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A Management and Selection System for R&D Projects

Volume I — Overview

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MTR-7694
Volume I

A Management and Selection System for R&D Projects

Volume I — Overview

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ABSTRACT

This report describes an R&D project management and selection system developed for the Utilization Technology Branch of the Division of Geothermal Energy, Department of Energy. The proposed project management system (PMS) consists of a project data system (PDS) and a project selection procedure (PSP). The project data system consists of a series of project data forms and project status logs, and descriptions of information pathways. The PDS emphasizes timely monitoring of the technical and financial progress of projects, maintenance of the history of the project and rapid access to project information to facilitate responsive reporting to DGE and DOE upper management. The project selection procedure emphasizes an R&D product-oriented approach to benefit/cost analysis of individual projects. The report includes: (a) a description of the system, and recommendations for its implementation, (b) the PDS forms and an explanation of their use, (c) a glossary of terms for use on the forms, (d) a description of the benefit/cost approach, (e) a data base for estimating R&D benefits, and (f) examples of test applications of the system to nine current DGE projects.

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SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

BACKGROUND AND PURPOSE

The Division of Geothermal Energy (DGE) within the Department of Energy (DOE) had an operating budget of \$83.2 million for FY 1977. In the Department of Energy (DOE) the DGE budget for FY 1978 exceeds \$88 millions. The Utilization Branch (UB) of the DGE is responsible for R&D in the areas of Geothermal Drilling Technology, Geochemical Engineering, Advanced Heat Exchangers, Extraction Technology Improvements and Reservoir Stimulation. The Branch Chief and the three Program Managers in this branch select, monitor and control the R&D projects in the above-mentioned technical areas*.

The proposals for various R&D activities originate from a variety of sources (national laboratories, universities, industrial researchers, etc.) in response to solicitation in a number of different ways (Request for Proposal (RFP), Program Opportunity Notice (PON), Program Research and Development Announcement (PRDA)). A number of unsolicited proposals for R&D are also submitted to DOE. The Branch Chief of the Utilization Branch felt that the volume and diversity of the R&D activities in various stages of advancement (proposal solicitation, proposal evaluation, contract processing, project monitoring and control, and commercialization) make it difficult for the Program

* In FY 78, there were more than 60 projects involving a budget in excess of \$15 millions under the purview of the Chief of the Utilization Branch.

Managers to optimize the utilization of the resources for R&D, without the aid of a rational system for evaluating competing R&D concepts and a well documented and regularly updated system for monitoring and controlling various ongoing projects.

Although the existing DOE Contract Reporting Procedures provide most of the data needed for monitoring funded R&D activities, considerable improvement appears to be necessary in the procedures for selecting R&D concepts to be funded by DGE.

The proposed project management and selection system was developed for the purpose of

- creating better coordination between DGE goals and R&D strategy;
- enhancing the accountability of R&D efforts;
- providing a rational base for R&D program subelement (project) selection, assignment, termination, modification, renewal, and extension;
- promoting more productive utilization of R&D resources through appropriate response to industry needs;
- creating an up-to-date and organized data base for R&D program monitoring and control.

APPROACH

In order to ensure that the selection of R&D activities to be funded is related to identifiable impacts on the cost and/or availability of geothermal energy, the selection of an R&D program subelement*, and the monitoring and control of subelements/project were

* A Program subelement consists of one or more projects which jointly lead to an identifiable impact on the cost/availability of geothermal energy. A detailed explanation is provided in Volumes I and II of the final report.

emphasized in the proposed system. This approach forces the decision makers to lay out their plans for the entire program subelement, i.e., from the first phase of the project to the commercialization stage. The benefits (net savings attributable to the subelement) and costs need to be estimated for all phases of the project prior to a positive decision concerning the pursual of the associated R&D concept (for estimating the benefit/cost ratio).

The major steps involved in following this approach are:

- A detailed review of the existing documentation for a set of selected projects;
- A determination of the information needs of a rational method for project selection, and an effective project monitoring and control system;
- A review of the existing DOE Contract reporting system (to prevent duplication of effort as much as possible);
- Development of a Project Management System composed of a Project Data System and a Project Selection Procedure;
- Testing and modification of the data forms for operating the proposed system; and
- A test application of the model for estimating benefit/cost ratios.

RESULTS

The development of the Project Management System revealed many gaps in the existing documentation of ongoing projects. In addition, a lack of uniformity in project evaluation and selection procedures became evident. The test application of the new data forms for project monitoring and control indicated that regular updating of these forms will enable the Program Managers to ensure that all

documents pertaining to each project are received and filed in a timely manner.

The utilization of the model for estimating the benefit/cost ratios for a project will bring about some uniformity in the evaluation of the proposed and ongoing R&D programs. Although the estimation of the benefits of some projects may be difficult, the R&D proposers will be forced to identify benefits which result in increased availability and/or reduced cost of geothermal energy. It is expected that very few projects will be funded unless the proposers can provide a quantitative justification for undertaking these projects.

The results of the test application of the proposed system indicate that the ability of the Program Managers to monitor and control their R&D programs will be enhanced by the utilization of the proposed system.

