GEOPRESSURED-GEOTHERMAL DIRECT USE POTENTIALS ARE SIGNIFICANT

by

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INTRODUCTION

Development activities are currently in progress to utilize the thermal and hydraulic energy available in geopressured-geothermal (geopressured) resources for a variety of direct uses. The higher temperature and pressures found in geopressured resources create the opportunity for many new applications. The Idaho National Engineering Laboratory, E G & G Idaho, Inc. (INEL) is presently evaluating potential direct uses for geopressured resources, as are a number of industries, firms, organizations, and educational institutions. In addition, the INEL is spearheading the formation of an industrial consortium to use the energy available in geopressured resources. Some of the applications under consideration include agriculture and aquaculture integrated systems, thermal enhanced oil recover, the use of supercritical processes for detoxification of pollutants, desalination and brine production, processing, and others.

This paper, supported by the United States Department of Energy (DOE), Idaho Operations Office under contract No. DE-AC07-761D01570, provides an overview of developments that are occurring, relevant background information about the geopressured resource, and hydrothermal-geothermal (hydrothermal) direct applications that can be installed at geopressured resources. Any specific development has unique considerations; these too are discussed.

THE STATUS AND TRENDS OF HYDROTHERMAL DIRECT USES

Before about 1973, the use of hydrothermal resources in the United States for direct use projects was mostly limited to pool/health spa applications, and for space and district heating. With the oil price increases of the 1970s, DOE initiated numerous incentive and technical programs that caused significant growth of the hydrothermal direct use industry. Figure 1 is based on data developed by the Oregon Institute of Technology Geo-Heat Center and the INEL, and shows the rapid increase of resorts and pools, space and district heating, agriculture (mostly greenhouses), aquaculture, and industrial processes (Lunis and Lienau, 1989). Heat pumps (also shown in Figure 1), which utilize geothermal gradient heat contained in the earth and subsurface waters, are a phenomenon of the 1980s resulting in part from promotional activities by utility companies. The Electric Power Research Institute and industry sources estimate that 800,000 heat pump units (of all kinds) are now installed annually, with annual sales growth of

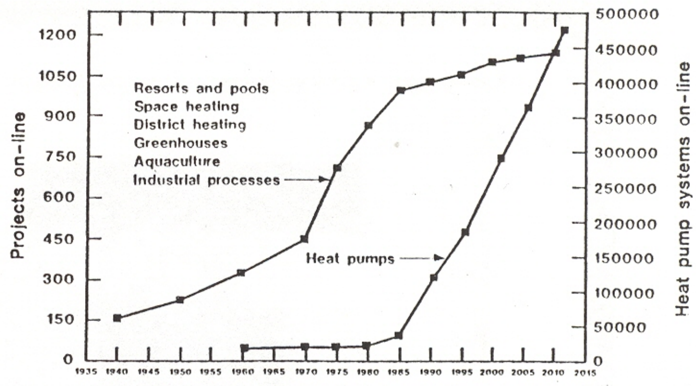

Figure 1. Hydrothermal-geothermal projects on-line.

25 to 40 percent. Since 1986, Canadian geothermal heat pump growth exceeded 50 percent annually and by 1990, the Executive Director of the Canadian Ground-Source Heat Pump Association expects the growth to exceed 100 percent annually (Lund, 1989).

Table 1 is included to identify principal direct use applications in the United States (Lunis and Lienau, 1989). This helps show the breadth of the industry that is supported by a broad based infrastructure of designers and developers who are available to apply their expertise toward the application of hydrothermal direct use projects for geopressured resources.

THE GEOPRESSURED RESOURCE

Geopressured-geothermal resources are a normal phase of basin evolution and are found in many locations throughout the United States (Figure 2) and the world (Negus-deWys, 1989). Geopressured resources have three energy forms: thermal, hydraulic and methane gas. These three forms of energy can be converted to higher value forms of energy using available technologies. The thermal energy can be converted to electricity using a geothermal binary turbine. The hydraulic energy can be converted to electricity with a hydraulic turbine. Dissolved methane gas can be separated and sold, burned, compressed, liquified, converted to methanol, or to electricity by fueling a turbine (Negus-deWys, 1989).

