SGP-TR-25-23

PROCEEDINGS
THIRD WORKSHOP
GEOTHERMAL RESERVOIR ENGINEERING

December 14-15, 1977

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Stanford Geothermal Program
Workshop Report SGP-TR-25*

*Conducted under Subcontract No. 167-3500 with Lawrence Berkeley Laboratory, University of California, sponsored by the Geothermal Division of the U.S. Department of Energy.

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PANEL SESSION--RAPPORTEURS' REPORTS

VARIOUS DEFINITIONS OF GEOTHERMAL RESERVES

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Panelists: Dr. Stephen Lipman, Union Oil Co., P.O. Box 6854, Santa Rosa, CA 95406
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James G. Leigh, Vice-President Lloyd's Bank of California, 612 S. Flower St., Los Angeles, CA 90017
Dr. L. J. Patrick Muffler, USGS, 345 Middlefield Road, Menlo Park, CA 94025
Mark Mathisen, Planning Department, Pacific Gas & Electric, 77 Beale St., San Francisco, CA 94106

Rapporteurs: George A. Frye, Aminoil USA, Inc., P.O. Box 11279, Santa Rosa, CA 95406
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Introduction: Jack Howard and Werner Schwarz, LBL

To assess the importance of the confidence level of geothermal resources to those involved with the decisions on utilization, it was felt that a panel discussion to review the factors which affect the confidence level would be of general interest. With that objective, the panel members listed above were convened to discuss the problems of confidence level of the various sectors of the geothermal community. To allow for freedom of expression of the panel members, formal prepared presentations were not required. Instead three rapporteurs also representing diverse sectors of the community, industry, non-profit institutions, and government agencies, were requested to prepare summary overviews of the panelists' remarks. The rapporteur reports follow:

George A. Frye

The title of the panel could have alternatively been "What Constitutes Geothermal Reserves?" To answer this question the panelists presented almost a continuum of viewpoints from optimistic liberalism to extreme conservatism.

Dr. L. J. Patrick Muffler from the U.S. Geological Survey presented the Survey's methodology in reserve classification. He discussed the analogy with petroleum and mineral classification and presented Flawn's 1966 definition of reserves as "that quantity of minerals that can be reasonably assumed to exist and which are producible with existing technology and under present economic conditions." To implement this

definition the Survey first identifies a resource base, quantifies the resource within it, and finally applies existing technology and present economic condition constraints to develop a reserve number.

Under this methodology, the concept of reserves in the future is highly speculative even for a quantified resource. Geological Survey Circular 726, Assessment of Geothermal Resources - 1975 is therefore explicitly resources and "in lieu of an objective analysis, subjective decisions were made as to the most likely divisions" (reserves or other categories). As a final comment Dr. Muffler stated "you must have drill holes for reserve calculations."

The second panelist, Stephen C. Lipman of Union Oil Company of California, concurred that Flawn's reserve definition was reasonable for Circular 726 as a national energy planning guide. He cautioned, however, that we should not be overly optimistic in making reserve estimations. For a resource industry standpoint the key phrases in this definition are existing technology and present economic conditions.

The geothermal developers are spending large sums of money to establish the size of the geothermal reserves, which are orders of magnitude larger than the initial plants being planned. Initial designs at East Mesa, Brawley, Heber, Valles Caldera, and Roosevelt Springs vary between 10 and 50 megawatts. The capital requirements for this initial reserves determination must come from the corporation, which will not see any return on its investment for eight to ten years. In contrast, this utility will begin generating income within three years from its initial capital outlay. The rate payer could benefit by having the utility share some of the developer's risk by installing the small initial plants during the reserve determination phase of development.

Union does not list geothermal reserves in their Annual Report to the stockholders until a contract has been consummated with a utility and the required construction permits have been obtained (e.g., Philippines, The Geysers).