RECOMMENDATIONS

On the basis of the results of the test application of the proposed system, it is recommended that this project management and selection system be introduced in stages. In order to ensure that the new system is implemented without any disruption of the regular activities at the DGE headquarters, the concerned DGE officials including Mission Team Leaders and Program Managers, and DOE Laboratory Officials should be briefed about the requirements and benefits of this system. The following recommendations are aimed at a smooth

introduction of the proposed system:

- In planning R&D activities, the emphasis should be placed on the entire program subelements (from original concept state to commercialization or technology transfer stage);
- To assist the Program Managers in computing the benefit/cost ratios for their program subelements, a set of discrete economic-engineering-process models for specific technical areas (e.g., well drilling, heat exchangers, etc.) should be initiated;
- Starting with the next budgetary cycle, all decisions concerning the funding of new subelements, and the extension, renewal or termination of ongoing subelements must be based on the benefit/cost ratios among other considerations;
- A short document should be prepared for explaining the system to organizations (contractors, DOE laboratories, etc.) that interface with DGE in the control of R&D activities;
- For each active subelement, one record file should be created. A separate section of this file should consist of the project data forms only;
- Each Program Manager should start maintaining Program Status logs with effect from January 1, 1978; the Branch Chief and other senior officials in DGE can utilize the logs for determining the up-to-date status of various R&D activities;
- The Program Managers should be provided with a regularly updated scenario for the development of geothermal prospects, so that they may assess the benefits of their program subelements relative to the latest national goals for geothermal energy utilization;
- All new R&D concepts submitted to DGE should be processed through the proposed system;
- Benefit/cost ratio should be estimated for all ongoing R&D projects;

- At an appropriate time, the model for computation of the benefit/cost ratios, and the project/subelement data system should be computerized.

1.0 ORGANIZATION OF THE REPORT

The final report for the Project Management and Selection System task consists of four volumes. This volume (Volume I) presents an overview of the system together with a summary of the results and recommendations for the implementation of the system.

Volume II describes the program management sequence and contains the details of the subelement information system. The paths for the flow of information and the associated data forms are explained in that volume. A glossary of standard items and definitions for recording and transmitting information is also presented.

The details of the benefit analysis model and the relevant data collection and figure of merit computation forms are presented in Volume III. The latest scenario for the development of geothermal prospects, which forms the basis for the estimation of the economic benefit of the successful completion of a program subelement, is presented in that volume.

The results of the test application of the proposed system are presented in Volume IV. It contains nine sets of filled-in data forms for subelements/projects, and the results of the benefit/cost ratio estimation for the Terra Tek "Improved Geothermal Drill Bit" subelement.

2.0 INTRODUCTION

2.1 Background and Purpose

The Division of Geothermal Energy (DGE) within the Energy Research and Development Administration (ERDA) had an operating budget of \$83.2 million for FY 1977. Most of these funds were allocated to six RD&D subprograms and the Loan Guaranty Program. These subprograms are designed to achieve the basic objective of the Federal Geothermal Program--"to stimulate the development of geothermal resources as economic, reliable, operationally safe, and environmentally acceptable energy sources". Every R&D effort undertaken by DGE should have an identifiable impact on the accomplishment of the objectives of the Federal Geothermal Program.

During 1976, selected projects funded by the DGE Utilization Technology Branch were reviewed with the objective of determining their expected impact on DGE goals⁽²⁾. The major impact was expected to be a reduction in the cost of power generated by exploiting geothermal resources. Quantifiable impacts could be identified for only about 10 percent of the work units/projects, primarily because of the lack of prospect scenario data necessary for estimating benefits. In the absence of identifiable potential impacts, it is difficult to make a quantitatively justifiable selection of R&D efforts and to determine whether an effort has been successful.

The research and development efforts authorized by DGE originate from many sources (unsolicited proposals, DGE Program Managers,

competitive procurements, requests from national laboratories, etc.) and flow through numerous channels (national laboratories, Field Operations Offices, DGE Headquarters) prior to the final approval. A management information system exists within DGE to cover projects and work units already under contract. However, R&D concepts in the approval chain are not tracked systematically.

The existing system allows substantial variation in the criteria and procedures for project/work unit selection, assignment, monitoring and control. These variations permit considerable inconsistency in the treatment accorded various individual projects/work units.

The need for a logical but simple system for coordinating and controlling R&D activities is enhanced by the expected increase in the number of R&D projects and the introduction of a matrix organization in which regional Mission Team Leaders identify site-specific needs. The proposed Project Management System (PMS) should increase the responsiveness of projects/work units to the DGE goals and strategy. At all levels of approval and control, the PMS could bring about consistency in relating a project/work unit to DGE goals. The PMS should permit the determination of the up-to-date status of the total R&D program as well as of individual projects/work units.

2.2 Terminology

A few terms are defined here to explain the context in which the Project Management System will be used.

The Utilization Technology Branch of the DGE currently sponsors about 80 R&D projects. To coordinate relationships among these projects, they are aggregated into various groupings in a hierarchical manner. This hierarchy is given the name "DGE Technical Aggregation Levels".

The technical aggregation levels consist of, from the top down:

- (1) DGE Branch - The collection of R&D activities which support a main thrust of the DGE overall effort.
(Run by a Branch Chief.)
- (2) Technical Program - An aggregation of R&D activities focused on one major subsystem for geothermal energy production or utilization. (Run by a Program Manager.)
Example: Well Drilling and Completion.
- (3) Technical Program Element - R&D activities focused on one small subsystem for production or utilization. Example:
Drill bits.
- (4) Technical Program Subelements (Subelement) - Activities that are directed toward the development of a specific product or process that can be incorporated into a geothermal energy system. The defining characteristic is that the product of the subelement will stand or fall on its own technical and economic merits, regardless of the success of the products of other subelements. A subelement consists of one or more projects conducted in series or parallel, as needed.
Example: An improved unsealed bit for air drilling.
- (5) Project - R&D activities conducted by one contractor to support a subelement. A project typically consists of a series of a few (two to four) contracts to research or develop a specific product or process.
Example: The three-year Terra Tek improved geothermal drill bit project.
- (6) Contract - the legal arrangement by which projects are executed. The duration of a contract is usually one year or less.

