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DOE/ET/27196--T17

**WATER FOR GEOTHERMAL DEVELOPMENT
IN IMPERIAL COUNTY:
A SUMMARIZING REPORT**

DE84 013636

SPECIAL REPORT
DOE Cooperative Agreement DE-FC03-79ET27196

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January 1984

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INTRODUCTION

The economy of Imperial County is based on agriculture. Other industrial activity is limited. Agriculture and agriculture-related industries provide approximately 47% of total County employment. In 1982, the gross agricultural income was nearly \$762 million. The warm climate supports four season agricultural production from approximately 530,000 acres of irrigated farmland.

Imperial County also overlies major geothermal resources. The electric generation potential from identified resources has been estimated by the U.S. Geological Survey to total as much as 6700 megawatts for 30 years. Development of this resource has begun: three 10 megawatt power plants are in operation, three larger facilities are under construction, and additional facilities are anticipated by 1990.

The County has the highest unemployment rate in California and has undertaken efforts to attract new industry and increased tourism to the County. Local economic development efforts focus on the major assets of the County: The climate, the agricultural base, the geothermal resource, and available labor. Agriculture-related industries that could utilize geothermal resources to fuel production processes are of particular interest to the County.

Geothermal development has great potential for improving the local economy. In the long run, development could provide benefits in the form of jobs (both in the geothermal industry and in service and support industries) and substantial increases in local property and sales tax revenues. Industrial development would also result in secondary economic benefits such as increased demand for local goods and services. Development could help to stabilize the local economy by diversifying the economic base.

Availability of sufficient water for use by geothermal electricity generation facilities, and potential development-related impacts on the natural water system have been cited as possible impediments to full development of local geothermal resources. This paper reviews information on water issues related to geothermal development, including research on local water resources and quality, cooling water requirements for geothermal power plants, and water for geothermal development. Topics of on-going research are noted and questions for future research are posed.

LOCAL WATER RESOURCES

Colorado River water supports most farming, industrial, commercial, and household water requirements in the County. The Imperial Irrigation District is the major supplier of Colorado River water, providing water to farmers and communities in the central irrigated area. The Palo Verde Irrigation District supplies water in the northeast corner of the County, and the Bard Water District supplies water in the southeast corner.

The Imperial Irrigation District (IID) has prior perfected rights to 2.6 million acre-feet of water per year from the Colorado River. If excess water is available in the river, additional water can be allocated. Conservation measures, such as lining canals, could make more water available

for beneficial uses. IID has a water conservation program. The District has implemented certain conservation measures of the program, and are considering other options for saving water.

IID policy specifies that agricultural and domestic usage of water receive top priority. Any project that uses or processes agricultural products, such as a food processing plant, would be considered an agricultural project and thus would be eligible for a water allocation. Other industrial projects, such as geothermal power plants, may not receive any water priority and thus may be forced to utilize other water sources.

RESEARCH ON LOCAL WATER RESOURCES

Studies of Imperial County hydrology have been made, notably by the U.S. Geological Survey and the U.S. Bureau of Reclamation. Studies discuss the natural water system, the hydrology, geohydrology, precipitation, quality, and water balance of the Imperial Valley region.

Work by the Bureau of Reclamation and the California Resources Agency described Salton Sea conditions, uses, and problems, and suggested possible salinity control measures. Further work assessed those measures and estimated costs of implementation, but feasibility studies were not performed.

Initial local efforts to plan for development of geothermal resources resulted in detailed study of baseline environmental conditions, including study of the natural water system. Research performed by Lawrence Livermore Laboratory (LLL), as part of the Imperial Valley Environmental Project (IVEP) (funded by the U.S. Department of Energy), compiled baseline data on water quality and studied the hydrology of the Salton Sea.

Baseline water quality data is currently collected by the Regional Water Quality Control Board (RWQCB). Biannual sample collection and analysis is performed for a number of sites throughout the County as part of the on-going RWQCB program.

