Geothermal Energy

HR
3/23/81

NATIONAL ESTIMATE

#61

for DIRECT USE

GEOTHERMAL HEAT-ON-LINE

NEW MEXICO ENERGY INSTITUTE

December 1980

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

GLOSSARY OF TERMS

Direct-use - non-electric use of heat from geothermal effluent without conversion to another energy form.

Co-location - spatial proximity between a geothermal resource and a nearby, prospective energy user.

Market Penetration - that portion of the market potential that geothermal will actually serve; market supply.

Quad - a quantity of energy equal to 10^{15} BTU's. Total annual energy use in the U.S. is approximately 78 quads¹.

A HISTORY

The market feasibility of direct applications of geothermal energy in the United States has been an issue of concern since the initial work of Reistad in 1975. In his work, "Analysis of Potential Non-electric Applications of Geothermal Energy and Their Place in the National Economy," Reistad inferred the potential of geothermal on the basis of a comparison of heat/energy requirements of the current energy demand with the potential of the known geothermal resource endowment.² His conclusion was that if the resources with temperatures up to 150°C were used for space heating, 30% of the total U.S. energy demand could be met by geothermal energy.

SHORTCOMINGS OF PREVIOUS ESTIMATES

As estimates of energy market potential, the conclusions of Reistad and of others suffer from two shortcomings. The first of these is the failure to consider the extent to which geothermal resources are co-located with prospective users. Because of the relative lack of portability of geothermal energy, a precondition for utilization is that users be co-located with resources. Thus, a lack of coincident population could preclude many geothermal anomalies from being exploited.

A second shortcoming of early estimates of market feasibility is the failure to consider the economic competitiveness of geothermal use. The economic feasibility of geothermal energy depends upon a number of economic as well as technological considerations. Each of these must be individually examined in order to evaluate the financial viability of geothermal energy as an alternate energy form.

NEED FOR SITE-SPECIFIC INFORMATION

These two shortcomings underline the need for estimates which aggregate the results of site-specific analyses. Until the recent compilation of a site-specific national data base at the New Mexico Energy Institute (NMEI), there was no basis for developing such estimates. Now, however, reliable estimates can be compiled which may be validated at both the local and at the national levels.

PURPOSE OF THIS STUDY

The purpose of this report is to present the first national estimate of direct geothermal energy use based upon an aggregation of site-specific analyses of all known geothermal resources.

CONCLUSIONS

1. Geothermal energy can make a significant contribution to the nation's low temperature energy needs and can lessen dependence on foreign energy sources.
2. Federal tax incentives and regulatory easement will enhance the development of geothermal energy in the U.S.
3. District heating applications will constitute the major portion of geothermal market penetration.
4. Most development will occur in the western U.S.

THE NMEI DATA BASE

The NMEI data base may be categorized into three files - resource, population center, and industrial user. An initial data base was developed for ten states in the Rocky Mountain Basin and Range.³ During the past year, these files have been extended to include all states with geothermal manifestations.

RESOURCES FILE

The resource listings were developed from efforts of state commercialization and resource assessment teams, geologists, DOE contractors, and USGS resource files. The file is a compilation of physical manifestations of geothermal energy ranging from actual production wells with measured temperatures and depths to educated guesses about expected resources. The resource listings are divided into two categories, including potential and inferred resources, to indicate degrees of uncertainty. Data for each resource include name, location, depth, temperature, and source

of information. The locations of the known geothermal resources are illustrated below in Figure 1.

POPULATION FILE

The population centers consist of villages, towns and cities which are prospective heating districts. Within each population center, individual users include both residential and commercial establishments utilizing both space and water heating. Data sources for this file include state directories, census data, and atlases. Information contained in the listings include name, location, population, annual heating degree days, and available fuel types and prices.

INDUSTRIAL USER FILE

The industrial user file is a listing of all industrial firms by name, SIC category, average number of employees, 1976 annual heat requirements, maximum temperature requirement, and location. Sources for the information included individual state directories of manufacturers and industry.

Figure 1.

NMEI METHODOLOGY

The NMEI methodology for estimating the market penetration of geothermal energy consists of three steps. These include (1) the identification of co-located geothermal resources and users, (2) the economic determination of the market potential of all of the co-located resource/user pairs within the U.S., and (3) the estimation of market penetration at the state and national levels.

