AN INTEGRATIVE ANALYSIS OF THE
SOCIAL, ENVIRONMENTAL, AND INSTITUTIONAL CONSTRAINTS
UPON THE DEVELOPMENTAL PROSPECTS FOR GEOTHERMAL
ENERGY IN THE SOUTHWESTERN UNITED STATES

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The previous papers in this session have discussed many economic factors and some technological considerations which impact upon the geothermal development process. The present paper, while not ignoring those issues, will stress the so-called institutional constraints and opportunities associated with the goal of developing geothermal resources. Many, if not most, developers believe, or at least talk as if they believe, these institutional factors—often linked to a lack of coherent policy or policy conflicts—are the major cause of the long delays and high costs associated with the development of this natural resource.

The overall goal of this aspect of the Southwestern Regional Operations Research Program is to identify the individuals and agencies whose single and mutually interactive participation affect the rate of geothermal resource development. These participants in the development process may be categorized into four major classes as a function of the locus, if not the magnitude, of their potential effect: (a) Federal agencies and regulations; (b) State agencies and regulations; (c) resource developers and utility operators; and (d) local officials and residents.

During the past year the Southwest Regional Program has concentrated on identifying State agencies and the State laws and regulations that affect geothermal development within the region. The issues involved at the Federal level and between the Federal and State levels of operation have been addressed by the Institutional Barriers Panel of the Geothermal Advisory Council. The activities and perceptions of the developers and of citizens living near the location of geothermal fields has to date been inadequately assessed and frequently ignored. The core team at New Mexico State University with the assistance and cooperation of teams from each state in the region will address these latter categories of institutional factors during the coming year.
The institutional studies conducted by the New Mexico State University program have several specific goals. First, it is recognized that institutional factors are a major element in regional aggregated scenarios which depict the time-phased activities required to develop geothermal energy. Hence, these studies were necessary to the creation of those scenarios. Second, it was reasoned that through an analysis of the development scenarios it would be possible to identify factors which acted as constraints and, hopefully, other factors which served as opportunities to the development of geothermal resources. Third, based upon the knowledge acquired from an examination of development scenarios it should be possible to recommend policy initiatives which would overcome or mitigate the constraints and exploit the opportunities to geothermal development.

While not explicit in our contract goals or in our published reports, a fourth goal of the program is to assist in the development of a knowledgeable and properly motivated infrastructure that could and would promote the development of geothermal resources within each state of the region. It has been pointed out by a previous investigator (Hiatt, 1977) that whether the climate for the use of geothermal energy sources will be positive or negative is often directly related not only to state policies but also to the attitudes of the governors and other elected officials. Hence, by the very act of conducting these investigations it is hoped that there will be an increase in public perception of the issues at hand and that these perceptions will lead to a higher degree of political interest and an increase in necessary political leadership.

None of the goals listed are unique to the program centered at New Mexico State University. Significant efforts directed at the same goals have occurred at the national level through the efforts of such groups as the National Conference
of State Legislatures (c.f., Sacarto, 1976) and at regional level by such groups as the Pacific Northwest Regional Commission (c.f. Balmer et al., 1977) and the Battelle Human Affairs Research Centers (c.f., Schuller et al., 1976). In fact, the institutional constraints and opportunities identified by the Southwest Operations Research Program are distinctive primarily to the extent that they are often unique to the five states which comprise the regional area. While there is no intention to deemphasize the significance nor the generality of the results to be reported, the most noteworthy accomplishment of these efforts may have been the establishment of knowledgeable proponents of geothermal energy in the executive branch of each state and to have facilitated an interaction among local, state, and regional agencies.

The comments which follow are organized into three sections: (a) a discussion of the definition of institutional factors that was adopted by the program leaders; (b) a description of two procedures which have been used to obtain information relevant to institutional factors affecting the development of geothermal resources in the southwest region; and (c) a summary of the results obtained through March 1978.

Definition

The core team has adopted a position which parallels the one so adequately described by Schuller et al. (1976) in their analysis of institutional problems in developing geothermal resources in the State of California. Those researchers argue that the so-called institutional problems usually occur when one participant in the development process has to deal with another. That is, the factors of interest occur as a result of actions of and the interaction among participants in the development process; actions and interactions initiated and constrained by various statutes, regulations, and policies. In short, institutional problems are behavioral issues. To underscore the behavioral aspects of the entire process, it should be noted that any given regulation or the consequences of any
given action may be perceived quite differently by different participants. For example, one developer has complained to the core team that it may take as long as six months to obtain a permit to drill a geothermal well. On the other hand, a state-level regulator was attempting to be quite positive when he pointed out that a permit to drill a geothermal well can be obtained in as little as 12 to 18 months. These types of behavioral problems may be resolved through a type of mutual learning process (institutional learning), or as a result of changes in technology or in the legal and regulatory context.

