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RAFT RIVER GEOTHERMAL AREA OVERVIEW

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ABSTRACT

At the Raft River Geothermal Area in south central Idaho's Raft River Valley, the Idaho National Engineering Laboratory (INEL) is investigating practical uses for moderate-temperature (90 to 150°C) geothermal fluids. This research is sponsored by the Department of Energy (DOE), and EG&G Idaho, Inc. is the prime contractor. Several broad areas of experimental activities and facility construction are being conducted or are planned. In the area of electrical power generation, a binary cycle, prototype power plant is now being operated. This prototype unit serves as a test bed for advanced engineering concepts that can be incorporated into a larger, 5MW(e) Pilot Plant that is now under construction. Concurrent with the plant construction, a seven-well geothermal fluid supply and injection system is nearing completion.

In the Direct Application Program researchers are investigating several uses of hydrothermal fluids, to enhance the competitive economic position of geothermal energy. Specific areas of experimentation include food production, food processing, synthetic fuel production, and space conditioning.

BACKGROUND

In 1973, Raft River Rural Electrical Cooperative (RRREC) and the Idaho National Engineering Laboratory (INEL) initiated a cooperative effort to develop geothermal energy at Raft River. In 1974, the DOE, the State of Idaho, and the RRREC reached a cooperative agreement, and in the fall of that year drilling began on the first deepwell at Raft River, designated RRGE-1. This well was successfully completed in early 1975. The second deep well, designated RRGE-2, was completed in mid-1975.

In late 1975, design work was initiated on the Prototype Power Plant and the 5MW(e) Pilot Plant. The Prototype Power Plant was completed and put on-line in the spring of 1978. The 5MW(E) Pilot Plant is currently under construction and is scheduled for completion and startup in mid-1980.

The first Direct Application Program experiment began in the spring of 1976 with the planting of argricultural crops irrigated with geothermal water. This was the first in a series of argricultural experiments that are still underway.

The fall of 1976 also marked the initiation of a second supportive experiment. Corrosion experiments were started to evaluate scale buildup, general and pitting corrosion on various metal compounds, heat exchangers, and valves. Experiments in this series are continuing and have provided invaluable information for selecting material types and component design for the Raft River power plants.

The third deep geothermal well, designated RRGE-3, was completed in mid-1976. This was the first Raft River well to be multiple-legged using directional drilling techniques. In early 1977, the first monitor well was drilled to provide environmental, geochemical, and reservoir engineering data. Monitor well drilling continued through the fall of 1978 with the completion of seven wells, designated MW-1 through MW-7.

In early 1977, the DOE applied to the Bureau of Land Management (BLM), for a land use withdrawal of the 4846 acres that encompass the Raft River Geothermal Area. The BLM land withdrawal is for a 10-year period. Thus, the planned development of the Raft River Geothermal Area and associated commercialization programs are scheduled for completion in 1987.

In the spring of 1977, the fourth geothermal well was drilled and was designated RRGI-4. Since testing of this well indicated greater potential as a production well, it was reentered in the fall of 1978 and drilled and cased to a deeper depth. Both leg A and a subsequently directional-drilled leg B have indicated a hot, but low-flow hole. This well was redesignated RRGP-4.

In the fall of 1977, another Direct Applications Program experiment was initiated with the first aquaculture experiment. Warmwater talapia, channel catfish, and Malaysian shrimp were successfully raised and subsequently harvested in mid-1978. The second aquaculture experiment, with channel catfish and mirror carp, commenced in the fall of 1978. This experiment continues to show extremely promising results.

Through the spring and fall of 1978, the remaining three of the seven planned geothermal wells were drilled, and were designated RRGP-5, RRGI-6, and RRGI-7. As piping systems are completed and production pumps installed, supply and injection testing is being conducted. The first integrated well field supply and injection tests are scheduled for the fall of 1979.

