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REGIONAL OPERATIONS RESEARCH PROGRAM
FOR COMMERCIALIZATION OF GEOTHERMAL ENERGY IN THE
ROCKY MOUNTAIN BASIN AND RANGE

Final Report
(8/1/78 - 2/28/80)

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ABSTRACT

This report describes the work accomplished from August 1978 to February 1980 in the Regional Operations Research efforts for the Rocky Mountain Basin and Range Geothermal Commercialization Program. The scope of work is as described in New Mexico State University Proposal NMSU-79-20-039. The work included continued data acquisition and extension of the data base, enhancement and refinement of the economic models for electric and direct use applications, site-specific and aggregated analyses in support of the state teams and special analyses in support of several federal agencies.

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X

EXECUTIVE SUMMARY

This report describes the work accomplished in the second contract phase (August 1978 - February 1980) of the Regional Operations Research Program for development of geothermal energy in the Rocky Mountain Basin and Range Region. The work has been performed by a team at New Mexico State University/New Mexico Energy Institute in cooperation with state teams from each of the 10 states in the region (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, North Dakota, South Dakota, Utah and Wyoming).

The objectives of the efforts are to support the Department of Energy's State Commercialization Planning and Outreach Program. To this end, there has been developed a regional data base of geophysical, demographic, economic and energy use information and techniques for interactive computer analyses. These analyses have been used in:

- a) Support of the site-specific and aggregated commercialization plans.
- b) Investigations of the impact of variations in public policy and economic factors.
- c) Development of patterns of projected regional geothermal energy development.
- d) Cost benefit analyses of federal and state geothermal expenditures.
- e) Developing energy demand projections.
- f) Analyzing the market potential for geothermal energy in the region.

The basic report describes the data base, the major models, the support furnished to the state-teams and several special studies performed.

The emphasis has been on commercialization and potential for energy market capture.

This summary describes the potential market penetration (market shares) for direct use geothermal energy in the Rocky Mountain Basin and Range (10 states) by the year 2020, and related assessment of the effects on geothermal development of a range of federal policies and initiatives.

The following analysis is a result of more than 15,000 computer simulation studies of individual geothermal economic prospects in the ten intermountain states. NMEI has analyzed more than 1300 possible geothermal sites paired with as many cities, and with several thousand possible industrial users of direct geothermal heat.

Present herein are three policy cases for review. The High Case depicts 0.55 Quads per year on line by 1990. A Mid Case depicts 0.27 Quads per year. The Low Case is 0.05 Quads per year. Following is a table which summarizes the key factors by 1990. Net Federal Outlays are defined as the summation of reservoir confirmation, direct construction grants and investment tax credits, with federal income tax and royalty payments serving as offsets. Also shown is a Low-low Case, which contains no federal stimulus.

CASE	NET FEDERAL OUTLAYS \$ BILLIONS BY 1990	CONSUMER SAVINGS \$ BILLIONS BY 1990	QUADS/YEAR ON LINE BY 1990	OIL IMPORT DISPLACEMENT MILLION BARRELS PER YEAR BY 1990
HIGH	5.86	36.3	0.55-0.9*	305
MID	1.70	9.9	0.27	122
LOW	0.28	0.2	0.15	70
LOW-LOW	N/A	0.06	0.015	20

* This is 0.55 Quad from NMEI analysis, with possible 0.35 Quad from major new geothermal industrial parks in California, Oregon and Idaho which DSS Industries analyzed and recommended by study a dated March 1978.

Note also the above data excludes California, Hawaii, Oregon, Washington, Alaska, Texas, Louisiana, Arkansas and Nebraska, and other eastern states where direct use potential also exists. Data also excludes geothermal ground water heat pumps, co-generation of electricity and direct steam and geothermal electricity.

The NMEI High Case portrays approximately one-half quad on line by 1990. This case also represents a 35-year acceleration in geothermal usage in comparison with the Low Case, and a 20-fold acceleration in geothermal usage in comparison with the Low Case, and 20-fold acceleration in the amount of geothermal energy in use (See Graph on Page 32).

This High Case represents the most stimulative of scenarios, and rests on two fundamental governmental initiatives. First assumption is that there is a government-funded reservoir confirmation program of direct

grants and funded research so as to accelerate knowledge of geothermal energy, and to remove the investment risk associated with dry holes. Analysis suggests strongly that an investor faced with a sizeable research investment for the relatively low profitability of geothermal (compared with oil or natural gas) will be unwilling to risk the investment unless he has a high rate of return on his investment. From sensitivity analysis, the combination of investor and high rate of return acts to force to an unacceptably high level (non-price competitive) the geothermal price per million BTU.

The High Case also incorporates an analysis of governmental direct funding on a matching funds basis, with one dollar of federal money for three dollars of private or city funds. This is the type of program within the Economic Development Administration program, and also the HUD-UDAG program.

The following table illustrates the policy initiatives considered, for each case.

<u>CASE</u>	<u>POLICY INITIATIVES</u>
High	100% Federal Reservoir Confirmation; 25% Federal Matching Funds. Rate of return on investment 15%.
Mid	100% Federal Reservoir Confirmation. Rate of return on investment 15%.
Low	50% Federal Reservoir Confirmation and rate of return 25%.

Low-low 0% Federal Reservoir Confirmation and rate of return 35%. (This Low-low Case is used only for illustration, since without stimulative policies, geothermal development is likely to require decades for widespread usage. Also included in this case are assumptions that alternative energy tax credits and depletion allowances terminate under 1978 law.)

The geothermal facility construction will create jobs, which is of critical importance to economically depressed cities and rural areas. In addition, the consumer savings on energy costs resulting from geothermal usage are also highly important to overall state and region economic considerations. Depicted as follows is a summary of potential target cities and their population that could be served economically by geothermal energy. This High Case population level represents almost one-third of the expected 1990 population of these ten intermountain states.

<u>STATE</u>	<u>CITIES BY 1990</u>	<u>POPULATION SERVED BY 1990</u>
Arizona	105	1,259,844
Colorado	154	1,151,622
Idaho	80	595,475
Montana	129	260,393
Nevada	51	406,235
New Mexico	91	445,154
North Dakota	137	229,306
South Dakota	64	112,064
Utah	103	1,056,063
Wyoming	<u>29</u>	<u>222,452</u>
Totals	944	5,740,608

Concerning foreign oil displacements, NMEI data depict only the geothermal energy usage at point of final consumption. Thus, the multiplier for foreign oil displacement after factoring in conversion

efficiencies at point of consumption and transmissions losses is two to three, depending on which form of energy usage is displaced by geothermal. The imported oil displaced is of the order of magnitude as shown below, using a 50 percent transmission and conversion efficiency factor for imported oil:

<u>CASE</u>	<u>MILLION BARRELS/YEAR OIL DISPLACED BY 1990</u>	<u>MILLION BARRELS/DAY OIL DISPLACED BY 1990</u>
High	305*	0.83
Mid	122	0.33
Low	70	0.19
Low-low	20	0.06

* Includes the 0.345 Quad from industrial parks.

In summary, this detailed NMEI report clearly displays the potential for geothermal energy and the positive contribution federal incentives can provide this partial solution of the nation's energy crisis.

The work presented herein rests upon a foundation of pioneering work performed at NMEI in the past two years. In brief, a sophisticated and comprehensive series of computerized files and computer simulation programs have been developed to perform a methodical and logical evaluation of the economic potential of geothermal energy. Concerning the electronic files, some 10 million bytes of data are now in electronic storage, including key information for the following categories of data:

Number of Cities: 2,257
Number of Industries: 11,007
Number of Potential Geothermal Sites: 1,568

This report is organized into sections which describe the methodology, simulation models, data bases, each section providing details concerning procedures used to acquire and develop data concerning geothermal.

1.0 INTRODUCTION

The work described in this Draft Final report is part of a Regional Operations Research Project for the commercialization of Geothermal Energy in the Rocky Mountain Basin and Range Region. This project is in support of the Division of Geothermal Energy of the United States Department of Energy, the Four Corners Regional Commission, and the Department of Energy and Minerals, state of New Mexico; and is under the sponsorship of the New Mexico Energy Institute. In support of the project, a group of computer simulation models and a data base have been created to provide users with multi-level scenario predictions, market penetration analyses, data access for economic studies, and factual statistical studies of information on file.

