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A STRATEGIC ANALYSIS OF HYDROTHERMAL RESOURCE DEVELOPMENT

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PURPOSE

The purpose of the strategic analysis is twofold: 1) to design several alternative strategies for the Federal hydrothermal program and 2) delineate the implications of each such strategy for program structure, effectiveness and cost. Comparisons among these strategies can serve as a guide to the selection of the most desirable strategy.

DEFINITIONS

Three terms to be used in the subsequent discussion require definition: strategy; strategic component; and program element. The relationship among the three is illustrated in Figure 1. A strategy is considered a plan which establishes the thrust or emphasis of the Federal program. Each strategy presented below is labeled to indicate the general nature of this emphasis, e.g. Emphasize Economic Incentives.

A strategic component is a general type of activity, e.g. provision of Economic Incentives. It is a generic term which embraces a class or group of qualitatively similar program elements. A program element, in turn, is a specific form of activity. Each program element is included under the relevant strategic component and serves to detail activities within that component, e.g. the Loan Guaranty and Residential Tax Credit program elements would most properly be included under the Economic Incentives component.

SUGGESTED ANALYTICAL APPROACH

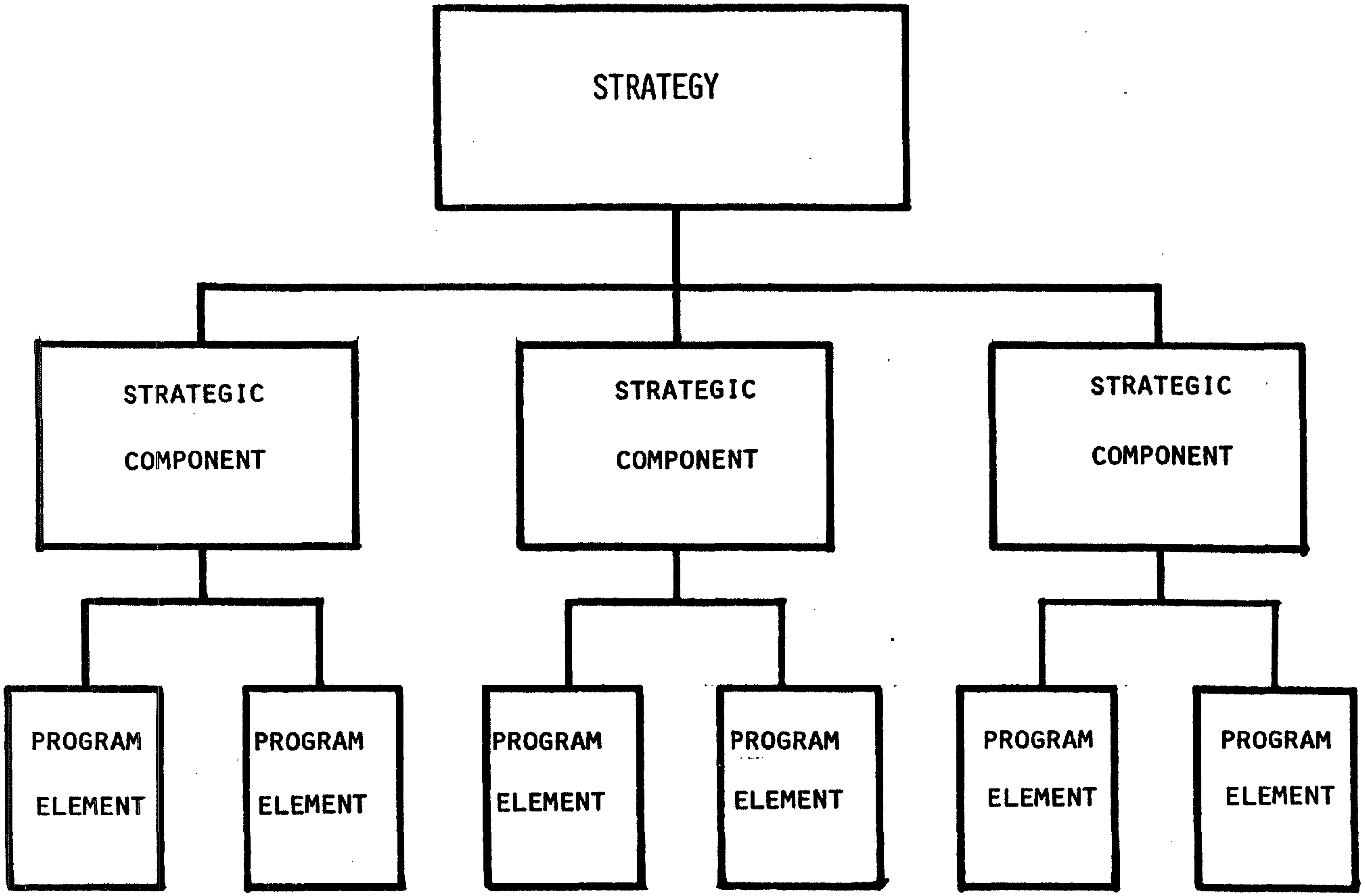
The analysis consists of four basic steps:

1. Identification of Barriers to Resource Development
2. Identification of Strategic Components
3. Identification of Alternative Strategies
4. Evaluation of Strategy Effectiveness

The analysis begins with the identification of the major economic, technical or institutional barriers to accelerated private development of

FIGURE 1

RELATIONSHIPS AMONG KEY ANALYTICAL TERMS



hydrothermal resources. These barriers are used as the basis for defining the strategic components (the general types of Federal activities.) Alternative strategies are then developed, each of which gives a unique thrust or emphasis to the program. Finally, each strategy is evaluated for its effectiveness in accomplishing the program objective. This evaluation gauges the impact of each strategy on selected quantitative measures.

Step One: Identification of Barriers

More rapid private development of hydrothermal resources presently confronts a series of economic, technical and institutional barriers which vary in their degree of severity. The Federal objective is to accelerate such private development by mitigating these barriers in an efficient and socially desirable manner. Seven such barriers are identified and considered:

1. the perception that investment in hydrothermal energy extraction, conversion or use carries with it a high degree of risk and/or low profitability.

