RENEWABLE ENERGY

Energy from Geothermal Resources

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RENEWABLE ENERGY:
ENERGY FROM GEOTHERMAL RESOURCES

GEOTHERMAL ENERGY

State of Florida
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Energy From Geothermal Resources is the fourth in a series of reports on renewable energy resources being prepared by the Governor's Energy Office. The reports provide information on the current status of both promising and proven sources of renewable energy in the State of Florida. Available conversion technologies, federal and state governmental promotional efforts, and private sector utilization of renewable energy are reviewed. Issues and factors that may advance or inhibit the greater use of renewable energy sources are identified and discussed. Through this series, it is hoped that the public and others in government can obtain a greater understanding of the contribution renewable energy can make in limiting our dependence on imported petroleum and other fossil fuels, which are gradually being depleted.

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ENERGY FROM GEOTHERMAL RESOURCES

INTRODUCTION

Geothermal energy is the natural heat of the earth. The heat, originating from the decay of radioactive materials in the earth's core and from frictional movement of rock masses, generally decreases in temperature outward from the core. Although the potential geothermal resource base, as defined by the U.S. Geologic Survey, includes all the stored heat above 60°F to a depth of six miles, most of the heat is so diffuse that it cannot be recovered economically. In some areas where the underlying geologic structure has led to elevated temperatures at shallow depths, the geothermal energy is concentrated in hot solid rocks or water-steam mixtures in rock pores and fractures. This energy can be recovered and used for direct space heating, industrial and agricultural processes, and electrical generation. Currently non-electric applications exceed electric applications in the over 50 countries exploiting this energy source. The largest use is in Russia where the equivalent of 5,000 megawatts (MW) of geothermal energy is used to heat greenhouses. Almost all the city of Reykjavik, Iceland is heated with natural hot water.

Concentrations of geothermal heat may be found in the presence or absence of water. The most commercially attractive are hydrothermal systems in which geothermal heat is transferred to water percolating through fractures and pores in rock above a heat source. Geothermal heat that is not in contact with water is called hot dry rock geothermal energy. The Los Alamos National Laboratory in New Mexico is conducting research in this area.

Traditionally, geothermal energy in the U.S. has been associated with geologically young volcanic areas such as portions of California, New Mexico, Hawaii, and Alaska. The source of heat for these high temperature geothermal resources (greater than 300°F) is magma or mol-

ten rock sometimes found near the surface. This type of geothermal resource occasionally can be used for generating electricity. The best known U.S. project is the Geysers electric power plant, north of San Francisco.

A lower-temperature type of geothermal energy is found in parts of the eastern United States. This resource exists where there is a greater than normal thermal gradient with depth; that is, the temperature in a well is higher at a given depth than expected. The regions of most interest are those where the temperatures reach 95°F or above at a depth of 3,000 feet. These areas are associated with buried granitic plutons which are overlain by the sedimentary rocks of the Coastal Plain. The granite contains relatively high concentrations of radioactive uranium and thorium which provide the sources of heat for the sedimentary rocks.

Geopressured resources, found principally along the central Gulf Coast at depths below 12,000 feet, contain methane dissolved in saline water under abnormally high pressure. The possibility of recovering heat from geopressured formation hot water (above 200°F), as well as producing methane gas, provides incentives to investigate the use of these geopressured zones for energy.

Shallow ground water normally is unaffected by magma and radioactive decay. The temperature of the water in most regions is the same as the average annual air temperature for that region. Such water, since it does not deviate from its mean temperature as much as air, derives energy value from being cooler than the air in the summer and warmer in the winter. As a result, ground water heat pumps may offer greater potential benefits than traditional heat pumps which draw energy from the surrounding air.

Of the heat resources discussed above, the ones of interest to Florida are above average thermal gradients in the earth (due to granitic plutons) and the use of ground water for heat pumps.

TECHNOLOGY

Geothermal wells are drilled with the standard rotary rigs typically used by the oil and gas industries. However, special techniques must be employed when excessively high temperatures are encountered during drilling. Some wells in the West have been drilled with air rather than a drilling fluid to overcome the high temperature problem. Well stimulation techniques sometimes are used to increase the flow of hydrothermal fluids or to create cracks in impermeable hot rock formations.

The uses for geothermal resources found in areas with higher than normal thermal gradients are mostly for modest temperature applications involving space heating and heat pump/heat exchanger applications in industry, agriculture, or mariculture. When these geothermal waters contain only small amounts of dissolved salts, few utilization problems occur because the temperature of the water does not change enough to cause the salts to precipitate and foul the heat exchanger.

The technology for all ground water heat pumps consists of an air-side heat exchanger, a water- or fluid-side heat exchanger, and a refrigerant system connected to both heat exchangers. These units are used primarily for air conditioning in Florida. Since performance decreases with increasing water temperature, the heat pump efficiency in Florida would be higher if the ground water were cooler; however, even with ground water temperatures in Florida ranging from 70° to 78°F, the ground water heat pump still remains an effective air conditioner. A waste heat recovery unit can be added to produce domestic hot water. Because of possible problems with ground water depletion or saltwater intrusion, closed loop water source heat pumps have been designed. These recirculate the same water without consumptive water use and do not require reinjection. Closed loop systems are relatively new and few have been installed. It is expected that the costs and payback periods for closed loop systems will not be significantly greater than conventional systems as the closed loop systems require less energy to run pumps, and water does not have to be forced back into the aquifer through a reinjection well.