CO-LOCATION

As a precondition for estimating the market potential of geothermal energy, the identification of co-located resources and users is required. This involves spatially matching each geothermal resource with the nearest optimum prospective energy consumer(s). The NMEI data files identify a total of more than 4,000 co-located resource/user pairs within the United States. A detailed examination of the economic feasibility of geothermal energy for each prospective user provides a definitive measure of the energy market potential of geothermal energy.

MARKET POTENTIAL

The market potential of geothermal energy is the total energy demand of all of the co-located users for whom geothermal energy is price competitive with other fuels. A computerized engineering/economic model was developed at NMEI in order to estimate the cost (price) of supplying geothermal to users.⁴ Using this model, a market price has been estimated for each of more than 900 co-located users in the U.S. during the past three years.

These studies have revealed that five factors are paramount in determining the price of geothermal energy:

IMPORTANT ECONOMIC CRITERIA

1. Resource temperature
 2. Resource depth
 3. Distance between resource & user
 4. Annual heating degree days
 5. User size
-

Taken together, these five factors account for approximately 95 percent of the variation in estimated geothermal energy prices.

Using this information, a geothermal energy price was calculated for each of the 2,300 co-located users for each year during the 1980-2000 period. The market potential for each year was then calculated as the sum of the energy demands of all users for whom geothermal energy was price competitive with available fuels at each location. These estimates of market potential are presented by state for the year 2000 in Column 2 of Table 1.

MARKET PENETRATION

Market penetration is a measure of the volume of geothermal energy that will actually be supplied. An abundance of marketing research suggests that many factors in addition to price competitiveness influence the consumer purchase decision. In the case of geothermal energy, these include a lack of product awareness and numerous institutional barriers. For these and other reasons, not all of the co-located users for whom geothermal is price competitive will necessarily adopt geothermal energy.

A method for estimating the market penetration of geothermal energy has been developed on the basis of preliminary consumer research conducted at NMEI and several years of energy modeling conducted at the International Institute for Applied Systems Analysis in Austria.⁵ A variant of the Logistic Substitution Model has been developed which forecasts the dynamics of market penetration by geothermal energy as a percent of the estimated market potential.⁶ The major determinants of estimated market penetration are the size of the estimated market potential and the estimated relative price advantage of geothermal versus conventional fuels.

PENETRATION by STATE

DIRECT USE

YEAR 2000 WITH GOVERNMENT SUPPORT

STATE	POTENTIAL x 10 ¹² BTU	PENETRATION x 10 ¹² BTU	NUMBER OF CITIES	CO-LOCATED POPULATION
ALASKA	.63	.37	8	2,400
ARIZONA	74.97	48.18	103	1,844,872
ARKANSAS	3.07	2.18	9	42,301
CALIFORNIA	404.50	265.30	154	8,868,754
COLORADO	120.84	99.24	164	874,503
DELAWARE	1.87	1.80	45	69,010
GEORGIA	12.78	12.29	190	588,684
IDAHO	61.47	58.75	71	405,825
KANSAS	1.16	1.06	62	161,409
MARYLAND	57.78	55.56	42	153,423
MONTANA	29.69	25.79	120	225,974
NEBRASKA	4.44	3.90	301	486,726
NEVADA	39.29	36.90	53	191,562
NEW JERSEY	125.52	103.77	189	1,438,625
NEW MEXICO	38.93	28.28	97	645,655
NEW YORK	.02	.00	1	1,024
NORTH CAROLINA	.38	.08	6	7,869
NORTH DAKOTA	30.00	28.78	157	214,525
OREGON	8.84	6.52	30	74,457
SOUTH DAKOTA	13.08	12.13	68	99,768
TEXAS	255.57	245.74	357	4,441,064
UTAH	91.15	64.33	77	777,463
VIRGINIA	.74	.06	8	34,650
WEST VIRGINIA	.19	.01	3	2,244
WYOMING	25.07	21.74	29	166,861
TOTAL	1,454.63	1,170.83	2,344	21,819,657

Table 1.

RESULTS

The modified Logistic Substitution Model was employed to forecast market penetration under two contrasting scenarios. In the first scenario, market penetration is forecasted from 1980 through 2000 with virtually no federal support for geothermal energy development.

