an organic Rankine cycle using state-of-the-art components

(2) To obtain realistic cost data from which commercial conversion costs can be predicted

(3) To gather data on reservoir deliverability and longevity

(4) To allow utilities and private companies to participate in the development and demonstration of geothermal energy conversion

(5) To identify operating problems so that solutions can be addressed

(6) To determine the expected life of the selected design and components

(7) To ensure that the environmental impacts from the use of geothermal fluids for power generation, are acceptable

In addition to the completion of technical objectives, the successful commercialization of geothermal electric power generation requires the resolution of a number of potential institutional problems. The Raft River geothermal pilot power plant project will also:

(1) Provide a basis for evaluating the impact of resource conversion on future energy shortages in the United States

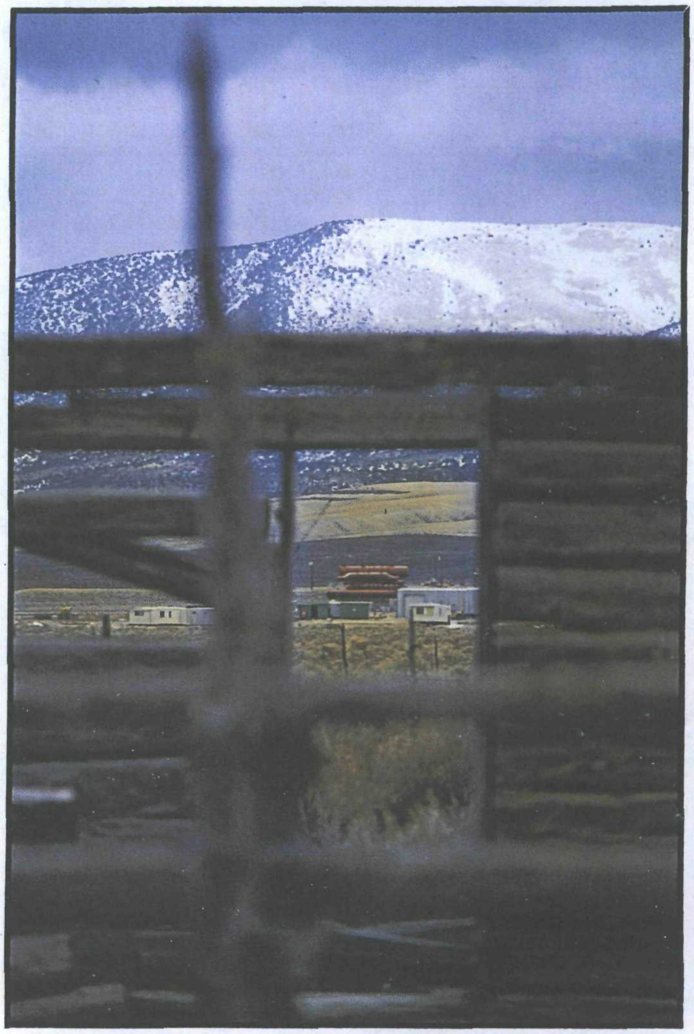
(2) Contribute trained manpower and technical information to the embryonic United States geothermal industry

(3) Encourage commercial investment in geothermal development

(4) Provide first-time experience for construction and licensing of hydrothermal power plants.

mission

One of the missions of DOE is to stimulate the development of hydrothermal resources in an economic, reliable, operationally safe, and environmentally acceptable manner. With today's technology and economics, geothermal fluid temperatures in excess of 200°C are required for electrical power production. Efforts are being made to reduce this temperature limit to 150°C and below. The 5-MW pilot power plant at Raft River is the major portion of DOE's efforts in developing and demonstrating the utilization of these moderate-temperature resources.



Raft River, Potential Energy for Tomorrow