2. uncertainty as to the location and characteristics of geothermal resources.

3. a lack of experience with existing technologies.

4. a lack of technically feasible solutions to various problems of extraction, conversion or use (exclusive of environmental impacts.)

5. the perception that unresolved environmental problems associated with hydrothermal development render its use impractical or very risky.

6. delays in bringing on line economically competitive, technically proven processes due to such factors as unfamiliarity with hydrothermal energy on the part of potential users and developers, lack of appropriate planning efforts, the abscence of necessary infrastructure, etc.. but not including laws or regulations.

7. cumbersome, repetitive or contradictory laws or regulations.

Step Two: Identification of Strategic Components

The identification of strategic components provides a linkage between barriers and Federal activities. Each component is defined in terms of an individual barrier and activities within the component are addressed to a reduction of that barrier's severity.

Seven strategic components have been identified, each relating to one of the barriers listed above.

Barrier	Strategic Component
1. high risk/low profitability	Economic Incentives
2. resource uncertainty	Resource Definition
3. lack of operating experience	Demonstration Program
4. lack of technology	R&D/Enabling Technology
5. unresolved environmental problems	R&D/Environmental Control Technology
6. delays in bringing on line economically competitive technically proven technologies	Technical Assistance and Industry Support
7. regulation	Streamlining

Step Three: Identification of Strategies

Each strategy emphasizes a different strategic component or set of components. This difference in emphasis is the principal factor distinguishing one strategy from another.

A great number of alternative strategies can be devised within the proposed analytical framework. This number increases geometrically as more strategic components are added. The analyst's task is to choose, from among these alternatives, a limited number of strategies which merit further consideration.

Seven strategy designs, shown in Table 1, will be analyzed. Each strategy postulates hypothetical levels of activity within each strategic component. These levels are defined in terms of actual levels of expenditure under the current program. A whole number represents a factor by which expenditures within the component are assumed to increase over current levels. "CL" indicates a maintenance of current expenditure levels.

The strategies range between two extremes - - a baseline "Phase-Out" case and the "Establish Industrial Capacity" case. The five remaining strategies are considered intermediate permutations which place priority on the mitigation of selected barriers.

Strategy #1 Phase Out of Federal Program: A baseline case which assumes that hydrothermal development will be left exclusively to the non-Federal sector after a five-year phase out of the Federal program.

Strategy #2 Emphasize Economic Incentives: This strategy, which emphasizes the provision of generalized economic incentives to the private sector, is grounded in the assumption that the perception of high risk and/or low profitability is the key barrier to the acceleration of development. Basic research and development of enabling technology, demonstration of technical feasibility, technical assistance and industry support are left primarily to the non-Federal sector.

Strategy #3 Emphasize Resource Definition: Uncertainty regarding the location and characteristics of resources is assumed to be the key barrier under this strategy. As in Strategy #2, enabling technology, demonstration, technical assistance and industry support are phased out. Economic incentives are maintained at current levels.

Strategy #4 Provide Advanced Technology: This strategy presumes that a lack of technically feasible solutions to problems of extraction, conversion and/or use poses the most severe obstacle to development. The availability of technical assistance and industry support from non-Federal sources is considered sufficient, and will not warrant long-term committment of Federal resources. Current program levels for the remaining components are deemed adequate to support a sufficiently rapid dissemination of new technologies once the basic products and processes have been developed.

Strategy #5 Promote Existing Technology: Under this strategy, existing technology is considered sufficiently developed to justify suspension of Federal activity in basic research and development. However, lack of adequate operating experience, delays in bringing on line proven technologies and legal barriers present particularly acute problems.

Strategy #6 Establish Industrial Capability: This strategy assumes that economic, resource definition, technological factors and legal barriers all present important barriers to resource development. If these barriers are adequately addressed, however, the current level of technical assistance and industry support efforts will be sufficient to produce rapid establishment of capacity.

Table 1

SUGGESTED ALTERNATIVE STRATEGY DESIGNS

	Economic Incentives	Resource Definition	Demonstration Program	R&D Enabling Technology	R&D Environmental Control Technology	Technical Assistance and Industry Support	Streamlin:
Strategy #1 Baseline	Phase Out - - - 5 Years						
Strategy #2 Emphasize Economic Incentives	2X	CL	Phase Out - 5 years	Phase Out - 5 years	Phase Out - 5 years	Phase Out 5 years	CL
Strategy #3 Emphasize Resource Definition	CL	2X	Phase Out - 5 years	Phase Out - 5 years	Phase Out - 5 years	Phase Out 5 years	CL
Strategy #4 Provide Advanced Technology	CL	CL	CL	2X	2X	Phase Out- 5 years	CL
Strategy #5 Promote Existing Technology	CL	CL	2X	Phase Out - 5 years	Phase Out - 5 years	2X	2X
Strategy #6 Establish Industrial Capability	2X	2X	2X	2X	2X	CL	2X
Strategy #7 Establish Capacity	4X	2X	2X	2X	2X	2X	2X

Strategy #7 Establish Capacity: This strategy assumes that all barriers must be more forcefully addressed if an adequate rate of development is to be attained. In addition to the components emphasized in Strategy #6, technical assistance and industry support are given added weight. Economic incentives are also stressed more heavily to insure that financial considerations do not deter new private investment. This approach envisions an agressive Federal role at all stages of resource development, and stands in sharpest contrast to the baseline case.

In Steps One, Two and Three, a high level of specification was purposely avoided. Several advantages of framing the analysis in general terms through these first three steps are believed to exist. First, a more general level of specification helps clarify the thrust of the strategy under consideration. Secondly, it allows discussion to be focused on a limited number of strategic components rather than diffused over several dozen individual program elements. Thirdly, it greatly simplifies the tasks of constructing alternative strategies and of choosing a set of strategies which merit further consideration from among the many alternatives.

The analysis is also not overly concerned with the specific expenditure levels assigned each strategic component under the various strategies. It is not intended as a budgeting exercise.The changes in levels are used primarily to test the sensitivity of program effects to changes in the design of the program. They can, on the other hand, be useful in helping to estimate cost/benefit ratios of particular program changes.