In the second scenario, an active support program consisting of tax credits, grants, and resource confirmation support is assumed.

GOVERNMENT INITIATIVES

Geothermal Tax Credit -15% in addition to standard 10%
 Grants - 10% federal cost sharing of successful project
 Resource Confirmation - government assumes 80% of
 cost of unsuccessful well
 Percentage Depletion - 15.5% as legislated

The results of the government support scenario for the year 2000 are presented for individual states and for the nation in Column 3 of Table 1.

IMPLICATIONS

GEOHERMAL SIGNIFICANT IN CO-LOCATED AREAS

Forecasts of market penetration with government support indicate that, in those states where resources and users are co-located, geothermal energy could be a significant energy source by the year 2000. In total, market penetration of 1.17 Quads is forecast by the year 2000. This would serve approximately 8% of the country's population and represent more than 1% of the nation's total energy demand and 5% of the nation's residential and commercial energy consumption.

DISTRICT HEATING IS THE TARGET

The majority of heat-on-line from geothermal will evolve from district heating applications. Figure 2 illustrates the relative shares of the forecasted market penetration which are attributable to district heating and to industrial applications.

Figure 2.

GOVERNMENT PARTICIPATION NECESSARY

The development of geothermal energy will be sensitive to the support role of the federal government. Figure 3 illustrates that forecasted market penetration by the year 2000 totals 1.170 Quads with federal support and only 0.75 Quad without support. Federal initiatives accelerate the adoption of geothermal energy, helping to reduce energy imports.

Figure 3.

DEVELOPMENT IN THE WESTERN U.S.

A large percentage of the successful geothermal energy development will be located in the western U.S. Figure 4 depicts the geographical dispersion of penetration. The color intensity indicates relative knowledge and probability of a successful resource.

Co-Located Cities

Figure 4.

REFERENCES

1. U.S. Department of Energy. Energy Information Administration. Annual Report To Congress, 1979 Volume Three Synopsis. Washington, D.C.: Government Printing Office, October 16, 1980, DOE/EIA-0173 (79)/3(SYN).
2. Reistad, Gordon. Analysis of Potential Non-Electrical Applications of Geothermal Energy and Their Place In the National Economy. Lawrence Livermore Lab., UCRL 51747, Livermore, California, 1975.
3. O'Dea, P.L.; Hydrothermal Sites in the Rocky Mountain Basin and Range Region of the United States; New Mexico Energy Institute, Las Cruces, New Mexico, NMEI 10-3, February 1979.
4. Cunniff, Roy A.; Glazner, Gary; and Houldsworth, Mark. Geothermal Energy for Residential, Commercial, Industrial Users. New Mexico Energy Institute, NMEI 30-5, Las Cruces, New Mexico.
5. Peterka, V.; Macrodynamics of Technological Change: Market Penetration by New Technologies, International Institute for Applied Systems Analysis, Laxenburg, Austria, November 1977.
6. (Same as 3 below)

SUPPORTING TECHNICAL REPORTS (Methodology and Details of this Study)

1. O'Dea, P. L.; Description of Data Files of the Geothermal Operations Research Project, New Mexico Energy Institute, Las Cruces, New Mexico; November, 1980.
2. Houldsworth, M.; The Potential for Direct Use Geothermal Energy Supply in the United States, 1980-2000; New Mexico Energy Institute, Las Cruces, New Mexico, November 1980.
3. Munson, J.; National Market Penetration For Geothermal; New Mexico Energy Institute, Las Cruces, New Mexico, November 1980.

FOR FURTHER INFORMATION

Please contact:

**Joe Marlin, Geothermal Project Director,
P.O. Box 3-NMEI
New Mexico State University
Las Cruces, New Mexico 88003
(505) 646-1745**

NOTICE

This report was prepared to document work sponsored by the United States Government. Neither the United States nor its agent, the Department of Energy, nor any Federal employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The New Mexico Energy Institute (NMEI) at New Mexico State University in Las Cruces, New Mexico administers alternative energy research and development programs in Geothermal, Solar, Biomass and Wind technologies. The institute is able to draw professional staff from its own organization and the university, to develop and perform energy-related tasks for private and public agencies.