A STUDY OF THE GEOTHERMAL INDUSTRY'S R&D PRIORITIES

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ABSTRACT

On 29 April 1993, a one-day meeting was conducted by the author to discuss the relative priorities of major R&D topics in the DOE/Geothermal Division budget. Participation was restricted to representatives of geothermal developers, utilities and their consultants and contractors — the geothermal industry. A total of 21 people participated in the meeting. They recommended that the DOE budget be allocated approximately as follows:

Reservoir Technology (40% of budget). Injection Technology, Exploration Technology, Industry Coupled Drilling, Improved Reservoir Simulation, Reservoir Assessment.

Energy Conversion (21% of budget). Advanced Heat Rejection, Corrosion and Scaling, Advanced Energy Conversion, Binary Technology, Flash Technology, Improved Gas Extraction, Production Geochemistry.

Drilling (27% of budget). Slim-Hole Technology, Drilling Technology, Completion Technology, Lost Circulation, Logging Technology, Advanced Drilling.

Other (12% of budget). Hot Rock, Geopressured, Magma, Other.

INTRODUCTION

The Geothermal Division of the U.S. Department of Energy funds R&D programs whose main goal is to lower the cost of using geothermal resources. Since their budget is very limited, it is important for DOE to use care in selecting and prioritizing R&D projects. To complicate matters, not all of their budget is under their own control. Mandates from Congress to fund certain projects derive from the political activity of those with special interests. As a result, the Geothermal Division may control less than half of a budget that has averaged about $27 million during the past several years.

For many years, the Geothermal Division has gathered and carefully considered the opinions of others, especially representatives of the geothermal industry, in determining what R&D to fund. They have sponsored separate studies and have used periodic meetings of industry groups to provide needed information. The Reservoir Technology, Drilling Research and Energy Conversion committees as well as The Geysers Working Groups are examples of this process. The Geothermal Division has the responsibility also to consider pursuing topics that are not part of the industry's current business plans but nevertheless have large potential. Magma and hot dry rock energy are examples of topics that fall into this category.

Beyond the above considerations, the geothermal industry has been increasing its presence in Washington, D.C. during the past several years. The Geothermal Energy Association (GEA) has provided information to the DOE/Geothermal Division on assistance the industry needs from DOE's programs.[1] The GEA also works with a coalition of energy - and environmental advocacy groups which has produced a document known as the Sustainable Energy Budget. This coalition annually provides written recommendations on DOE budget levels to the Administration and the Congress. The author has been heavily involved in determination of R&D priorities on behalf of the GEA, and this involvement provided the motivation for the particular study reported in this paper.

INDUSTRY PRIORITIES MEETING

On 29 April 1993, a one-day meeting was conducted by the author for the purpose of helping to determine priorities among the major, overarching topics of potential geothermal energy R&D. This meeting immediately followed the DOE Geothermal Program Review XI, and was held in Berkeley, CA. Three primary activities were carried out:

1. A presentation on the current DOE research program was given as background by Dr. John E. (Ted) Mock, Director of the Geothermal Division;

2. Participants responded to a prepared questionnaire that asked them to; (a) answer questions about their perceptions of the general status and future of the geothermal industry, (b) rank a list of potential R&D topics (the "Questionnaire

[1]The GEA was formed in April, 1994 from the merger of its two predecessor organizations, the National Geothermal Association (NGA) and the Geothermal Resources Association (GRA).

Priorities Matrix" in the discussion below), and (c) recommend an allotment of research funding for each of 8 major R&D categories assuming total budget levels of $24 million, $40 million and $60 million; and,

2. Participants constructed and discussed at length a list of recommended R&D topics and then ranked these topics by priority using an especially designed method (the "Participant's Priorities Matrix" in the discussion below).

A total of 21 people participated significantly in these activities. These people can be roughly divided into two groups — those concerned mainly with subsurface processes (e.g. geology, reservoir simulation, drilling) and those concerned mainly with surface processes (e.g. pipelines, power plants, materials). There were 13 subsurface-processes people and 8 surface-processes people. None of these people represented either the Department of Energy or any federally funded or state funded organization — they were all from geothermal development companies or the consultants and contractors that support them. Most of the people represented the management of technical functions within their company, and so were possibly in the best position to represent their company's position on R&D needs and priorities. Ted Mock left the meeting soon after his presentation and did not participate in the other activities. I acted simply as a meeting facilitator and recorder. Thus, the results presented below should be quite free in influences and opinions other than those brought by the geothermal industry representatives themselves.