2.3 Approach

The key elements in a system for project selection, monitoring, and control are a logical model for selection of R&D concepts, and a streamlined project information system. The Metrek Division of The Mitre Corporation initiated the task of developing this system by reviewing the current procedures. In consultation with the Branch Chief and the Program Manager of the Utilization Branch, a set of current program projects was selected for reviewing the documents pertaining to these projects. This activity enabled Metrek staff to become familiar with the content and format of the existing documentation.

As anticipated, the documentation of various program subelements indicated a number of areas for improvement in the existing system. In many cases, some important documents, such as the original proposal, final report, contract, etc., were missing from the project file. Since a listing of various documents is not maintained, it is impossible to detect deficiencies in the documentation unless the whole subelement file is reviewed. Although many contracts call for regular submission of progress and technical reports by the contractors, the existing contract record-keeping system has no capability for detecting noncompliance with the contract stipulations in a timely manner.

A review of the proposals, proposal evaluation documents, and contract justification memoranda revealed that the specification

of quantitative objectives had not been emphasized. In most cases, relationships between expected project achievements and the scenario for geothermal power-on-line had not been made explicit. This is apparently due to the fact that many of these objectives were specified at a time when a well-defined scenario for geothermal power-on-line had not been formulated. In many cases, an expected improvement in technology performance which would result from the successful completion of the project was not quantified.

Following the review of existing documentation, discussions were held with the Branch Chief and Program Managers to determine their project information needs. These discussions were also instrumental in identifying the technical/economic performance parameters relevant to various R&D efforts, for which estimates of improvement might be obtained from contractors and/or Program Managers.

This was followed by the conceptualization of a model for selection of R&D concepts and the identification of data elements, data sources, and data transmission links which will constitute the new Project Data System. After this, the forms needed for the Project Data system and the Project Selection Procedure were designed. Using a representative set of projects, the project management forms were tested. The computation of the figure of merit was carried out for one program subelement (Terra Tek Improved Geothermal Drill Bit). On the basis of the experience gained through these tests, the data forms and the benefit/cost procedure were modified.

Finally, the whole set of forms was filled out (to the greatest extent possible) for several current DGE projects by extracting the relevant data from the existing documentation. A detailed benefit/cost analysis of the Terra Tek Improved Geothermal Drill Bit subelement was carried out with reference to the geothermal power-on-line scenarios.

2.4 General Comments

The anticipated increase in the number and complexity of R&D projects will make it increasingly difficult for the Program Managers to monitor and control their programs successfully without the aid of an effective project management system.

With the establishment of the national power-on-line goals for geothermal energy and the formulation of the development scenarios for 37 prospects,⁽³⁾ the Program Managers will have to make their R&D projects responsive to the needs of the overall geothermal energy program. A rational technique for R&D project selection will assist the decision makers in maximizing the effectiveness of the R&D activities.

Recognizing the current and anticipated problems, the Program Managers were most helpful in guiding the Metrek technical staff in becoming familiar with their programs as well as with the associated documentation. They also assisted the Metrek staff in understanding the technical content of the ongoing projects and the technical objectives of the future (near-term and long-term) program. Without

the close cooperation of the concerned DGE officials, it would not have been possible to develop the proposed Project Management and Project Selection Systems. The Program Managers are also aware of the fact that they will have a vital role in the successful implementation of the new system.

3.0 THE PROPOSED PROJECT MANAGEMENT SYSTEM

3.1 Overview of the Proposed System

The overall effort of designing the Project Management System (PMS) was divided into two major activity areas, namely (1) the development of a Project Data System (PDS), and (2) the development of a Project Selection Procedure (PSP), which constitutes the core of the Subelement Management Sequence (SMS). Figure 1 shows the relationships among the PMS, PDS, and PSP.

In developing the PDS, the emphasis was on creating a program subelement/project documentation system that would enable the Program Managers to maintain an up-to-date recording of the status of each activity. Through a set of forms and status logs, the Program Managers are provided with a system that can display the current technical progress, fiscal status, and future plans for each program subelement. The basic design approach focused on the need for transmitting the information needed for effective project management horizontally and vertically through the organizational structure of DGE in a compact form and a timely manner.

Since the Program Managers carry out the day-to-day supervision of various projects, the most detailed documentation has to be maintained at their level. The Concept Evaluation Form, Contract Processing and Project Monitoring Form, and the Subelement Monitoring Form are designed to enable the Program Manager to record detailed information about the latest status of various aspects of

FIGURE 1
STRUCTURE OF THE PROJECT MANAGEMENT SYSTEM

each project and program subelement. The R&D Concept Evaluation Form provides input for the benefit/cost analysis of a concept. A summary of the information in the above-mentioned forms is presented in the Log of R&D Concept Status, the Log of Project Status, and the Log of the Program Subelement Status. The logs, when updated regularly, will provide the R&D program status information needed by the Branch Chiefs and other senior officials in DGE. The detailed explanation and description of the forms and logs is contained in Volume II of this report.

The R&D Concept Evaluation Form and the Benefit/Cost Evaluation Form are the main vehicles for the Project Selection Procedure, and are focused on a benefit/cost analysis of each R&D concept. The benefit/cost ratio (figure of merit) can be viewed as a uniform basis for comparing various projects. A detailed explanation of the logic and methodology associated with the benefit/cost analysis is presented in Volume III of this report.

The analysis procedure involves the estimation of financial savings due to the improvement in the performance of a standard-sized unit of geothermal energy production technology (50 MW_e capacity). This is followed by the computation of the overall benefit by applying the performance improvement to all the geothermal power units expected to come on line (according to the DGE power-on-line scenario) by the year 2000. The expected degree of success of the R&D effort and the associated R&D costs are the other

factors which are used to estimate the figure of merit of a program subelement. In instances where a program subelement consists of a number of logically related projects, the figure of merit is computed for the whole subelement and not for individual projects.