1.1 NMEI Data Bases

Concerning the data bases, four separate but logically interconnected data sets have been placed into electronic storage. Subsequent sections of this report describe in more detail each of these data bases, which are defined as follows:

<u>FILE NAME</u>	<u>NMEI REPORTS</u>
SITEX - Working file of Geothermal Sites	10-3 (Feb., 1979) 30-7 (Sept., 1979) 30-11 (Dec., 1979) 30-15 (May, 1980)

CITY2 - Files containing demographic and energy data for RMBR cities	10-4 (May, 1979) 30-3 (Sept., 1979)
IND - File containing data on industries in RMBR	30-4 (Oct., 1979) 30-18 (April, 1979)
CASH - Files containing output of the simulation modeling for RMBR potential users which give results from different policy scenarios	10-4 (May, 1979) 30-7 (Sept., 1979) 30-8 (Sept., 1979) 30-13 (Jan., 1980)

1.2 Simulation Models

Computer simulation models have been developed which enable the NMEI team to define geothermal potential markets along with an engineering-economic assessment of the cost effectiveness of geothermal energy. Together with an energy-demand forecasting group of models, the simulation models permit an assessment of the possible geothermal market penetration (market share capture) as a function of policy initiatives. Each of these models is briefly described as follows:

<u>MODEL NAME</u>	<u>NMEI REPORTS</u>
MARKET - A linear program model	10-6 (June, 1979)
GIRORA-ELECTRIC - Computer simulation model for the cost of geothermal electricity	30-1 (July, 1979) 30-17 (March, 1980)
BTHERM - Computer simulation model for the cost of geothermal direct use	10-4 (May, 1979) 10-7 (Feb., 1979) 30-5 (Nov., 1979) 30-6 (Oct., 1979) 30-9 (Oct., 1979)
CASH - Computer assisted scenario hydrothermal simulation	10-4 (May, 1979) 30-2 (July, 1979) 30-8 (Sept., 1979) 30-13 (Jan., 1980)

Energy Demand Forecast - Simulation of future
energy demand by fuel
type and consuming
sector

30-1 (July, 1979)
30-17 (April, 1980)

HYPOT - Geophysical Potential of Hydrothermal
Sites

10-4 (May, 1979)
30-7 Sept., 1979)

1.3 Description of Potential Users and Geothermal Sites

For two years, the NMEI team has assembled a large array of data concerning geothermal sites and potential users in the intermountain states. All of this data, including type and cost of conventional energy along with demographic data on the potential users, is placed in electronic storage in the AMDAHL Computer at NMSU. Data are accessed by APL program routines written and modified for this special use. To date, an aggregate total of more than 10 million bytes of data have been stored. An overview of this data is presented in the following table.

1.3 Table 1
NMEI DATA FILES

STATE	CITY FILE		INDUSTRIAL FILE TOTAL INDUSTRIES	SITE FILE		
	TOTAL CITIES	1977 POPULATION		TOTAL SITES	ELECTRIC POTENTIAL (MW) ($>150^{\circ}\text{C}$)	DIRECT THERMAL QUAD BTU ($>40^{\circ}\text{C}$)
ARIZONA	182	1,956,626	1280	72	450	81.88
COLORADO	313	2,037,580	3600	113	350	6.37
IDAHO	261	560,395	1100	310	7200	155.81
MONTANA	332	574,800	800	136	0	6.92
NEVADA	97	487,150	161	307	3400	31.74
NEW MEXICO	192	908,016	1000	114	3400	25.55
NORTH DAKOTA	260	403,603	379	161	0	10.35
SOUTH DAKOTA	258	443,439	383	67	0	1.24
UTAH	225	950,053	1816	224	1700	13.50
WYOMING	137	306,600	488	64	150	11.00
<u>TOTALS</u>	<u>2,257</u>	<u>8,628,262</u>	<u>11,007</u>	<u>1,568</u>	<u>16650</u>	<u>344.36</u>

2.0 METHODOLOGY FOR NMEI GEOTHERMAL MARKET PENETRATION

2.1 General

The NMEI methodology is characterized by a bottoms-up method of aggregating over the next 40 years the economic potential for geothermal market penetration. Under this methodology, a geothermal resource is matched with a potential user (city or industry). The user-resource pair is then analyzed for site-specific values, including weather factors, population growth rate, industrial heat demand and average hours of industrial operation, commercial energy consumption, building density factors, and the type and cost of conventional energy. Using those values, along with specific resource values known or estimated, the user-resource pair is analyzed using the BTHERM Computer simulation model to determine various economic and engineering factors, and a panoply of economic and social benefits which the geothermal resource could satisfy. Every resource-user pair is given sensitivity analysis and a most likely range of input values is assigned. The pairs are then loaded into a follow-on computer simulation routine termed Computer Assisted Scenario, Hydrothermal (CASH) which contains a version of the BTHERM model. The CASH program is then used to develop a 40-year scenario of price-competitive geothermal development for a variety of policy and economic options. The following figure is a schematic overview of the methodology.

2.1 Figure 1

GEOHERMAL MARKET PENETRATION

2.2 Description of MARKET Program

The MARKET Program is a computer simulation routine using linear programming techniques developed by NMEI to assist in the analysis of the economic potential for geothermal development. This program draws upon data stored in the Geothermal SITEX, CITY2, and industrial files. The program uses operator-selected values for distance (0 to 100 miles), temperature of geothermal resource (0°C to 500°C), city population (0 to 15,000,000 people), and industry size (0 to 10,000,000 employees). For any combination of these values, the MARKET Program will produce a unique ordering of city-site pairs, or industry-site pairs for follow-on economic analysis. The program is summarized by the following table.

2.2 Table 1

MARKET PROGRAM

- Operates on City and Site Files
- Input Parameters (Population, Distance, Temperature)
- Assigns Weighting Factors
 - Resource temperature
 - City-Site Distance
- Computes and arrays:
 - Optimum city-site pairing
 - Unique city-site relationship
 - Resource name, temperature, city name, population, distance from resource, and weather data
 - Residential heat demand
- Commercial and Industrial Demand Computed Separately

Output from the MARKET Program can take one of several forms, as illustrated by the following examples:

This is a sample regular MARKET output which depicts the optimized relationship between known and inferred geothermal resources and prospective city/industrial users. This version of MARKET is used as the starting point in the economic analysis of geothermal potential and is greatly supplemented by interaction with state planners and resource assessment teams to devise the unique factors affecting each city and/or industrial user of geothermal energy.