Mr. Lipman was questioned on Union's method of reserve determination. He responded that it would take a minimum of three deep wells to perform an interference test. Assuming that these wells were in hydrologic communication with each other, this would provide data of reservoir productibility, injectivity, permeability, and porosity-thickness. Geological and geophysical studies could provide estimates on the size and configuration of the resource. This is the stage of development when a small power plant would be most beneficial in determining the optimum surface and subsurface engineering design for the ultimate field development.

Mark R. Mathisen, Pacific Gas and Electric Company, substituted for Arthur L. Martinez, Public Service Company of New Mexico. Due to Mr. Mathisen's experience he confined his comments to The Geysers and related PG&E's history. PG&E began construction on their first unit of twelve megawatt capacity in 1958. All wells required for this unit were drilled and completed. At that time the company viewed this effort as a research and development project. The unit commenced commercial production in 1960; additional units followed and by 1965 the company had adopted a development attitude toward geothermal resources at The Geysers.

Reflecting on this history, Mr. Mathisen commented that a utility is closely regulated and reviewed for undue risks; a utility does not normally fund research and development. However, in this case risk acceptability was favored by low entry costs. Thus for utility, as with many private enterprises, risk has a size connotation. Risk acceptance is increased by knowledge and at The Geysers PG&E has made commitments to build units of 110 megawatts on about 800 acres of proven area. The number of steam wells per unit varies due to individual well flow capacities. Even at The Geysers reserves determinations contain uncertainty and pose the problem of reservoir guarantee. That is, the company must be on the alert for any reduction in geothermal generating capacity so it can fulfill its supply commitments.

James G. Leigh, Lloyd's Bank of California, spoke as a representative of the banking industry. A banker is not trained to determine the reservoir, but to assess its value. A banker utilizes the asset anology "Can it be sold?" If affirmative, "What is its fair market liquidation value?" A banker's method for this value (and implicitly reserves) is to discount (at loan interest rate) future cash flows from a proven field. A proven field must be running a minimum of six months. In addition, commercial banks will only write loans with firms of established collateral value, i.e., loan is fully guaranteed against balance sheet or the federal government.

As to risk analysis, banks assess more carefully than steam suppliers or utilities, generally one per cent and under. Rates of interest are contingent on risk and federal guarantees command the best rate. Finally, the contract geothermal steam price and terms are crucial to the fair market liquidation value, i.e., take or pay, advance payments.

Mark N. Silverman, Director, Geothermal Loan Guarantee Program, DOE, discussed geothermal reserves from the federal government aspect. While the goal of the DOE is to encourage geothermal exploration, the loan guarantee program requires reasonable assurance that the loan can be repaid. Sufficient data must be available to substantiate claims of applicant. While the definition of sufficient data varies, an application based solely on geothermal surface manifestations, i.e., tuffa mounds, is clearly inadequate. The federal program's risk acceptability appears to be more conservative than the geothermal resource seller, buyer, and federal scientist; it certainly must be more liberal than a commercial bank in order to encourage geothermal development. In actual numbers, approved loan applications have been assessed at greater than 60 per cent success. Mr. Silverman believed that utilities can and will do more, as knowledge is gained, to assume more of the risk caused by uncertainty of reserves that is now assumed by the steam supplier.

Vasel W. Roberts

At a time when geothermal energy producers and users are on the threshold of commercial development of water-dominated geothermal resources, the need for a common basis of communicating ideas and concepts about a relatively complex commodity has never been greater. The Workshop organizers are to be commended for recognizing this need and addressing the perplexing use of the term "geothermal reserve." Since a commonly accepted definition of geothermal reserve has not yet emerged, it is difficult to use the term with any degree of certainty.

The panel discussion revealed some of the reasons for this difficulty, namely, the use of different definitions for different purposes, none of which are mutually exclusive, but may yield significantly different interpretations of the quantity of energy on hand at any given time. Similar problems exist with other terms, such as reservoir, resource and resource base, due in part to the possibility of different depth and temperature datum, coincidence of heat and fluid deposits, and purity and producibility.