Figure 2 illustrates the flow of information in the proposed project management systems. Samples of filled-in project/subelement forms are presented in Section 3.3 of this volume, and also in Volume II. The linkages in the proposed Project Data System are discussed in Section 3.3.

3.2 Subelement Management Sequence

The subelement management sequence (SMS) is a nominal sequence (it can be varied) of technical analyses, technical decisions, and management activities for managing the progress of a specific R&D subelement. The sequence is put forth here, not to suggest what such a sequence for the DGE is or ought to be, but rather to describe a context in which the various forms and the project selection procedure can be used.

The sequence consists of: Concept Origination, Initial Screening of Concept, Detailed Evaluation of Concept (benefit/cost analysis), Subelement Funding Recommendation, Subelement Funding Approval, Stimulation and Selection of R&D Proposals, Contract Processing, Contract Approval, Project Monitoring and Control, Project Annual Evaluation, Project Termination, Project Critique, and Technology Transfer Review. These terms are defined in the Glossary of Terms appended to Volume II of this report.

FIGURE 2
LINKAGES IN THE PROJECT MANAGEMENT SYSTEM

The principal purpose of postulating an SMS and discussing it here is to point out that concepts originating from unsolicited proposals are handled in somewhat different ways from those originating from solicited proposals (e.g., responses to PRDAa and PONs). Figure 3 shows the progress of R&D concepts through the subelement management sequence.

If the concept originates from an unsolicited proposal, the concept makes only one pass through the SMS. The operations associated with the Initial Screening and the Detailed Evaluation transform the "concept" into a planned, organized, and evaluated subelement. In most cases this content of the subelement will be synonymous with the technical content of the unsolicited proposal. Thus, for this subelement, completion of the Subelement Funding Recommendation and Subelement Funding Approval is synonymous with approval of the proposal by DGE upper management.

If the origin of the concept is other than an unsolicited proposal, it is treated as if it originates from a Program Manager. He is responsible for developing the concept into a defensible subelement, often before the exact technical specifics of the subelement are known. In this situation, benefit/cost analyses can be performed only following the stimulation and receipt of specific proposals. This iterative process is depicted by the arrows marked "1" and "2" in Figure 3. In the first part of this loop, the subelement will usually have to be approved before PRDAs, PONs, or

LEGEND:

- 1 Concept Originates From Program Manager.
- 2 Concept Originates From Solicited Proposal.
- 3 Concept Originates From Unsolicited Proposal.

FIGURE 3
PROGRESS OF R&D CONCEPTS THROUGH SUBELEMENT
MANAGEMENT SEQUENCE

RFPs are issued. Once the responses to these stimulating mechanisms are received, the subelement may have to be reorganized to reflect adequately the technical substance of the proposals.

3.3 Forms for Program Subelement Monitoring and Control

The R&D program monitoring and control system is based on a set of forms that are relevant to individual projects, program subelement, or the total program. The frequency of updating these forms depends on the functions (evaluation or monitoring) to which the forms pertain. There are seven forms in this set:

- (1) R&D Concept Evaluation Form
- (2) Contract Processing and Project Monitoring Form
- (3) Subelement Status Monitoring Form
- (4) Post Technology-Transfer Form
- (5) R&D Concept Status Form
- (6) Project Status Log
- (7) Subelement Status Log.

The relationships among the forms are shown in Figure 4, which depicts the anticipated flow of information.

In order to make the program monitoring and control system compatible with the DOE Contractor Reporting Guidelines,⁽⁴⁾ parts of ERDA Form 535, Form 533P, Form 536, Form 533M and some additional charts have been incorporated into the data forms for the proposed system. As a result of this arrangement, the Program Managers can transfer much contractor-provided information directly onto the relevant sections of program monitoring and control data forms.

FIGURE 4
FLOW OF INFORMATION IN THE PROGRAM MANAGEMENT SYSTEM

These forms were tested by using the information in the existing documentation for a number of subelements. A sample of some of these completed forms is presented in this section. Volume II of this report contains an explanation of these forms along with a flow chart for the program management system.

The effectiveness of the proposed project management and selection system is dependent on the utilization of a set of standard terms, definitions and phrases. To ensure that a common understanding of various terms exists, a glossary of terms is provided for use in conjunction with the forms for the proposed system. The terms in this glossary pertain to the subelement management sequence, technical aggregation levels, stages of R&D, benefits, R&D costs, contracts, work plans, technical objectives, geothermal technology and economics.

In order to assist the Program Managers and R&D proposers, a set of standard phrases for filling out various forms was initiated. These standard phrases will enable the individuals filling out the forms to use code numbers rather than explicit text. The codes of phrases will also facilitate the computerization of the data base for the project management and evaluation system. Whenever a new phrase (i.e., a phrase not in the original set) is used, it will be assigned a code number and be added to the appropriate section of the glossary of terms. The full set of standard terms is included in Volume II of this report.

The experience gained during the test of the program monitoring and control forms indicates that the proposed forms can be utilized without making major changes in the existing procedures for submitting and processing R&D proposals. However, the task of monitoring and controlling future R&D activities would be facilitated by modifying the format and content of the project progress reports. A sample of project/subelement monitoring and control forms follows.