2.2 Sample 1

SITE ID	SITE NAME	CITY ID	CITY NAME	DIST (MI)	POP	TEMP (°C)	DEGD	LT (°F)	YR. HEAT (BTU × 1E10) (FOR CITY)
25034	PREWITT NORTH E RA19	25653	MCCARTYS	28	400	150	6200	17	2.381
25034	PREWITT NORTH E RA19	25678	SAN RAFAEL	22	400	150	6100	17	2.342
25036	HOT WELL RA10	25669	PONDEROSA	6	150	100	5500	20	.792
25037	SAN YSIDRO RA17	25535	JEMEZ PUEBLO	6	1197	100	5400	20	6.205
25037	SAN YSIDRO RA17	25561	SAN FELIPE PUEBLO	24	1187	100	4850	18	5.527
25037	SAN YSIDRO RA17	25586	SAN YSIDRO	4	250	100	5700	19	1.368
25037	SAN YSIDRO RA17	25620	ALGODONES	24	250	100	5000	18	1.200
25051	GUADALUPE AREA RA16	25647	LAGUNA	33	600	170	6300	17	3.629
25051	GUADALUPE AREA RA16	25663	PAGUATE	26	600	170	6500	17	3.744
25052	COLUMBUS AREA RA46	25592	COLUMBUS	9	260	155	3250	27	.811
25053	SAN DIEGO MTN RA35	25529	HATCH	12	920	125	3310	26	2.923
25053	SAN DIEGO MTN RA35	25614	RINCON	10	300	125	3310	26	.953
25055	SOCORRO RA24	25546	MAGDALENA	16	650	72	5110	18	3.189
25055	SOCORRO RA24	25566	SOCORRO	3	5875	72	3915	24	22.081
25055	SOCORRO RA24	25675	SAN ANTONIO	11	500	72	3200	25	1.536
25056	JEMEZ RESERVOIR RA20	25603	JEMEZ SPRINGS	1	500	150	5330	20	2.558
25057	LORDSBURG RA41	25540	LORDSBURG	15	3900	150	3950	26	14.789
25058	FORT WINGATE RA18	25526	GALLUP	12	15300	61	6400	16	94.003
25058	FORT WINGATE RA18	25581	ZUNI PUEBLO	33	3958	61	6000	16	22.798
25058	FORT WINGATE RA18	25628	BRIMHALL	21	200	61	6300	16	1.210
25058	FORT WINGATE RA18	25642	GAMERCO	11	400	61	6500	16	2.496
25058	FORT WINGATE RA18	25655	MANUELITO	24	100	61	6300	16	.605
25058	FORT WINGATE RA18	25684	TONATCHI	27	400	61	6500	16	2.496
25062	LAGUNA	25502	ALBUQUERQUE	14	286300	50	4270	24	1173.601
25062	LAGUNA	25508	BERNALILLO	19	2775	50	4725	18	12.587
25062	LAGUNA	25543	LOS RANCHOS DE ALBQ	13	1950	50	4550	19	8.518
25062	LAGUNA	25550	NORIARTY	48	830	50	5800	17	4.621
25062	LAGUNA	25552	NORTH VALLEY	14	10366	50	4270	24	42.492
25062	LAGUNA	25567	SOUTH VALLEY	14	29389	50	4270	24	120.471
25062	LAGUNA	25585	SANDIA PUEBLO	18	6867	50	4500	18	29.665
25062	LAGUNA	25587	TIJERAS	28	185	50	5990	18	1.064
25062	LAGUNA	25618	ALAMEDA	14	6000	50	4700	23	27.072
25062	LAGUNA	25624	ARMILJO	14	9000	50	4700	23	40.608
25062	LAGUNA	25630	CEDAR CREST	28	450	50	6000	20	2.592
25062	LAGUNA	25664	PAJARITO	16	1500	50	4200	24	6.048
25062	LAGUNA	25667	PLACITAS	27	150	50	4200	24	.605
25066	PHHELPS DODGE #3-Y BE	25515	CIMARRON	16	950	51	5670	19	5.171
25066	PHHELPS DODGE #3-Y BE	25556	RATON	21	7700	51	6600	17	48.787
25066	PHHELPS DODGE #3-Y BE	25568	SPRINGER	22	1450	51	5680	19	7.907
25066	PHHELPS DODGE #3-Y BE	25578	WAGON MOUND	45	620	51	5750	18	3.422

Sample MARKET Output

This is a sample of a special MARKET output, which is created after the CASH analysis has been completed. This routine reads the CASH data file and creates an output which depicts city-site pairings used in the analysis, and displays key input and calculated parameters. Calculated parameters include the year 2020 population, annual heat demand (ten billion Btu) and industrial annual heat demand (PHDI) in ten billion Btu units.

2.2 Sample 2

SITE	CITY	DIST	POP 1980	TEMP °C	DECD	L.T.	ANN-HT. 1980	POPG1	POPG2	POP 2020	ANN-HT. 2020	POPI	PHDI 1976 1E10	PHDI 2020 1E10
IDAHO HOT SPRING	EMPIRE	9	249	80	8300	10	1.98	.0000	.0000	249	1.98	.010	.000	.000
IDAHO HOT SPRING	SILVER PLUME	10	164	80	8300	10	1.31	.0000	.0000	164	1.31	.010	.000	.000
IDAHO HOT SPRING	SILVER SPRING	30	400	80	10000	8	3.84	.0462	.0462	2436	23.39	.010	.000	.000
IDAHO HOT SPRING	SUN TON	24	171	80	6000	15	.98	.0181	.0181	350	2.02	.010	.000	.000
IDAHO HOT SPRING	WINDY PARK	17	250	80	9000	1	2.16	.0452	.0452	1465	12.66	.010	.000	.000
GLENWOOD HOT SP	KAG.	27	986	65	8426	8	7.65	.0300	.0300	2203	18.63	.010	.050	.077
GLENWOOD HOT SP	GLENWOOD SPRING	0	5351	65	7400	0	38.01	.0051	.0300	13661	97.05	.010	.950	1.457
GLENWOOD HOT SP	GYPSON	21	420	65	8200	8	3.31	.0300	.0200	1022	8.05	.010	.050	.077
SOUTH CANYON HO	RIFLE	20	2016	75	6795	0	13.15	.0066	.0066	2618	17.08	.010	.540	.828
SOUTH CANYON HO	GRAND VALLEY	35	270	75	7000	4	1.81	.0520	.0300	1088	7.31	.010	.000	.000
SOUTH CANYON HO	NEW CASTLE	7	447	75	7000	0	3.00	.0129	.0200	920	6.18	.010	.030	.046
SOUTH CANYON HO	SILVER	14	434	75	6400	0	2.83	.1111	.0300	3021	19.72	.010	.000	.000
PENNY AVALANCHE	CARBONDALE	10	1128	75	7800	6	8.45	.0300	.0200	2746	20.56	.010	.000	.000
PENNY AVALANCHE	BASALT	14	419	75	8200	5	3.30	.0300	.0200	1020	8.03	.010	.000	.000
PENNY AVALANCHE	MARBLE	11	50	75	10600	1	.51	.0264	.0264	142	1.44	.010	.000	.000
COL CHINN HOT	AUSTIN	18	1363	51	6000	0	7.05	.0300	.0200	3318	19.11	.010	.050	.077
COL CHINN HOT	CEDAREDGE	10	702	51	6242	16	4.69	.0300	.0200	1904	11.41	.010	.000	.000
COL CHINN HOT	DELTA	26	3632	51	5903	0	20.58	.0300	.0200	8841	50.10	.010	.060	.092
COL CHINN HOT	HOTCHKISS	7	507	51	8100	0	3.94	.0300	.0200	1234	9.60	.010	.000	.000
COL CHINN HOT	OLATHE	28	746	51	7000	0	5.35	.0260	.0300	2497	16.78	.010	.000	.000
COL CHINN HOT	ONCHARD CITY	18	1327	51	6000	1	7.64	.0300	.0200	3230	18.60	.010	.010	.015
COL CHINN HOT	PALESADE	43	889	51	5122	17	4.34	.0300	.0200	2150	10.57	.010	.050	.077
COL CHINN HOT	PAONIA	3	1331	51	9600	0	12.27	.0300	.0200	3240	29.86	.010	.030	.046
COL CHINN HOT	PLETON	45	900	51	5200	17	4.49	.0216	.0216	2116	10.56	.010	.000	.000
COL CHINN HOT	DE BRQUE	45	172	51	6000	10	.99	.0216	.0216	404	2.33	.010	.000	.000
COL CHINN HOT	COLLORAN	31	225	51	7400	0	1.60	.0216	.0216	529	3.76	.010	.000	.000
COL CHINN HOT	CHAMFORD	11	171	51	8100	0	1.33	.0150	.0150	310	2.41	.010	.000	.000
COLUMBIAN HOT S	ASTEN	13	3346	45	8948	8	28.74	.0687	.0300	15783	135.58	.010	1.540	2.362
COLUMBIAN HOT S	RED CLIFF	44	731	45	9700	0	6.01	.0442	.0442	4123	38.39	.010	.000	.000
HAWKES HOT SP	CRESTED BUTTE	7	372	45	10654	0	3.80	.0300	.0200	906	9.27	.010	.000	.000
HAWKES HOT SP	ALMA	23	73	70	10000	6	.70	.0000	.0000	73	.70	.010	.000	.000
HAWKES HOT SP	FAIRPLAY	18	419	70	10000	6	4.02	.0000	.0000	419	4.02	.010	.000	.000
CHINWOOD CRK JUM	LEADVILLE	29	10152	170	10671	0	104.00	.0050	.0200	19320	190.01	.010	.030	.046
CHINWOOD CRK JUM	TAYLOR PARK RES	21	94	170	11675	0	1.11	.0300	.0200	241	2.70	.010	.000	.000
CHEK CRK MT VRI	BUENA VISTA	0	2549	200	7715	0	10.88	.0510	.0300	10175	75.36	.010	.130	.199
PANCHA HOT SPR	SALIDA	5	5188	145	6910	13	34.42	.0280	.0200	12386	82.16	.010	1.440	2.209
PANCHA HOT SPR	PONCHA SPRINGS	1	201	145	7400	10	1.43	.1040	.0400	1753	12.45	.010	.000	.000
CANON CITY HS	CANON CITY	2	12791	50	5500	14	67.54	.0300	.0200	31137	164.40	.010	10.000	15.340
CANON CITY HS	PIANENCE	9	3153	50	5500	14	16.65	.0300	.0200	7675	40.52	.010	1.000	1.534