Ground water heat pumps are generally considered to be more efficient than air souce heat pumps. For Florida conditions, however, the efficiencies of water source heat pumps may be lower than in more northerly areas because the ground water in Florida is warmer and the air conditioning season is longer. One advantage of a water source heat pump is that it can be mounted inside of the house. In coastal areas such units would not be exposed to salt spray. Air source heat pumps exposed to salt spray rapidly deteriorate and may become economically unrepairable within three to four years.

FEDERAL PROGRAMS

The two federal agencies with primary responsibilities for geothermal energy are the Department of Energy (DOE) and the Department of Interior, Geological Survey. The DOE program has been directed towards development of advanced technology and site-specific studies. Federal budget cuts in the early 1980s caused the DOE to pull out of most national geothermal commercialization efforts and to eliminate eastern U.S. geothermal projects. The Geological Survey has focused on an overall assessment of the national geothermal resource.

Under the Safe Drinking Water Act of 1974, the Environmental Protection Agency is required to adopt regulations to control the drilling and use of underground injection wells, including injection wells for ground water heat pumps which are Class V wells. Class V wells under the act are those into which non-hazardous fluids can be injected into or above formations that contain underground sources of drinking water.

The Navy is investigating a combination of ocean thermal energy and geothermal energy (GEOTEC) in which the temperature difference between hot geothermal water and cooler surface water of the ocean is used to generate electricity. An engineering concept study has been completed for a GEOTEC plant on a naval base in the Aleutain Islands of Alaska. Other sites in the U.S., including the Naval Air Rework Facility at Jacksonville, also are being considered.

Businesses that wish to invest in geothermal systems are eligible for a 15 percent federal energy investment tax credit until December 31, 1985. In order to qualify, the water extracted must be 122°F or hotter. The definition of "geothermal" used in the federal regulations eliminates ground water heat pumps from this tax credit, and it also places most of the potential eastern U.S. low-grade geothermal resources at or below the borderline for federal tax credits.

FLORIDA PROGRAMS

The University of Florida Geophysical Laboratory has investigated heat flow values for the Gulf Coastal Plain and north-central Florida. Thermal gradients found in the majority of the wells drilled in Florida were below average to average, indicating little promise of a significant geothermal resource. However, researchers found above average thermal gradients in the extreme western Panhandle of Florida. This zone of low-grade geothermal gradients extends from Pensacola northwestward to Mobile, Jackson, and northeastern Louisiana and merits further investigation because of its proximity to several large cities. At present, there are no plans to develop this resource.

A second data gathering and investigative process with interest for Florida is being undertaken by the Geothermal Utilization Division of the Naval Weapons Center in China Lake, California. In a feasibility study of Naval bases in Virginia, South Carolina, and Florida, the Naval Air Rework Facilities at Jacksonville and Norfolk were identified as the two best installations for geothermal energy usage. At the Naval Air Rework Facility in Jacksonville, a central station steam power plant is fueled by natural gas. Even though temperature gradients in the Jacksonville study area are only average, the 124°F water from 4,900 feet below ground level is warm enough to preheat water entering the steam boiler. The warm water also can be pumped directly through buildings for space heating and air conditioning. To make the project economically feasible, a flow rate of 200 gallons per minute of water is needed. At present, no geothermal flow rate tests have been conducted. The initial investment for the project would be $1.2 million and would require the installation of a reinjection well in addition to a production well and heat

exchangers. Estimated fuel cost savings would be $181,000 annually with a fuel savings of 63 billion Btu.

In Florida the Underground Injection Program has been delegated to the Florida Department of Environmental Regulation (DER), and permits for Class V wells can be obtained from regional offices of the DER. The easily accessible ground water areas in Florida favor installation of ground water heat pumps. While the exact number of all types of ground water heat pumps are not known, records do exist for the majority of those heat pumps having return wells for reinjecting water into the aquifer. The most recent survey of injection wells in Florida listed about 9,600 Class V wells, the majority of which were air conditioning return flow wells.

The St. Johns River Water Management District estimates there are 16,000 heat pumps which use ground water in Brevard County. Most of these do not return water to the aquifer. The water ejected from these pumps is sprinkled on lawns or runs into the sewer. Large numbers of ground water heat pumps without reinjection wells are a cause for concern, since heavy withdrawal may result in saltwater intrusion. Local ordinances for Brevard County now require air conditioning return wells in new installations.