Figure 1 summarizes the nature of the interactive behavioral system the core team has in mind. The rows and columns of the block diagram shown in Figure 1 represents the various participants; the crossing of rows and columns shows their interaction. The third dimension shown in Figure 1 represents stages in the general development sequence. Cell entries should be data showing the frequency, importance, and duration of contacts among participants at each stage of development.

We have begun to make inroads into acquiring the data needed to fill the cells shown in Figure 1. The progress to date is especially noteworthy when it is recognized that there was no one person or agency familiar with the specifics of institutional factors in any state nor, obviously, with the characteristics and magnitude of variations in factors across the five states in the southwest region.

**Procedures and Results**

Two procedures have been used to acquire information needed for an understanding of institutional factors: (a) an examination of statutes, regulations, and policies, and (b) an examination of leasing and permitting information. These two procedures and the results obtained with each are presented below.

Regulations and policies—The core team drew up a list of general information needs (see Tables 1 and 2). These information needs were submitted to each
MODEL ILLUSTRATING THE INTERACTION AMONG PARTICIPANTS OVER STAGES OF DEVELOPMENT.
Legal Information Needed for S.W. Regional Or Project

Legal Analysis: State and local laws (court decisions, statues, and regulations) which prescribe the basic rules under which the process in geothermal development occurs. These rules may be concerned with environmental impact, limitations, leasing procedures, land use, tax burdens, responsibilities to the public, etc.

A. State level
   1. Copies of laws and regulations
   2. Contact points (offices or individuals)
   3. Have the laws and regulations ever been tested or challenged?
   4. Are any changes in these laws or regulations anticipated?
   5. Are any new legal issues anticipated?

B. County level

C. Regional level

D. City or local level

E. Relationships and potential sources of conflict among laws and regulations issued by various levels of control.
TABLE 2

INSTITUTIONAL AND POLITICAL INFORMATION NEEDED FOR S.W. REGIONAL OR PROJECT

Institutional Analysis: Individuals and agencies in the process.

Beginning at the state level and proceeding through county, regional, special purpose district, and local levels. Also note any public interest or community action groups who have or may acquire some interest in the geothermal development process. For each institutional entity provide the following information:

1. Their name/contact point
2. Their objective
3. Their operating procedures
4. Their defined tasks and responsibilities
5. Their organizational structure
6. Their history, experience, track record
7. Who reports to them and to whom do they report.
8. Their specific relationship to the various stages of geothermal development:
   a. Leasing
   b. exploration
   c. selling of the resources
   d. field development
   e. power plant construction, etc.
9. Response times
10. The relationships among these individuals and agencies and between them and federal agencies.
state team. As can be seen, we gave the state teams a general shopping list hoping that the information we were seeking did in fact exist. For the most part, we were looking for copies of relevant regulations, other written policies, and any other documentation that might be relevant in describing the activities of participants.

As the respective state teams began to provide the information required, we were able to create a broad brush picture of the legal, institutional, and political environments within which geothermal resources were to develop. These initial descriptions of institutional factors permitted us to generate more specific sets of questions and information needs which were then sent back to the state teams. A continuing interactive process was established in which the core team and the state teams exchanged information and questions concerning institutional factors. The core team has, in effect, served as the coordinator of information that flows about in a Delphi-type procedure of information acquisition currently used in many types of planning and forecasting studies (see for example Dalkey, 1965). Two specific examples of the results of this procedure are shown in Figures 2 and 3.

Figure 2 illustrates a preliminary scenario which shows time-phased activities of institutional entities relevant to the leasing of state lands for geothermal development in the state of Arizona. This preliminary scenario and another concerning exploration are based upon information contained in Arizona House Bill 2257 and 1972 Oil and Gas Conservation Commission Rules and Regulations Governing Geothermal Resources. As shown in Figure 2, all state land used for geothermal development in Arizona is leased by competitive bidding after the State Land Department has designated a site as a known geothermal resource area. The State Land Department apparently has solitary responsibility for the leasing of state lands.
FIGURE 2

ARIZONA

Time-Phased Activities

Relevant to Geothermal Development

Developer(s)

State Land Dept.

State Oil & Commission Gas Conserv.

Initial Lease Applic.

KGRA Listings Announced

Review Lease Proposals

Notice of Availability

Refusal to Lease

Lease Bids

Lease to Highest & Best Bid

Reject Bids

Designation of KGRA's

10 wks.

Review Written Bids
An examination of the scenario shown in Figure 2 led to several specific questions which were communicated to the Arizona State Team. Three examples will illustrate this phase of the iterative process. (a) There was a need to clarify just how the call for bids were announced. (b) Once leasing bids were accepted, it was not clear how tied bids would be dealt with. We already knew that some states had anticipated this possibility. Utah, for example, has a public drawing to resolve ties. (c) It was not clear what, if any, procedures there might be within the Arizona Land Department to deal with appeals by either the applicant or the public to decisions made by the department.