3.0 BTHERM METHODOLOGY

3.1 General

In estimating the aggregate supply potential for geothermal energy for a given region, many studies assume a penetration at some point in time. This penetration is then grown at some assumed rate through time to generate time-specific penetration. This approach is unacceptable. The aggregate supply potential at some point in time t is equal to the sum of its parts at time t :

$$Q_t = \sum_{i=1}^n q_{i,t}$$

where

Q_t = Total Supply in Time t
 n = Total number of city-resource pairings.
 $q_{i,t}$ = Geothermal heat supplied from the i^{th}
city-resource match in time period t .

The NMEI approach is to estimate the economic attractiveness of each element, namely city-site pairs, through time, and sum the heat-on-line in a bottoms-up method of aggregation to estimate aggregate supply. In this manner, then, the approach utilizes the summation of many site-specific engineering-economic analyses developed from the model BTHERM.

The methodology used in the model BTHERM follows directly from its objectives, philosophies and assumptions.

The objective of the model use is to determine an order-of-magnitude levelized price per MMBTU which would have to be charged to consumers to cover all of the costs of a geothermal district space, hot water heating and industrial process system. It further makes an assessment of the relative economic attractiveness of geothermal versus some other form of energy at the site specific level. In order to obtain a calculated price it is necessary to assess the average costs of the system through time. This involves estimating the heat demand, calculating the costs required to supply that heat demand, and finally, dividing through to determine the cost per unit of heat. Algebraically, the general calculation is as follows.

$$\text{Levelized Price/MMBTU} = \frac{\sum_{t=1}^t (\text{AMOR} + \text{COSTS}) \times (1 + r)^{-t}}{\sum_{t=1}^t \text{Consumption} \times (1 + r)^{-t}}$$

where

AMOR = Annual payment to principle on capitalized investments
 Costs = Annual operating costs
 Consumption = Annual heat demand in MMBTU

Following along these lines further assumptions become apparent. These will be developed in some detail in the paragraphs below.

3.2 Market Capture

As the number of users increase in the system, the increased usage initially is supplied from surplus capacity, so increased costs are the marginal cost of increased operator costs. This effect stimulates a decrease in the price charged as the number of users increases. At some point, costs begin accumulating at a faster rate when additional

quantities of heat are demanded from the system, thus necessitating increased capital expenditures.

Although there is no empirical evidence to indicate the point at which dis-economies of scale might set in, geothermal cost curves should at least approximate other district energy system cost curves. The aforementioned indicate the following points.

- A. That entire market capture will minimize average costs in the long run.
- B. That short run dis-economies of scale may exist.
- C. That the larger the market, the longer the time requirement to capture the market while avoiding short run diseconomies of scale.

The models B THERM and CASH handle this problem by dividing cities up into heating districts of population size 3000 and pro-rata shares of the commercial and industrial sectors. When the first heating district becomes price competitive, it is developed with a two-year lag assumed. Other heating districts within the city are then assumed to follow in a sequential manner with one to three year lag for construction between subsequent heating districts.

To assure price competitiveness sufficient to capture the entire market, the geothermal price per MMBTU must obviously be competitive with the cheapest form of energy currently being utilized. For geothermal to be competitive with only some portion of a given community's energy market, there exists no incentive for the major portion of the community to convert. This follows from the previous assumption in that capturing

only a portion of the market, the amortization of the investment would be borne by fewer users and hence a higher average cost would result.

3.3 Retrofit Costs and Other Investments

Another implicit assumption is that for the energy to be price competitive to consumers, the developer will cover all of the necessary investments. This would include the retrofit and hook-up investment required by homeowners and commercial establishments to utilize the resource. For example, assume that a homeowner must pay \$5000 for retrofitting his house to a system capable of utilizing geothermal. If he can obtain a second mortgage for this amount at an 11 percent interest rate for 20 years, his resulting monthly payment would be \$52.32 per month. This cost, of course, excludes any additional property taxes or insurance and is additional to the cost of the energy delivered to the house. This option would appear prohibitively expensive for homeowners.

In reality some homes within a system will require a complete retrofitting and some will require none at all. By incorporating this cost into the developers investment expenditure, the expense can be averaged across all consumer classes. Also, the developer generally would pay a lower interest rate than the homeowner, and the investment could be amortized over the life of the project rather than the life of the mortgage. The combination of these factors would, overall, reduce the monthly expenditure per person required to utilize the geothermal resource.

4.0 GEOTHERMAL PRICE COMPETITIVENESS

4.1 Theoretical Basis

When examining the viability of a geothermal district heating system for a particular city, the average cost, spread across all users in the system, is the threshold cost per price, which must be considered. The desire is then to maximize the energy consumption per unit of dollar investment. This is obviously the same as minimizing average costs. In order to achieve the economies of scale required to minimize average costs, NMEI at the outset assumes that for smaller cities the entire city must be converted to geothermal. For larger cities, the heating district segments will be totally converted. Following through the logic, the levelized price delivered by the geothermal system must be price competitive with the least expensive form of energy currently being used in the city. In other words if geothermal were to displace only electrical space heating systems, two problems would arise. Firstly, there would exist no valid basis for assuming that all of these consumers would be centrally located. This would serve to increase the central distribution investment per capita and therefore cause a prohibitively expensive average cost to consumers. Secondly, the cost of the transmission investment (resource field to central system) will be borne by fewer users and hence the per consumer cost of this investment will be greater.

Given the aforementioned, the weighted average price of the least expensive alternative fuel (PALT) is then computed for each city and

finally compared with the levelized geothermal price per million BTU to assess price competitiveness. PALT is calculated in the following manner:

$$\text{PALT} = \frac{(P_{\text{res}} \times Q_{\text{res}}) + (P_{\text{com}} \times Q_{\text{com}}) + (P_{\text{ind}} \times Q_{\text{ind}})}{Q_{\text{TOT}}}$$

where

P = Price
Q = Quantity Demanded
RES = Residential Sector
COM = Commercial Sector
IND = Industrial Sector
TOT = TOTAL

4.2 Conventional Fuel Cost Growth

For price increases of conventional fuels, economists generally break the increase into two categories. Part of the increase is generally attributed to general price level increases or inflation. Because of the homogeneity in degree 0 of demand (our concern) with respect to prices and income, general price level induced increases are irrelevant for the present analysis. In other words if both prices and income increase at the same rate, there is no incentive for consumers to alter their demand patterns.

The other portion of the price increase is usually attributed to a lack of supply with respect to demand, thus causing a real increase in price with respect to the consumer. Real increases in the price of energy either constrain the consumers purchase of other goods or reduce his consumption of energy. Therefore, an incentive arises for the consumer

to alter his energy consumption patterns. It is for this reason that real price increases are the only increases which are considered to be relevant to geothermal development, and, hence, to this model.

Obviously, irrespective of any price increases in conventional fuels, if geothermal utilization is price competitive immediately, then heat on line can be assumed (in the BTherm METHODOLOGY) immediately with an assumed one to two-year construction lag. However, when this is not the case, the present model loops through time with an assumed real price growth rate affixed to the base year conventional fuel price. The year in which the real price of conventional energy becomes greater than the BTherm levelized price for geothermal energy then becomes the point in time in which geothermal conversion is economical. Then system construction with lead and lag time centered around this year results in assumed geothermal market capture for that user or heating district.