I will first present the results of the Participant's Priorities Matrix and will then present the analysis of information obtained from the questionnaire.

THE PARTICIPANT'S PRIORITIES MATRIX

The Participant's Priorities Matrix is considered by the author to be the primary result of the meeting. Potential R&D topics were suggested from the floor, with the growing list being continuously reworked and honed until the 22 potential R&D topics that resulted were believed by the participants to encompass the essence of an ideal DOE R&D program. The 22 topics were then ranked using a matrix format, with each topic being given a preference rating individually against every other topic. I believe that this method is superior to scanning a list of items and simply selecting in turn the highest ranked item, the second-highest and so on. Since the list included 22 topics, the matrix prioritization process required participants to make 242 independent decisions which can be easily quantified and analyzed statistically.

Figure 1 shows an example 5 X 5 matrix of the type used to rank the 22 research topics. The items to be ranked are listed in corresponding position along both the horizontal and vertical elements of the chart. Then individual comparisons are made. Item 1 of the vertical axis is compared individually with items 2, 3, 4 and 5 on the horizontal axis. If item 1 is pre-

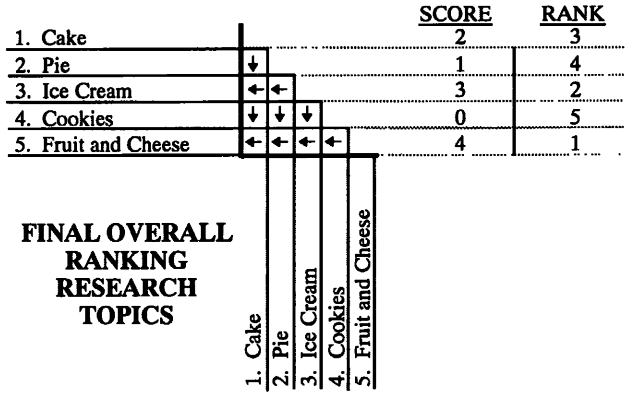

Figure 1. A 5 X 5 version of a priorities ranking matrix.

ferred over item 2, a vertical arrow is drawn in the appropriate box, pointing downward toward item 1. If item 3 is preferred over item 1, a horizontal arrow is drawn in the corresponding box, pointing toward item 3. This process is continued until all items have been individually compared. The score for an item is found by counting the total number of arrows pointing toward the item on both the vertical and the horizontal axes. The top ranked item is the one with the highest score.

Table 1 shows the results of analysis of the Participates Priorities Matrix. The 22 R&D topics recommended by the company representatives are listed along the left side. The table shows simple statistical parameters derived from the 21 completed priority matrices — mean, standard deviation, minimum and maximum number of votes for each R&D topic by each person. Since there were 22 topics, the maximum number of votes a given topic could receive from any participant is 21. The mean and standard deviation, as well as a number of other statistical quantities not shown, were derived from the data using the Statistical Package for the Social Sciences, Version 4 (SPSS-4) running on an IBM-compatible PC. The mean values are listed in descending order so that the highest priority items are toward the top of the table. The horizontal lines are meant more to guide the eye than to divide the table based on the results. This table includes all responses without regard to bias that may have been introduced through imbalance in the technical expertise of the participants.

As expected, both the maximum and minimum number of votes for each topic show a decreasing trend from top to bottom in the table. The substantial differences between the maximum and minimum number of votes for every R&D topic indicates significant differences of opinion among the participants on priorities. This suggests that achieving consensus in R&D priorities among these industry representatives might be difficult, and that no matter what the outcome, there will be some who disagree with the results. The standard deviations are somewhat smaller toward the top and bottom of the table than they are in the middle, showing more general agreement

R&D Topic	Mean	Std Dev	Min	Max
Injection Technology	15.29	4.11	7	21
Slim Hole Technology	15.24	5.45	2	21
Drilling Technology	14.48	4.26	10	21
Exploration Technology	13.95	3.99	5	21
Corrosion and Scaling	13.38	5.31	4	21
Advanced Heat Rejection	11.71	5.87	1	20
Binary Technology	11.67	5.31	3	21
Reservoir Assessment	11.62	6.28	1	20
Industry Coupled Drilling	11.29	6.49	1	21
Improved Reservoir Simulation	11.14	6.67	0	21
Improved Gas Extraction	10.67	6.17	0	21
Completion of Wells	10.57	5.27	1	19
Advanced Drilling	10.48	5.49	3	19
Flash Technology	10.33	5.32	1	19
Lost Circulation	10.19	5.51	2	21
Geochemistry	9.48	4.03	2	16
Case Histories	8.95	5.60	1	20
Advanced Energy Conversion	8.86	5.95	0	21
Logging Technology	8.76	3.97	2	16
Heat Mining	7.38	4.89	1	17
Geopressured R&D	3.14	3.04	0	11
Magma R&D	2.43	4.46	0	17

Table 1. Analysis of Participant's Priorities Matrix, All Participants Included.