Research sponsored by Southern California Edison is evaluating the Salton Sea ecosystem, water quality, fish populations and breeding, and effects of increasing salinity on fish life. Results are expected to be of value in assessing the impacts of various development projects and in developing feasible measures for mitigating impacts.

The U.S. Geological Survey (USGS) is planning a "Regional Aquifer-System Analysis (RASA) study of Southern California, to be initiated in the near future. The study area will include the Imperial Valley region. As part of this comprehensive study, USGS will compile existing information and undertake additional research. The overall objective of USGS's RASA program is to collect the data necessary for effective management of ground-water resources. Regional studies will provide a foundation for detailed local investigations.

A data base developed by the Electric Power Research Institute focuses on the Colorado River Basin region and describes water collection efforts of many agencies, including data about the region, organizations, and results of past monitoring studies. This data base is available for use in future research projects.

GEOTHERMAL COOLING WATER REQUIREMENTS

The two primary electricity generation technologies for geothermal resources have different requirements for cooling water. "Flash" facilities separate steam from the geothermal brine and use the steam to drive a turbine. The spent brine is then injected into the geothermal reservoir. The condensed steam, about one million pounds per hour from a 50 megawatt power plant, could be used for cooling water, or injected. "Binary" facilities use brine to vaporize a working fluid which is then used to drive a turbine. The spent brine is injected. In general, binary power plants require a greater volume of cooling water than an equivalent size flash plant, and, in Imperial County, will always require an external source of cooling water.

Volume of cooling water required by a particular geothermal power plant also depends upon the heat of the geothermal resource and the resulting energy conversion efficiency, the cooling system technology, and the initial quality of the cooling water. The higher the temperature of the resource, the lower the per megawatt water use.

Early analysis of water needs for geothermal development estimated that from 60 to 120 acre feet per megawatt per year would be required, the lower amount for high temperature resources, such as Salton Sea, Brawley, and South Brawley, and the higher amount in Heber and East Mesa.

Current use by 10 megawatt demonstration plants shows a lower per megawatt consumption. According to the operator of the Edison power plants at Brawley and Salton Sea, actual water use is about 50 acre feet per megawatt per year, and is expected to be lower for a larger capacity plant. The operator of the 10 megawatt binary plant reports that water use in their facility's cooling pond system is also lower than early analyses predicted. Cooling water use by the two commercial power plants, currently under construction in Heber, is estimated at 100 acre feet per megawatt per year.

IID has authorized that up to 20,000 acre feet of water per year for geothermal development may be allocated. Under this policy, projects can be allocated water by IID for the initial 5 years of operation. If water usage for geothermal electricity generation ranges from 50 to 100 acre feet per megawatt per year, as indicated by current facilities, then the IID geothermal water allocation would support 200 to 400 megawatts. Maximum development by 1990 is currently estimated at 500 megawatts, at least half of which would utilize condensate cooling. The current water allocation is thus sufficient through at least 1990. At present, contracts with geothermal developers have allocated 12,000 acre feet per year, and, of this, less than 1,500 acre feet per year are used.

In summary, if all geothermal power plants currently operating, under construction, or proposed were in operation, total cooling water demand would be less than the 20,000 acre feet per year currently allocated for geothermal projects by the Imperial Irrigation District. Therefore, sufficient water for long-term geothermal development may still be a concern, but the short term demand by the geothermal industry is low and meeting that demand is not a problem.

RESEARCH ON WATER FOR GEOTHERMAL DEVELOPMENT

The question of water availability for geothermal energy development was raised during the initial planning for the development of Imperial County geothermal resources. In early studies, researchers hypothesized that geothermal development would be a water producer, that geothermal resources could be used to desalinate brines which would produce water for other uses. Testing by the Bureau of Reclamation and others found that although desalination was feasible, cost of desalinated water would be excessive in comparison with the cost of other usable water supplies. Later studies determined that reinjection of geothermal fluids would be necessary in order to prevent subsidence, dispose of geothermal brines, and improve reservoir productivity.