4.3 Description of Conventional Fuel Prices and Future Costs

The NMEI methodology for geothermal market penetration rests heavily on the price and availability of conventional energy in the specific locale of a geothermal anomaly. Because of different rate structures across the states, and with different sources of energy (interstate, intrastate, and imported natural gas, for example) there is no uniform pricing structure across the intermountain states. Instead, cities in the same state can vary widely in price and availability, and the differences can compound across state boundaries.

A methodical search was conducted in an effort to determine specific energy costs in dollars per equivalent million Btu, and fuel source for each of the roughly 1200 cities which showed an apparent economic attractiveness for geothermal energy. Data were acquired from state teams, public utility commissions, utility firms, and individual cities. As appropriate, raw costs were adjusted for tax factors (sales taxes and revenue taxes) because the BOTHERM geothermal unit cost contains tax factor adjustments. In the case of natural gas, some communities and utilities still charge on a volume (MCF) basis; appropriate altitude adjustment factors were made to adjust the unit price to a heating value basis.

Projecting real price growth over a 40-year space is much more difficult, and use was made of the DOE-EIA Median Case (April, 1979) as the basis for projecting real price growth rates. Local or state-wide adjustments to this Median Case were made in a few cases for which more detailed and regional specific values were available.

All conventional fuel prices for future years were subjected to an NMEI devised SYN-FUEL price limit, which is a theoretical upper limit to conventional fuels price growth. After reviewing sensitivities, a SYN-FUEL limit of \$20 per MMBTU was chosen as the modular case, representing an imported fuel limit of \$100-120 per barrel. This limit was chosen in the belief that it represents a realistic threshold, above which competition from solar, synthetic fuels, and other alternatives could act to constrain further price growth.

Following are tables and graphs which reflect the results of this methodology.

4.3 Table 1

ROCKY MOUNTAIN BASIN & RANGE
REGION WIDE PRICE RANGE BY FUEL
Dollars / MMBTU

<u>Natural Gas</u>	<u>Distillate</u>	<u>LPG</u>
2.37 - 6.03	4.39 - 7.20	5.33 - 12.11

4.3 Table 2

STATE WIDE PRICE RANGE
of Conventional Fuels
Dollars / MMBTU
(Oct. 1979)

STATE	NATURAL GAS	DISTILLATE	LP GAS
Arizona	3.39 - 3.55	5.59 - 6.19	5.33 - 7.16
Colorado	2.38 - 4.89	4.94 - 5.30	5.55 - 5.70
Nevada	3.04 - 3.67	6.39 - 7.02	6.90 - 8.12
New Mexico	3.56 - 4.40	4.39 - 5.01	6.22 - 7.80
Utah	2.37 - 2.56	4.85 - 7.17	6.00 - 12.11
Idaho	4.18 - 4.45	5.07 - 5.28	5.87 - 6.60
Montana	5.65 - 6.03	6.43 - 7.20	6.53 - 6.95
North Dakota	2.55 - 2.98	6.37 - 6.86	6.70 - 7.19
South Dakota	2.87 - 3.34	5.28 - 5.67	5.38 - 6.12
Wyoming	2.60 - 3.45	5.69 - 5.90	6.01 - 6.37
Overall Avg. of 10-States	4.00	6.00	8.00

EXCLUDES EFFECTS OF

Mexico gas agreement
Canadian gas price increase
December, 1979 OPEC Nations oil price increases

4.3 Table 3

REAL PRICE GROWTH RATES
(BY FUEL TYPE AND CONSUMING SECTOR)

TIME FRAME	RESIDENTIAL			
	ELEC	DIST	LPG	N. GAS
1980-1990	.026	.04	.044	.066
1990-2020	.02	.03	.035	.05

	COMMERCIAL			
	ELEC	DIST	LPG	N. GAS
1980-1990	.027	.042	.052	.066
1990-2020	.02	.032	.045	.05

	INDUSTRIAL			
	ELEC	DIST	LPG	N. GAS
1980-1990	.039	.035		.085
1990-2020	.03	.03		.06

4.3 Graph 1

5.0 GEOHERMAL MARKET PENETRATION

5.1 Policy Cases

In order to derive estimates of geothermal market penetration and market shares, earlier sensitivity analysis had indicated that selection of policy options would heavily influence the results. (NMEI 30-9). These policy options should consider the cost and timing of federal taxation legislation, and stimulative federal policy. In addition, the policy options should attempt to assess the effect on private sector investment of the presence or absence of federal initiatives, along with possible effects of financial markets and competition from other possible alternative energy forms.

Analysis suggested that inter-fuel competition would be extremely difficult to assess in such a multi-faceted energy market as exists in the intermountain states. However, this difficulty is common to all policy cases. Hence, a decision was made to apply a uniform interfuel competition (SYN-FUEL limit) to all policy cases, so as to determine possible scenarios in a common framework.

Earlier sensitivity analysis had suggested that five parameters had the greatest effect on price competitiveness of geothermal energy. The presence or absence of a federally funded reservoir confirmation program, coupled with resulting investor uncertainty could effect the the price competitiveness. The presence or absence of a reservoir confirmation program could also affect the production well success ratio, and a large reservoir assessment program could likely result in a

high success ratio. Federal grants obviously have a large effect on development, but there is no logic to assuming a 100 percent grant program, because anything is possible given a large enough public outlay.

The fifth category is stimulative tax policy, particularly investment tax credits and depletion allowances.

With these five parameters, a need existed to have a base case, which would be the unstimulated case of geothermal development assuming current federal incentives expired per then existing law.

5.2 Policy Options

The extent of direct use geothermal development is obviously a function of the policy infrastructure in which it must exist. There are four possible scenarios which might exist in the future and would influence development. The scenarios were used by NMEI to develop ranges of possible geothermal supply through time.

High: With a 100% reservoir confirmation program one would expect fairly high well production success ratios (PSS). For this case a PSS of 0.9 for potential sites and 0.7 for inferred sites was used. Also with the 25 percent matching fund, and investment and depletion credits, private developers would approach geothermal development with reduced risk, and hence require relatively smaller rates of return. After-tax rate of return of 20 percent for the first 15 years, and 12 percent for the balance of the project life was used for this policy case.

Mid: This case is the same as the high, with the exception that matching funds grants were eliminated. The potential geothermal supply estimate is obviously reduced.

Low: In this scenario the reservoir confirmation funding level has been reduced to 50 percent, and grants were eliminated. The rate of return requirement to developers has been increased to 25 percent as a result of the increased risk in reservoir exploration. The production well success ratios have also been assumed to decrease to a lower level of 50 percent for potential sites, and 20 percent for inferred sites.

Low-Low: In this case virtually no federal stimulus, or investment tax credits, are available to provide private sector development. Accordingly, the risk portion of the rate of return requirements has been increased. Our estimates show that virtually no development occurs during the period analyzed under this policy.

5.3 Results of Policy Analysis

Review of the simulation outputs, using the policy cases previously defined, revealed a distinct shift in economical geothermal direct heat potential as a function of policy options. The four cases chosen represent essentially three sub-sets. The High Case and Mid Case reflect the effects solely of changes in the federal grants program. A 25 percent grant program could produce 0.5 Quad by 1990 for the High Case, whereas the Mid Case, without a grant program would take until year 2000 for the same level.

Comparing the Mid Case and Low Case, the major parameter varied was reservoir confirmation. If the investor rate of return reaction is as specified, and production well success ratios are accurately depicted, the greater risk associated with a 50 percent reservoir confirmation could result in a significant delay in heat on line, along with an absolute reduction of heat on line by year 2020.

The Low-Low Case compared with the Low Case clearly reflects the development lag if no federal stimulus is applied, particularly reservoir confirmation and investment tax credits.

5.3 Graph 1

5.4 Policy Options vs Payback by 1990

Given that the foregoing analysis clearly highlights the need for stimulative federal policies, an immediate concern is what these policies options might cost. Similarly, an assessment is required as to benefits which might accrue in terms of consumer savings and imported oil displacement. These factors are available as part of standard output from the BTHERM-CASH methodology.

