USER COUPLED DRILLING PROGRAM

RESERVOIR CONFIRMATION

for

LOW- AND MODERATE-TEMPERATURE HYDROTHERMAL RESOURCES

by

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PROGRAM SUMMARY

An ambitious program of DOE cost-shared reservoir confirmation is recommended as a vital catalyst to the development of hydrothermal direct heat utilization in the United States. Development is presently hampered by lack of resource knowledge and by the high risks and costs of reservoir confirmation. In addition, there is presently no experienced infrastructure in the private sector for direct heat development of the magnitude indicated as possible by the predicted large size and widespread occurrence of the resource. The Nation's urgent requirement for alternate energy sources would be substantially and favorably impacted by the recommended program.

The program would consist of DOE cost-shared surface exploration and drill confirmation of hydrothermal reservoirs. Users and developers in the private sector would share costs with DOE and would perform the work. DOE's cost share would be low for a successful project[1] but would be high for an unsuccessful project. Thus, much of the risk associated with reservoir confirmation is assumed by DOE. Development of the hydrothermal resource, once confirmed, would consist of further drilling to obtain the amount of hydrothermal fluid required and then installation of utilization hardware. This development would proceed by private investment, aided, where necessary, by Geothermal Loan Guarantee or PON funds.

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[1]A successful project is one that results in a hydrothermal resource having temperature and production characteristics suitable for direct application.

The recommended program could be implemented at nearly any reasonable level of funding. However, in order to be most effective a farily high level would be required. The total cost to DOE for the program scenario recommended in this document would be about $250 million during the years FY81 to FY86 inclusive. During this interval private capital in the amount of about $255 million would be required. The peak year of the program would be 1983 when DOE would be required to budget $69 million and private capital would supply $145 million. Further details of the recommended program are summarized in Table 1 at the end of this report.

The User Coupled Drilling Program would result in development of an estimated 25 percent of the total infrastructure that will be needed in order for private users to bring on line about 1.5 Quads of direct heat uses by the year 2000, an amount well within the DOE stated goal of 0.5-2.0. The remaining 75 percent of the required infrastructure would result through private development once the risks and costs of exploration and confirmation of these resources are reduced as a result of the recommended program. In the near term, about 0.15 Quads of utilization would result directly from the User Coupled Drilling Program by 1987, in line with DOE's near-term goals.

It is believed that a program of the proposed magnitude will be required in order to produce the experienced infrastructure needed to lower risks and costs sufficiently so that direct heat hydrothermal energy is economic and can make a significant contribution to the Nation's energy supply.

INTRODUCTION

Most geothermal geoscientists agree that there are many more low- and moderate-temperature ($30^{o}C$ to $150^{o}C$) hydrothermal resources than there are high-temperature ($>150^{o}C$) hydrothermal resources. Muffler (1979) in U.S. Geological Survey Circular 790, Assessment of Geothermal Resources of the United States--1978, documents the distribution of hydrothermal resources as we presently known them as a function of temperature down to $90^{o}C$, with the conclusion that there is an exponential increase in the number of known occurrences as temperature of the resource decreases. This implies that the geographic distribution of resources is wider and that the possibility of co-location with a user is increased as temperature decreases. The above exponential relationship seems to be a property of many natural resources for it has also been documented for a number of other cases. For example the quantity of copper ore above a certain cutoff grade is known to increase approximately exponentially as the cutoff grade is decreased, both within individual copper deposits and for the world's copper resource as a whole.

Considering the relationship stated above, it is possible that direct heat utilization of low- and moderate-temperature hydrothermal resources will ultimately contribute more power on line than will electrical generation from high-temperature resources simply because lower temperature resources are so much more plentiful and widespread.

There is *very little use* presently being made of low- and moderate-temperature hydrothermal resources. The main reasons for this appear to be 1) *lack of enough knowledge of the resource* itself to attract users, and 2) *present high risk level and high costs* associated with reservoir confirmation. By contrast, utilization of a hydrothermal resource, once it is discovered and confirmed, usually consists of reasonably straightforward engineering.[2]

Lack of resource knowledge occurs on two levels of detail:

1. On a regional scale, the locations of low- and moderate-temperature resources are poorly known. Phase I of the State Coupled Program (see p. 6) has the objective of correcting this deficiency, but maps and compilations of information are only now becoming available in preliminary form through this program;
2. On a site-specific scale, the lateral limits, depth, temperature, productivity, and longevity of very few low- and moderate-temperature hydrothermal reservoirs are known. Very little surface exploration and drilling have been done by the private sector. There are no present federal or state programs to correct this deficiency, but the User Coupled Drilling Program recommended herein would fulfill this need.