Step Four: Evaluation of Strategy Effectiveness

The purpose of Step Four is to provide a quantitative basis for the evaluation of strategies chosen in Step Three. To provide the basis for evaluation, it is first necessary to choose the type of effects most important to judging the merits of a given strategy.

Two effects are used in this analysis.as evaluative yardsticks. The first is the projected amount of power brought on line by the year 2000. This effect provides an indication of a strategy's impact on investment behavior.

This performance standard is supplemented by a measure of the expenditures necessary to achieve whatever level of power on line is projected to be delivered under a given strategy.

Each of these effects is quantifiable. Power on line is measured in megawatts or gigawatts; expenditure levels are measured in dollars.

The actual measurement of effects involves three tasks. The first is to define the program elements under each strategic component. These elements may consist of existing or contemplated programs. Secondly, expenditures assigned to a given strategic component must be allocated among the program elements nested under that component. The specific level of expenditure devoted to a particular program element depends on judgments regarding the best use of resources within that generic class of program elements. Thirdly, a linkage must be established between the individual program elements and the behavior of the private sector so that the relevant effects of changes in Federal program design can be ascertained.

A method of accomplishing these tasks for the two suggested effects, i.e., power on line and resource levels, would be to utilize the TECHNECON electric and non-electric models to 1) establish the linkages between program element and private sector behavior and 2) to quantify the effects.

Limitations of the Analysis

It should be explicitly noted that a strategic analysis such as that outlined above is not a substitute for policy-making. At best, the analysis can define various approaches which could be followed and measure the magnitude of their relative effects. The adoption of a particular strategy, however, must be based on the judgment of policy-makers as to the nature and severity of the individual barriers, the types of expenditures best suited to their mitigation and the appropriate balance between Federal program levels and the pace of development.

Secondly, a strategic analysis is not a substitute for the budgeting process. The resource levels assumed may be set unrealistically high (or low) in order to more clearly delineate the differential effects of various strategies. They provide a "shorthand" approach to getting a grip on the best policy orientation. The analysis can later be supplemented by a detailed budget analysis which considers the politico-economic constraints in which policy-makers must operate. The strategic analysis can then be used to guide budgeting decisions over which a degree of discretion can be exercised.

INPUTED VARIABLES - ELECTRIC HYDROTHERMAL MODEL

*	ADV1	Local ad valorem tax rate
	ADV2	Percentage of the real value of the property that is assessed
	BCI	Brine contamination index (0: low salinity to 4: high salinity)
	BETAA	Recurrent cost fraction for alternative power plant
	CALT	Capital cost of alternative generation inclides transmission ($/kwe)
	CAPA	Capacity factor for alternative power plant
	DEBT	Annual debt interest charges for utility in 1980
*	DELDP5	# of years between making decision and plant on line
	DR	Discount rate
*	DV10	0 - no previous plant or commitments at a site; 1 if there are
	DWC	Dry well cost as a fraction of producer well cost
	FCA	Common equity fraction of alternative power plant capital
*	FCH	Common equity fraction of hydrothermal power plant capital
	FDA	Long term debt fraction of alternative power plant capital
*	FDH	Long term debt fraction of hydrothermal power plant capital
	FPA	Preferred equity fraction of alternative power plant capital
*	FPH	Preferred equity fraction of hydrothermal power plant capital
	G	GNP deflator (general inflation rate)
	GC	Capital cost inflation rate
	GF	Alternative fuel price inflation rate
	GU	Inflation rate for revenue & debts for electric utilities
*	IF	Intangible well cost fraction
*	IRD	Fraction of new wells which are redrilled
*	ITC2	Investment tax credit for well field capital
	ITCA	Investment tax credit for alternative power plant
*	ITCH	Investment tax credit for hydrothermal power plant
	KCA	Common equity cost for alternative power plant
	KCH	Common equity cost for hydrothermal power plant
	KDA	Long term debt cost for alternative power plant
*	KDH	Long term debt cost for hydrothermal power plant
	KPA	Preferred equity cost for alternatie power plant
	KPH	Preferred equity cost for hydrothermal power plant
	LSB	Lease bonus ($/acre)
	MWV5	Vector of sequence of plant capacities
	NB	Book life
	NCNF	# of confirmation wells required at a site
	NETY	Net revenues to utility in base year
	NF	# of firms participating in joint venture

* : Potentially Significant Policy and Program Dependent Variables

	PALT	Fuel cost of alternative generation (mills/kwh)
	PCAP	Sequence of capital expenses in 4 years prior to well field start up
*	PDPL	Percent depletion allowance in years specified by YPDL
*	PEXP	Same 4 years as PCAP well field expenses prior to start up
*	PIR	Producer/injector well ratio
*	PIV5	Minimum # of years between plants at the site
	PLFA	Economic life of alternative power plant (yrs)
*	PLFH	Economic life of hydrothermal power plant (yrs)
*	PTLF	Well field tax life
*	PTYPE	Type of plant (0: flash ; 1: binary)
*	PUMP	Binary variable - 0: unpumped ; 1: pumped
	RDC	Redrilled well cost as a fraction of producer well cost
	RLF	Resource royalty fraction
	RNT	Annual rent on leased acres ($/Acre)
*	RPF	Fraction of replacement power costs allowed into rate base
	RPWR	Replacement power cost (mills/kwh)
	RWC	Rework well cost as fraction of producer well cost
*	RWF	Fraction of replacement wells which are reworked
*	SWF	Spare well fraction
	T	Resource temperature loss and heat exchange pinch point ^{o}F
*	TDSC	Year of discovery
*	TF2	Resource developer's federal tax rate
	TFA	Federal income tax rate for alternative power plant owner
*	TFH	Federal income tax rate for hydrothermal power plant owner
	TFIRST	First year of simulation
	TLAST	Last year of simulation
	TLFA	Tax life of alternative power plant (yrs)
*	TLFH	Tax life of hydrothermal power plant (yrs)
	TS2	Resource developre's state tax rate
	TSA	State income tax rate for alternative power plant owner
	TSH	State income tax rate for hydrothermal power plant owner
	TXC	Hydrothermal power plant transmission cost data
	TYF	Index - identifies type of developer
	TYPE	Geological classification (1: sedimentary; 2: igneous)
*	WO	Write off time allowable by PUC in event of plant failure
	WSPACE	Well spacing (acres/well)
*	YDPL	Date cooresponding to PDPL