R&D Topic	Mean	Std Dev	Min	Max
Slim Hole Technology	16.62	5.22	2	21
Drilling Technology	16.08	4.55	10	21
Injection Technology	15.38	3.95	7	21
Exploration Technology	14.23	4.09	5	21
Completion of Wells	13.00	4.04	7	19
Corrosion & Scaling	12.77	5.66	4	21
Lost Circulation	12.62	5.58	2	21
Industry Coupled Drilling	11.85	6.67	1	21
Binary Technology	10.85	4.58	4	20
Improved Reservoir Simulation	10.69	7.20	0	21
Improved Gas Extraction	10.46	4.89	3	18
Logging Technology	10.31	3.64	5	16
Reservoir Assessment	9.92	6.97	1	19
Advanced Heat Rejection	9.62	4.72	4	18
Flash Technology	9.31	4.15	3	18
Advanced Drilling	9.15	5.54	3	19
Geochemistry	8.85	4.10	2	16
Case Histories	8.69	6.60	1	20
Heat Mining	7.54	5.59	1	17
Advanced Energy Conversion	5.62	4.21	0	15
Geopressured R&D	3.77	3.56	0	11
Magma R&D	3.69	5.31	0	17

Table 2. Analysis of Participant's Priorities Matrix, 13 Subsurface-Processes People.

R&D Topic	Mean	Std Dev	Min	Max
Injection Technology	15.13	4.64	8	21
Advanced Heat Rejection	15.13	6.24	1	20
Reservoir Assessment	14.38	3.93	8	20
Corrosion & Scaling	14.38	4.87	6	21
Advanced Energy Conversion	14.13	4.42	9	21
Exploration Technology	13.50	4.07	9	20
Slim Hole Technology	13.00	5.37	5	20
Binary Technology	13.00	6.44	3	21
Advanced Drilling	12.62	5.01	6	18
Flash Technology	12.00	6.80	1	19
Improved Reservoir Simulation	11.88	6.08	4	20
Drilling Technology	11.88	1.96	10	15
Improved Gas Extraction	11.00	8.21	0	21
Geochemistry	10.50	3.96	4	15
Industry Coupled Drilling	10.38	6.52	3	18
Case Histories	9.38	3.81	1	14
Heat Mining	7.13	3.83	2	14
Completion of Wells	6.63	4.75	1	17
Lost Circulation	6.25	2.19	3	9
Logging Technology	6.25	3.28	2	11
Geopressured R&D	2.13	1.64	0	4
Magma R&D	0.38	0.74	0	2

Table 3. Analysis of Participant's Priorities Matrix, 8 Surface-Processes People.

on the highest- and lowest-priority items. The table clearly demonstrates the industry's interest in R&D on topics of concern to hydrothermal resource development. The top ten R&D topics, in order of priority, are injection technology, slim hole technology, drilling technology, exploration technology, corrosion and scaling, advanced heat rejection, binary technology, reservoir assessment, industry coupled drilling, and improved reservoir simulation.

To help elucidate any bias between the surface-processes and subsurface-processes groups, the data gathered from the two groups were analyzed separately using the same techniques. The results from the 13 subsurface people are shown in Table 2, and the results from the 8 surface people are shown in Table 3. The top ten R&D projects as ranked by the subsurface-processes people are slim hole technology, drilling technology, injection technology, exploration technology, completion of wells, corrosion and scaling, lost circulation, industry coupled drilling, binary technology, and improved reservoir simulation. A preference for topics of an earth science nature is quite clearly shown. The top ten R&D topics as ranked by the surface-processes people are injection technology, advanced heat rejection, reservoir assessment, corrosion and scaling, advanced energy conversion, exploration technology, slim hole technology, binary technology, advanced drilling, and flash technology. As one would expect, R&D topics concerning power conversion dominate this list, although certain subsurface topics received very high ranking by this group also.