The present *high risk level* for reservoir confirmation stems partly from the lack of resource knowledge stated above and partly from the fact that present surface surveying techniques are not well enough developed to ensure with a high level of probability that a drill hole will intercept a resource.

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[2] Low-temperature hydrothermal resources generally have low salinities. Special high-temperature equipment and special techniques to handle high salinities are problems usually encountered only with high-temperature resources. Most direct heat hydrothermal applications can use off-the-shelf equipment and techniques.

Hydrothermal reservoirs are never uniform or continuous, and dry holes can be drilled in the middle of the best of resources. Better techniques for and more experience in siting wells are needed to decrease the risk of drilling an unproductive well.

The *high costs* of reservoir confirmation result mainly from the high cost of drilling. Although federal and private funds are being spent to improve drilling techniques, it is unlikely that substantial cost reduction will result in the near term. Drilling costs have been increasing faster than the inflation rate over the past several years. In addition to high drilling costs, there is often a waste of exploration funds through application of inappropriate geological, geophysical or geochemical techniques. New technique development and more experience in application are needed to decrease cost as well as risk.

Present developers of electrical power generation from high-temperature reservoirs are generally large companies that can finance reservoir confirmation by spreading the high risk and cost over many projects. However, these large companies are usually not interested in development or utilization of lower temperature reservoirs because of the relatively small scale of such projects. Small developers, the ones most likely to be interested in low- and moderate-temperature geothermal resources, are unable to spread risk and cost in the same way that a large company can. A single unproductive well can mean financial disaster for them. For these reasons, it is not expected that the direct heat user in the private sector will be able to perform needed reservoir confirmation for low- and moderate-temperature hydrothermal resources by himself in the near future. Without federal assistance there will continue to be very little use of the large hydrothermal resource base that exists in the United States.

RELATION TO PRESENT DOE RESOURCE DEFINITION PROGRAMS

At the present time, DOE is supporting a number of programs which would support but would not overlap or replace the User Coupled Drilling Program. The *State Coupled Program* is carried out in each participating state by an appropriate state agency or university who is funded by DOE. The program's primary objective is compilation and publication of regional scale maps and reports that identify potential low- and moderate-temperature hydrothermal resource areas. A small portion of this program has been addressed to detailed exploration and drilling of a few select sites. But the State Coupled Program is neither structured nor funded to perform reservoir confirmation projects at many specific sites in the amount needed to make an impact on the Nation's energy problems. Even with increased funding the State Coupled Program would be an inappropriate vehicle to carry out reservoir confirmation. The User Coupled Drilling Program, proposed herein, would be much more effective because the work would be done and the infrastructure developed in the private sector rather than in state agencies.

The *Industry Coupled Program* of DOE is a cost-sharing program with industry which has the objective of increasing the amount of exploration and reservoir assessment that industry is able to do for high-temperature resources suitable for electrical power production. In the process of exploration for high-temperature resources, data on low- and moderate-temperature resources are automatically generated at specific sites. This program is currently active at only about 15 sites which have specific high-temperature potential, whereas low- and moderate-temperature reservoir confirmation is needed at many more sites which have no current interest to the large developer.

The DOE *Geothermal Direct Application Field Experiment Program*, known as the *PON program*, has the goal of demonstrating direct heat use of geothermal energy at sites where the risk associated with reservoir confirmation is low or where the reservoir is already confirmed. This program is currently active at 22 of the 23 sites for which funds have been allocated, and future PON solicitations are planned. As it is currently operating, the PON program is actually performing reservoir confirmation activities. This has been done because very few confirmed reservoirs are available, but it is being done without the benefit of appropriate geologic exploration guidance. Because the purpose of the PON program is not reservoir confirmation, and because few confirmed reservoirs are known today, the program proposed herein would not overlap the PON program but rather would replace inappropriate PON reservoir confirmation activities with an aggressive, exploration-oriented program that would provide reservoirs needed for continuing the PON program along the originally intended lines.