* : Potentially Significant Policy and Program Dependent Variables

COMPUTED VARIABLES - ELECTRIC HYDROTHERMAL MODEL

	AC	Fraction of producible acreage utilized
	ACC	Escalation factor for CC2
	ACF	Annualized capacity factor
	ADD	Acres developed to date
	ADVT	Advalorem taxes after production
	ADVT	Advalorem tax dollars prior to production
	AEC	Escalation factor for EC2
	AL	Alpha - define shape of probability distribution
	ALTP	Alternative price of power
	AWO	Allowable write off time
*	BETAH	Recurrent cost fraction of hydrothermal power plant
	CAPC	Matrix of capital costs
*	CAPH	Hydrothermal plant capacity factor
	CC2	Capital cost in well field cashflow
*	CH	Hydrothermal power plant capital costs
	CHI	Hydrothermal plant transmission cost
	CHT	Hydrothermal power plant capital costs and and transmission cost
	CONF	Confidence level - likelihood you have required acreage for plant in question
	CRT20	Used to determine probability of last year of operation
	CRT20	Used to determine probability of last year of operation
	CRT30	Used to determine probability of last year of operation
	CRT30	Used to determine probability of last year of operation
	CT	Transmission cost
	DELDP	Years between decision and when the plant comes on line
	DELP	Levelized hydrothermal plant transmission cost (wells/kwh)
	DPFA	Intermediate variable - used to calculate levelized busbar cost for alternative plant taking into account capitalization and taxes
	DPFH	Intermediate variable - used to calculate levelized busbar cost for hydrothermal plant taking into account capitalization and taxes
	DPL	Depletions (dollar figure)
	DVT	index of the # of years - picks DELP element of DELP corresponging to Nth plant
*	DWF	Dry well fraction
	DX	Matrix of annual depreciation charges
	DX	Matric of depreciation factors

* : Potentially Significant Policy and Program Dependent Variables

	EC2	Expensed cost of well field cashflow
	EPA	Intermediate variable - used to determine levelized busbar cost (taking into account capacity and escalation factor)
	EPHP	Multiplier for capacity used to calculate levelized busbar cost Hydrothermal plant
	EPHT	Multiplier for capacity used to calculate levelized busbar cost Hydrothermal plant with transmission
	FCNF	# of producer wells and required injection wells required for confirmation
	GAA	Intermediate variable - used to calculate levelized busbar cost taking into account alternative transmission
	GAHP	Gamma - multiplier used to determine levelized busbar cost for hydrothermal power plant
	GAHT	Intermediate variable - used to calculate levelized busbar cost taking into account hydrothermal transmission
	GREV	Gross revenues
	IRR	Internal rate of return
*	LY	Year prior to estimated plant failure - last year of plant operation
	FSTAT	Matrix of 2 rows; the first contains the net income of electric utilities and the 2nd row contains total debt interest payments of the utility
	MCPH	Marginally competitive hydrothermal resource price
	MWCAP	Capacity of resource
	MWV	Sequence of plant sizes - (changes if you have committed plant)
	NACTM	# of active producer wells required
	NET	Net cash flow including revenue concerns
	NET1	Expense and capital costs for tax purposes prior to revenue consideration
	NETY	Net income attributable to hydrothermal plant
	NPV	Net present value of the project
	NPVR	NPV of resource
*	NSE	Net specific energy
	OP10	Binary matrix - 1: plant operating during year ; 0: otherwise
	PAY	Weighted average discounted pay back time
	PDPL	Vector of percentage depletion allowances
	PF20	Probability the last year of operation is year 20
	PF20	Used to determine probability of last year of operation
	PF30	Used to determine probability of last year of operation
	PF30	Probability the last year of operation is year 30
	PINV	Probability of investment in well field
	PIV	Plant interval - vector of years between plants - expansion of PIV

* : Potentially Significant Policy and Program Dependent Variables

	PLF	Project life
	PROB	Probability of electric utility investment
*	PUMP	Binary variable (0: well pumps ; 1: no well pumps)
	PVLS	Present value of the loss
	PYV	Sequence of years plant on line
	ROYL	Royalties
	SDRL	# of wells required including spares & injectors
*	SRP	Surface piping cost
	SYD	Vector for SYD depreciation
	TAX	Combined state and federal tax for well field (prior to revenue considerations)
	TAX	Taxes (taking into account revenues)
	TCOST	Total yearly cost of the hydrothermal plant
	TDNP	Year during which current decision is being made
	TF	Effective federal tax rate
	TIER	Change in times interest earned ratio
	TT1	# of years since first plant on line
	UBBC	Utility of hydrothermal powers cost
	UCF	Utility of capacity factor
	UG	Multiattribute utility of the gain
	UL	Disutility of the loss
	UMA	Multiattribute utility of the project
	UP	Utility of pay back time
	UR	Utility of rate of return
	UTIER	Utility of change in TIER
	UV	Utility of NPV
*	WC	Deep well cost
	WDD	Wells drilled to date
*	WF	Flow rate per active producing well (1000 lbs/hr)
*	WFOM	Well field operation and maintenance cost
*	WLF	Well life
	WT	Wellhead temp
	Y2	Vector of years corresponding to well field cashflow
	YT1	Year first plant comes on line at site
	YV	Vector of years plant in operation

* : Potentially Significant Policy and Program Dependent Variables

Note: Several variables are also time-dependent as a function of policies and programs; (e.g. well cost may be reduced over time as a function of R&D efforts). Changes to these time profiles are also significant.