Geopressured resources normally exist between 12,000 - 20,000 ft below the surface. Flow rates can vary between 10,000 - 40,000 barrels per day (BPD), and temperatures will range from 273 - 500 degrees Fahrenheit (°F). Bottom hole

Table 1 Principal Direct Use Systems in the United States

Application	Resource Temperature °C	Resource Temperature °F	Annual Energy (10^9 Btu/yr)
Industrial			
Enhanced Oil Recovery			
Amoco, WY	93	200	9480
Heap Leaching			
Round Mountain Gold Corp., NV	84	186	197
Pegasus Gold Corp., Florida Cary, NV	114	238	40
Food Drying			
Gilroy Foods, NV	132	270	86
Mushroom Growing			
Oregon Trails Mushrooms, OR	113	235	54
Geothermal Heat Pumps (Heating)			
Florida, all of state	24	75	839
Michigan, all of state	8	47	355
Indiana, all of state	12	54	335
Pools/Spas			
Payne's Fountain of Youth RV Park, WY	52	125	665
Hot Springs State Park, WY	57	135	478
Hunt's Ash Springs, NV	36	97	177
Aquaculture			
Hot Creek Hatchery, CA	16	61	201
Fish Breeders of Idaho, ID	32	90	174
Hyder Valley, AZ	41	105	140
Greenhouses			
Burgett Floral Greenhouses, NM	118	245	65
Utah Roses, UT	51	124	45
High Country Roses, MT	66	151	33
Troy Hygro, UT	110	230	30
Space Heating			
Residences (550 each), Klamath Falls, OR	93	160	96
Peppermill Casino, NV	53	127	63
Residences (300 each), Reno, NV	49	120	39
Merle West Medical Center, OR	88	191	24
District Heating			
Mammoth Lakes, CA	149	300	118
Litchfield Correctional Center, CA	77	170	79
Boise City, ID (two systems)	77	170	73
San Bernardino, CA	59	138	45

Figure 2. Location of geopressured geothermal basins in the United States.

pressures are 12,000 - 18,500 pounds per square inch absolute (psia). Salinity will be present in the amount of 20,000 - 200,000 milligrams per liter (mg/l), and between 23 -100 standard cubic feet (scf) of gas will exist in each barrel of fluid (Negus-deWys, 1989).

Resource potentials are significant for hydrothermal resources, but are even higher for geopressured resources. According to the United States Geological Survey (USGS) (Muffler, 1978), hydrothermal resources have energy potentials equal to 23,000 megawatts electric (MWe), plus or minus 3,400 MWe, for 30 years (y). Gulf area geopressured resources are estimated to contain from 23,000 to 240,000 MWe for 30 y; Louisiana alone has the potential for 4,100 to 43,000 MWe for 30 y. Geopressured resources are known or inferred to exist in other sedimentary basins of the United States, such as the central valley of California. However, the USGS (Muffler, 1978) made no thermal potential estimate of those areas because knowledge was scanty at the time of preparation of Circular 790.

INTEGRATED APPLICATIONS

In addition to power generation, there are numerous industrial, agriculture and aquaculture applications that could use the energy contained in geopressured fluid and gases. Figure 3 is a conceptual layout for a variety of integrated applications at a geopressured resource. Figure 4 gives the approximate temperature requirements for various processes that can have their energy needs met by using geopressured resources. There are other processes that could apply; the listing is not intended to be exhaustive. Following is a brief summary of some processes that are under consideration.

Power Generation

Power can be generated utilizing the thermal and hydraulic energy, and the gases contained in geopressured resources. Approximately 1 MW of power is presently being generated at the DOE Pleasant Bayou facility located about 50 miles south of Houston, TX. A binary power plant and two gas fired generators are producing the power.

