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LIMITING FACTORS ON GEOTHERMAL DEVELOPMENT, IMPERIAL COUNTY, CALIFORNIA, U.S.A.

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ABSTRACT

Imperial County's geothermal resource development is potentially limited by numerous factors. This paper examines six limiting factors of potential importance.

Routing and construction of high voltage transmission lines of 1,000 MWe capacity are essential, because the county is presently restricted by a local transmission network of only 300 MWe capacity. Financing is a limitation because of the large sums of money required for power production. Political factors are likely to surface into major importance, if geothermal development threatens the present agribusiness orientation of the County, among other reasons. The origins of several recent geothermal leadership disputes are discussed. Another limitation is the supply, quality, and environmental impact of cooling water. Direct use transmission pipelines are a limiting factor, because of both high cost and environmental impacts. As geothermal capacity reaches maximum levels, brine waste disposal will become a problem, as brine reinjection is not always feasible.

INTRODUCTION

Imperial County's geothermal electrical capacity is estimated at 2,500 to 6,800 MWe by the year 2020. Presently, total County generating capacity consists of Magma Power Company's 11 MWe pilot plant in the East Mesa KGRA. Direct uses will be added beginning in the early 1980s, with such planned projects as the geothermal heating/cooling of a Community Center building in the town of El Centro, and the utilization of geothermal heat in the Holly Sugar beet processing plant. Chronologically, Imperial County will likely become the second major geothermal area, after The Geysers, to be developed in the United States.

The present study stems from a larger research project at the University of California, Riverside, to study geothermal development in Imperial County, California, which has run from 1975 to the present, partly under NSF/DOE sponsorship from 1975-77, as well as under Lawrence Livermore Laboratory sponsorship from 1976-78. In this broad project, the present researchers were involved in studying the population, socioeconomic, public opinion, leadership, and policy aspects of the County's geothermal development, results of which are summarized in a previous report. (Pasqualetti et al,, 1979), as well as in two forthcoming reports (Pick and Butler, 1979; Butler and Pick, 1979--a full summary volume).

LIMITING FACTORS ON GEOTHERMAL DEVELOPMENT

As large scale geothermal development commences in the County, many factors will combine to limit its size and pace. For the purposes of this paper, a limiting factor is defined as a major impediment to the realization of geothermal potential. The following list presents major limiting factors for Imperial County:

1. Transmission lines
2. Financing
3. Political factors
4. Cooling water availability
5. Direct use transmission pipes
6. Brine waste disposal

Although all these are considered important as limiting factors, the list is ordered in importance. However, the real order of importance will depend on unknown future chains and sequences of events, as the geothermal development process unfolds.

Transmission Lines

Central to transmission lines as a limiting factor is the existing transmission network of the local utility, the Imperial Irrigation District (IID), which can only transmit a maximum of about 300 MWe out of the County. Although the problem of geothermal energy will be solved by construction of one or more 500 kV lines out of the County, there are delays of five to ten years in planning the corridors, purchasing and condemning land, overcoming regulatory and legal delays, and constructing the transmission lines.

One solution proposed by the Imperial Valley Action Plan (1978) is to allow export of 2,000 MWe of geothermal energy by expanding the existing IID network into a triangular-shaped collector' system consisting of 230 kV lines. This collector system has nodes in all four KGRAs and has three interconnection substations to the 500 kV lines. To realize such a full system, however, will take from 5 to 20 or more years. Recently, the San Diego Gas and Electric Company announced construction plans for a 500 kV line from Arizona to San Diego, to follow either a lower (Heber) route or middle route (Niland) across the County. Construction is planned in two stages, with the Imperial Valley-San Diego link going in a year or so before the Valley-Arizona link. Energy imported to California from Arizona and New Mexico will be largely coal-fired rather than nuclear, because the Palo Verde nuclear energy is already under contract. This plan is conditional on approval by the California Public Utilities Commission. This announcement appears to imply an increase above the present 300 MWe limitation in the late 1980s.

Financing

This is a factor of major importance, because of the large development cost per installed kW--a cost estimated at $417-865/kW in 1979 dollars, based on Larson (1977). Hence, for complete development of a field and power plant of 50 MW capacity, 20.8 to 43.2 million dollars must be raised by developers, utility companies, and others. A conference of the Geothermal Resources Council was recently devoted to the subject of geothermal financing (Geothermal Resources Council, 1978). The brief discussion below is largely based on that conference. For a fuller discussion, the reader is referred to the conference proceedings.

There are different ratios for distributing a dollar sum of geothermal investment between developer, utility, and possibly also banks, finance companies, insurance companies, the general investing public, and the government. In addition, however, it is also necessary to spread the risk of financial loss among one or several of the above parties. Since a geothermal development project takes place over many decades, the distribution ratios for money and for financial risk may vary at different time points in development.