ELECTRIC POWER GENERATION FACILITIES

Since it is economically impractical to generate power with the low pressure steam flashed from moderate-temperature geothermal fluid, power generation facilities at Raft River have concentrated development on a binary cycle system. Using the geothermal fluid in a primary system to heat a secondary system working fluid of isobutane, a high working pressure vapor is generated which allows system construction with conventional components. This design reduces machinery costs while allowing the advantage of preventing the somewhat corrosive geothermal fluid from contacting with the turbogenerator machinery, thereby reducing maintenance costs and equipment downtime.

The Prototype Power Plant was the first to produce electricity using this binary cycle and moderate-temperature geothermal fluid. The output of this power plant is connected directly to the Raft River Valley electrical distribution system and, while running, provides enough power to meet the lighting requirements of the nearby town of Malta, Idaho. The primary purpose of this plant, however, is to provide a test bed to study improved equipment designs and advanced concepts that can be incorporated into the design of larger pilot plants. Specifically, the prototype power plant is being used to: (a), develop a better understanding of the isobutane binary cycle system; (b), experiment with different pure or mixed hydrocarbons as a secondary working fluid; (c), accumulate operational, safety and maintenance data on power plant operation; and (d), evaluate advanced heat exchanger designs, specifically a direct contact heat exchanger and a fluted tube condenser.

A schematic of the Prototype Power Plant's binary cycle is presented in Figure 1.

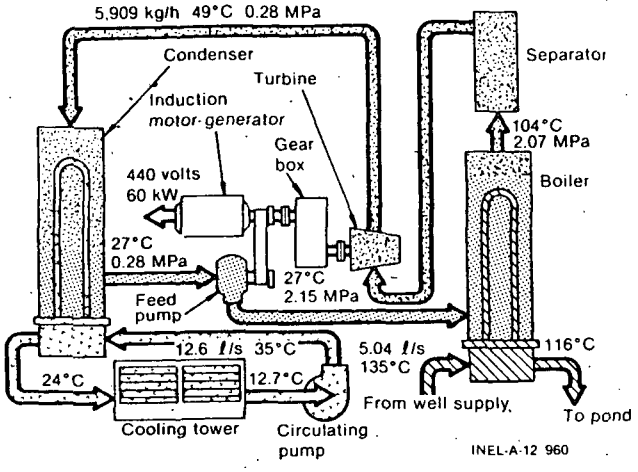

Fig. 1 Prototype Power Plant Binary System.

The main thrust of the activity at the Raft River Geothermal Area is the construction and operation of the 5MW(e) Pilot Plant. The objectives of this power plant are: (a), to evaluate the binary power system using design and components employing conventional technology; (b), to evaluate the fault-controlled moderate-temperature resource that exists at Raft River; (c), to obtain long-term operational and maintenance data that will provide an input to plant economics and advanced power plant design; (d), to enlarge the power industry's geothermal familiarity and thereby advance the commercialization of geothermal energy; and (e), to obtain environmental impact data and resolve problems encountered in the development of a geothermal area.

While some of these objectives cannot be realized until plant startup in mid-1980, those objectives of resource definition, environmental data, and industry's geothermal familiarity are being actively pursued during the development of the geothermal fluid supply and injection system.

Figure 2 presents a schematic drawing of the process system fluid flowpaths for the binary, dual-boiling cycle of the 5MW(e) Pilot Plant. State point temperatures and system flow rates are provided for the isobutane, geothermal fluid, and cooling water systems. Note that all flow rates and temperatures are based upon an inlet geothermal fluid temperature of 143°C. Actual operating conditions as specified may require adjustment depending upon the final temperature of the integrated fluid supply system.