Industrial

There are various industrial applications that could utilize the thermal and hydraulic energy found in geopressured resources. Following is a brief summary of potential uses and some of the present activities.

Desalination: Fresh water can potentially be removed from geopressured fluids. G. S. Nitschke and J. A. Harris, Wichita State University, are proposing a system that will use the pressure gradient of the reservoir to produce electricity by way of a pressure reduction turbine and generator combination. The natural gas would be separated for sale or on-site use, and the thermal energy would be used to produce potable water through a multi-effect distillation unit. In turn, the remaining saturated brines can be sold. The brine is ideal for solar ponds that utilize binary power generators, a method effectively proven in Israel. The produced potable water can also be used for cooling water for power plants, especially in those areas where potable water supplies are limited (Nitschke and Harris, 1990).

Gas Use and Sales: Gas contained in the geopressured fluid can be separated, used directly, and/or sold to a pipeline company. This is being done at the DOE Pleasant Bayou facility where each barrel of geothermal fluid contains about 24 scf of methane gas. The gas is sold to a pipeline company and is used in two 325 kW gas engine generators. The gas can also be used for refrigeration and to drive pumps.

Pollutant Removal: The Air Force Engineering and Services Center, the DOE Hazardous Waste Remedial Actions Program, and the Los Alamos National Laboratory are investigating the use of supercritical water (above 705°F and 3,208 psia) processes for the destruction of hazardous wastes (Rofer, 1990). Processing methods appear suitable but require additional development. The feasibility of the utilization of the energy contained in geopressured resources for supercritical water processes is under study at the INEL.

Thermal Enhanced Oil Recovery: Geopressured resources, often encountered while drilling for oil and gas, can provide hot brines under pressure to flood reservoirs containing medium or heavy oils to enhance recovery. The INEL is proposing a program for the thermal enhanced recovery of heavy oil from the Alworth Field in the "Mirando" trend of south Texas. It is not possible to consider a hot water-steam type flood in this part of Texas because of the lack of steam quality fresh water. However, geopressured brines can be considered. In the San Joaquin Basin of California, cyclic steam injection has been used successfully, but is now under scrutiny because of the pollution generated by the equipment used in producing the steam. In contrast, using geopressured brines offers an environmentally clean process (Negus-deWys, 1989).

Dr. C. J. Newell, Groundwater Services, Inc., is proposing to use geopressured fluids for the remediation of hazardous waste sites wherein hot water is introduced through patterned drill holes to release the underground waste and pumping it to the surface for additional processing.

Sulfur Frasching: Sulfur can be recovered from salt dome deposits using a process devised by Dr. Herman Frasch. This process was perfected commercially in 1903. The technique melts the sulfur while still underground in porous limestone and calcite deposits. Superheated water (320 to 330°F) under 125 to 200 psi pressure is injected into the sulfur deposits. As the sulfur melts, it is forced to the surface where it can be transported in liquid form, solidified, or made into flakes or pellets (Carlson, 1976). Adequate pressure and temperature are available in geopressured fluid to perform sulfur frasching with geopressured fluid.

Petroleum and Natural Gas Pipelining: Petroleum and natural gas pipelining require large quantities of energy to operate the systems. The pipeline companies operate throughout geopressured areas and could benefit from technology developments using the energy available in geopressured resources (Carlson, 1976).

Coal Desulfurization and Preparation: There are a number of processes that are used to process solid or liquid fuel from high-sulfur, high ash coal. Much of the lignite found along the Texas Gulf Coast region is either high sulfur, high ash, or both. These types of processes require large quantities of process heat, pumping, and conveying; geopressured energy could be applicable to all or part of these energy needs (Carlson, 1976).

Lumber and Concrete Products Kilning: Typical kilns for lumber drying and concrete products require low-quality steam or heated air. These facilities could easily operate with the heat available in geopressured resources (Carlson, 1976).