R&D CONCEPT EVALUATION FORM

DATE: June 1974
CONCEPT I.D. NO.: 1

- (1) TITLE OF THE CONCEPT:
CONTINUOUS CHAIN DRILL BIT DEVELOPMENT
- (2) PROGRAM NAME:
DRILLING AND COMPLETION
- (3) PROGRAM MANAGER'S NAME:
C. CARWILE
- (4) NAME OF THE ORIGINATOR OF THE CONCEPT
H.K. TOGAMI; J.A. ST. CLAIR; SANDIA LABORATORIES
- (5) BRIEF TECHNICAL DESCRIPTION OF THE CONCEPT:
The face of the continuous chain drill bit is surfaced with diamonds set in a tungsten carbide matrix. The bottom hole cutting surface consists of six chain segments. When the diamonds on the surface wear, a new cutting surface can be cycled into place by pulling the bit off the bottom and activating a spring-piston-pawl/assembly, which is driven by mud pressure, to cycle the chain drive. The bit is then returned to the bottom and drilling continued. A higher instantaneous penetration rate and long downhole life of the bit can be expected to result from the application of this concept of bit design.
- (6) TECHNICAL OBJECTIVES OF THE CONCEPT:
 - (a) To reduce the costs per foot of hard rock drilling.
 - (b) To increase instantaneous penetration rate.
 - (c) To prolong downhole life of the bit.
 - (d) To develop an improved bit compatible with existing rotary drilling rigs, pipe, collars, and liquid circulation systems.
- (7) DESCRIPTION OF WORK PLANS FOR ACHIEVING THE OBJECTIVES:
A working mechanical model of each bit, which can be used to demonstrate this drilling technique in the laboratory, will be prepared. Working prototypes will be developed for each bit, which can be used with an existing rotary rig. The system potential of the prototype drill bits will be demonstrated. The feasibility demonstration will culminate in a deep hole field test of the prototype bits within 16 months of program initiation.

(8) TENTATIVE SCHEDULE, RESOURCE REQUIREMENTS, OUTPUTS AND THEIR EXPECTED IMPACT:

SCHEDULE

RESOURCES

- (a) \$757 K; 10 Man-Years
- (b) \$648 K; 10 Man-Years
- (c) \$767 K; 10 Man-Years
- (d) \$728 K; 10 Man-Years
- (e) \$805 K; 10 Man-Years

OUTPUTS AND IMPACTS

<u>OUTPUT</u>	<u>EXPECTED IMPACT</u>
(A) Results of Improved Link Design Tests	Basis for Decision to Continue Full Prototype Fabrication
(B) Results of Performance Tests on Drilling and Hydraulic Units	Basis for Decision to Fabricate Field Prototype
(C) Results of Laboratory Test & Evaluation	Basis for Proceeding to Deep Well Drilling Tests.

(9) RELEVANCE OF THE R&D CONCEPT TO DGE GOALS:

- (a) Promises to provide capability for drilling hard rock.
- (b) Will reduce cost of power by decreasing drilling costs.
- (c) Will accelerate exploration and exploitation through faster drilling.

(10) DOES A FORMAL PROPOSAL EXIST FOR THIS R&D CONCEPT?

☒ YES ☐ NO (Go to 12)

(11) NAME OF THE ORGANIZATION WHICH SUBMITTED THE PROPOSAL:

Sandia Laboratories

- (12) DOES THIS CONCEPT DESERVE TO BE EVALUATED FOR POSSIBLE FUNDING OF RD&D?

PROGRAM MANAGER

(P.M.)

☒

YES

☐

NO

BRANCH CHIEF

(B.C.)

☒

YES

☐

NO

JOINT DECISION

☒

YES (Go to 16)

☐

NO

P.M.'s Initials

B.C.'s Initials

- (13) REASONS FOR NOT EVALUATING THE CONCEPT FOR FUNDING:

- (a)
- (b)
- (c)
- (d)

- (14) SHOULD THE CONCEPT BE CONSIDERED FOR EVALUATION AT A LATER DATE?

☐

YES (Go to 15)

☐

NO

PLACE THE DOCUMENTATION FOR THIS CONCEPT IN THE "REJECTED CONCEPTS" FILE. THE REST OF THE FORM NEED NOT BE COMPLETED.

DATE:

- (15) DATE FOR RECONSIDERATION OF THE CONCEPT:

PLACE THE CONCEPT PAPERS IN THE "PENDING CONCEPTS" FILE.
THE REMAINDER OF THIS FORM NEED NOT BE FILLED OUT.

- (16) ON THE BASIS OF A BENEFIT/COST ANALYSIS, WHAT IS THE "FIGURE OF MERIT" FOR THIS CONCEPT?

(Not calculated.)

- (17) THE QUALITATIVE EVALUATION OF THIS CONCEPT IS TO BE CONDUCTED BY

☐

INTERNAL EVALUATIONS ONLY

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EXTERNAL EVALUATIONS ONLY

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INTERNAL AND EXTERNAL EVALUATIONS

(18) EXTERNAL EVALUATION DATA AND FIGURE OF MERIT (B/C RATIO)

	<u>Name and Address Of Evaluator</u>	<u>Date on Which Evaluation Was Requested</u>	<u>Date on Which Response Was Received</u>	<u>Evaluator's Grade For The Concept</u>	<u>Comments</u>
(i)					
(ii)					
(iii)					
(iv)					

(19) ON THE BASIS OF THE FIGURE OF MERIT, THE EVALUATOR'S GRADING, AND OTHER CONSIDERATIONS, SHOULD THE CONCEPT BE FUNDED?

☐	YES (Go to 21)	P.M.'s Initials: _____
		DATE: _____
☐	NO	B.C.'s Initials: _____
		DATE: _____

(20) REASONS FOR NOT RECOMMENDING THE CONCEPT FOR FUNDING:

- (a)
- (b)
- (c)
- (d)

PLACE THE DOCUMENTATION FOR THIS CONCEPT IN THE FILE FOR "CONCEPTS NOT RECOMMENDED FOR FUNDING". DO NOT COMPLETE THE REST OF THE FORM. DATE:

(21) REASONS FOR RECOMMENDING THAT THE CONCEPT BE FUNDED:

- (a) This concept has the potential for eliminating a major impediment to the growth of the geothermal industry.
- (b) This concept can be expected to lower the cost of geothermal energy.
- (c) This concept will speed up the exploration and exploitation efforts related to geothermal energy extraction.