RECOMMENDED DOE RESERVOIR CONFIRMATION PROGRAM

There is a clear need for a federal program to stimulate site-specific, detailed reservoir exploration and confirmation. Once a reservoir is confirmed it is unlikely that much federal stimulation would be needed to ensure its use. The reservoir confirmation program should include funds for detailed surface exploration aimed at drill site selection and for sufficient drilling to confirm reservoirs. This work should be performed in resource areas where a user is available so that private capital would finance utilization and full field development.

Objectives

The objectives of the proposed program are:

1. To foster economically viable use of low- and moderate-temperature geothermal resources by the industrial and private sectors by the year 1986, at which time the program would phase out, and
2. To develop an infrastructure of a) exploration, reservoir confirmation, drilling, and utilization engineering consultants and contractors, b) equipment manufacturers, and c) financial institutions that will facilitate increased *economic* use of low- and moderate-temperature geothermal resources without the need for federal support beyond 1986.

It is believed that a program of the magnitude proposed herein will be required if both of these objectives are to be achieved.

Strategy

Both of the above objectives can be achieved by a *DOE program to fund private users and developers on a variable cost-share basis to carry out confirmation of low- and moderate-temperature hydrothermal reservoirs.* Private capital would then take over in most cases to finance the installation and operation of utilization systems, the high front-end risk having been assumed by the confirmation program. During the course of the proposed program, an experienced infrastructure would be developed *in the private sector* that would be able to carry on without federal support beyond 1986. The program would enable *development of the techniques, knowledge and experience base* necessary, but presently lacking in the private sector, *to decrease the present high risk and cost of reservoir exploration, confirmation and testing*. Hard data, now unavailable, on the economics of hydrothermal direct heat utilization for the entire sequence from exploration to reservoir confirmation to equipment installation and operation would be generated. It is anticipated that by the end of the program, market forces would favor further direct heat development.

Program Size

The required size of the program must be based upon what is needed for development of a self-sustaining infrastructure in the private sector and upon generation of the knowledge and experience base necessary within that infrastructure to decrease risks and costs for direct heat development. Only in this way will development carry forth when the recommended program is phased out. The infrastructure developed by the program must be large enough that substantial growth in direct heat application can occur both in the short term and in the mid- and long-terms, so that DOE's direct heat utilization goals of 0.1-0.2 Quads by 1985 and 0.5-2 Quads by 2000 can be achieved. In the following, one possible scenario for the User Coupled Drilling Program is developed as an illustration of the program magnitude, content and cost. The program can be easily modified to correspond to almost any reasonable level of funding.

Let us *assume* that in order to make a desirable impact on the Nation's energy supply, direct heat utilization of hydrothermal resources is to be 1.5 Quads by the year 2000 and that 90 percent of this amount must be developed by private industry between 1986 and the year 2000. This would require private development of an average of about 3350 MWt-yr per year[3]. Let us further assume that the average *yearly* distribution of utilization system sizes[4] brought on line is as follows:

Utilization System Size	Number	Contribution
100 MWt	4	400 MWt
50	15	750
25	50	1250
10	75	750
5	40	200
	184	3350 MWt

This means that private users would be required to bring 184 reservoir confirmation projects to a successful conclusion each year between 1986 and the year 2000. Assuming an average 25 percent success rate for reservoir confirmation projects, about 736 projects would have to be initiated per year, or an average of about 15 projects per year per state.

[3] 1 Quad = 10^{15} BTU = 33,400 thermal megawatt-yrs. (MWt-yr)

[4] This distribution assumes a decreasing number of larger systems because of the fall-off in number of occurrences as temperature and size increase. The number of uses under 10 MWt drops off because economics of very small utilization systems will probably not be favorable.

