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# ECONOMICS OF GEOTHERMAL DEVELOPMENT

The following article by Dr. Robert W. Rex is the text of his remarks to the Sub-Committee on Energy, Committee on Science and Astronautics, U.S. House of Representatives, on September 18, 1973. This text was previously published in Geothermal Energy, vol. 1, no. 4, December 1973. We are reprinting it in this issue of The ORE BIN because we believe the thoughts expressed are pertinent to Oregon at this time and should have as wide dissemination as possible.

Dr. Rex is the President of Republic Geothermal, Inc., Playa del Rey, California. He was formerly Exploration Manager of Pacific Energy Corporation, and prior to that he headed the geothermal energy studies at the University of California, Riverside.

For many years, Dr. Rex has been one of the nation's most articulate spokesmen for geothermal power development and a leader in applying the multipurpose concept to development of geothermal resources.

## Hearing on Geothermal Energy

### Introduction

Mr. Chairman, members of the Sub-Committee:

I am honored to be invited to present comments on H.R. 9658* and to discuss the potential for geothermal energy in the U.S.

The previous witnesses have given you a picture of Federal effort in geothermal energy research and of the potential both at home and abroad. Dr. Smith** has also informed you of the very exciting and remarkably successful program at the Los Alamos Scientific Laboratory to extract useful heat from hot dry rock. It is my intention to brief you on my determinations

*Bill for funding geothermal studies

**Morton Smith, A.E.C. Los Alamos Scientific Laboratory, Project on Extraction of Power from Hot Dry Rock

on the relationship between resource price and the quantity of potentially available resources. Then I intend to present an analysis of the revenue accruing to the government from geothermal development of Federal lands by private industry.

## U.S. resource size - price relationship

It is my opinion that most of the variations in the estimates of U.S. geothermal potential are caused by variations in the assumed market price for this energy. Most of the conservative estimates were the result of assuming energy prices fixed at the 1970, 1971, or 1972 levels. Clearly this is unrealistic. The National Petroleum Council clearly states that their most recent reserve estimates were based on "current market prices", whatever that means. There is a logical and overweaning reason for this. County government places a property tax on reserves in the ground called the ad valorem tax. No energy extraction company is going to allow an exploration manager to gather data on presently non-marketable reserves because any such action would most probably trigger ad valorem taxes on such marginal reserves. Consequently, the geothermal, oil, and natural gas industries assiduously avoid bankrupting themselves by gathering data on current non-profitable energy reserves. This means that the public sector has great difficulty in obtaining a realistic appraisal on the relationship between total U.S. recoverable reserves and a reasonable market price for those reserves. I view this head-on conflict between Federal and county interests to be the overwhelming fundamental cause of the present energy crisis. Without this conflict we would long ago have had the necessary information to develop a rational national energy policy and could have avoided the present dislocations.

My colleagues and I have attempted to model many hundreds of geothermal ventures including dry steam, various types of hot water, and hot dry rock. These models suggest the energy price which would be required to sustain a viable corporate venture. Then I have tried to make regional estimates of resource size. The combined results of these analyses are given in Table 1, which compares known, probable, and undiscovered reserves as a function of cost. In order to keep within the areas of maximum data available at the time of preparation of this table, I focused on steam, hot water and hot dry rock in the states west of the Rockies. The addition of the Gulf Coast potential for the geopressured geothermal resource would serve to substantially increase the present figures.

The two primary points that I would like to make in this area are as follows:

First, the data available suggest that large scale utilization of the U.S. geothermal resource is very close to economic feasibility. Small scale use is developing rapidly at present. Consequently, positive action by the Federal government has the potential for major leverage by the private sector.



By this I mean that the forces of the marketplace are bringing geothermal energy into the U.S. energy portfolio. Congress, however, has the ability, by providing seed money for technology demonstration, to accelerate by from ten to twenty years the pace of development of the U.S. geothermal potential and in this way save substantial foreign exchange liabilities and help control inflation.

Second, there is a large amount of dissolved natural gas in the geopressured Gulf Coast geothermal waters. The dollar value of this gas is about double the value of the thermal and pressure energy. However, the wells to develop this resource will be deep (often 14,000 feet or more) and expensive. The threshold price for this gas is about $1.00 per mcf [thousand cubic feet]. The Federal Power Commission is presently rejecting sales prices above $0.50 per mcf. Consequently, the FPC is preventing development of this gas reserve by its pricing policy. It should be noted that imported natural gas costs the U.S. more than $1.00 per mcf, as does synthetic natural gas. Current fuel oil prices are the equivalent of from $0.90 to $1.10 per mcf. This FPC pricing policy is therefore blocking the development of the geopressured natural gas resource.