PLACE ONE COPY OF THE CONCEPT EVALUATION FORM IN THE FILE FOR "CONCEPTS"

- INITIATE THE PROCESS OF SECURING FUNDS FOR THIS CONCEPT.
- START A "FUNDING AND CONTRACT PROCESSING" FILE FOR THIS CONCEPT. DATE:

- (1) Program Manager initiates the Concept Evaluation Form.
- (2) Program Manager and Branch Chief make this determination.
- (3) This file is maintained by the Program Manager.
- (4) This evaluation is made by a panel of evaluations and Program Manager.
- (5) This determination is made by the Program Manager and Branch Chief.
- (6) The Program Manager records this idea in the Pending Ideas File and sets a date for reconsideration.
- (7) The Program Manager starts a "Funding and Contract Processing" File and initiates action for securing funds and contracting the RD&D Projects pertaining to the concept.

FIGURE 5
FLOW CHART OF PROCESSING CONCEPT EVALUATION FORM

SUBELEMENT STATUS MONITORING FORM

- DATE OF FIRST ENTRY: _____ DATE OF LAST ENTRY: _____
- (1) SUBELEMENT I.D. NUMBER: 1 (2) SUBELEMENT TITLE: Continuous Chain Drill Bit Development
- (3) PROGRAM: Well Drilling and Completion (4) PROGRAM MANAGER(S): C. Carwile
- (5) STARTING DATE: 11/74 (6) COMPLETION DATE: SCHEDULED 6/79 ACTUAL _____
- (7) TOTAL FUNDING (PLANNED) FOR THE SUBELEMENT: DATE 9/77 ; \$ 1,030,000 ; DATE _____ ; \$ _____
- PROJECT MANAGER(S): _____
- (8) TECHNICAL OBJECTIVES/RELEVANCE TO DGE GOALS: (1) To reduce the cost per foot of hard rock drilling, (2) To increase the instantaneous penetration rate, (3) To prolong the downhole life of bit, (4) To develop an improved bit compatible with existing rotary drilling rigs, drill pipes, collars, and liquid circulation systems.
- (9) TECHNICAL DESCRIPTION OF THE SUBELEMENT: This effort is aimed at the development of a bit with replaceable cutting surfaces. The surface consists of six chain segments, which are successively moved into cutting position by activating a spring-piston-pawl assembly. Lab tests, field tests, and demonstrations of the concept will be conducted.
- (10) FIGURE OF MERIT (F.O.M.) AT THE TIME OF APPROVAL OF THE INITIAL PROJECT IN THE SUBELEMENT - F.O.M. REVISIONS (F.O.M. SHOULD BE RECOMPUTED AT EACH CHECK POINT IN THE SUBELEMENT)

DATE				
F.O.M.				
REASONS FOR CHANGE IN F.O.M.				

11. PROJECT DATA (ENTRIES IN THIS TABLE SHOULD BE BASED ON THE R&D CONCEPT EVALUATION FORM AND FORM ERDA 536 FOR THE RELEVANT PROJECTS)

DATE	PROJECT I.D. NO.	PROJECT TITLE (ABBREVIATED)	CONTRACTOR (IF KNOWN)	STARTING DATE		COMPLETION DATE		COMMENTS
				SCHEDULED	ACTUAL	SCHEDULED	ACTUAL	
9/74	1-1	Continuous Chain Bit - Phase I	Sandia Labs	11/74	11/74	6/75	6/75	Actual Expenditures \$100K
7/75	1-2	Continuous Chain Bit - Phase II	Sandia Labs	7/75	7/75	9/76	9/76	Actual Expenditures \$120K
11/76	1-3	Continuous Chain Bit - Phase III	Sandia Labs	10/76	11/76	9/77	9/77	Actual Expenditures \$510K
10/77	1-4	Continuous Chain Bit - Phase IV	Sandia Labs	10/77	10/77	9/78		

(12) FOR TERMINATED PROGRAM SUBELEMENTS: DATE OF TERMINATION: _____

REASONS FOR TERMINATION

(a)

(b)

(c)

SUGGESTIONS FOR FUTURE ACTION

(a)

(b)

(c)

(13) RELATIONSHIP WITH OTHER SUBELEMENTS

(a) OTHER SUBELEMENTS WHICH DEPEND ON THE SUCCESS OF THIS SUBELEMENT (S.E.)

S.E. I.D. NO.	S.E. TITLE	PROGRAM MANAGER (P.M.)	DETAILS OF COMMUNICATIONS SENT TO THE P.M.		COMMENTS/NOTES
			DATE	CONTENT	

(b) OTHER SUBELEMENTS ON WHOSE SUCCESS THIS SUBELEMENT DEPENDS

S.E. I.D. NO.	S.E. TITLE	PROGRAM MANAGER (P.M.)	DETAILS OF COMMUNICATIONS SENT TO THE P.M.		ACTION TAKEN	COMMENTS
			DATE	CONTENT		

(14) SUGGESTIONS FOR FUTURE ACTION FOLLOWING SUCCESSFUL COMPLETION OF THE SUBELEMENT

3.4 Example of Subelement Figure of Merit

As an example of how a figure of merit might be calculated for one R&D subelement, Phase III of the Terra Tek Improved Geothermal Drill Bit, was evaluated. Figure 6 shows the progress of the development of the drill bit through various phases. A general discussion of the evaluation procedure is contained in Volume III of this report: "Project Selection Procedure". The details of the Terra Tek Phase III evaluation are also presented in Volume III.