THE QUESTIONNAIRE

The questionnaire given to each participant is shown as Illustration 1 at the back of this paper. The purposes of this questionnaire were to serve as a warmup exercise for constructing and ranking the Participant's Priorities Matrix and to gather other important information. Two primary results from the questionnaire will be presented in this paper. The first deals with the issue of R&D priorities and the second deals with how the participants would allocate the amounts in three given funding levels among major R&D categories.

The Questionnaire Priorities Matrix

The questionnaire contained a table of potential R&D topics constructed by the author (see Illustration 1). The topics were divided into four major categories — reservoir technology, conventional drilling technology, conversion technology and advanced technology. Within each category, the participants were asked to rank the suggested R&D topics as low, medium or high in priority. Of the 22 meeting participants, 15 filled out the questionnaire in sufficient detail to be useful in this ranking.

Table 4 shows the results. The 20 R&D categories are listed on the left side of the table. For purposes of analysis, I assigned values of high priority = 3, medium priority = 2, and low priority = 1. This table shows the R&D categories in order of decreasing priority, as the other tables have done. The top ten R&D topics are discovery techniques, injection studies, reservoir delineation, slim hole technology, drilling techniques and equipment, corrosion and scaling, cooling technology, reservoir simulation, lost circulation, and binary technology.

Budget Recommendations

Item 9 in the Questionnaire (see Illustration 1) deals with the issue of allocation of the Department of Energy's budget among major R&D categories. The categories selected were reservoir technology, energy conversion, conventional drilling, advanced drilling, conventional hot dry rock, expanded hot dry rock, geopressured resources, magma resources, and other. Definitions for each of these categories are given in the questionnaire except for the "other" category, which the respondent was to specify. Items mentioned by meeting participants in this category were advanced energy conversion, export assistance and geothermal heat pumps. Three budget levels were assumed, $24 million, $40 million and $60 million per year. The figure $24 million corresponds to the actual DOE/Geothermal Division budget for fiscal year 1993. The $60 million level is roughly the amount that the National Geothermal Association and the Blueprint Coalition were then recommending to the Administration and Congress for geothermal R&D. Tables 5, 6 and 7 show the results from the 15 meeting participants who completed the questionnaire. The values for mean, standard deviation, minimum and maximum are all in millions of dollars.

Reservoir technology is recommended for the largest budget allocation by far at all budget levels, followed distantly by energy conversion and conventional drilling in nearly equal amounts. These categories will be recognized as those of most concern to the development of hydrothermal resources. The advanced technologies had significantly less support except at the highest budget levels.

DISCUSSION

R&D Priorities

Examination of Tables 1 through 4 is interesting. The fairly large standard deviations and the spread between minimum and maximum values indicate the diversity of opinion on particular R&D categories that was found among the participants. Geologists tended to rank reservoir technology topics higher whereas power plant people ranked them lower, and conversely. These are the realities of the industry. There is such a wide range of disciplines that directly affect the economics of geothermal development that each person advocates most strongly for his or her areas of interest and expertise. This shows the need for having enough money that meaningful work can be done in high-priority topics across this broad range.

There are some differences in the ranking of R&D topics between the Participant's Priorities Matrix (Tables 1, 2 and 3) and the Questionnaire Matrix (Table 4), but these differences appear to be small and of limited consequence. The top-ranked items in both matrices are reservoir technology (discovery techniques, exploration techniques, injection technology, industry-coupled exploration drilling), drilling technology (slim-hole techniques, drilling technology) and conversion technology (cooling technology, corrosion and scaling, binary technology).

Surprisingly, case studies ranked low despite the fact that a Reservoir Technology panel convened by Lawrence Berkeley Laboratory in March 1993 had ranked case studies as very high in priority.

Budget Allocations

Table 8 presents a consolidation of the information in Tables 5, 6 and 7. The numbers are recommended spending levels in millions of dollars in each topic area, and the figures in parentheses are the percentages of the total budget recommended for each topic. Note that at low budget levels, the advanced technologies (hot rock, geopressured and magma) are not recommended for enough funding to carry out a meaningful program, but at higher funding levels their recommended allocation increases significantly. The percentage allocation for reservoir technology and energy conversion decline as total budget increases, but the percentage allocation for drilling stays constant.

By applying the priority rankings discussed above to the budget-allocation recommendations shown on Table 8 for the current size of the DOE geothermal budget ($24 million), we get a sense for the recommended level of spending on each R&D topic. Topics to be included in each budget category, in order of priority within each category, are given below.