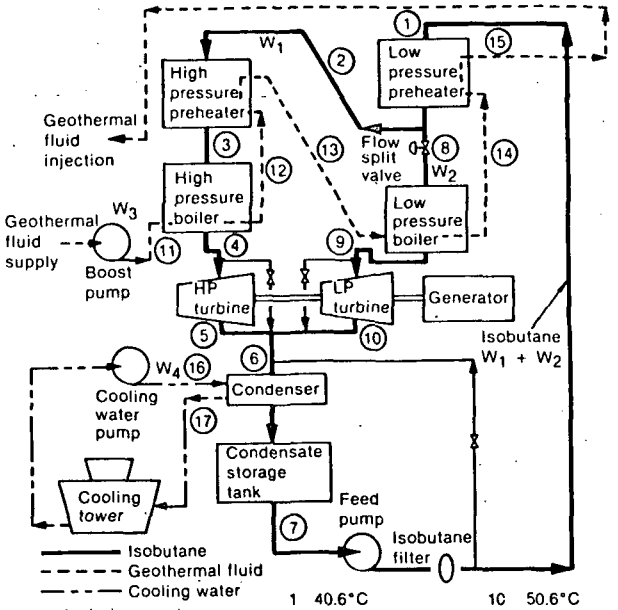

Fig. 2 5MW(e) Pilot Plant Dual-Boiling Cycle.

Fluid Supply and Injection System

Paralleling the power plant construction is the development of the integrated fluid supply and injection system. The development of this well field is based on the general criteria that: (a), the Raft River Geothermal Area is a moderate-temperature resource (132-149°C); (b), production is from the deep aquifer with production well depths approximately 1524 m; (c), injection is into the intermediate aquifers with injection well

depths approximately 1219 m; (d), the well field will consist of seven wells; four production wells and three injection wells; (e), the buried pipelines connecting the individual wells to the pilot plant are asbestos cement; (f), flow through the system will be controlled remotely from the pilot plant control building.

Figure 3 presents a cross sectional view of the existing well field. Wells RRGP-5, RRGE-3, RRGE-1, and RRGE-2 are the planned production wells; RRGI-4, RRGI-6, and RRGI-7 are the planned injection wells. Note that leg A of RRGP-5 contains a cement plug and is not productive and well RRGI-4 is essentially a hot dry hole. An extensive well stimulation program is planned for mid-1979 to improve the respective well production or injection capability of wells RRGP-5 and RRGI-4, 6, and 7.

Figure 4 is a layout of the Raft River pipeline system. Buried pipelines are all asbestos cement and aboveground piping is carbon steel. All indicated pipelines are completed with the exception of the pilot plant tie-in.

Supporting Projects

In support of the 5MW(e) Pilot Plant development, numerous tests are underway in the areas of conversion technology. These include heat exchanger fouling tests and scaling experiments, long-term corrosion-erosion tests on various metal compounds, surface water injection chemistry tests, mixed-well water chemistry tests, continued injection and production pump performance tests, and asbestos cement pipe performance tests. Of particular significance at the present time are cooling tower water treatment chemistry tests. These tests are required to develop improved methods of treating geothermal fluids for use as makeup cooling water for the evaporative cooling tower.

An extensive environmental program is also in progress. In the physical area, studies in progress include air quality and meteorology, water quality and hydrology, soil quality including erosion hazards and long-term deleterious effects of geothermal irrigation, subsidence caused by geothermal fluid production and consumptive uses, and induced seismicity. Results to date indicate that air quality, subsidence, and seismicity are not major concerns in the Raft River Valley.

Soil quality and especially water quality are significant concerns with experimentation and data gathering continuing in these areas. Currently, seven dedicated monitor wells have been drilled around the well field and are monitored continuously to provide reservoir engineering and environmental data. In addition, numerous other privately owned irrigation and government monitor wells are sampled periodically.

In the biological area, studies are continuing to determine environmental effects on small mammals, common birds, raptors, insects, native vegetation, and aquatic flora and fauna in the Raft River. Data analyses have indicated that these areas are not of major concern except for one sensitive raptor species, the ferruginous hawk.

Another area of environmental interest is an experiment termed the Wetlands Purification Pilot Project. This project is investigating the use of selected macrophytes, invertebrates, and aquatic species to remove undesirable minerals and ions from spent geothermal fluids. If this experiment is successful, a larger scale experiment is planned which may provide purified water for agricultural uses and power plant cooling water makeup.

