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GEOTHERMAL RISK/BENEFIT ASSESSMENT MODEL

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ABSTRACT

The goal of a current project at SDG&E is to develop methods of quantifying the risks and benefits of proposed geothermal power projects. A computer model is being developed to be used to evaluate the probabilities of various cost impacts resulting from significant uncertain parameters.

Preliminary results indicate that the probabilistic computer model can be a valuable tool, but it requires high quality input data. Model is intended to be used as a screening tool and in conjunction with an indiviudal evaluation of projects. The model does not act as a replacement for individual evaluations.

INTRODUCTION AND OBJECTIVES

The perception by utilties and financial institutions of geothermal powerplants is that they involve more risk than conventional fossil fueled plants. This perception is a major barrier to geothermal development. Uncertainties on the resource temperature and chemistry, plant operation and environmental impacts exist and can result in major risks. Expected value analysis does not evaluate the potential of major financial risks. Overly conservative (worst case) analysis can result in limited development and lost benefits to the consumer.

SDG&E is actively participating in geothermal development as a potential economic and reliable source of power to supply its electric customers. The transition from research and development activities to commercially viable projects requires a carefully assessment of the commercial risks and benefits. Because of a regulated rate of return (benefit to the shareholders), a privately owned utility must limit the risks to the shareholders associated with any commercial venture.

The objective of this study is to provide a management tool to assist in the evaluation of commercial geothermal project risks and benefits. The model does not replace a detailed evaluation of each project, but is intended to provide a consistent methodology during the evaluation process.

The primary use of the model in the evaluation process is expected to be as a screening tool. Detailed evaluation of every feasible geothermal plant site or contract offer would be prohibitively expensive. If sufficient data is available, the model can be used to provide the most likely range of performance and costs as well as the likelihood of failure. Default input values are provided, if necessary at this initial evaluation phase. If the resulting range of performance and costs justify further evaluation, the model will be able to identify the major causes or project risks and benefits. This identification should provide opportunities to search for risk mitigation measures and optimize benefits.

PRELIMINARY MODELS AND LITERATURE REVIEW

A deterministic geothermal busbar cost model was prepared for SDG&E (Ref. 1). The model treated the power plants as an entity with brine supplied as the fuel. This deterministic model has also be used for sensitivity analysis.

A literature review identified other deterministic models (Ref 2). Reservoir models were identified that can be used to predict reservoir behavior, but they are generally overly complex for economic probability applications. Groundwater contamination, subsidence and seismic models were also identified but were also not generally applicable to this type of economic evaluation.

The most flexible single point model identified was Geocost (Ref. 3). Other single point estimate economic models were also identified. However, these models essentially provide engineering design estimates. Cost impact of off design conditions and the associated corrective actions is not addressed. None of the deterministic models was found to be directly applicable to a probabilistic assessment.

Available probabilistic or risk models were also reviewed. These models provided a probabilistic framework to exercise a user supplied deterministic model. These were expected to be useful in development of a risk/benefit model, but programming constraints limited direct application.

Reports by Technecon Analytic Research for the U.S. Department of Energy requires separate discussion. Geothermal investment and policy analysis was the focus of these reports. A model was developed and is probabilistic. Utility and developer investments were related to geothermal powerplant economics. Although the reports represent a significant effort in the state of the art, and concepts developed in these reports were used, they could not be used directly for the engineering risk/benefit model. The level of detail was found insufficient to aid in the engineering evaluation of the probable cost of a geothermal power project.

Thus, although many deterministic and probabilistic models were identified, none were directly applicable. However, concepts and portions of some of these models were applied.

INITIAL RISK/BENEFIT CONCEPTUAL MODEL

A list of 210 uncertainties related to a geothermal powerplant was generated. Each uncertainty was evaluated on the basis of the possible range of values and the cost effect of these variations. Three categories of uncertainity range and three categories of cost impacts were used. Significant uncertainties were selected based on only those factors which were in the highest categories. Table I lists the significant uncertainties.

Two classifications of impacts resulting from the significant factors were developed. The first classification include those uncertainties that impact busbar cost. The second category included those uncertainties that could result in project failure or premature shutdown. The initial conceptual model provided separate treatment of these two categories.

REVISED RISK/BENEFIT CONCEPTUAL MODEL

Although two major classifications of impacts classified during initial modeling were developed, many of the significant uncertainties affected both categories. Most of the uncertainties affected busbar costs, but many also resulted in economic failure as the value changed towards the extremes. Examples include scale, corrosion, capacity factor, regulatory constraints and schedule delays. Identification of the boundary separating the two categories was difficult.

The conceptual model was revised to provide a continuum of impacts. This eliminated the need for categorizing ranges of uncertain factors, and simplified modeling. Outputs were selected to evaluate both impacts previously identified.

SUBMODEL DESCRIPTION

The deterministic model (See Figure 1) consists of 8 submodels. This includes 5 engineering input submodels, an accounting submodel, an ownership submodel and an output submodel. A probabilistic submodel exercises the deterministic submodels to develop distributions in output variables. The engineering input submodels convert independent uncertain factors into capital, operating and maintenance costs impacts, performance, extended downtimes or project failure. Failure only occurs in these submodels when power output is technically impossible or after foreseeable corrective actions fail.

Inputs assume that a preliminary engineering feasibility study and reservoir assessment has been completed. Outputs can be put in terms of utility functions (risk preferences) and assigned a weighting value if desired.

The limitations of the model are primarily related to the quality of data input. Obtaining valid distributions on uncertain parameters where little directly applicable data exists requires a significant effort. A review of related data and selection, modification or application of the related data is required. Where related data is insufficient, a collective assessment of experts is an interim input until valid data is available. Without this significant data input effort, the results will be highly suspect. Other limitations involve program simplications. These limitations are expected to be corrected with future use.