POTENTIALLY SIGNIFICANT
POLICY- AND PROGRAM-DEPENDENT VARIABLES
(Refer to Attached Glossary for Definitions)

VARIABLE	VALUES USED BY HYDROTHERMAL NONELECTRIC MARKET ESTIMATE TASK FORCE	
	WITHOUT FEDERAL PGM	WITH FEDERAL PGM
ADVI	.015	(same)
DWF	.25	(same)
FE	.25	.10 For Municipalities for GLGP
IF	.75	(same)
IRD	.30	(same)
ITC	.25 or .10 after 1985	.25
KD	.11	.12 with GLGP
LTYPE	See Appx. B of Market Estimates Task Force Report for Learning Curve Characteristics	Accelerate Learning Curves by 5 Years after 1985
CP	See Task Force Report section by EG&G on Capital Cost Differentials	(see Note 1 below)
MCAP	District Heat Distribution System Capital Cost (NMEI Eqn): = 0.01933 x Q where Q is Annual Heat Demand.	(see Note 1 below)
MDOT	Design Flow Rate Dependent Upon User Heat Demand, Fluid Specific Heat, Utilization Factor and Temperature Drop.	(see Note 1 below)
MOM	District Heat Distribution System Annual O&M Expense (NMEI Eqn): = 0.00049 x Q where Q is Annual Heat Demand.	(see Note 1 below)
OMF	Well Field O&M Expense with Free-Flowing Wells Estimated per Note 2 below.	Use 90% of Value after 1985
OMP	Well Field O&M Expense with Pumped Wells Estimated per Note 3 below.	Use 90% of Value after 1985
PC	Downhole Pump Cost per Note 4 below.	Use 75% of Value after 1985
PDPL	Depletion Allowance Schedule: 1980 : 22% 1981 : 20% 1982 : 18% 1983 : 16% After 1983 : 15%	(same)

VARIABLE	VALUE WITHOUT FEDERAL PGM	VALUE WITH FEDERAL PGM
PIR	1.25	(same)
RWF	.30	(same)
SPF	Surface Piping Cost with Free-Flowing Wells per Note 2 below.	Use 92% of Value after 1985
SPP	Surface Piping Cost with Pumped Wells per Note 3 below.	Use 92% of Value after 1985
T	Time of Resource Discovery as Specified by UURI (refer to Task Force Report)	Acceleration in Resource Discoveries as Specified by UURI (see Task Force Report).
TF2	.46	(same)
TLF	11	(same)
ΔT	10	(same)
ΔTU	2	(same)
WC	Well Cost ($ millions): Igneous Geology = $2.887\ D^{1.496}$ Sedimentary Geology = $102.8\ D^{1.035}$ where depth, D, is 1000's of Ft.	 Use 85% of Value after 1983 Use 75% of Value after 1985
WLF	Well Life (Yrs): $10 \div [.5 \times (1 + BCI)]$	Use 128% of Value after 1985

<u>Note 1</u>: Federal Program Impact: 2% improvement by 1982

2%	improvement	by	1982
7%	"	"	1983
12%	"	"	1984
17%	"	"	1985
19%	"	"	1986
21%	"	"	1987

<u>Note 2</u>: Annual well field O&M expense equation:

$$OMF = [SPF \times .01 \times (BCI^2 - BCI + 2)] \times [NPRF \times V]$$

where: Surface Piping Cost, $SPF = MDOT \times \exp\,[.879 - (.00126 \times WFF)]$
Well Flow Rate Free-Flow, WFF, specified by UURI
Brine Contamination Index, BCI, specified by UURI
Number of Production Wells, $NPRF = MDOT \div WFF$

$$V = \left\{\left[1 + \frac{SWF}{1-SWF}\right] \times \left[RPL + (13.5 \times (1 + BCI))\right]\right\} + \frac{RPL + [30 \times (1 + BCI)]}{PIR}$$

Replacement Well Cost, $RPL = \dfrac{WC \times [1 + (RWF \times (RWC - 1))]}{WLF}$

Well Reworking Cost, $RWC = 0.33 \times WC$

<u>Note 3</u>: Annual well field O&M expense with pumped wells:

$$OMP = [SPP \times .01 \times (BCI^2 - BCI + 2)] + [NPRP \times V(\text{note 2})]$$
$$+ NPRP \times \left[1 + \frac{SWF}{1-SWF}\right] \times [56.3 + 23.5 \ln (.001 \times WFP)]$$
$$+ [.005 \times ELEC \times MDOT \times CFAC]$$

where: Surface Piping Cost, $SPP = MDOT \times \exp\,[.879 - (.00126 \times WFP)]$
Well Flow Rate Pumped, WFP, specified by UURI
Number of Production Wells, $NPRP = MDOT \div WFP$
Electric Energy Cost, ELEC, in mills/kWh
Utilization Factor, CFAC, provided by EG&G.

<u>Note 4</u>: Downhole pump cost equation:

$$PC = NWLP \times WFP \times \exp - [0.607 + (0.000995 \times WFP)]$$

where: Number of Active and Spare Producer Wells, NWLP
$= NPRP \times \left[1 + \dfrac{SWF}{1-SWF}\right]$