Displayed is the net federal outlays compared with the potential consumer savings which might accrue as a result of the investment. Net federal outlay is defined as the summation of reservoir confirmation, matching grant funds, and investment tax credits, less the federal taxes paid. Also shown is the data for the cities on line, heat on line, and possible foreign oil displacement per year. Depending on the amount of space and hot water heating provided by electricity, the foreign oil displacement may be understated.

The 0.35 Quad for new industrial parks in Oregon, Washington and Idaho is based on a conclusion reached by DSS Industries in a 1977 study. That report indicated that the lumber and food processing industries were the only near-term feasible new industries which might relocate to western geothermal resources.

5.4 Table 1

POLICY OPTIONS
VS
PAYBACK BY 1990

CASE	NET FEDERAL OUTLAY	CONSUMER SAVINGS	CITIES SERVED	HEAT ON LINE	FOREIGN OIL
	\$ BILLIONS (NOMINAL)	\$ BILLIONS (DISCOUNTED)		QUADS	DISPLACEMENT MMBBL/YEAR
HIGH	5.86	36.3	961	0.55 - 0.9*	305**
MID	1.70	9.9	461	0.27	122
LOW	0.28	0.2	87	0.09	67
LOW-LOW	N/A	0.06	20	0.015	20

* Includes 0.35 Quad for New Industrial Parks in Oregon, Washington, Idaho

** Assumes 2 to 1 ratio of oil imports to final end-use consumption

5.5 Discounted Costs and Benefits Thru 2020

Using the High Case policy option, this is a tabulation of the required investments, taxes and royalties paid, realized consumer savings, and heat on line, by year, for each of the intermountain states. All values are discounted at the cost of capital, which for this analysis was calculated to be 10.57 percent. The BTherm program calculates the cost of capital by taking equity percentage times after tax rate of return, plus debt percentage times bond rate (interest rate).

Considering the range of savings, the High Case represents a 9:1 ratio of consumer savings to investment, which suggests the investment of public funds represented by reservoir confirmation and federal grants as a good investment.

5.5 Table 1

HIGH CASE
ROCKY MOUNTAIN BASIN AND RANGE
DISCOUNTED COSTS AND BENEFITS THRU 2020
(\$ BILLIONS)

	<u>INVESTMENTS</u>	<u>TAXES & ROYALTIES</u>	<u>CONSUMER SAVINGS</u>	<u>TRILLION BTU/YEAR HEAT ON LINE</u>
ARIZONA	2.3	0.35	18.6	176
COLORADO	1.5	0.28	14.0	244
IDAHO	1.2	0.24	14.7	178
MONTANA	0.9	0.07	3.2	51
NEVADA	0.2	0.04	3.6	75
NEW MEXICO	0.6	0.13	5.6	99
NORTH DAKOTA	0.4	0.14	3.6	51
SOUTH DAKOTA	0.2	0.03	1.6	15
UTAH	0.8	0.17	8.5	145
WYOMING	0.5	0.08	3.7	56
	<u>8.6</u>	<u>1.51</u>	<u>77.1</u>	<u>1,090</u>

5.6 Required Drilling Program (By 1990)

One of the many checks and balances built into the B THERM-CASH methodology is a test of reasonableness on the well drilling program. If the geothermal investment appears profitable, and would supply significant heat, but the reservoir data is skimpy, a modest well drilling program would be necessary in the early years, accelerated as knowledge and confidence is gained.

The program defined in each of the four policy cases resulted in output concerning production and reinjection wells. These wells are based in almost all cases on an assumed 500 gallon per minute flow rate. Well depths are separately defined for each user-site pair.

Considering that the current yearly geothermal well drilling program is less than 60 wells, the High Case would necessitate a substantial increase in the rigs, crews, and surface exploration. As noted, the well drilling program in the High Case represents roughly a five-fold increase over current experience. The Low Case represents a drilling effort effort roughly comparable to current experience.

5.6 Table 1

REQUIRED DRILLING PROGRAM (BY 1990)

<u>CASE</u>	<u>RESERVOIR CONFIRMATION</u>	<u>PRODUCTION WELLS</u>	ASSUMPTION FR 500 gal/min
			<u>REINJECTION WELLS</u>
HIGH	650	3000 - 4000	1500 - 2000
MID	350	1500 - 2000	750 - 1000
LOW	150	500 - 1000	250 - 500

* COMPARES WITH 50,000 - 60,000 1000 FEET OR DEEPER NATURAL GAS AND OIL WELLS/YEAR

6.0 METHODOLOGY FOR ESTIMATING MARKET SHARES

6.1 Description of Methodology

The first problem in attempting to measure the potential market share of geothermal energy is to estimate the market. In NMEI terms, energy consumption is a geothermal target of opportunity only if:

1. Energy used is in a temperature range suitable for geothermal.
2. Energy is in a process suitable for geothermal usage.
3. There is a potential geothermal source near enough to be considered.
4. An economic analysis clearly shows that the geothermal energy is, or could be, economically competitive with conventional energy.

The NMEI team attempts to estimate usable geothermal potential by first determining energy demand by fuel type and consuming sector. Next, an analysis is made as to what this demand (consumption) might become as a function of price of fuel, population and industrial growth rates, per capita personal income, and GNP growth rate. The result is then adjusted to define by sector (residential, commercial or industrial) and fuel type what portion of this growth demand (consumption) appears to be adaptable to some form of geothermal energy. (Geothermal energy potential availability is not a factor at this point in the calculations).

Using another model (MARKET), all existing cities and industries are screened to define co-located potential markets. In this routine, the industrial demand for a city is an input value based on separate work using directory's of manufacturing and state team data as available. The residential and commercial energy demand are restricted to

space-heating and domestic hot water consumption, which are the initially selected geothermal targets. This market co-located demand then is expanded over time as a function of population and industrial growth rates for the particular city; then aggregated statewide.

BTHERM and CASH models are then used to make site/city/industry specific analyses of the effects on geothermal energy development of the cost of geothermal energy compared with the cost of conventional energy. Obviously, this comparison rests heavily on city specific energy costs, and a number of assumptions about geothermal energy costs, and possible real price growth rates for conventional energy. The BTHERM and CASH models also provide an internal estimate of heat energy (potentially displaceable by geothermal) in order to specify, and then estimate the cost of the system required to deliver the geothermal energy.

At this point in analysis, three possibilities exist for future year demand - (1) energy demand forecast, (2) MARKET, (3) BTHERM-CASH. These three possibilities are used as cross-checks for order of magnitude values, and as long as the three estimates of future year demand provide general agreement, then more confidence exists in the calculation of the cost (relative attractiveness) of the geothermal system.

Using the methodology outlined above, NMEI can determine the possibilities for economic geothermal energy on-line, as a function of total future energy demand and displaceable future energy demand. Obviously, the portion of demand to be satisfied by geothermal energy will be influenced greatly by governmental policies. So too will

governmental policies influence energy demand. As a consequence, the absolute percentages of total market share and displaceable energy market share represent possible mid-points of future energy demand and supply curves, and are not absolute predictions.

6.2 Definition of Results

The following table illustrates the percentage of market shares as a function of total energy demand, and the energy demand of the co-located market, which for this analysis was considered to be 50 miles. Note also that the figure depicts market shares according to each of the four policy scenarios previously defined.

6.2 Table 1

ROCKY MOUNTAIN BASIN & RANGE				
Geothermal Economical Market Shares (%)				
	<u>HIGH</u>	<u>MID</u>	<u>LOW</u>	<u>LOW-LOW</u>
Total Demand				
1990	28.65	14.43	2.81	.70
2020	24.91	26.05	11.43	1.12
Co-Located Market				
1990	41.67	21.04	4.16	1.12
2020	47.24	39.6	17.44	2.2

7.0 POTENTIAL FOR GEOTHERMAL ELECTRICITY

7.1 Market Area Defined

The ten intermountain states are not normally considered a regional grouping for electricity production and consumption. Instead, these states are an artificial grouping for which it is difficult to make definitive projections. Those states in aggregate are a net exporter; however, the picture changes radically when considering individual states. Because many of the states are net importers of electricity, the power needs of the intermountain states, along with future construction plans, are difficult to assess in isolation. The following figure illustrates the state and regional overview of electricity.