Agriculture and Aquaculture Applications

Various agriculture and aquaculture applications are under consideration that could use the fluids and energy found in geopressured resources. One or more of these applications can be installed in cascaded uses where the hot fluids that have been used for one process are then used in another application.

The production of both aquatic and agriculture products are limited commercially by colder winter weather. This in turn disrupts established markets, often making it necessary to create new markets when the products are once again available. Growth rates can be severely hampered by lowered and fluctuating temperatures. For example, alligators grown in Louisiana achieve a marketable length of about 4 ft in 3 y with ambient temperatures. If the surrounding air and water temperature is maintained near 90°F, crocodiles will grow to 7 ft in the same 3 y period, almost doubling the potential income (Ray, 1990). Thus, utilizing the heat and fluid available in geopressured resources for agriculture and aquaculture applications can significantly improve growth rates, marketability, and profits. A brief summary follows of some agriculture and aquaculture applications under consideration for use at geopressured resources.

Greenhouses: A large variety of fruits, vegetables, flowers, and ornamentals can be grown in geothermally heated greenhouses; this has effectively been proven using hydrothermal resources. The type of product selected for growth at a geopressured site will depend on the market. Market research is being conducted by organizations such as Agro-Flex, a broad-based, 13 parish nonprofit rural economic development program for southwestern Louisiana. The University of Southwestern Louisiana is proposing to utilize four greenhouses, each planted with a single crop of high

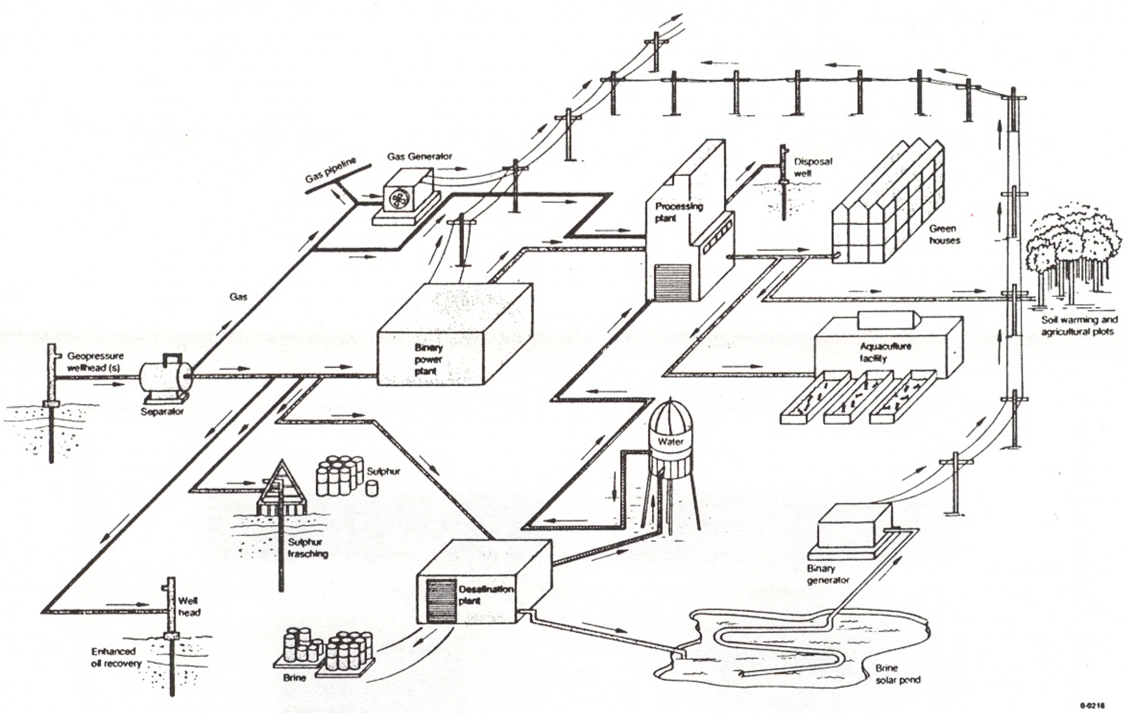

Figure 3. Conceptual geopressured integrated facility.