INPUTED VARIABLES - NONELECTRIC HYDROTHERMAL MODEL

	ABETA	Matrix of coefficients defining the shape of the logit curves
*	ADV1	Local ad valorem tax rate
	BCI	Brine contamination index
	BLF	Book life
	DR	Discount rate
	DWC	Dry well cost
*	DWF	Dry well fraction
	ENERGY	Matrix of energy requirements by SIC by region (BTU's/YR/Estab)
*	FE	Equity fraction
	G	General inflation rate
*	GAMMA	Defines the percentage of firms in each SIC category who are willing to consider using geothermal energy
	GC	Inflation rate for capital
	GDH	District heat growth rate
	GE	Inflation rate for expenses
	GF	Alternative fuel price inflation rate
	GH	Uniform escalation rate at which resource is sold
	GROWTH	Matrix of growth rates for industries by SIC by region
*	IF	Intangible well cost fraction
*	IRD	Fraction of new wells which are redrilled
*	ITC	Investment tax credit
*	KD	Cost of debt
	KE	Cost of equity
*	LTYPE	Defines the shape of the learning curve for each industry
	MDR	Municipal discount rate
	METH	Matrix of information for methanol facilities
*	MKD	Municipal cost of debt
*	PDPL	Percentage depletion allowance in years specified by YDPL
*	PIR	Producer/injector well fraction
	PRICE	Price of alternative types of energy by region (1980 $/10*6 BTU)
	RDC	Redrill well cost as a fraction of producer well cost
	RLF	Resource royalty rate
	RWC	Rework well cost as a fraction of producer well costs
*	RWF	Fraction of replacement wells which are reworked
*	SWF	Spare well fraction
*	T	Time period index 0 - 4 for resource discovery
	TEMP	Vector of temperature requirements by SIC category
*	TF2	Resource developer's federal tax rate
*	TLF	Tax life
	TREQ	Temperature required by industry at point of use
	TS2	Resource developer's state tax rate
*	ΔT	Resource temperature loss & heat exchange pinch point (^{o}F)
*	ΔTU	Time from resource discovery to use
	USEFF	Share of energy used per region by fuel type devided by the use efficiency for the respective fuels
	WSPACE	Well spacing (acres/well)
	WT	Well head temperature
*	YDPL	Years cooresponding to depletion allowance in PDPL

* : Potentially Significant Policy and Program Dependent Variables

COMPUTED VARIABLES - NONELECTRIC HYDROTHERMAL MODEL

	AC	Acreage used
	ACRF	Producible acreage required under free flow conditions
	ACRP	Producible acreage required under pumped conditions
	AL	Alpha - coefficient for closed form simulation of cash flow
	CAP	Capital cost requirement
	CFAC	Capacity factor
	CP	Specific heat of fluid
	CP	Capital cost
	CR	Capital recovery
	DF	Fraction of resource used
	DLT	Delta - temperature drop in heat exchange
	ELEC	Regional price for electricity
	EP	Epsilon - coefficient for closed form simulation of cash flow
	ESC	Esclation factor for capital
	ESE	Escalation factor for expenses
	HPR	Discounted present value of the resource price
	INT	Interest on debt financing
	K	Cost of capital
	KCR	Coefficient for closed form simulation of cash flow - takes into capital recovery
	KCRIN	Coefficient for closed form simulation of cash flow - takes into capital recovery and interest payments
	KEX	Coefficient for closed form simulation of cash flow - takes into expenses
	KEX2	Esclation and discouunting factor for KEX
	KIN	Coefficient for closed form simulation of cash flow - takes into interest payments
	KSY	Coefficient for closed form simulation of cash flow - takes into depreciation
	KSY2	Esclation and discounting factor for KSY
	LAM	Inverse of (1 - royalty fraction)
*	MCAP	Municipal capital cost of the distribution system
	MCR	Municipal capital recovery factor
*	MDOT	Flow rate to user
*	MOM	Municipal operation and maintenance cost of the distribution system
	MN	Vector of the number of industries in each SIC group by region to be considered in the decision analysis
	MPV	Municipal present value of distribution system
	NPRF	# of active producer wells required under free flow conditions
	NPRP	# of active producer wells required under pumped conditions
	NR	# of resources in each region
	NS	# identifying industries
	NWLF	# of total wells under free flow conditions
	NWLP	# of wells required under pumped conditions
*	OMF	Well field O & M expense for unpumped wells
*	OMP	Well field O & M expense with pumped wells

* : Potentially Significant Policy and Program Dependent Variables

	PALT	Price of alternative form of energy
	PC	Capital cost pumped
	PDPL	Percentage depletion allowances
	PRCE	Price adjusted for use efficiency
*	PUMP	Binary variable - 0: unpumped 1: pumped
	PV	Lower of Present value for pumped or free flow wells
	PVA*	Present value of alternative
	PVF	Present value of the resource for free flowing wells
	PVP	Present value of the resource for pumped wells
	PVR	Ratio of the present value of the hydrothermal resource to the present value of the alternative
	QANN	Annual heat requirement/estab (10^6 BTU/YR)
	QT	Total district heat by region
	RG	Region number
	RPL	Replacement well cost
*	SPF	Surface piping cost - unpumped
*	SPP	Surface piping cost - pumped
	SYD	Vector of sum of years digits for depreciation of capital less intangibles
	T10	Binary variable (1: Resource temp is compatible ; 0: otherwise)
	T2	Coefficient for closed form simulation of cash flow - takes into account taxes
	TCAP	Capitalize cost for tax purposes
	TEX	Expensed cost for tax purposes on pumped wells
	TH	Coefficient for closed form simulation of cash flow - takes into account taxes
	TOT	Total geothermal energy use in a region
	TU	Coefficient for closed form simulation of cash flow - takes into account taxes
	YR	Vector identifying years for the cash flow
	TXR	Intermediate variable used to calculate taxes & credits
*	WC	Well cost
*	WFF	Unpumped well flow rate
*	WFP	Pumped well flow rate
*	WLF	Well life

* : Potentially Significant Policy and Program Dependent Variables

Note: Several variables are also time-dependent as a function of policies and programs; (e.g. well costs may reduce over time as a function of R&D efforts). Changes to these time profiles are alos significant.

POTENTIALLY SIGNIFICANT POLICY- AND PROGRAM-DEPENDENT VARIABLES

(Refer to Attached Glossary for Definitions)