Reservoir Technology (40% of budget). Injection Technology, Exploration Technology, Industry Coupled Drilling, Improved Reservoir Simulation, Reservoir Assessment.

Energy Conversion (21% of budget). Advanced Heat Rejection, Corrosion and Scaling, Advanced Energy Conversion, Binary Technology, Flash Technology, Improved Gas Extraction, Production Geochemistry.

Drilling (27% of budget). Slim-Hole Technology, Drilling Technology, Completion Technology, Lost Circulation, Logging Technology, Advanced Drilling.

The item entitled "Advanced Drilling" refers to the new initiative at DOE (the National Advanced Drilling and Excavation Technology (NADET) initiative) to develop innovative new drilling technology.

R&D Topic	Mean	Std Dev	Min	Max
Discovery Techniques	2.73	.59	1	3
Injection Studies	2.67	.49	2	3
Reservoir Delineation	2.60	.63	1	3
Slim Hole Technology	2.47	.74	1	3
Drilling Tech/Equipment	2.40	.63	1	3
Corrosion & Scaling	2.27	.70	1	3
Cooling Technology	2.27	.70	1	3
Reservoir Simulation	2.20	.86	1	3
Lost Circulation	2.13	.83	1	3
Binary Technology	2.13	.83	1	3
Advanced Drilling	2.07	.70	1	3
Completion of Wells	2.07	.80	1	3
Flash Technology	1.93	.88	1	3
Tracer Development	1.80	.68	1	3
Well Testing	1.73	.88	1	3
Expanded Hot Rock	1.40	.51	1	2
Piping & Gathering	1.27	.59	1	3
Conventional HDR	1.27	.59	1	3
Magma R&D	1.20	.41	1	2
Geopressured R&D	1.13	.35	1	2

Table 4. Geothermal Program Priorities, Analysis of Questionaire Priorties Matrix (Higher Numbers Indicate Higher Priority).

R&D Topic	Mean	Std Dev	Min	Max
Reservoir Technology	9.55	3.87	3.00	15.00
Energy Conversion	4.97	2.22	1.00	9.00
Conventional Drilling	4.55	3.38	.00	10.00
Advanced Drilling	1.94	1.61	.00	7.00
Conventional HDR	.49	.87	.00	2.40
Expanded Hot Rock	1.00	1.08	.00	3.50
Geopressured R&D	.57	.90	.00	2.50
Magma R&D	.27	.68	.00	2.50
Other	.67	1.29	.00	4.00

Table 5. Analysis of Budget Recommendations, $24 Million Budget Level

R&D Topic	Mean	Std Dev	Min	Max
Reservoir Technology	13.44	6.51	5.00	24.00
Energy Conversion	8.03	4.76	1.00	20.00
Conventional Drilling	6.97	4.48	1.50	15.00
Advanced Drilling	4.09	2.44	.50	10.00
Conventional HDR	2.06	1.56	.00	5.00
Expanded Hot Rock	1.94	1.83	.00	5.00
Geopressured R&D	1.34	2.10	.00	6.00
Magma R&D	.50	1.10	.00	4.00
Other	1.62	2.16	.00	5.00

Table 6. Analysis of Budget Recommendations, $40 Million Budget Level

R&D Topic	Mean	Std Dev	Min	Max
Reservoir Technology	20.23	9.54	6.00	34.00
Energy Conversion	10.03	4.94	2.00	18.00
Conventional Drilling	9.80	6.42	2.00	22.00
Advanced Drilling	6.13	3.77	.50	15.00
Conventional HDR	3.47	2.29	.00	8.00
Expanded Hot Rock	3.50	2.65	.00	7.00
Geopressured R&D	2.63	3.46	.00	11.00
Magma R&D	1.73	2.31	.00	5.00
Other	2.47	3.36	.00	10.00

Table 7. Analysis of Budget Recommentdtions, $60 Million Budget Level.

	$24 Million	$40 Million	$60 Million
Reservoir Technology	9.5 (40%)	13.5 (34%)	20.2 (34%)
Energy Conversion	5.0 (21%)	8.0 (20%)	10.0 (17%)
Drilling	6.5 (27%)	11.1 (28%)	15.9 (26%)
Hot Rock	1.5 (6%)	4.0 (10%)	7.0 (12%)
Geopressured and Magma	0.8 (3%)	1.8 (4%)	4.4 (7%)
Other	0.7 (3%)	1.6 (4%)	2.5 (4%)

Table 8. Summary of Recommended Allocations among Major Budget Categories for Three DOE/Geothermal Division Budget Levels (millions of dollars).