FUTURE WORK

Additional work is planned, if the model is successful. Areas which repeatedly cause major project risks will be subjected to further analysis and modeling. Model is also expected to be used to evaluate risk mitigation alternatives. The model's methodology may also be useful for evaluating other developing technologies.

A modification to the model to evaluate binary process power plants has been initiated in conjunction with the Heber Project Binary Project. Process uncertainties are being prioritized. Results are expected to be available in mid 1982.

REFERENCES

1.Management Analysis Corporation, Geothermal Busbar Cost Model, User Manual, June 30, 1980.

2.Woodward-Clyde Consultants, an Engineering Risk/Benefit Assessment of Geothermal Development in the Imperial Valley, May 23, 1980.

3.Battelle Pacific Northwest Laboratories, User Manual For Geocost: A Computer Model for Geothermal Cost Analysis, November 1975, BNWL-1942 VI.

FIGURE I

GEOTHERMAL DETERMINISTIC MODEL

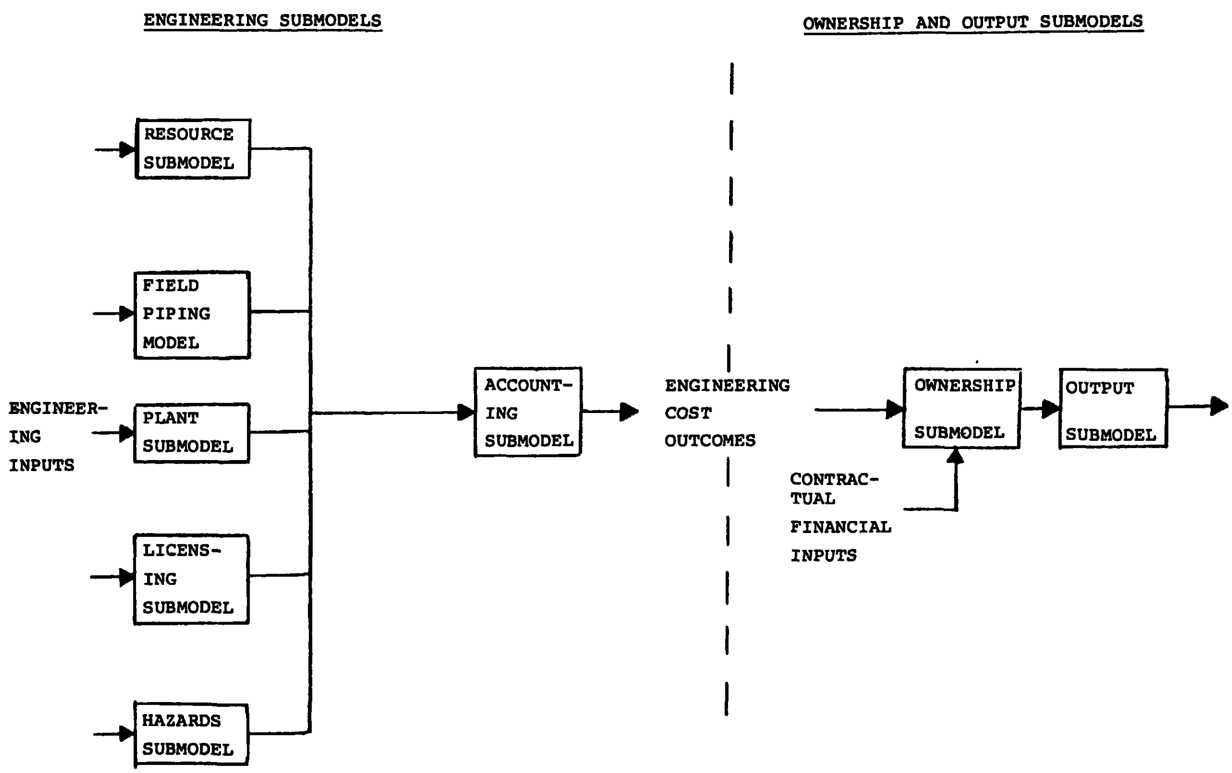

TABLE I

SIGNIFICANT FACTORS

Reservoir

1. Proven Reserves of Resource
   - State of the art
   - Extent
   - Convection or Drainage Flows

2. Reservoir Operation
   - Performance with Time

3. Brine Supply, Wellhead
   - Temperature
   - Pressure
   - Heat Content
   - Changes with Time
   - Changes with Use
   - Reliability
   - Effect of Major Event
   - Well Scaling or Blockage
   - Well Corrosion
   - Surface Leakage
   - Expected Life

4. Injection Well
   - Expected Life
   - Intrusion or Leakage from or into other strata

Plant

1. Design
   - Corrosion
   - Plant Efficiency
   - Separator & Scrubber Performance
   - Cooling Water Chemistry & Supply
   - Brine Effluent Treatment
   - Gas "Burps"

3. O&M
   - Chemical Treatment Required
   - Plant Reliability
   - Availability of Transmission
   - Water Supply Reliability
   - Corrosion
   - Resource Availability

Contractual Relations

3. Construction Firm(s)
   - Liability
   - Financial Integrity

5. Resource Company
   - Minimum Guaranteed Supply
   - Financial Resources & Integrity
   - Type of Contract
   - Performance
   - Liquidated Damages
   - Escalation
   - Rate of Return

Regulatory

1. Regional Permits
   - Conditions
   - Schedule
   - Limitations

2. State Federal Licensing
   - Conditions
   - Schedule
   - Limitations

3. PUC
   - Rate Treatment
   - Rate of Return
   - Customer Charges

Other Institutions/Groups

- Legal requirements
- Cost
- Liability
- Schedule