Many solutions to geothermal financing have been proposed. Four of these are mentioned briefly.

1. Developer-utility contract. This is the standard geothermal financial package, which generally has costs split rather evenly between developer and utility, but with risks weighted more heavily towards the developer.

2. Developer-IRAC-Utility contract. This is a modification of solution 1. An IRAC, or Interim Risk Assuming Company. is a corporation created only for the purposes of a single development project. The IRAC, falling between the developer and utility, is responsible for power plant construction and assumes most or all of the financial risk.

3. Leveraged Leasing. This solution is analagous to leasing a home, as follows: The "homeowner" (that is, leasing company which owns the power plant) obtains financing from a "mortgage company" (that is a bank or insurance company) and leases the "house" (that is, power plant) to a lessee (that is, utility). A weakness of leveraged leasing for geothermal purposes is that the distribution of risk has not yet been determined by the legal system.

4. Geothermal Loan Guarantee Program. In this DOE program, 25% of the financing cost is borne by the federal government for qualified development companies. A weakness in this program is that large companies are not willing to risk loss of company-wide credit ratings in the case of default.

Besides financial packaging options, there are other measures to reduce risk in geothermal financing. These include shared projects and reservoir insurance. In a shared project, several utilities join together for percentage participation in a project. A second risk reduction measure is insurance of the reservoir for both length and quality of production. As the geothermal energy sector grows, the insurance industry will most probably develop plans for this type of insurance.

Political Factors

These include public opinion and leadership disputes. Disputes involving geothermal energy have already surfaced. For example, a dispute has arisen over the proposed location of a secondary sewage treatment plant in the Brawley KGRA. Landowners were concerned about displacement of their agricultural holdings. The geothermal developer (Union Oil) was involved, because of city proposals for possible injection of the sewage plant effluent into Union Oil's geothermal reservoir. The outcome of this complicated dispute is not yet clarified, but may involve litigation. Another dispute which recently surfaced involved a retraining program to train County residents in geothermal skills. This dispute has revolved around the question of precedence of union workers over retrained residents for geothermal jobs.

These two examples are precursors of many potential political disputes as geothermal development unfolds. As limiting factors, political conflicts will surface unpredictably, depending on developmental events. Many recent energy events in the United States, including the dispute over the location of the Sun Desert nuclear plant, have been limited by political factors.

Direct Use Transmission Pipes

Direct use applications of geothermal are limited by the distances from geothermal fields to the urban areas or industrial plant sites, which use the hot water. For house heating in the Western United States, a very small percent of the population lives within 10 miles of the water-dominated geothermal fields (Lienau, 1978). The major towns of Imperial County, Brawley, El

Centro, and Calexico, accounting for 58.6 percent of the 1970 population, are either in the middle of a KGRA (Brawley) or bordering a KGRA (El Centro and Calexico). Therefore, distances from major town to KGRA direct heat sources are, at the most, several miles.

The El Centro Community Center and Holly Sugar Plant direct use projects do not plan to utilize heat sources in KGRAs. Rather, drilling will be done within a half-mile distance from each site on non-KGRA land. Many of the other potential industrial direct uses are likewise within a half mile of KGRA or non-KGRA heat sources.

With such small hot water transmission distances relative to the rest of the western U.S., direct use would appear very favorable in the county. Such a picture, however, is made less rosy by the high cost of deep geothermal drilling in the Imperial Valley, and by the high cost and environmental problems of transmission pipes. Drilling costs are high because the three reservoirs near the populated areas are all at the minimum 3,000 feet deep. The cost of a production well at such depths ranges in cost between $500,000 and $1,200,000. At other direct use locations such as Boise and Klamath Falls, drilling costs are much lower because the medium and low temperature reservoirs underneath these cities are much shallower, sometimes only several hundred feet in depth.

A second problem is the cost of transmission pipes. Goldsmith (1976a) cites costs (installed) for surface transmission pipes of $10,000/mile per inch of pipe diameter. For a typical hot water well, steam and water pipes with one-way flow will cost $220,000/mile. However, the cost is considerably increased by burying the pipe. The increase is due to costs of excavation, of special insulation to protect against ground water, and of special thermal expansion outlets. TRW (1977) estimates that buried 14" insulated pipes, with two-way flow, cost $1,290,000 per mile. Similar 10" pipes would cost $850,000 per mile. In Imperial County direct use applications, two-way brine flow is necessary because of the necessity to reinject. Therefore, even for the maximal, several mile distances in the County, transmission pipe costs would be substantial.

Under such financial constraints, how could the huge Icelandic direct use have been built? In Reykjavik, Iceland, for instance, the direct heating system serves 15,600 homes and apartments, The project economics are viable because of the consistency of Iceland's seasonal and diurnal patterns, and because of cost sharing achieved by a large number of consumers.