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REFERENCE

Anonymous, 1993, Sustainable Energy Budget for the U. S. Department of Energy, Fiscal Year 1995: Sustainable Energy Blueprint Coalition, 76 p.

Illustration 1.

INDUSTRY R&D NEEDS AND PRIORITIES

QUESTIONNAIRE[1]

29 April 1993

Name:____________________ Company:____________________

Do You Want This Questionnaire Kept Confidential? __Yes __No

1. What are the current perceptions within your company regarding the future and potential of geothermal energy?

2. What are the most significant technical problems faced by your company in geothermal energy development?

3. What are the most critical technical problems the DOE geothermal program should address?

[1] THIS QUESTIONNAIRE WILL BE KEPT CONFIDENTIAL IF YOU SO DESIRE. The information will be used in helping to assess industry's research and technology development needs in geothermal energy. Compilations and summaries of information from this questionnaire will be made publicly available, but this will be done such in a manner as to preserve the confidentiality of individual responses.

4. Please rate your <u>personal</u> knowledge of the present DOE geothermal R&D program as a whole.

   __None __Some __Fair __In-Depth

5. Do you believe that the DOE geothermal program has contributed to your ability to do business in the competitive energy-development world? If so, how?

6. How can DOE improve its communication and technology transfer with your company?

   a. Are DOE personnel open and responsive to communication, suggestions and requests? __Yes __No __No Comment.

   b. Are DOE's contractor personnel open and responsive to communication, suggestions and requests? __Yes __No __No Comment.

   c. Is the annual DOE Program Review series helpful? __Yes __No __No Comment.

   d. Are the results of DOE-funded R&D published in a way that is useful to you? __Yes __No __No Comment.

   e. What are your comments and suggestions?

7. Do you know about the Geothermal Drilling Organization and the Geothermal Technology Organization and how to use these organizations to cost-share R&D with DOE?

8. Considering that the results of DOE-funded R&D must be made public, how can DOE increase its cost sharing with industry? What should be the percentage split of DOE's budget between funding for the Laboratories and funding for direct industry cost-sharing?

In the tables below, the following definitions are assumed:

a. Reservoir Technology. All technology having to do with resource exploration and discovery, reservoir delineation, reservoir engineering, injection studies and similar topics.

b. Energy Conversion. All above-ground technology and equipment, including materials R&D.

c. Conventional Drilling. All technology and equipment for conventional rotary and core drilling and completion.

d. Advanced Drilling. Cutting-edge drilling techniques such as high-pressure abrasive jet drilling, flame-jet drilling, laser drilling, or other techniques not in regular commercial use.

e. Conventional Hot Dry Rock. The classical Los Alamos concept of creating fractures in hard, impermeable rocks and circulating water between injection and projection wells for heat removal.

f. Expanded Hot Rock. Heat mining from rock in cases where natural fluid circulation is insufficient for economic production. Includes the Japanese "hot wet rock" ideas. Hot rock resources form a continuum from conventional hydrothermal resources to conventional HDR resources.

g. Geopressured Resources. The conventional definition.

h. Magma Resources. The conventional definition.

9. In the following topic areas, how should DOE allocate its financial resources given the indicated budget levels?

Reservoir Technology			
Energy Conversion			
Conventional Drilling			
Advanced Drilling			
Conventional HDR			
Expanded Hot Rock			
Geopressured Resources			
Magma Resources			
Other ( )			
TOTAL	$24 Million	$40 Million	$60 Million

10. Please fill in the table as indicated.

Current and Potential Areas of DOE-Funded R&D	Priority: High, Medium, Low	Would You Share Costs, $ or In-Kind?
RESERVOIR TECHNOLOGY		
Discovery Techniques		
Reservoir Delineation		
Reservoir Simulation		
Well Testing		
Injection Studies		
Tracer Development		
Other ( )		
CONVENTIONAL DRILLING TECHNOLOGY		
Drilling Techniques/Equipment		
Lost Circulation		
Completion		
Slim-Hole Drilling		
Other ( )		
CONVERSION TECHNOLOGY		
Flash Power Plants		
Binary Power Plants		
Gathering and Piping		
Cooling Technology		
Corrosion and Scaling Control		
Other ( )		
ADVANCED TECHNOLOGY		
Advanced Drilling		
Conventional Hot Dry Rock		
Expanded Hot Rock		
Geopressured		
Magma		
Other ( )		