The next generation of water studies focused on the identification of water sources for long term geothermal energy production and the limitations to use of these supplies. As one task of the IVEP, LLL identified five potential water sources: Irrigation water, waste water from agriculture (available from drains and the New and Alamo Rivers), steam condensate, ground water, and Salton Sea water. As a general conclusion, LLL found that only under the most optimistic geothermal energy development scenario (8,000 megawatts by the year 2010) would cooling water availability restrict development, and then only in the East Mesa and Heber resource areas. According to this analysis, then, sufficient external water supplies are available to support development.

IID and other current or prospective water uses, including the geothermal industry, have begun discussions of opportunities for implementation of water conservation measures that could result in water savings. Water savings could thus be an additional source of geothermal cooling water.

Individual studies of one or more water source, and the technical, environmental, and policy issues regarding use of each source for geothermal cooling, have been performed. Feasibility of the use of a particular water source will depend upon the cost of water treatment and/or utilization technologies. Possible environmental impacts must then be identified and measured for each technology.

For example, if power plant operators use steam condensate for cooling, no external water supply will be needed for flash power plants. Acceptability of condensate cooling will depend upon whether 100 percent reinjection will be necessary, and, if necessary, whether alternative water supplies can be injected into geothermal reservoirs at an acceptable cost. Monitoring of different types and sizes of geothermal facilities over a number of years will be necessary to determine the environmental acceptability of less than 100 percent reinjection. Based on the findings of monitoring programs, requirements for acceptable operations and monitoring and mitigation programs can be determined.

If condensate cooling is environmentally acceptable, then flash steam geothermal projects can be self-sufficient for water. Imperial County has authorized less than 100 percent injection for several commercial power plants. Two operating 10-megawatt plants have authorization to reinject less than 100 percent so that tests of the use of condensate for cooling water can be performed. To date, no project related subsidence has been detected, but operating experience is still limited.

Geothermal injection programs are conditionally approved, and projects are carefully monitored to determine if any detrimental impacts result. According to the California Division of Oil and Gas (DOG), the agency responsible for evaluation, approval, and monitoring of injection programs, geothermal injection programs must be evaluated on a case-by-case basis. DOG anticipates no notable subsidence or other detrimental impacts from currently permitted projects, which total about 150 megawatts.

On-going research and testing by geothermal developers is also assessing the possible use of other water supplies to augment reinjected brines, in the event that 100 percent reinjection proves to be necessary. Preliminary findings of research by the geothermal industry indicates that surface waters are not compatible with geothermal fluids, but the feasibility of water treatment to achieve compatibility has not been determined.

Research on alternative cooling systems is also underway. A study sponsored by the California Energy Commission and the Electric Power Research Institute compared alternate cooling systems for geothermal power plants in order to identify make-up water requirements for different systems and to develop analytical techniques for comparison of cooling options. Other studies have assessed particular water sources, water treatment requirements, environmental impacts of water use, and final disposal of water following use in cooling systems. Research in these areas continues.

CONCLUSION

Existing information on Imperial County hydrology and related issues is extensive. Substantial information on water issues as related to geothermal development has been collected and research is proceeding.

Early researchers expected that geothermal development could produce water for other uses, but it now appears that development will require at least some external water supplies. The current use of water for geothermal development is minor. The short term demand can be met by the current geothermal water allocation. The long term demand for water by the geothermal industry is undetermined. Industry researchers are continuing to study issues related to water for geothermal development. Questions to be resolved include:

What are the water demands of current geothermal technologies as utilized in Imperial County?

What are the water costs for various water sources and cooling system technologies?

What new technologies for water use and conservation have promise for local application by geothermal facilities?

What percent injection of produced geothermal fluids will be acceptable given the geologic conditions within the various geothermal anomalies?

What electricity generation capacity will ultimately be developed in Imperial County and where will facilities be located?

Answers to these questions will require experience with operating geothermal facilities. Various water supply alternatives have been identified, but technical and economic feasibility of the alternatives must still be determined. The possible environmental impacts have been identified, but actual impacts must be measured.

The facilities currently operating and those under construction will help to define local need for water for geothermal development. Local decision makers should periodically evaluate water needs for geothermal development and assure that development of local resources is not unnecessarily limited.