VARIABLE	VALUE USED BY HYDROTHERMAL ELECTRIC MARKET ESTIMATE TASK FORCE: WITHOUT FEDERAL PGM	WITH FEDERAL PGM
ADV1	.04 for CA .037 for CO,ID,WY,MT,NV,UT .02 for OR,WA .01 for AZ .021 for NM	(same)
BETAH	Annual O&M ($1000) for Binary Plants: O&M = 548.5 + [.02 x CI_o] for Flash Plants: O&M = 509.5 +[.02 x CI_o]+ BCI(BCI-1)[92.88 $\frac{MW}{N_s}$ + 112] where CI_o is Capital Cost, BCI is Brine Contamination Index, MW is Capacity, and N_s is Net Specific Energy (see NSE).	Use 103% of Binary Value after 1985 Use 92% of Flash Value after 1985
CAPH	Capacity Factor represented by triangular distribution with: MIN = .80 - .2838exp[-(.35 + .739t)] MODE = .85 MAX = .90 where t is years of production experience at site.	Use 105% of Value after 1985
CH	Plant Capital Cost ($/KW) for Flash Plants: CAP = exp[3.040 - .00261(TEMP) + .069(BCI)] for Binary Plants: CAP = exp[2.508 - .0014(TEMP)]	Use 99% of Flash Value after 1985 Use 98% of Binary Value after 1985 For First Plant of Site Use 75% of Value ("Ice Breaker")
DELDP5	5 Yrs to First Plant	3 Yrs to First Plant
DV10	Commitments: Salton Sea 10MW 1982 Salton Sea 49MW 1984 Brawley 10MW 1980 East Mesa 11MW 1979 Heber 41MW 1982 Roosevelt 20MW 1983 Geysers 33 Units thru 1988	Add: Heber 45MW 1984 Raft River 5MW 1980 Valles Caldera 50MW 1982
DWF	Dry Well Fraction represented by triangular distribution with: MIN = .10 MODE = .15 MAX = .35 - [.15 x (Lesser of 5 or WDD) ÷ 5] where WDD is Wells Drilled to Date at Site.	(same)
FCH	.35	.175 With GLGP
FDH	.50	.75 With GLGP
FPH	.15	.075 With GLGP
IF	.75	(same)
IRD	.30	(same)
ITC2	.25 or .10 after 1985	(same)

VARIABLE	VALUE WITHOUT FEDERAL PGM	VALUE WITH FEDERAL PGM
ITCH	.10	(same)
KDH	.08	Add .01 With GLGP
NSE	Plant Net Specific Energy: $N_s = -16.90 + .0615(TEMP) + 2.344(TYPE) - .534(BCI)$ where: N_s = net specific energy (W hr/lb fluid) TEMP = resource temperature (^oF) TYPE = 1 if binary; 0 if flash BCI = brine contamination index (0 = low salinity to 3 = high salinity)	Use 109% of Value after 1985
PEXP	$95K for Permit/License Studies	Reduce to $70K
PDPL	.22 in 1980 .20 in 1981 .18 in 1982 .16 in 1983 .15 after 1983	(same)
PIR	2	(same)
PIVS	3 Yr. Min. Between Units 1 and 2 2 Yr. Min. Between Units 2 and 3 1 Yr. Between Subsequent Units	(same)
PLFH	30	(same)
PTLF	11	(same)
PUMP	Max. Wellhead Temp. for Down Hole Pump = 370F	Increase to 400F after 1985
RPF	1	(same)
RWF	.33	(same)
SRP	Surface Piping Cost ($1000) for Flash Plant: $SRP_f = \exp[9.245 - .008(TEMP) - 1.207(WF) + .055(BCI)]$ Flash with Pumped Wells: $SRP_{fp} = \exp[9.806 - .0105(TEMP) - 1.337(WF) + .064(BCI)]$ for Binary Plant: $SRP_b = \exp[9.506 - .0109(TEMP) - 1.347(WF) + .071(BCI)]$ Binary with Pumped Wells: $SRP_{bp} = \exp[8.137 - .0063(TEMP) - 1.152(WF) + .066(BCI)]$ where WF is Well Flow Rate.	Use 96% of Flash Value after 1985 Use 92% of Binary Value after 1985
SWF	.20	(same)
TDSC	Timing of Resource Discoveries Estimated by UURI; see Market Estimates Task Force Report.	(see Report)
TF2	.46	(same)
TFH	.46	(same)
TLFH	22	(same)
WC	Well Costs Sedimentary Geology, $WC = 102.8 \times d^{1.035}$ Igneous Geology, $WC = 2.89 \times d^{1.496}$ where Depth, d, is in 1000's of Feet.	Use 85% of Value after 1983 Use 75% of Value after 1985
WFOM	Well Field O&M ($1000/Yr): $WFOM = 320 + 110.2(1+BCI)NACT + .01(BCI^2-BCI+2)SRP$ where NACT is the Number of Active Producer Wells.	Use 90% of Value after 1985
WLF	Well Life Prior to Replacement or Major Rework represented by triangulear distribution with: MIN(t=1) = .40 x [15-(5 x BCI)] MIN(t>1) = .70 x [15-(5 x BCI)] MODE = 1.00 x [15-(5 x BCI)] MAX = 1.30 x [15-(5 x BCI)] where t is Years of Production Experience at Site.	Use 128% of Value after 1985
WO	3	(same)

Economic Incentives - Electric

Variable	Strategy 1	2	3	4	5	6	7
FCH	.35	.175	.175	.175	.175	.175	.175
FDH	.50	.75	.75	.75	.75	.75	.75
FPH	.15	.075	.075	.075	.075	.075	.075
ITC2	.25(.10)	.40(.10)	.25(.10)	.25(.10)	.25(.10)	.40(.10)	.70(.10)
ITCH	.10	.20	.10	.10	.10	.20	.40
KDH	.08	.09%	.09%	.09%	.09%	.09%	.09%
PDPL	.22 .20 .18 .16 .15	.22 .22 .20 .18 .16	.22 .20 .18 .16 .15	.22 .20 .18 .16 .15	.22 .20 .18 .16 .15	.22 .22 .20 .18 .16	.22 .22 .22 .22 .22
PTLF	11	5.5	11	11	11	5.5	2.25
TF2	.46	.23	.46	.46	.46	.23	.115
IF	.75	.75	.75	.75	.75	.75	.75
TFH	.46	.23	.46	.46	.46	.23	.115
TLFH	22	11	22	22	22	11	5.5

Resource Definition - Electric

Variable	Strategy 1	2	3	4	5	6	7
TDISC		U	U	R	I		
DWF	.35(.20)	.35(.20)	.34(,10)	.32(.20)	.32(.20)	.30(.20)	.30(.20)