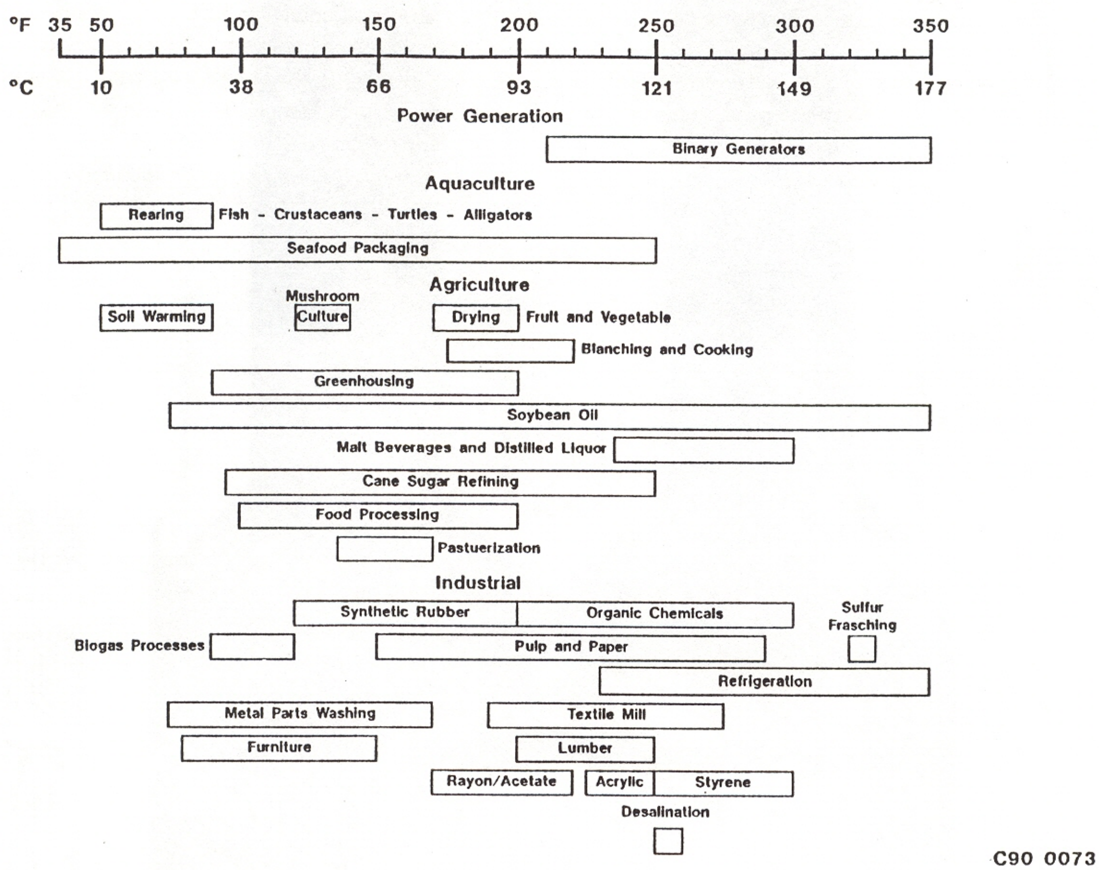

Figure 4. Approximate temperature requirements for potential geopressured applications.

density citrus to compare and evaluate with unheated greenhouses and outdoor plots. Heat from a geopressured resource would be applied through different heat exchange mechanisms.

Production Plot Warming and Frost Protection: The growing season for different agricultural products can be extended through the use of geothermally heated fluids in underground piping, or through aboveground sprinklers and distribution systems. Citrus production has been limited because of cold weather, and the University of Southwestern Louisiana, in conjunction with the greenhousing effort described above, proposes to use waste geothermal heat as a means of protecting and extending the production of citrus. A 1-acre plot will remain in a natural setting, a second will be heated by installing a subsurface system of hot water, and a third will utilize a warm-water sprinkler system (Huner, 1990).