In addition to specific questions and information needs, the core team was also able to identify other agencies within the Arizona state government about which information was needed. For example, the state team was asked to provide the core team with information concerning the Arizona Water Commission and the Advisory Commission on the Arizona Environment.

The scenario illustrated in Figure 3 shows the time-phased activities of institutional factors relevant to the leasing Colorado State Lands. Several things should be noted with respect to the information contained in Figure 3. (a) The Colorado state team estimates that the entire process of leasing state lands could be complete in seven to eight months. This type of response time information is critical for accomplishing the objectives of the overall operations research project. (b) Unlike the situation previously discussed for Arizona, leasing state lands in Colorado may occur through either competitive or noncompetitive bidding processes. (c) Colorado rules and regulations specifically require the Land Commissioners to send copies of the developer's application to other agencies for their review and comment.

Scenarios like those shown in Figure 2 and 3 were constructed for each state in the southwest region for the leasing, the exploration, and the field
FIGURE 3

COLORADO

Time-Phased Activities

Relevant to Geothermal Development

<table>
<thead>
<tr>
<th>Developer(s)</th>
<th>Application</th>
<th>Lease Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Board of Land Commissioners</td>
<td>Status of Land</td>
<td>Evaluate Impact and Feasibility</td>
</tr>
<tr>
<td>Oil and Gas Conservation Commission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mined Land Reclamation Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado Geological Survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>County</td>
<td></td>
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</tr>
</tbody>
</table>
development stages of geothermal development. Table 3 summarizes the information contained in these scenarios. Several facts become evident only after comparison of the rules and regulations existing in the five states. None of the states have any formal regulations for prelease exploratory (casual use) activity. Except for Colorado, a single office has sole responsibility for leasing state land. In addition, with the possible exception of Colorado, there are no legal and binding provisions at the state level for an environmental assessment before state land is leased for geothermal development. Drilling permits are handled by oil and gas commissions in three states and in Arizona that commission has sole responsibility for all water and environmental issues which might arise with respect to field development. The extent to which the states have explicitly dealt with issues of water and environmental protection varies considerably across the region. Colorado and Nevada have assigned responsibility for these environmental factors several agencies while Arizona and Utah have placed all responsibility in one office.

In summary, there is considerable variability in the status of legal and institutional factors across the five states which comprise the southwest region. While all of the information needed to conclude this approach to the overall effort are not currently available to the core team (or presumably to the respective state teams), it would also appear that each state has developed slightly different procedures for interacting with Federal agencies. One argument often heard from developers is that legal and institutional factors are a major if not the major problem inhibiting the development of geothermal resources. If this argument is true, the dimensions of the problem need to be more adequately identified and analyzed before solution can be formulated. As may be seen, the core team, working with the state team, has come a long way in accomplishing this objective.
### TABLE 3

**STATE-LEVEL PARTICIPANTS IN GEOTHERMAL DEVELOPMENT**

<table>
<thead>
<tr>
<th></th>
<th>AZ</th>
<th>CO</th>
<th>NV</th>
<th>NM</th>
<th>UT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leasing</strong></td>
<td>Land Dept.</td>
<td>Land Comm.</td>
<td>Div. St. Lands</td>
<td>Comm. of Public Lands</td>
<td>Div. of State Lands</td>
</tr>
<tr>
<td></td>
<td>OGC</td>
<td>Reclam. Bd.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>CGS</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>County</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Status of geothermal development -- In addition to analyzing the rules and regulations which affect the development of geothermal resources, action was initiated to determine what exactly has happened in each state with respect to leasing, exploration, and development. The information provided by state teams was analyzed to determine how much activity was occurring or was in the planning stage. The assumption was that an analysis of these activities and, by inference, the absence of significant activities would allow the core team to identify barriers and opportunities.

Table 4 summarizes the result of this approach. The upper portion of the table shows the number of acres that have been leased within each state and, when possible, the status of lease applications or land available for leasing. The numbers in parentheses refer to the number of leases or lease applications. The central row of the table shows the level of exploratory activity. The number of sites on which drilling has occurred is shown as well as the number of applications for drilling permits that have been made and/or approved. Finally, the lower portion of Table 4 shows the status of active field development within each state.