The Resource Appraisal Panel of the National Science Foundation Conference on Geothermal Energy in September 1972 made a preliminary calculation of the size of the recoverable resource on the Gulf Coast. It is 2,700 trillion cubic feet or enough gas to meet U.S. needs for 50 years.

It is my recommendation that high national priority be given to a research and development program to appraise this resource, demonstrate the technology necessary to utilize it, and develop an understanding of the environmental problems associated with its development. I view this need as so great that I would prefer to see it handled by existing entities such as the non-nuclear activities group of the A.E.C., the National Science Foundation, and the U.S. Geological Survey rather than wait for a new entity. House bill H.R. 9658 is a partial step in this direction, but by itself it is less important than adequate program funding within the present National Science Foundation structure. If H.R. 9658 comes into law, it will be a positive move. If not, it is imperative that present programs be funded at increasing levels to permit acceleration of the pace of development of geothermal technology.

## Revenue accruing to government from development of Federal lands

It is clearly evident that development of geothermal plants in the U.S. displaces imported petroleum. This means that the fuel bill for the generation of electricity can either be a foreign exchange burden or it can result in economic growth of the U.S. economy and yield tax, royalty, and rental revenue to the government.

In order to illustrate the large contribution that development of Federal lands for their geothermal potential makes to the U.S. taxpayer, I have

Table 1. Amount of producible geothermal energy in the United States (Mwcen* of electricity)

| Energy price (mill/kwhr)[a] | Known reserves Amount | Known reserves Areas** | Probable reserves Amount | Probable reserves Areas** | Undiscovered Amount | Undiscovered Areas** |
|---|---|---|---|---|---|---|
| 2.9- 3.0 | 1,000 | 1 | 5,000 | 1 | 10,000 | 1 |
| 3.0- 4.0 | 30,000 | 1-2 | 400,000 | 1-4 | 2,000,000 | 1-5 |
| 4.0- 5.0 | --- | --- | 600,000 | 1-6 | 12,000,000 | 1-7 |
| 5.0- 8.0 | --- | --- | --- | --- | 20,000,000[b] | d |
| 8.0-12.0 | --- | --- | --- | --- | 40,000,000[c] | d |

a Mills per kilowatt hour in 1972 dollars
b Hot, dry rock at less than 6.1 km (20,000 ft.) depth
c Hot, dry rock at less than 10.7 km (35,000 ft.) depth
d Development of hot, dry rock energy is assumed over 5 percent of the area of the western third of the U.S. Hot, dry rock systems development is based on hydraulic fracturing or cost-equivalent technology. Present drilling technology is assumed; new low-cost deep drilling could substantially improve these economics.

* Megawatt-Century: steam reserves sufficient to generate one megawatt of electricity for one century using efficiencies of present technology
** Areas: 1. Clear Lake-The Geysers; 2. Imperial Valley; 3. Jemez area, N.M.; 4. Long Valley, Calif; 5. remainder of Basin and Range area of western U.S.; 6. Hawaii; 7. Alaska

Table 2. Revenue to the public sector from 1,000 megawatts for 30 years from Federal land (including depletion allowance at 22 percent)

| | | |
|---|---|---|
| Lease rental | $ 45,000 | |
| Royalty | 244,887,000 | |
| Federal income tax | 482,998,000 | |
| Total Federal | | $ 727,930,000 |
| State income tax | 107,578,000 | |
| County ad valorem tax | 177,154,000 | |
| Total other governments | | 284,732,000 |
| Total government revenue | | $1,012,662,000 |



Appendix to Table 2

1. Plant factor = .909 (100 MW for each 110MW capacity)
2. Well size: 7.5 MW (150,000 lbs/hr)
3. Disposal: 1 disposal well for each producing well (first dry hole used as a disposal well)
4. Drilling program for each 55 MW unit:

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| Exploratory wells | 2 | - | - | - | - | - | - | - | - |
| Development wells | - | 3 | 3 | - | - | 1 | 1 | 1 | 1 |
| Dry holes | 1 | 1 | 1 | - | - | - | - | - | - |
| Disposal wells | 1 | 3 | 3 | - | - | 1 | 1 | 1 | 1 |

5. Cost of wells:

| | Tangible | Intangible | Total |
|---|---|---|---|
| Exploratory | $117,000 | $273,000 | $390,000 |
| Development | 116,000 | 174,000 | 290,000 |
| Dry holes | 117,000 | 273,000 | 390,000 |
| Disposal | 36,000 | 54,000 | 90,000 |