Rearing of Fish, Crustaceans, Exotics, Turtles, and Alligators: Aquaculture involves the raising of freshwater or marine organisms in a controlled environment to enhance production rates. The principal species being raised are catfish, bass, tilapia, sturgeon, shrimp, and tropical fish. Aquaculture is one of the fastest growing applications for using low-temperature geothermal energy (Lienau and Lunis, 1989). This growth is in response to an ever increasing demand, especially in Japan and other Asiatic countries. Controlled rearing temperatures increase growth rates by 50 to 100 percent, and thus, increase the number of harvests per year. In addition, the use of geothermal fluids in controlled rearing reduces the incidence of disease.

Alligator culture is an emerging and lucrative industry. As previously noted, maintaining growth temperatures at about 90°F can cause an alligator to grow to about 7 ft in 3 y, whereas those grown under ambient conditions only reach a length of 4 ft in the same time period. Fish Breeders of Idaho is planning to utilize their 90°F hydrothermal resource to evaluate the rearing of a small quantity of alligators (Ray, 1990). The University of Southwestern Louisiana is proposing to determine the cost effectiveness of using waste heat from a geopressured facility to warm alligator cultivation units, to evaluate the use of biofilters to control waste levels in culture water, and to observe the benefits of eliminating cold shocks from periodic water changes. They are also proposing to gather baseline data on snapping turtle growth in culture units, to examine the cost effectiveness of rearing soft shell crustaceans and high value ornamental fishes, and to cultivate fingerling food fishes (Huner, 1990).

Processing: Temperatures available in geopressured resources are generally adequate for food and grain processing, and packaging. Specific applications are determined by market needs, the types of food and grains available, and transportation economics. Cooling needs can be met by using refrigeration units that use energy from the hot geothermal fluids, or from gas-fired units using gas that is available in the geopressured resource. The refrigeration units can also be driven with electricity from a binary cycle generator installed at the geopressured facility.

DEVELOPMENT CONSIDERATIONS

Although most of the integrated applications being considered for development with geopressured resources are proven technologies, the proper blend of research, market investigations, and field development is needed to produce economically viable operations. Preliminary assessments of the economic viability of using geopressured energy for various applications indicate that the best potential exists when a variety of uses take advantage of cascading energy from one application to another. For example, the waste heat from a binary power generator becomes the process heat for a food processing facility; then the lowered temperature fluid is used in an agricultural plot and in an aquaculture facility. The extent of the development will be dependent upon the energy needs of each application and the available energy in the geopressured resource.

It will be more economically viable to utilize existing geopressured wells that are presently not being used by the oil field developer who drilled the well in search of oil and gas. Three gulf coast geopressured wells being investigated by the DOE may also become available for selected projects.

Other factors that could affect planned development include such items as the availability of land and water, use requirements, and restrictions. Because of the relatively benign environmental nature of geopressured fluids, environmental limits may not be as restrictive as for other forms of energy, such as hydrocarbons. Disposal of spent geopressured fluids can be by injection into the subsurface, or the fluids may be processed for potable water and brines. These and other factors need to be verified to produce the most viable combinations of integrated or singular applications.

Expertise is available for the economic development of various applications that can utilize the energy available in geopressured resources. With the proper blend of research, market investigation, and entrepreneurship, the potential exists for viable and economic development of geopressured resources.

An industrial consortium, spearheaded by the INEL, is being formed to promote direct uses of geopressured resources. A planning meeting was held in September, 1989 with 35 participants; 15 of whom were from industry. On January 10, 1990, the first consortium meeting was held to present industry cost-shared proposals for utilization of geopressured resources. Sixty-five participants convened at Rice University, Houston, TX, two-thirds of whom represented industry. The proceedings will be available the end of March 1990. The next consortium meeting is scheduled for September 11, 1990 at the University of Texas Austin Balcones Research Center.

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