The infrastructure needed for industry to perform this task will be large indeed, but there is no need for federal support for its entire development. Suppose instead that the total infrastructure develops along the lines shown in Figure 1. This figure shows one possible schedule for reservoir confirmation projects to the year 2000. Obviously the required infrastructure is approximately proportional to the number of projects per year. Figure 1 shows that the recommended DOE program should peak in 1983, when about 200 DOE-funded reservoir confirmation projects would be initiated. Assuming Figure 1 to be a viable scenario for the DOE program, the following project schedule would be indicated:

Year	FY80	FY81	FY82	FY83	FY84	FY85	FY86
Number of Reservoir Confirmation Projects Initiated	0	100	165	200	130	65	0

Thus the DOE program would fund initiation of a total of 660 projects during 5 years and would support the development of about 25 percent of the total infrastructure needed to reach the year 2000 direct heat utilization goals. The remaining 75 percent of infrastructure development would be completed by the private sector. Infrastructure development beyond 1986 would, of course, depend upon the overall economics of direct heat utilizaton at that time, which can not now be evaluated but which will be favorably changed as a result of this program and which will be amenable to evaluation in 1986 as a result of data generated by this program.

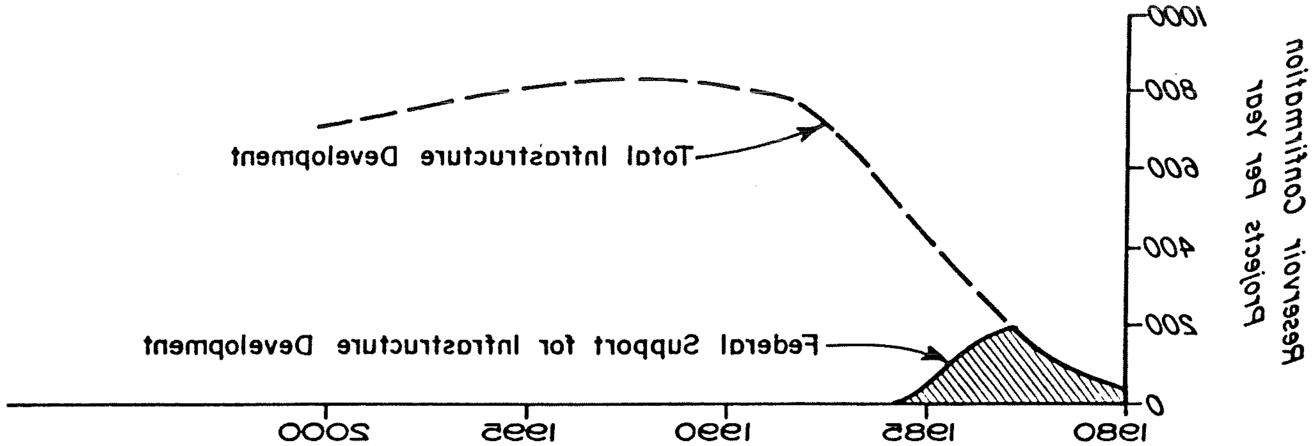

Figure 1

POSTULATED INFRASTRUCTURE DEVELOPMENT

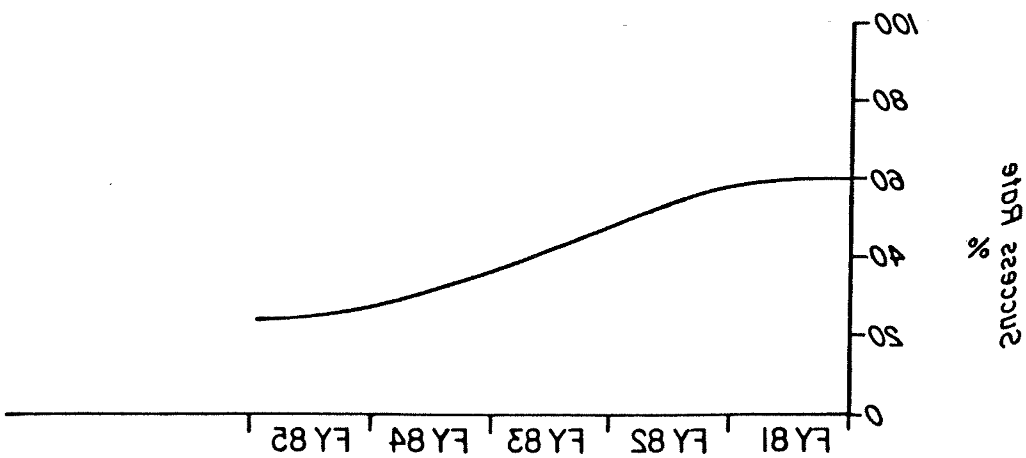

Figure 2

POSTULATED SUCCESS RATE

(3300 MWt) on line by 1985 and about 0.15 Quads (4500 MWt) by 1986, based on the assumed utilization size distribution shown on page 10.