7.1 Figure 1

7.2 Electricity Potential (Geophysical)

Given that the potential availability of geothermal electricity is a pacing factor, a definition of terms is necessary. A commonly accepted discriminator is that a resource temperature higher than 200°C is a prime candidate for early commercialization. However, known or inferred sites with a temperature that high are few in number. Another larger group of geothermal resources exist on the temperature range of 150-199°C. This latter resource temperature is hot enough, using binary cycle or Rankin cycle generators, to have early economic promise.

In order to assess the total geothermal electricity potential as known today, many assumptions are necessary concerning temperature, flow rates, salinity, depth and resource life. NMEI has developed a simplified algorithm which follows USGS Circular 726 methodology in estimating recoverable electricity potential. This method produces a range of values, consistent with the fact that many of the geothermal resources are speculative, while others are inaccessible due to other constraints, such as wilderness area designation. The possible range of potential is illustrated in the following table.

7.2 Table 1

<u>GEOHERMAL ELECTRICITY POTENTIAL</u>	
(10 States)	
	<u>MW Potencial</u>
12 Sites, Temperature Higher than 200° C	4,950 - 5,500
94 Sites, Temperature between 149-199° C	4,100 - 11,150
TOTAL POTENTIAL	9,050 - 16,650

7.3 Displacement of Existing Power Sources

Another possibility for geothermal electricity is as a replacement for existing and planned plants using other energy forms. As the following figure indicates, under current utility planning, approximately 8,000 MW of electricity is or will be generated by oil or natural gas plants. These then are a high priority for phase-out, and geothermal price-competitive electricity is a good candidate for substitution. With the major uncertainties surrounding new and existing nuclear plants, those too must be considered for displacement by geothermal. However, geothermal electricity is unlikely ever to displace hydroelectricity. Accordingly, the conclusion reached is that ultimately, geothermal will compete with coal and only coal. Environmental concerns are likely to have increasing effects in coal; hence, geothermal electricity will have a market potential limited only by resource availability and technology.

7.3 Figure 1

Rocky Mountain Basin and Range
Electrical Capacity by Fuel
(MEGAWATTS)

Data Sources:

1. Western Interstate Energy Board.
2. DOI - Projects to Expand Energy Sources in the Western States.
3. The 1975 Energy Production System in the States of the Rocky Mountain Region: Los Alamos Scientific Laboratory.
4. Basin Electric Power Cooperative: Bismarck, ND.

7.4 Geothermal Potential Market Penetration

From an economic perspective, the geothermal electricity potential is limited by a dual set of unknowns. Many geophysical, engineering, and financial unknowns exist concerning the economic potential of geothermal electricity. In addition, future demand for electricity in these intermountain states has a wide range of unknowns. Projections for future demand historically have been based on standard demographic data such as population growth rates only. With sharply increasing prices, and an increasing awareness of the need for conservation, it is plausible that future electricity needs (demand) might be much less than historically true. If this is correct, future electricity plants must consider not only planned retained capacity (by rule of thumb utilities plan for a capacity double peak demand) but also the impact on future demand of off-peak pricing policies, and major shifts in consumption patterns.

Using as a base the announced plans for new construction for the next decade, the following graph illustrates the problem. If retained capacity rules of thumb apply, and if demand is constrained by price, currently planned capacity by 1990 could be adequate for needs through the year 2020. On the converse, if substitution of electricity for fossil fuels, or other factors, causes demand to grow at historic rates, a need will exist for additional capacity. The two demand curves then represent a possible range of needs, with future demand possible in the range of 64,000 to 160,000 MW. Accordingly, future plant construction could consider needs in the range of perhaps 36,000 MW of new demand

by the year 2010. In this scenario, geothermal is then a possible option for new construction, if it is price competitive with other possible choices. With an apparent availability of 9,000 - 16,000 MW, geothermal could satisfy part of the demand over the next 30 years, and will be developed when price competitive.

7.4 Graph 1

8.0 NMEI REFERENCE PUBLICATIONS

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- 10 - 1Q Regional Operations Research Program for Development of Geothermal
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 (10 - 2Q - January, 1978); (10 - 3Q - April, 1978).
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- 10 - 3 Hydrothermal Sites in the Rocky Mountain Basin and Range Region of the United States, Patrick O'Dea, Roy Cunniff, Roy Heath, & Michael Shales, New Mexico State University, February, 1979.
- 10 - 4 Geothermal Energy: Rocky Mountain Basin and Range Geothermal Operations/Research Program, Presentation, May, 1979.
- 10 - 5 Geothermal Energy: Cities and Towns in the Rocky Mountain Basin and Range Region, Data Report, Patrick O'Dea, Roy Cunniff, John Jenkins, Gary Glazner, Michael Shales, & Roy Heath, New Mexico State University, May, 1979.
- 10 - 6 Geothermal Potential Applications for the Rocky Mountain Basin and Range Region, Draft Special Data Report, Roy Cunniff, C.R. Rao, Patrick O'Dea, John Jenkins, Gary Glazner, Michael Shales, & Roy Heath, New Mexico State University, June, 1979.
- 10 - 7 Geothermal Potential of Montana, an Economic Alternative to Conventional Energy, Roy Cunniff, C.R. Rao, Kenneth Nowotny, Gary Glazner, Keith Brown, New Mexico State University, July 1979.
- 30 - 1 The Electricity Supply Potential of Geothermal Energy in the Rocky Mountain Basin and Range Region, 1980-1990, Paul K. McDevitt, and Kenneth R. Nowotny, New Mexico State University, July, 1979.
- 30 - 2 Geothermal Market Penetration Assessment for Colorado, New Mexico, Montana, Roy A. Cunniff and C.R. Rao, New Mexico State University, July, 1979.

- 30 - 3 Geothermal Prospects for Urban Development Action Grants UDAG, Roy A. Cunniff, Gary Glazner, Patrick O'Dea, Dave Gose, Mark Houldsworth, Michael Shales, Roy Heath, Steven Bybee, September, 1979.
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- 30 - 5 Geothermal Energy for Residential, Commercial, Industrial Users - A Computer Simulation Model - BTHERM, Roy A. Cunniff, Gary Glazner, and Mark Houldsworth, 1979.
- 30 - 6 Geothermal Prospects for Lemmon, South Dakota, Roy A. Cunniff, Gary Glazner, Mark Houldsworth.
- 30 - 7 Data Report Sample NMEI Data Formats, Roy Cunniff, et al., September, 1979.
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- 30 - 9 Increased Investment Tax Credits on Geothermal Development, Roy Cunniff, et al., October, 1979.
- 30 - 10 Effect on Geothermal Development of New Mexico Leasing Policies, Mark Houldsworth, et al., November, 1979.
- 30 - 11 Geothermal Site Data for Rocky Mountain Basin and Range, An Informal Report, Pat O'Dea, et al., January, 1980.
- 30 - 12 Forecasting the Market Penetration of a New Technology - A Critique, Kim Knauf, et al., January, 1980.
- 30 - 13 State Team Handout, Salt Lake City Conference, Roy Cunniff, et al., January, 1980.
- 30 - 14 Potential Geothermal - Use Cities of New Mexico - An Informal Report, Gary Glazner, et al., February, 1980.
- 30 - 15 Geothermal Potential Sites in the Rocky Mountain Basin and Range - An Informal Report for URRI, Pat O'Dea, et al., March, 1980.
- 30 - 16 Information for DOE Rural Initiative Program, Keith Brown, et al., April, 1980.
- 30 - 17 Market Share Forecasts for Geothermally Produced Electricity in the Rocky Mountain Basin and Range Region, 1980-1990, Paul K. McDevitt, Kenneth Nowotny, Nancy Gallant, Bruce Stockton.
- 30 - 18 New Mexico Geothermal Candidates for Industrialization, Tim Tang, et al., April, 1980.

- 30 - 19 (Number reserved, but not used)
- 30 - 20 Energy Demand Projections for Geothermal Market Penetrations,
Kenneth Nowotny, Paul McDevitt, Bruce Stockton, Nancy Gallant,
Fekru Debebe, Mark Houldsworth, January, 1980.
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10 States, Roy A. Cunniff, Gary Glazner, Pat O'Dea, April,
1980.