ISSUES AFFECTING COMMERCIALIZATION POTENTIAL

The low-grade geothermal resources of the eastern U.S., which are generated by heat flow from radioactive rocks deep in the crust, are not as interesting from a commercial standpoint as the high grade volcanic resources of the western U.S. However, the proximity of the eastern resources to cities makes them worth evaluating as such resources could be used for space heating. Therefore, it is conceivable that the use of geothermal resources in Florida may be expanded in the future. Continued research into ways to efficiently tap the hot water resources below the surface of the earth will hasten the day when geothermal energy becomes a commercial reality.

In the West where geothermal development has proceeded quickly, problems in drilling have occured. Hot water may not exist in large enough volumes for the intended use. The disposal of spent hot geothermal fluids also may become an important issue. Reinjection back into the same reservoir normally is the preferred option, but this would increase costs since a disposal well would have to be drilled.

Possibly because of the advantages over air source heat pumps for coastal areas, the Florida market for water source heat pumps (which includes ground water as well as other water source pumps) represents 13 percent of the U.S. market. Sales trends have been relatively steady over the last few years. The projected sales in 1984 are expected to be greater then in 1983, but this may be related to improving economic conditions rather than to a general trend of increased usage.

At the present time, there are few policy options which have a major impact on the potential applications for low-grade geothermal energy in the eastern U.S. However, should the economic feasibility improve, the potential could be enhanced by a change in the geothermal tax credits to allow use of water with a temperature of less than 122°F. If the tax credit were amended to allow ground water heat pumps to qualify, a number of policy issues would become important. Much greater tax losses would be the immediate economic problem since the units are already economic for a number of applications. Environmental and energy policy problems should be seriously considered before such an amendment is contemplated.

From an enviromental standpoint in Florida, the use of discharged water from ground water heat pumps to water lawns and run off into storm sewers is not justified. State and local environmental agencies and water management districts are concerned about this practice. Use of these units on coastal barrier islands will lead to aquifer depletion and saltwater intrusion. If the aquifer is artesian, water will flow through the heat pump and out onto the lawn or drainage system even when it is not needed for air conditioning. In such cases, shutoff valves should be installed so that water only flows when needed. In addition, reinjec-

tion of water back into the aquifer should be required. Because of the potentially serious environmental problems with ground water heat pumps, the government may wish to provide incentives for the installation of closed loop water source heat pumps.

A research topic that may need investigation is the efficiency of ground water heat pumps in southern Florida. For air conditioning use, it is generally accepted that ground water heat pumps are more efficient than air-source heat pumps where the ground water temperature is lower than the air temperature. However, situations in southern Florida exist where the ground water temperature is near the air temperature, and for part of the day the ground water temperature may be higher than the air temperature. It would be useful to research air conditioning strategies in southern Florida with both air- and water-source heat pumps side-by-side to confirm whether the ground water heat pump is the more efficient of the two types of air conditioning units.

A second energy policy area worthy of investigation is the impact on electric utility load factors. In many areas of Florida, no one knows how many ground water heat pumps exist. If a survey were conducted, it is possible that many more than expected would turn up, especially in coastal areas. An effort to find out how many exist will greatly assist the making of energy and environmental policy in Florida.

CONCLUSION

The geothermal resources of Florida are poor in most parts of the state, but offer potential in one or two areas. Ground water heat pumps are efficient and presently abundant water resources exist in most Florida areas, but widespread use of these units could affect Florida's groundwater supplies if reinjection wells are not required. The effect of large numbers of wells on an aquifer in small geographic areas has not been adequately assessed. Data on ground water heat pump energy use for Florida climatic conditions are needed as is information on the number of units currently operating.

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Sources for Further Information

Florida

Governor's Energy Office, Room 301 Bryant Building, Tallahassee, Florida 32301, 904/488-6931.

Provides general information on geothermal energy in Florida.

Florida Department of Environmental Regulation, Twin Towers Office Building, 2600 Blairstone Road, Tallahassee, Florida 32301, 904/488-3601.

Provides information on permits for ground water heat pumps, administers the Federal Underground Injection Control program.

U.S.

U. S. Department of Energy, Division of Geothermal Energy, Resource Applications, 12th Street and Pennsylvania Avenue, N.W., Washington, D.C. 20461, 202/633-8909.

Performs site specific studies, develops advanced technology.

U. S. Department of the Interior, Geological Survey, National Center, Reston, Virginia 22092, 703/860-7444.

Assesses the distribution and magnitude of geothermal resources in the United States.

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EXECUTIVE SUMMARY

Geothermal resources, as traditionally defined, are not likely to make a major contribution to Florida's energy supply. Areas of interest include utilization of above average thermal gradients found in the Florida Panhandle and groundwater heat pump applications.

Federal investment tax incentives limit the development of applications for Florida's low-grade geothermal gradients. Regulations require that extracted geothermal water must be 122°F or hotter. Most sub-surface waters in Florida that can be economically used for heating or cooling purposes fall below this temperature.

Groundwater heat pumps are widely used today in Florida and could increase in importance in coming years. This kind of heat pump takes advantage of groundwater being cooler than ambient air temperatures in the summer and warmer in the winter. The closed loop system probably has better potential for Florida than other systems because it requires less energy to operate pumps and poses no threat to Florida's groundwater resources.

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