DIRECT APPLICATION EXPERIMENTS

Numerous direct applications experiments are being conducted at the Raft River Geothermal

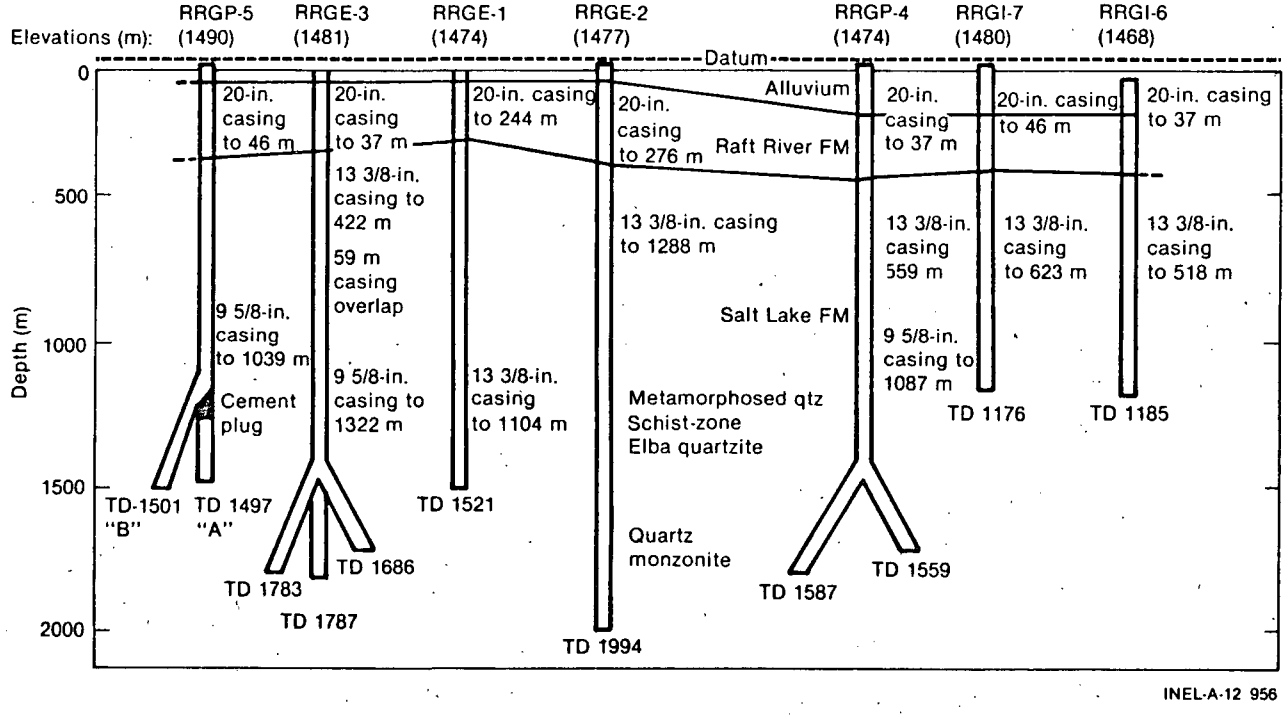

Fig. 3 Raft River Geothermal Area Well Field.