As may be seen, leasing activity varies considerably across the southwest region from nearly none in Arizona to over 600,000 acres in Nevada and Utah. The status of leasing is also moderately high in both Colorado and New Mexico. The total acres leased in Colorado include 40,000 acres which have been dropped after the completion of exploratory drilling. About 30,000 acres recently leased in New Mexico have not been identified to the core team as federal or state lands. Information concerning the status of lease applications or of non-leased geothermal resource land is not as complete as would be desired. Five federal KGRA's were offered in Colorado but no bids were received. Very many lease applications (1,374) by 150 applicants are pending in Nevada. The latter number of pending
<table>
<thead>
<tr>
<th></th>
<th>AZ</th>
<th>CO</th>
<th>NV</th>
<th>NM</th>
<th>UT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leases - ac (#)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KGRA</td>
<td></td>
<td></td>
<td></td>
<td>42,000</td>
<td>75,000 (45)</td>
</tr>
<tr>
<td>Non-KGRA</td>
<td></td>
<td></td>
<td>152,000 (79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td>494,000</td>
<td>117,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>83,000 (31)</td>
<td>79,000</td>
<td></td>
</tr>
<tr>
<td>Applic.</td>
<td>Several</td>
<td></td>
<td>(5 KGRA's)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2,638,000 (1,374)</td>
<td></td>
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</tr>
<tr>
<td>Exploration - #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fed</td>
<td></td>
<td></td>
<td>1 (deep TG)</td>
<td>40</td>
<td>51 deep</td>
</tr>
<tr>
<td>State</td>
<td></td>
<td></td>
<td>17 (TG)</td>
<td></td>
<td>- 14 done</td>
</tr>
<tr>
<td>Private</td>
<td></td>
<td></td>
<td>64 (tests)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applic.</td>
<td></td>
<td></td>
<td>1 deep, 5 shallow (TG)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>166 NOI (25 deep)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development</td>
<td></td>
<td></td>
<td>Several Valles Caldera</td>
<td>Roosevelt H.S.</td>
<td></td>
</tr>
</tbody>
</table>
leases seems very large. On the other hand it is worth noting that 23 of 30 KGRA's in Nevada have been offered for lease.

The level of exploratory drilling within each of the five states parallels the activity in leasing. While little exploratory drilling has occurred in Arizona and Colorado, and while no deep wells have been drilled on Federal lands in Nevada, there have been a number of thermal gradient wells drilled in all of the states. Furthermore, deep wells have been drilled in the four states which have had activity in leasing. Relatively large amounts of drilling activity are likely in the two most active states: Nevada has over 150 notices of intent on file (25 for deep exploratory wells) and only 14 of the 51 deep wells approved in Utah have been drilled.

Development of geothermal resources has progressed considerably on at least four sites. In each of those areas it is projected that there will be 50 - 55 megawatt demonstration plants with power on line before the mid 1980's.

It is of course very difficult to know how much progress there might be in the development of geothermal resources if there were no legal or institutional barriers. On the other hand, the data used in constructing Table 4 show that development is occurring and will continue to occur at an even faster rate in the near future. Overall, there is reason for optimism. Not only have plans for future field activity been formulated by developers, there are also several indications of meaningful changes in the structure and response times of agencies responsible for regulating these activities. A memorandum of understanding for cooperative procedures was approved in 1976 by the Bureau of Land Management, the U.S. Geology Survey, and the Fish and Wildlife Service. Another memorandum is under consideration which would add the U.S. Forest Service to the list of cooperating agencies. In addition, the Environmental Protection Agency has produced a set of recommended interim guidelines for environmental standards which
hopefully will be uniformly acceptable to all regulatory agencies, and hence, reduce the uncertainty which presumably served to constrain geothermal development. This type of action among the regulatory agencies is extremely meaningful and represents the types of interagency cooperation that should increase as the nature of the problems and benefits associated with geothermal resources become better understood.

Figure 4 shows evidence of institutional learning for agencies involved in the leasing of non-KGRA lands in the state of Colorado. This figure shows the number of months required to obtain a lease for 31 different sites as a function of the date of filing the lease application. While the exact nature of the lands in question were not known to the core team, it is clear that leasing time has decreased from 18 to 35 months for applications filed in January, 1974, to only 10 months for applications filed in March, 1975. As suggested earlier, there is evidence that barriers to geothermal development will be further reduced in the future.

Many of the improvements in the status of institutional factors have occurred in the Federal arena. It is expected that similar improvements will occur if meaningful integration of objectives and procedures were to occur among state agencies and between agencies at the State and Federal levels.

Conclusions

Two procedures used to obtain information relevant to the institutional factors have been described and some preliminary results from these efforts have been presented. Taken together, the data resulting from these efforts have allowed the core team to identify some constraints and some opportunities for the development of geothermal resources. Furthermore, these data are suggesting actions which may be used to overcome the barriers and to exploit the opportunities.
FIGURE 4

LEASING TIME NON-KGRA (FED.)

COLORADO

Date of Lease Application

Time to Obtain Lease (months)
References