The Terra Tek figure of merit estimate focused on the portion of that project that is attempting to improve the lifetime of unsealed rotary drill bits at the higher than usual temperatures encountered in drilling geothermal wells. It is hypothesized by the contractor that the lifetime of each bit at high temperature can be increased by fabricating the bit from improved steels and by altering the heat treatment applied during bit manufacture.

Engineering tests of improved small-diameter bits during Phase II of Terra Tek's project suggest that bit lifetime at high temperatures (up to 380°C) will be increased by factor of up to five compared to conventional oil and gas rotary bits. There will be no difference in lifetime at or below 180°C, and the maximum increase in lifetime is expected to be achieved at 280°C. The bit will be economically attractive only when air drilling is used, because liquid circulation cools conventional sealed bits enough to make them cost-effective

FIGURE 6
PHASES OF TERRA TEK IMPROVED GEOTHERMAL
DRILL BIT PROJECT

compared to this bit. Thus this bit will effect savings only when air drilling encounters rock temperatures greater than 180°C.

Estimates were made of the probable commercial price of the new bit (\$2500 compared to the \$2000 for a similar conventional bit) and of the rate at which it would penetrate its potential market.

Each of the 37 geothermal prospects in the Geothermal Wells Scenario was examined for applicability of this improved bit. Resources with temperatures below 180°C were ignored. It was assumed that the upper portion of each well in the "hot" prospects would be drilled with liquid circulation. Further assumptions were made concerning: (1) the number of hot wells to be drilled using this bit, (2) rig rental costs, (3) instantaneous rate of penetration in various rock types, and (4) rate for round tripping. Upper and lower bounds for the degree of success of this project were estimated.

All of the above estimates were embodied in a computational algorithm. Savings were totaled for all wells to which this bit is relevant.

For anticipated further R&D costs of \$302,000 this project was estimated to produce overall savings of \$9.8 million. The figure of merit was estimated to be 16.3 for Phase III and follow-on work, sunk costs not included. If sunk costs (R&D costs for Phases I and II) are included, the total project budget is about \$840,000 and the figure of merit is 5.9.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Overall Conclusions

It became apparent in the initial stages of this project that there are major deficiencies in the documentation of many DGE projects. Additionally, the content and format of various program subelements are not uniform. This is primarily due to three factors: (1) the transfer of program subelements from other organizations (e.g., the Atomic Energy Commission and the National Science Foundation) to DGE, (2) the transfer of program subelements from one section of DGE to another section (e.g., Resource and Reservoir Assessment Branch to Utilization Branch), and (3) the changes in the Program Managers responsible for various subelements. This observation is confirmed by the fact that the programs that were initiated during the last two years have uniformly complete files. It was observed that all the Program Managers have taken steps to improve the comprehensiveness and consistency of their documentation of the program that they manage.

Since many of the ongoing programs were selected noncompetitively (generally through the submission of unsolicited proposals), the proposals do not conform to any uniform specification for technical and economic objectives. This makes it difficult to quantify the impact of the expected achievements of these programs. In many cases, it is apparent that follow-on efforts will be required before a project can make an impact on the cost and availability of geothermal

power, but the project proposals do not contain outlines of necessary follow-on activities. Consequently, it is not possible to make a realistic estimate of benefit/cost ratios associated with the successful completion of a project.

Some recent developments within DGE have already addressed many of the problems mentioned above. The long-range planning/budgeting activities have made it necessary for each program subelement to be laid out explicitly to the point at which its expected achievements will have an identifiable impact on the growth of the geothermal industry. The Program Managers have utilized this opportunity to develop mid-term and long-term plans for various program subelements. The selection of projects through competitive routes (e.g., PRDA, RFP) can make the proposers follow a proposal format specified by DGE. The DOE laboratories have been using Form 189 successfully for reporting and documenting their R&D activities in a uniform format. The formulation of the development scenarios for 37 prospects will make it possible to quantify the benefits of various subelements.

In order to ensure that the trend toward systematic project selection and management is continued, it is appropriate to impart more uniformity to the rational structure of R&D project selection mechanisms and to develop a project management system which enables the Program Managers and other decision-makers to monitor and control

the R&D project selection mechanisms and to develop a project management system which enables the Program Managers and other decision-makers to monitor and control the R&D activities without going through the entire project file repeatedly.

The program subelement selection model proposed in this report is designed to shift the emphasis from the evaluation of individual projects to the evaluation of program subelements, which emphasize a practical product. Periodic updating of the benefit/cost ratio (whenever a program subelement is due to be renewed or extended) will enable DGE decision-makers to monitor changes in the relevance of each subelement to the scenario for the development of geothermal resources.

The project management system to be utilized in conjunction with the benefit/cost model is composed of a number of project/subelement monitoring forms and summary logs. This set of forms has been applied successfully to nine ongoing program subelements (see Volume IV).

4.2 General Recommendations

A review of the existing project management and control system indicated that most of the problems associated with the current procedures will be addressed by the proposed system. Therefore, it is recommended that the new project management and selection system be introduced gradually. The following general recommendations are made with regard to the strategy for phasing in the new system.

(1) In planning R&D activities, the emphasis should be on the entire program subelement (at the technology transfer or commercialization stage) rather than on individual projects. Multi-year planning has already been introduced in DGE, and the program subelement selection and management procedures should be coordinated with the planning activities in DGE.

(2) The scenario for the development of 37 prospects should be adopted as the basis for estimating the figure of merit (benefit/cost ratio) for various program subelements. Any changes in the development scenario for the existing prospects and any new prospects should be reflected in the evaluation of the benefits of the program subelements at the appropriate time.