Line 6 shows that a 10% initial DOE cost share for successful confirmation projects is assumed, but this will decrease to 5% in later years. A 100% cost share, which decreases to 90% in later years, is assumed for confirmation projects that are failures.

The data shown in Lines 7-17 are calculated with the assumption that 60% of the projects will be completed during the year they are initiated and that 40% will carry over into the next year. Programs that take more than one year to complete are listed in the table as being initiated in one year but costed the next year. This means, for example, that although 100 projects begin in FY81, only 60 of the projects are included in the costs for FY81; 40 projects are carried over to and are calculated with the costs for FY82.

An additional assumption is that the larger utilization systems will in general require more complex and deeper drilling projects. Thus the number of each confirmation program predicted on Lines 7-10 is consistent in this way with the utilization system size distribution on page 10. The numbers of post-confirmation programs identified in Lines 11 and 12 are calculated assuming the success rate of Line 2 for the 60% of the confirmation projects initiated and completed during a year and the 40% carried over from the previous year.

DOE confirmation costs (money which goes to the state or private contractors) in Line 13, and private investment costs in Line 14, are calculated using the success rate shown in Line 2 and the cost-share percentages shown in Line 6 for confirmation and post-confirmation programs (Lines

Program Ingredients

So far we have determined, using a number of assumptions, that the DOE program should consist of 660 reservoir confirmation projects to be performed over the interval FY81 to FY86 inclusive. In order to determine other program requirements and benefits and to estimate an annual cost, we must assume a more detailed success rate for early phases of the program. Figure 2 shows a decreasing success rate over the life of the DOE program from 60 percent in early phases to 25 percent in later phases. The success rate decreases with time because projects funded early on would be those where good resource data exist, where there are favorable surface geothermal manifestations, or where there are other factors which increase odds of success. Later projects would be more "wildcat" in nature, and the success rate would be even lower than 25 percent were it not for the development of exploration technology and experience as the program progresses.

Another ingredient needing specification is the make-up of a typical reservoir confirmation project. In practice there will be great diversity. Some projects will require deep drilling in complex geologic environments where exploration problems are difficult whereas others will only amount to shallow holes in simple environments. The following four confirmation projects are offered not as end members to the wide range of projects anticipated but perhaps as being *average or typical.* More complex and expensive, and less complex and expensive projects will both occur during the course of this program.

Confirmation Program 1--Deep wells, complex geology	Cost
Surface geology, geochemistry, geophysics	$ 200K
Temperature gradient holes (6000 ft total @ $50/ft)	300
Production well (5000 ft @ $160/ft) and Testing ($150K)	950
	$1450K

Confirmation Program 2--Deep wells, simple geology	
Surface geology, geochemistry, geophysics	$ 60K
Temperature gradient holes (3000 ft total @ $40/ft)	120
Production well (5000 ft @ $140/ft) and Testing ($150K)	850
	$1030K

Confirmation Program 3--Shallow wells, complex geology	
Surface geology, geochemistry, geophysics	$ 160K
Temperature gradient holes (4000 ft total @ $30/ft)	120
Production well (1500 ft @ $120/ft) and Testing ($70K).	250
	$ 530K

Confirmation Program 4--Shallow wells, simple geology	
Surface geology, geochemistry, geophysics	$ 40K
Temperature gradient holes (1300 ft total @ $30/ft)	40
Production well (1500 ft @ $80/ft) and Testing ($70K)	190
	$ 270K

At sites where a successful production well is drilled, the reservoir will be considered to be confirmed. At these sites a post-confirmation program of reservoir engineering, hydrology, and injection well drilling and testing will be needed. A typical range of post-confirmation programs might be as follows:

Post-Confirmation Program 1--deep well	
Engineering and Hydrology	$ 20K
Injection well (5000 ft @ $150/ft) and Testing ($70K)	820
	$ 840K

Post-Confirmation Program 2--shallow well	
Engineering and Hydrology	$ 20K
Injection well (1500 ft @ $100/ft) and Testing ($50K)	200
	$ 220K

7-12). The assumption is also made that DOE will cost-share the post-confirmation programs at the same rate (Line 2) as for successful projects. The costs in Lines 13 and 14 have been rounded to the nearest $10,000.