Environmental problems with transmission pipes stem from the extremely high temperatures (300-400^o F.) of the steam and brine in the pipes. There are dangers to humans and animals from pipe contact (Goldsmith, 1976a). In addition, for buried pipes, small persistent leakages could lead to ground contamination, while a pipe burst would be a major hazard to the land.

Cooling Water Availability

If no environmental controls are present, water presents no problem for geothermal development. For example, at the Cerro Prieto geothermal plant south of Mexicali, Mexico, agricultural drain water is used for cooling purposes without concern for environmental damages, such as land subsidence, land pollution, and others. In Imperial County, however, environmental controls will be strict. The Geothermal Element of the County General Plan has strictures against subsidence, damage to agricultural land, geothermal use of fresh irrigation canal water, and so forth. Therefore, cooling water requirements will need to be carefully analyzed by all power plant operators in the Valley.

VTN Inc. (1978) recently studied cooling water availability options for the Imperial County KGRAs under a variety of power plant designs (flash, binary) and a variety of cooling water sources (agricultural waste water, canal water, ground water). Perhaps the most realistic option, of seven options studied, is Option B (flash steam, complete reinjection, use of agricultural waste water). In this case, three KGRAs may be developed to maximum field capacity without cooling water constraints. These KGRAs with estimated maximum field capacity in parentheses, are Heber (1000 MWe), Salton Sea (2000 MWe), and Brawley (1000 MWe). The East Mesa KGRA (500 MWe) is constrained by water availability at only 40 MWe, because of the slight flow of agricultural waste water in the Alamo River in the southern part of the county. Another less probable option studied is Option D (flash steam, complete reinjection, use of ground water, indirect contact condenser). In this case, maximum field capacity is reached in all four KGRAs, without water constraints.

Although the volume of cooling water does not appear to be a major limiting factor for geothermal development, this factor is complicated by the potential effects of water options on the Salton Sea. When the Sea was formed, it rose to a height of 80 feet and then receded to a height of 55 feet. Since 1925, the Sea has been rising. If geothermal water options cause a rise, landowners on the Sea edge will be threatened. On the other hand, if an option causes the Sea to fall, sports facilities at the Sea edge will be endangered. If the Sea's salinity rises, certain aquatic species in the Sea, such as the sport fishes sargo (Anisotremus davidsoni) and gulf croaker (Bairdiella icistia) will be threatened (Layton, 1978). Goldsmith (1976b) performed computer simulations to determine effects of water options on the Sea's level and salinity. Depending on cooling water options chosen, for a 1000-2000 MW capacity, the Sea level would vary between a 4 foot fall and a 10 foot rise, and Sea salinity would vary between eventual stabilization and doubling in amount.

Brine Waste Disposal

A final limiting factor is the disposal of geothermal brines. Geothermal brines are very hot and corrosive. In addition, they may contain potentially damaging biological materials. There has been little experience worldwide with environmentally regulated brine disposal. The reason is that many existing plants are permitted to cause significant pollution from brine wastes. At Cerro Prieto, for example, brine wastes are discharged into an evaporation pond. At Lardarello, Italy, most wastes are disposed, untreated, into local streams, while at Wairakei, New Zealand, all brine wastes are emptied into the Waihato River.

What brine disposal options are available? Defferding et al. (1978) proposed the following list:

1. direct surface discharge
2. treatment and surface discharge
3. ponding
4. secondary use of effluents
5. reinjection
6. reinjection with pretreatment

Options 1 and 3 appear ruled out in Imperial County by the County General Plan. Presently, option 5 is the most popular one in the planning of power plants in the County. However, this option has several major problems. First, there may be plugging of the reinjection wells. Second, there may be reduction in the permeability of the geothermal field due to precipitation of the reinjected brines. Finally, there may be a sanitary danger to drinking water if biological organisms survive in reinjected fluids,

Options 2, 4, and 6 have the disadvantage of requiring sewage treatment facilities. The cost of these options will be related to the chemical quality of the geothermal brines. The extent of limitations from the brine waste disposal factor is unknown for a water-dominated resource in an environmentally regulated region. Presently, no provision has been made by the County for a shared disposal site. Although individual developers appear to favor option 5, they may be forced into forms of water treatment.

CONCLUSION

Geothermal energy is inherently regional, since it constrains locations of power plants and direct use applications to within several dozen miles of the resource. For this reason, geothermal will be developed in a wide variety of geographic, environmental, and social locations. Hence, the six limiting factors discussed for Imperial County will likely be different for other development locales. Such differences from region to region make it all the more important to identify a region's limiting factors early in the geothermal development process. Once the factors are clearly identified, private industry and governmental planners can hopefully proceed more quickly in mitigating them to allow a reasonably swift development process and maximize eventual energy capacities.

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