Dr. Muffler discussed a generic definition that has application to mineral resources in general. His definition was as follows:

> --Quantities of minerals that can be reasonably assumed to exist and that are producible with existing technology under present economic conditions--

Dr. Muffler also discussed the McKelvey diagram as a convenient method for graphically describing the resource. This definition is excellent from a national and regional point of view, for the purpose of estimating relative importance, developing policy, and placing effort in areas of greatest potential. On the other hand, the definition is not precise, since it relies on "reasonable assumptions" rather than hard data and marketability. It seems to have limited application at the point of negotiation of energy sales or purchase.

Dr. Lipman approached the subject from an entirely different point of view. From the resource companies' point of view the definition is as follows:

> --A geothermal resource becomes a reserve when commitments are made to build power plants to utilize a portion of the resource--

This definition says that a resource is not a reserve until a sales contract exists. This poses some interesting problems in that the prospective buyer of the energy usually would like assurance that a reserve exists prior to the commitment to build power plants.

Indeed, Mr. Mathisen's view was that:

> --A portion of the resource is considered a reserve only after the necessary wells for the power plant have been drilled and flow tested for a specified period of time--

The definitions by Dr. Lipman and Mr. Mathisen tend to be conservative, and underestimate reserves in comparison with Dr. Muffler's definition.

Mr. Leigh's viewpoint as a banker was:

> --A resource becomes a reserve only after its market liquidation value is known with 99 per cent certainty--

Under this definition, the market liquidation value of all leases might be construed to represent reserve, albeit small. Since the value of a lease may increase as exploration and development progresses, the amount of recognized reserve could steadily increase well into the production phase. This definition is only loosely related to the magnitude of the resource, but faces the reality of the need for liquidity by lending institutions.

The fifth definition was given by Mr. Silverman, Director of the Geothermal Loan Guarantee Program for the Department of Energy. His definition uses probability of project success as the criteria as follows:

> --A reserve is considered to exist if a project proposed by an applicant for a loan guarantee has a 60 per cent or higher probability of success--

It is interesting, but perhaps not surprising, that the five panelists, representing the resource, utility, and banking industries, and two federal agencies, expressed five different definitions of geothermal reserve. Each serves a particularly useful purpose, yet none of them seem to qualify as a common denominator. Although these definitions are valid under each set of circumstances and can be very useful, there still seems to be a need for an acceptable industry-wide definition that all can use in communicating with each other.

Mr. Leigh suggested that the resource be accounted in terms of BTU's to which a value could be associated. This is a fundamental approach that is well understood, and is one that most probably could be generally accepted; however, it is important to recognize that the value of a BTU will be dependent on the temperature at which it is delivered and the purity of the fluid in which it is contained. Temperature affects conversion efficiency, and both temperature and purity can affect capital costs and O&M.

Dr. Lipman suggested that utilities should be willing to share more of the initial risks of geothermal development with the resource companies. There are indications in evolving projects that there may be a trend in this direction. Certainly, the risk seems to be higher on first-of-a-kind geothermal resources or power plants, but may be a transient phase in the course of geothermal development. In any case, there is little actuarial geothermal data upon which to base risk assessment; however, as more power plants are constructed, the level of confidence in the resource among utilities should increase.

Alexander N. Graf

The purpose of this panel was to consider the definition of geothermal reserve. Each panelist represented a different viewpoint or entity concerned with the development of geothermal resources. It is quite evident that significant variations in the definition exist.

Dr. Muffler's interest was in defining reserves in terms of an available national energy resource. Dr. Lipman's concern centered on the importance of expediting the development of specific projects, and protecting the interest of stockholders. Mr. Mathisen's position was that of defending the conservative nature of public utilities in their cautious development of new energy sources. Mr. Leigh's concern with the definition of geothermal reserve was limited to the determination of collateral value of producing reserves, which might be used to finance new or further development. Mr. Silverman's interest seemed to focus on expediting development by providing needed guarantees to worthy projects, based on a definition of geothermal reserves utilizing probability of success.