6. Gathering lines: $15.5/KW capacity ($852,500 for 55 MW unit)
7. No operator fee
8. No production or severance taxes
9. Overhead at $50,000 per year per unit plus a percentage of land, drilling, and operating expense
10. Depreciation: straight line
11. Geology/Geophysics: $20,000 in each year of drilling plus $7,000 per year every year
12. Acreage: 560 acres per 55MW unit
13. Royalty: 10 percent
14. Lease rental: $1/acre in years 1-4
15. Working capital: $200,000 per 110 MW capacity
16. All equity capital: no debt structure; no interest accrual
17. Inflation: 5 percent per annum on all costs
18. Steam production begins in year 5
19. Gathering lines constructed in year 4
20. Steam sales price: 4.5 mills/kwhr in year 1; 5 percent yearly increase
21. State income tax at 9 percent
22. Federal income tax: 22 percent on total taxable income
    26 percent on taxable income over $25,000
23. Ad valorem tax: 10 percent of assessed value (25 percent of market value determined by discounting net income before taxes)

. . . . .

analyzed the economics of development of ten 100 megawatt units on Federal lands and considered the income stream accruing to the public sector from the 1,000 megawatts of power over 30 years. The various assumptions that went into these calculations are given in the appendix to Table 2. The calculations are based on development of hot water fields such as are found in many places in the western U.S. There is a possibility of some latitude in local cost factors that vary from field to field but this will have relative small impact on the tax income stream. The results are given in Table 2.

Every 1,000 megawatts of geothermal development on Federal lands yields about one billion dollars of public revenue; 73 percent to the Federal government, 11 percent to State governments which have income taxes, such as California, and 18 percent to county governments.

I strongly recommend that the enormous return on investment to the government on Federal geothermal research be acknowledged in national energy planning and budgeting. Furthermore, it becomes obvious that the slow pace of implementing the Federal lands leasing program is depriving the Federal government of a significant income stream. It illustrates that the earlier arguments concerning grandfather rights and a possible "give-away" of rights by granting grandfather leases is without basis. The income stream from royalties completely swamps any conceivable lease rental considerations.

If the projections for development of from 40,000 to 90,000 megawatts of geothermal energy in the next decade are realized, we will add 40 to 90 billion dollars in tax revenue to the public treasuries which would otherwise have been lost.

I seriously doubt that any other Federal investment in energy technology stimulation offers a better promise than does geothermal energy in all of its aspects, including hot waters, geopressured resources, and hot dry rock.

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## ENERGY FORUM PROCEEDINGS TO BE PUBLISHED

Authorities on wind power, solar power, geothermal power, conversion of oil shale, and coal gasification and liquefaction spoke to a capacity audience at the "Citizens Forum on Potential Future Energy Sources" held January 17, 1974, at Portland State University. Because of the great interest shown in these possible supplementary energy resources, the speakers have agreed to submit their reports to the forum sponsors (this Department and the Portland State University College of Science) for publication in a proceedings volume. Availability of the forum proceedings will be announced in The ORE BIN upon publication.

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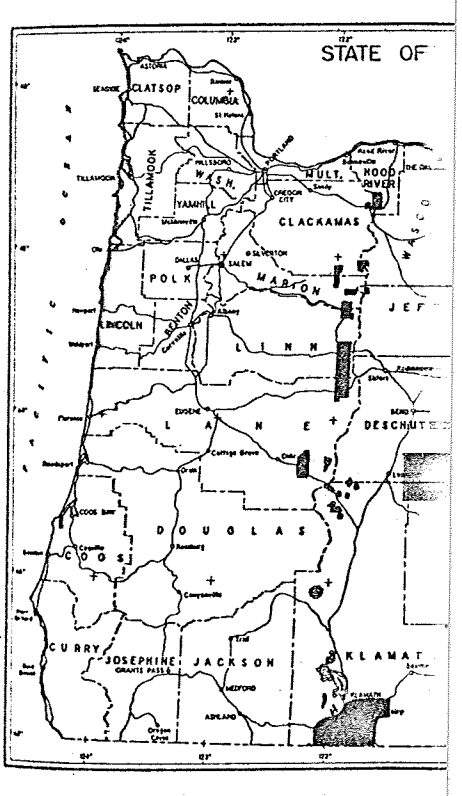
## GEOTHERMAL

February 1, 1974, was the first day for geothermal exploration on Federal lands and individuals filed for a total of Cascades and southeastern Oregon to Hood River, Clackamas, Marion Cascades, leasing was in Deschutes Counties with about 200,000 acres Heur Counties. Heaviest filing Desert, Glass Buttes, Newberry Belknap Springs.




Approximate locations of geothe

In some areas of the Alvord companies and individuals overlap may be declared a KGRA (Known require an environmental impact bidding can begin.