(3) In order to assist the Program Managers in computing the figures of merit for their program subelements, a set of discrete economic-engineering-process models should be developed for each specific technical area (e.g., well drilling, heat exchangers, scale control, etc.). The assumptions associated with these models should be stated clearly and an effort should be made to eliminate or relax these assumptions as more information becomes available.

(4) In certain cases there may be considerable uncertainty about the probability of success of a subelement and the magnitude of its benefit and cost, and it may not be possible to make a realistic estimate of the figure of merit for the subelement. In such cases, the Program Managers should be given the discretion to fund a phase

of preliminary study or basic R&D designed to reduce the uncertainty about the figure of merit of the subelement. A reasonable ceiling should be set for the funding of preliminary studies, and the subelements falling within this category should be evaluated only after the results of the studies are known.

(5) Starting with the next budgeting cycle, all decisions concerning the funding of new subelements, and the extension, renewal or termination of ongoing subelements must be based on the figure of merit, among other considerations.

(6) The program for updating and completing the subelement files at DGE headquarters should be pursued so that the new subelement/project data forms and status logs can be completed with minimum delay. The monitoring and control of all new subelements and projects should be based on the proposed project management system.

(7) In order to expedite the adoption of the figure of merit estimate as a major factor in decisions concerning the selection of R&D program subelements, it is recommended that DGE undertake a program of benefit/cost ratio estimation for all ongoing subelements. This program will have to be completed within six months so that the results may be utilized for preparing the budget for FY 79.

(8) Although very few R&D subelements have reached the technology transfer/commercialization stage, plans for post-technology transfer evaluation of R&D subelements should be formulated and implemented as soon as the current R&D programs reach the commercialization stage.

(9) The R&D proposal format and contract reporting requirements should be modified so that most of the entries for the proposed project management and selection system data forms can be made without extensive transformation. (The data forms for the proposed system are compatible with the DOE Contract Reporting Requirements.)

4.3 Plan for Implementing the System

The introduction of the proposed system will require careful planning and cooperation involving many parties, e.g., DGE officials, Mission Team Leaders, contractors, DOE laboratory officials, etc. In order to minimize the disruption of regular activities at the DGE headquarters, it is recommended that the following plans be pursued for introducing the proposed system.

(1) A series of briefings should be conducted at the DGE headquarters to familiarize various officials with the inputs and outputs of the proposed system.

(2) A short document should be prepared for explaining the system to organizations (contractors, DOE laboratories, etc.) that interface with DGE. If deemed appropriate, this report may be used as a vehicle for disseminating information about the new system. The need for using standard terminology and the computation of benefits relative to the scenario for the development of geothermal energy industry should be emphasized.

(3) The data forms should be filled out first for the program subelements that were initiated in FY 1977 and FY 1978. The

documentation for these subelements is likely to be adequate for filling out the data forms.

(4) For program subelements which were indicated prior to FY 1976 it may not be possible to complete the project data forms for some of the projects. In such cases, the data forms should be filled out as completely as possible. A brief summary sheet may be prepared for projects for which the available records are not adequate for filling out the regular data forms.

(5) For each active subelement, one record file should be created. This file should consist of the project data forms only and should not contain any proposals, program reports, etc. The progress reports and other correspondence may be retained in the existing contractor files. A target date should be set for switching over to the new program subelement record files.

(6) Along with the creation of subelement record files, the figure of merit computation for each program subelement should be undertaken. If the recommendation concerning the development of benefit/cost models for specific technical areas is accepted, the computation of figure of merit for any subelement should be delayed until the relevant model is developed. A target date should be set for completing this task.

(7) Each Program Manager should start maintaining program status logs (e.g., R&D Concepts Status, Project Status, Subelement Status) as of January 1, 1978. The Branch Chief and other senior DGE

officials should utilize these logs for determining the up-to-date status of various R&D activities. A reasonable frequency of updating these logs (about once every two months) should be adopted.

(8) The Program Managers should be provided with regularly updated scenarios for the development of geothermal prospects, so that they may assess the benefits of their program subelements relative to the latest national goals for geothermal energy utilization.

(9) The utilization of standard terminology for technical objectives, economic impact and R&D management procedures should be insisted on. The glossary of terms (presented in Volume II) should be revised whenever necessary.

(10) All new R&D concepts submitted to DGE should be processed through the new system.

(11) Progress in implementing the new system should be reviewed once every three months during CY 1978. These revisions should be aimed at resolving any problems. Possibilities for simplifying the proposed system should also be considered.

4.4 Suggestions for the Future

As proposed in this report, the project management and selection system is adequate for the current level of R&D activity. In the future, the number and complexity of R&D program subelements may reach a level at which it may be difficult to operate a manual system

for project management and selection. Therefore, it would be desirable to make plans for a computerized system. The benefit/cost models, the scenario for the development of the geothermal resources, and the project R&D budgets will be the major components of the computerized system.

In its present form, the benefit/cost model may be based on many assumptions pertaining to the estimates of the impact of a subelement on the cost and availability of power, resource characteristics, and the scenario for the development of various resources. As more information relevant to these areas becomes available, the associated assumptions should be either eliminated or relaxed to make the figure of merit computations more meaningful.

If the proposed system is implemented successfully within one or two branches of DGE, the possibility of adopting this system for all branches of DGE should be considered. A uniform system for project management and selection will enhance the effectiveness of the R&D programs of DGE.

REFERENCES

1. "Program Approval Document - Executive Summary - FY 1977"
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2. de Dufour, William, et al., "Review and Description of the
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3. Williams, F., et al., "Site-Specific Analysis of Geothermal
Development - Data Files of Prospective Sites," MTR-7586,
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4. "ERDA Uniform Contractor Reporting Guidelines," ERDA,
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