Line 15 shows the number of projects initiated, a repeat of Line 1. Line 16, projects terminated, includes for any particular year the 60% of the projects initiated and completed in one year, and the 40% of the previous years' projects that carry over to a second year. The number of confirmation projects in progress shown for each year thus includes all the projects begun in that year as well as the projects carried over from the previous year.

Line 18 shows estimates of the number of proposals that will be received, and Lines 19 and 20 present information on the amount management assistance that DOE will need. Geoscientists and engineers will be needed a) to review proposals, b) to track contracts and evaluate results for decision-making, and 3) to collect, interpret and publish the geoscientific, engineering and economic data that the program will generate. Costs for management assistance, not including DOE staff requirements, are shown in Line 21.

Final estimated cost totals are shown for DOE in Line 22 and for the combined DOE and private sector investment in Line 23. Total program costs are $251 million for DOE and $255 million for private investors, for a grand total of more than $506 million by 1986. This is indeed an ambitious program.

DEFINITION OF TERMS

Reservoir Confirmation - Geoscientific work that leads to proof that a supply of hydrothermal fluids exists at depth and that from the geologic viewpoint this supply is exploitable. The required geoscientific work includes geological, geophysical and geochemical studies and usually includes drilling.

Hydrothermal Resources - A geothermal resource of naturally heated, naturally occurring fluids in the ground. The fluid may be primarily water or steam. Heat is supplied to the fluids from rocks that contain and transmit heat from within the earth.

Implementation and Management

The program proposed herewith is in every aspect an *exploration* program. *It if is to succeed, it must be managed and performed by geoscientists who have an exploration background.* An average of 132 projects must be initiated per year during FY81-85 inclusive. Management (Wright, 1979) and performance of a program of this scope will be complex. Thorough planning will be needed.

It is recommended that the program be implemented through a series of competitive procurements directed at the non-federal, state and private sectors. The procurements would specify that acceptability of proposals would be based on 1) having a well-conceived, time-phased exploration and reservoir confirmation program under the direction of appropriate *private sector* geo-scientific expertise, 2) having a user tied to the project (preferably as project manager), and 3) having a clear land, regulatory and environmental situation so that no snags would develop along the way. Once proposals are evaluated and accepted, a variable cost-share contract would be negotiated with the proposer. This contract would specify 1) the definition of success on the project based upon technical achievement (generally upon temperature, quantity, and quality or other quantifiable parameters of useability of fluids encountered, 2) the share of the cost to be paid by DOE in case of success and in case of failure, and 3) the decision points during the project at which either DOE or the contractor could elect to proceed or to withdraw. The DOE cost share for a *successful* project would be about 10 percent initially and would decrease to 5 percent later on. It would be paid mainly for data which the project generates -- these data would be interpreted and published as case studies for the purpose of technology transfer and economic model development. For an *unsuccessful* project the DOE share would initially be 100 percent but would decrease to about 90 percent in later years.

Once the cost-share contract is negotiated, DOE would have effectively assumed the main risks in bringing direct heat use on line. At that point the contractor would simply take the DOE-backed contract to the bank and borrow money for the project, which he would then perform. DOE would monitor project progress and would evaluate results in order to determine whether or not to proceed at each decision point. When the project is completed, DOE would pay the contractor the previously agreed cost share, completing the DOE obligation. DOE would not have continuing obligation or be responsible for marketability of the geothermal fluid nor for the economics of the end use. Utilization of the resource would proceed using private capital or, alternatively, the project could become a PON candidate or a candidate for a federal Geothermal Loan Guarantee. This proposed funding scheme has advantages over full federal funding, which would double the total cost to DOE without developing a private sector financial infrastructure, and over existing federal programs such as the Geothermal Loan Guarantee program, which can obligate DOE depending on the economics of the end use of the resource. It has the advantage over the forgiveable loan of developing a tie between user and banks. In addition, no new federal legislation or regulations would be required for its implementation.