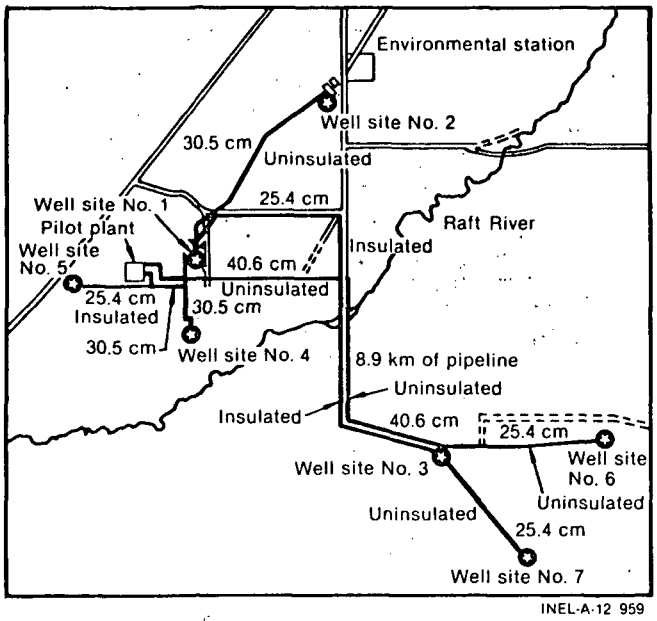

Fig. 4 Fluid Supply and Injection Pipeline System.

Area. Program objectives are to: (a) expand the commercialization potential for moderate temperature hydrothermal resources through field experimentation; (b) develop beneficial uses for energy spent hydrothermal fluids; (c) develop feasible unit operations technology and demonstrate proof-of-principle; and (d) provide an outreach for hydrothermal direct application marketing activities.

To meet these objectives, four major areas of experimentation are in progress or planned: food production, food processing, synthetic fuel, and space heating and air conditioning.

Food Production

The second phase of an aquaculture experiment and phase four of an irrigation experiment are in progress. In the current aquaculture experiment mirror carp and channel catfish are cultured in cooled (27°C) geothermal water to compare actual to predicted growth rates, study the bioaccumulation of heavy metals and fluorides, determine dietary requirements in geothermal water, analyze food conversion efficiencies, and determine product marketability. This experiment has produced several significant results. For example, the catfish and carp are growing 25 to 30% faster than similar fish in a control group using a commercial water supply. Other significant results are that geothermally cultured fish demonstrate early reproductive maturity and are virtually disease-free.

The irrigation experiment is being conducted to determine the effects of irrigating with cooled geothermal water. Results indicate no significant difference between crops grown with geothermal irrigation and control crops.

Food Processing

A small-scale fluidized bed dryer experiment, which has a high level of industry interest, is intended to demonstrate the potential for moderate-temperature geothermal drying, determine design characteristics and product data, and to determine scale-up economics data. To date, the moisture content of potato peel waste and potato biomass waste has been successfully reduced to as low as 0.2%. Operation is essentially trouble free, and the protein content of the dried product is as high as 37%. The economic picture is also bright, with a plant producing 25 dry tons per day realizing a 1.5- to 3-year payback on a $4 million capital investment.

Synthetic Fuel

Design work is underway to construct a pilot biomass conversion plant to produce ethyl alcohol. This plant will use 136°C geothermal fluid as an energy source to produce alcohol from raw products such as sugar beets, grains, and timber byproducts. This proof-of-principle plant will provide valuable economic and operational data to aid in the development of a geothermal gasahol industry.

Space Heating and Air Conditioning

Several experiments are in progress. Most of the buildings in the Research and Development Section at Raft River are space heated with geothermal energy. This heating system has been in operation for two years and has proven to be dependable and maintenance free. The current system is presently being upgraded to provide geothermal heat to more of the site buildings.

Geothermal energy is also being used to demonstrate a residential-sized lithium bromide air conditioning unit. This unit, in its second year of operation, has presented no significant operational problems.

A SUMMATION

To date, numerous 18 experiments have been successfully completed at Raft River in the areas of water chemistry, materials testing, reservoir assessment, direct heat applications, and environmental studies. Only a few experiments could be mentioned in this overview, but researchers are actively engaged in 27 projects, all aimed at advancing the widespread industrial use of geothermal energy.

Projected new experiments include an advanced binary power plant, larger-scale wetland development, high-temperature heat pump investigations, advanced geothermal air conditioning systems, residential and industrial heat exchanger evaluations, essential oil extraction experiments, and cascaded heat operations experiments.

Information opbtained from these and future experiments will provide technological and economic inputs to promote the industrial development and integrated utilization of geothermal energy in the United States.