Dr. Muffler, USGS-Menlo Park, began the discussion with three commonly accepted definitions--Resource base, Resources, and Reserves. Reserves were defined as the quantities of minerals that can be reasonably assumed to exist and which are producible with existing technology under present economic conditions. Dr. Muffler reviewed the McKelvey Diagram, and a logic diagram which might jointly be described as follows: The resource base is split into accessible and inaccessible, the accessible resource base (defined by depth) is divided into useful (Resource) and residual, with useful split further as identified and undiscovered. Reserves are defined as accessible, useful, identified, and economic. Dr. Muffler concluded that a reserve is something you really know, and that you can make hard, immediate investment decisions on.

Dr. Lipman, Union Oil Company, felt that Dr. Muffler's definitions are useful for defining national energy strategies, but that the key words in the definition of geothermal reserves should be economically recoverable, and using current technology. From an industry standpoint the use made of reserve determinations are twofold, to convince a utility that there are sufficient reserves to build a plant, and for reservoir management planning. Industry's experience has been that they have been required to 'over prove' by many orders of magnitude the reserves required to safely install an electrical generating plant, resulting in delays and greater capital expenses. The development process might be expedited if the utilities would assume a share of the initial risk. The economics of geothermal energy are different than those of oil and gas because of the extended development/return of investment time period. Dr. Lipman indicated that Union Oil Company carries economic identified resources on its books as reserves only if there is a commitment from a utility to build a plant. The only current Union Oil Company reserves are at The Geysers, and in the Philippines.

Mr. Mathisen, Planning Department-PG&E, stated that PG&E recognizes that its position with regard to geothermal resources development has been conservative. Among the reasons cited for this approach are that PG&E is responsible to the CPUC, concerned about maintaining its high bond rating, and naturally wary about entering financial commitments to new energy sources. PG&E's position in the past has been that only after the wells necessary to service a plant have been drilled and satisfactorily flow tested by the developer, can the resource be elevated to a reserve. PG&E's position has become more flexible due to the positive experiences it has had at The Geysers. Mr. Mathisen believes that faced with the opportunity to develop a new geothermal field PG&E might require less proof of multiple reserves than they did from the developers of The Geysers.

Mr. Leigh, Energy Department-Lloyd's Bank of California, considers a geothermal reservoir an asset. A bank's definition of a reservoir is its fair market liquidation value today (which is the sum of all discounted future net revenues from the field, assuming that it has been operating at least six months), as opposed to definitions involving economic recoverability or current technology. It is the practice in the oil and gas industry to raise capital for the development of a new field by using their producing fields as collateral. A commercial bank is not in the business of providing funds for a new geothermal field

development without additional collateral. A commercial bank's risk ratio must be 1 per cent or less, thus a bank's definition of geothermal reserve is a resource suitable for use as collateral, which is 99 per cent known. Very few geothermal fields can qualify as collateral.

Mr. Silverman, Geothermal Loan Guarantee Program-DOE/SAN, considers each loan guarantee application to determine if the data submitted is sufficient to substantiate the applicant's claims. If the claims are confirmed then an economic analysis is conducted in order to determine that the applicant will be able to repay the loan according to the specified schedule. The definition of reserve will vary depending on the type of application, location, known data, and claims made by the applicant. As a general rule a reserve is considered to exist if the analysis of the applicant's proposal indicates that the probability of success is in excess of 60 per cent.

Each of the entities represented by the panelists plays an essential role in the development of geothermal prospects. A common definition of reserves would be a useful tool for communication among these groups. Developing a definition common to all of them may be an unrealistic goal; however, discussions of this type are very stimulating, and play an important part in defining differences.