DOE would require management assistance for this program (Wright, 1979). Principal tasks would be proposal evaluation and assistance in contract tracking and evaluation of project results. The evaluation and tracking teams could be composed of geoscientists from UURI and from the present State Coupled resource assessment contractors, whereas utilization and reservoir engineers could be supplied by EG&G, Idaho, and by members of the present Commercialization Planning state teams. UURI could coordinate the geoscientific aspects of the project and EG&G could coordinate the engineering aspects. The respective state team members would help provide state-level management assistance. This arrangement would guarantee high-quality exploration and confirmation projects in areas where good utilization potential has been identified.

Consideration of the size and structure of the DOE staff required for management is not determined in this study but would have to be given if this recommended program is implemented.

Costs and Schedule

Table 1 gives an estimate of the program costs and a proposed schedule. Costs are quoted in 1978 dollars on the basis of the several assumptions listed above. A detailed explanation is given below. It should be noted that exploration costs are escalating yearly, with drilling costs presently rising at nearly 20 percent per year. On the other hand, it is anticipated that some of the confirmation costs will decrease (in terms of 1978 dollars) as knowledge and experience are gained. These opposing factors have not been evaluated in Table 1.

The schedule for project initiation (Line 1) and an estimate of success (Line 2) for reservoir confirmation projects are given at the top of Table 1. These figures are used to calculate the expected numbers of successful and unsuccessful projects as shown on Lines 3 and 4, respectively. It is expected that utilization of confirmed reservoirs will begin in late 1983, allowing one to two years beyond reservoir confirmation for additional drilling and construction of facilities. Line 5 shows a prediction of about 0.1 Quads

ACKNOWLEDGEMENTS

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TABLE 1

RECOMMENDED PROGRAM COSTS AND SCHEDULE

	ITEM	FY80	FY81	FY82	FY83	FY84	FY85	FY86	TOTALS
	Program Schedule								
1.	Confirmation Projects Initiated	0	100	165	200	130	65	0	660
2.	Average Success Rate, %	-	60	54	41	31	25	-	43(av)
3.	Successes	-	60	89	82	40	16	-	287
4.	Failures	-	40	76	118	90	49	-	373
5.	MWt on Line, cumulative	0	0	0	800	2,000	3,300	4,500	4,500
	Program Budget								
6.	% DOE Cost/share (Succ./Fail.)	-	10/100	10/100	5/95	5/92	5/90	5/90	-
7.	No. Confirm Prog 1 @ $1450K	0	7	15	21	17	10	3	73
8.	No. Confirm Prog 2 @ $1030K	0	7	15	21	17	10	3	73
9.	No. Confirm Prog 3 @ $ 530K	0	23	54	72	62	36	10	257
10.	No. Confirm Prog 4 @ $ 270K	0	23	55	72	62	35	10	257
11.	No. Post Confirm Prog 1 @ $840K	0	8	18	19	13	7	2	67
12.	No. Post Confirm Prog 2 @ $220K	0	28	59	66	43	19	4	219
13.	DOE Confirm Costs (money to private sector)	0	17,740	44,270	65,250	60,690	37,170	10,740	$235,860K
14.	Private Investment	0	30,900	64,500	74,910	51,450	26,220	7,250	$255,230K
	Management Assistance to DOE								
15.	Confirmation Projects Initiated	0	100	165	200	130	65	0	660
16.	Confirmation Projects Terminated	0	60	139	186	158	91	26	660
17.	Confirmation Projects in Progress	0	100	205	266	210	117	26	-
18.	No. Proposals Received	300	400	500	400	200	100	0	2,250
19.	No. Geoscientists, Prop Eval/Proj Monitor	8/0	8/10	10/20	8/26	6/21	4/12	0/0	-
20.	No. Engineers, Prop Eval/Proj Monitor	4/0	4/5	5/10	4/10	3/8	2/4	0/2	-
21.	Management Costs, $K	960	2,160	3,600	3,840	3,040	1,760	160	$ 15,520K
22.	Total DOE Costs (excluding DOE staff)	960	19,900	47,870	69,090	63,730	38,930	10,900	$251,380K
23.	Total DOE and Private Capital Needed	960	50,800	112,370	144,000	115,180	65,150	18,150	$506,610K