Demonstration Program - Electric

Variable	Strategy 1	2	3	4	5	6	7
PTYPE	(site-specific)						
DELPD5	5	4	4	3	3	3	3
TDISC		U	U	R	I		
DWF	.35(.20)	.35(.20)	.34(.20)	.32(.20)	.32(.20)	.30(.20)	.30(.20)

R & D - Enabling Technology - Electric

Strategy

Variable		1	2	3	4	5	6	7
BETAH	B	B_b	B_b	B_b	B_b	B_b	B_b	B_b
	F	B_f	B_f	B_f	-16%	B_f	-16%	-16%
CAPH		.85	.85	.85	.89	.85	.89	.89
CH	B	CH_b	CH_b	CH_b	-4%	CH_b	-4%	-4%
	F	CH_f	CH_f	CH_f	-2%	CH_f	-2%	-2%
DV 10	#	9	9	9	13	9	13	13
	MW	+55	+55	+55	+200	+55	+200	+200
DWF		.35(.20)	.35(.10)	.34(.20)	.32(.20)	.32(.20)	.30(.20)	.30(.20)
NSE		NSE	NSE	NSE	+18%	NSE	+18%	+18%
PIR		2	2	2	2	2	2	2
PUMP		370^{o}	370^{o}	370^{o}	400^{o}	370^{o}	400^{0}	400
RWF		.33	.33	.33	.25	.33	.25	.25
SRP	B	S_f	S_f	S_f	-8%	S_f	-8%	-8%
	F	S_b	S_b	S_b	-16%	S_b	-16%	-16%
SWF		.20	.20	.20	.20	.20	.20	.20
WC		WC	WC	WC	-15%	WC	-15%	-15%
					-25%		-25%	-25%
					-30%		-30%	-30%

R & D Enabling Technology - Electric (cont.)

Strategy

Variable	1	2	3	4	5	6	7
WFOM	O_{wf}	O_{wf}	O_{wf}	-20%	O_{wf}	-20%	-20%
WLF	L	L	L	+56%	L	+56%	+56%

R & D Environmental Control - Electric

Strategy

Variable		1	2	3	4	5	6	7
BETAH	B	B_b	B_b	B_b	B_b	B_b	B_b	B_b
	F	B_f	B_f	B_f	-16%	B_f	-16%	-16%
CH	B	CH_b	CH_b	CH_b	-4%	CH_b	-4%	-4%
	F	CH_f	CH_f	CH_f	-2%	CH_f	-2%	-2%

Technical Assistance - Electric

<u>Strategy</u>

Variable	1	2	3	4	5	6	7
TDISC		U	U	R	I		

Streamlining - Electric

Strategy

Variable	1	2	3	4	5	6	7
DELDP5	5	4	4	3	3	3	3
PEXP	95	70	70	70	70	70	70
TDISC		U	U	R	I		

Economic Incentives - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
FE	.25	.10M	.10M	.10M	.10M	.10M	.10M
IF	.75	.75	.75	.75	.75	.75	.75
ITC	.25(.10)	.40(.10)	.25(.10)	.25(.10)	.25(.10)	.40(.10)	.70(.10)
KD	KD	+.1%	+.1%	+.1%	+.1%	+.1%	+.1%
MKD	MKD	MKD	MKD	MKD	MKD	MKD	MKD
PDPL	.22	.22	.22	.22	.22	.22	.22
PDPL	.20	.22	.20	.20	.20	.22	.22
PDPL	.18	.20	.18	.18	.18	.20	.22
PDPL	.16	.18	.16	.16	.16	.18	.22
PDPL	.15	.16	.15	.15	.15	.16	.22
TF2	.46	.23	.46	.46	.46	.23	.115
TLF	11	5.5	11	11	11	5.5	2.25

Resource Definition - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
DWF	.25	.25	.25	.25	.25	.25	.25

T U U R I

Demonstration Program - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
L TYPE	LC	LC	LC	+2.5	+7	+6	+7
GAMMA	G	G	G	+2.5%	+10%	+7.5%	+10%
T				U U R I			
DWF	.25	.25	.25	.25	.25	.25	.25

R & D - Enabling Technology - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
CP	C_p	C_p	C_p	-42%	C_p	-42%	-42%
MCAP	M_c	M_c	M_c	-42%	M_c	-42%	-42%
MOM	M_o	M_o	M_o	-42%	M_o	-42%	-42%
OMF	O_f	O_f	O_f	-20%	O_f	-20%	-20%
OMP	O_p	O_p	O_p	-20%	O_p	-20%	-20%
PC	P_c	P_c	P_c	-50%	P_c	-50%	-50%
SPF	S_f	S_f	S_f	-16%	S_p	-16%	-16%
SPP	S_p	S_p	S_p	-16%	S_f	-16%	-16%
WC	WC	WC	WC	-15% -25% -30%	WC	-15% -25% -30%	-15% -25% -30%
WFF				(site-specific)			
WFP				(site-specific)			
WLF	W_L	W_L	W_L	+42%	W_L	+42%	+42%

R & D Environmental Control - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
CP	C_p	C_p	C_p	-42%	C_p	-42%	-42%

Technical Assistance - Direct Heat

Strategy

Variable	1	2	3	4	5	6	7
GAMMA	G	G	G	+2.5%	+10%	+7.5%	+10%
LTYPE	LC	LC	LC	+2.5	+5	+6	+7
T		U	U	R	I		

Streamlining - Direct Heat

Variable

Multiple Impacts – Electric

Variable		Total Effect	RE	DEMO	R&D TECH	R&D ENV.	TA	ST
TDISC			X	X	UURI		X	X
DWF		-1.00	.25	.50	.25			
DELDP5		-1.00		.50				.50
CH		-1.00			.90	.10		
BETAH	B	±1.00			TE* – .1 $\lvert TE \rvert$	-.10		
	F	-1.00			.90	.10		

*TE = Total Effect

Multiple Impacts – Direct Heat

Variable	Total Effect	RE	DEMO	R&D TECH	R&D ENV.	TA	ST
T		X	X	UURI		X	
DWF	-1.00	.25	.50	.25			
LTYPE	1.00	.50				.50	
GAMMA	1.00	.50				.50	
CP	-1.00			.90	.10		