In addition, each state team was furnished voluminous information resulting from interactive sessions using BTHERM and CASH analyses. These included definitions of prospective sites and users, projections of energy demands and supply, and industrial analyses of site-specific developments.

9.1 APPENDIX A

Results for each Intermountain State

Part I Energy Demand Versus Geothermal Supply Potential

9.1 Graph 1

ARIZONA ENERGY DEMAND

v.s

POTENTIAL GEOTHERMAL SUPPLY

(Trillion Btu)

9.1 Graph 2

COLORADO ENERGY DEMAND

v.s

POTENTIAL GEOTHERMAL SUPPLY

(Trillion Btu)

9.1 Graph 3

IDAHO ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 4

MONTANA ENERGY DEMAND

v.s

POTENTIAL GEOTHERMAL SUPPLY

(Trillion Btu)

9.1 Graph 5

NEVADA ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 6

NEW MEXICO ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 7

NORTH DAKOTA ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 8

SOUTH DAKOTA ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 9

UTAH ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Graph 10
WYOMING ENERGY DEMAND
v.s
POTENTIAL GEOTHERMAL SUPPLY
(Trillion Btu)

9.1 Part II Mid Case Geothermal Market Penetration

Arizona
Mid-Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	17.1	52.0
	Industrial	38.4	47.8
Inferred	Residential/Commercial	5.8	21.3
	Industrial	22.0	26.8
Total	Residential/Commercial	22.9	73.3
	Industrial	60.4	74.6
Totals		<u>83.3</u>	<u>147.9</u>

9.1 Table 1

Colorado
Mid-Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	41.0	87.7
	Industrial	8.8	9.5
Inferred	Residential/Commercial	27.2	84.6
	Industrial	7.9	11.9
Total	Residential/Commercial	68.2	172.3
	Industrial	16.7	21.4
Totals		<u>84.5</u>	<u>193.7</u>

9.1 Table 2

Idaho
Mid-Case

**Economically Possible Market Penetration
(Trillion Btu)**

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	16.1	40.1
	Industrial	8.4	10.3
Inferred	Residential/Commercial	44.1	70.6
	Industrial	46.3	55.1
Total	Residential/Commercial	60.2	110.7
	Industrial	<u>54.7</u>	<u>65.4</u>
Totals		<u>114.9</u>	<u>176.1</u>

9.1 Table 3

Montana

Mid-Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	11.9	16.8
	Industrial	.3	.4
Inferred	Residential/Commercial	16.0	22.8
	Industrial	6.5	7.4
Total	Residential/Commercial	27.9	39.6
	Industrial	<u>6.8</u>	<u>7.8</u>
Totals		<u>34.7</u>	<u>47.4</u>

9.1 Table 4

Nevada
Mid-Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	23.5	57.9
	Industrial	3.2	3.4
Inferred	Residential/Commercial	.3	.4
	Industrial	0.0	0.0
Total	Residential/Commercial	23.8	58.3
	Industrial	<u>3.2</u>	<u>3.4</u>
Totals		<u>27.0</u>	<u>61.7</u>

9.1 Table 5

New Mexico

Mid - Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	21.3	47.6
	Industrial	8.6	9.7
Inferred	Residential/Commercial	10.4	16.8
	Industrial	8.1	11.1
Total	Residential/Commercial	31.7	64.4
	Industrial	<u>16.7</u>	<u>20.8</u>
Totals		<u>48.4</u>	<u>85.2</u>

9.1 Table 6

North Dakota

Mid - Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	15.8	32.1
	Industrial	4.9	6.1
Inferred	Residential/Commercial	0.0	1.8
	Industrial	0.0	.3
Total	Residential/Commercial	15.8	33.9
	Industrial	<u>4.9</u>	<u>6.4</u>
	Totals	<u>20.7</u>	<u>40.3</u>

9.1 Table 7

South Dakota

Mid - Case

Economically Possible Market Penetration

(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	7.8	9.6
	Industrial	.3	.4
Inferred	Residential/Commercial	2.3	4.8
	Industrial	.04	.05
Total	Residential/Commercial	10.1	14.4
	Industrial	<u>.34</u>	<u>.45</u>
Totals		<u>10.44</u>	<u>14.85</u>

9.1 Table 8

Utah
Mid - Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	7.6	10.7
	Industrial	2.0	4.3
Inferred	Residential/Commercial	25.0	53.3
	Industrial	17.1	28.8
Total	Residential/Commercial	32.6	64.0
	Industrial	<u>19.1</u>	<u>33.1</u>
	Totals	<u>51.7</u>	<u>97.1</u>

9.1 Table 9

Wyoming

Mid - Case

Economically Possible Market Penetration

(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	2.1	3.6
	Industrial	10.8	11.5
Inferred	Residential/Commercial	4.0	23.0
	Industrial	3.6	5.2
Total	Residential/Commercial	6.1	26.6
	Industrial	<u>14.4</u>	<u>16.7</u>
Totals		<u>20.5</u>	<u>43.3</u>

9.1 Table 10

9.1 Part III High Case Geothermal Market Penetration

Arizona
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	45.2	72.2
	Industrial	42.8	49.1
Inferred	Residential/Commercial	19.8	26.6
	Industrial	24.7	28.4
Total	Residential/Commercial	65.0	98.8
	Industrial	<u>67.5</u>	<u>77.5</u>
Totals		<u>132.5</u>	<u>176.3</u>

Colorado

High Case

Economically Possible Market Penetration

(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	54.2	96.8
	Industrial	10.3	11.8
Inferred	Residential/Commercial	79.5	120.0
	Industrial	13.7	15.8
Total	Residential/Commercial	133.7	216.8
	Industrial	24.0	27.6
Totals		157.7	244.4

Idaho
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	24.2	40.2
	Industrial	6.9	7.8
Inferred	Residential/Commercial	51.6	80.7
	Industrial	43.2	49.6
Total	Residential/Commercial	75.8	110.9
	Industrial	<u>50.1</u>	<u>57.4</u>
Totals		<u>125.9</u>	<u>178.3</u>

9.1 Table 3

Montana

High Case

Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	14.1	16.8
	Industrial	.5	.6
Inferred	Residential/Commercial	20.5	24.1
	Industrial	8.3	9.6
Total	Residential/Commercial	34.6	40.9
	Industrial	8.8	10.2
Totals		43.4	51.1

9.1 Table 4

Nevada
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	42.3	71.4
	Industrial	3.3	3.8
Inferred	Residential/Commercial	.3	.4
	Industrial	0.0	0.0
Total	Residential/Commercial	42.6	71.8
	Industrial	3.3	3.8
Totals		45.9	75.6

9.1 Table 5

New Mexico
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	39.0	56.4
	Industrial	9.1	10.2
Inferred	Residential/Commercial	13.1	18.1
	Industrial	5.3	6.1
Total	Residential/Commercial	52.1	74.5
	Industrial	14.4	16.3
Totals		66.5	90.8

North Dakota

High Case

Economically Possible Market Penetration

(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial		
	Industrial	32.9	42.2
Inferred	Residential/Commercial	5.2	5.9
	Industrial	2.3	2.5
Total	Residential/Commercial	.3	.4
	Industrial	35.2	44.7
Totals		5.5	6.3
		40.7	51.0

9.1 Table 7

South Dakota
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	8.19	9.93
	Industrial	.43	.49
Inferred	Residential/Commercial	4.51	4.99
	Industrial	.05	.06
Total	Residential/Commercial	12.70	14.92
	Industrial	.48	.55
Totals		13.18	15.47

9.1 Table 8

Utah
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	9.2	11.9
	Industrial	6.0	8.6
Inferred	Residential/Commercial	56.9	74.2
	Industrial	39.1	50.4
Total	Residential/Commercial	66.1	86.1
	Industrial	45.1	59.0
Totals		111.2	145.1

9.1 Table 9

Wyoming
High Case
Economically Possible Market Penetration
(Trillion Btu)

		Heat on Line	
		2000	2020
Potential	Residential/Commercial	2.9	3.9
	Industrial	11.5	11.7
Inferred	Residential/Commercial	26.6	35.2
	Industrial	4.7	5.4
Total	Residential/Commercial	29.5	39.1
	Industrial	16.2	17.1
Totals		45.7	56.2

9.1 Table 10

9.2 APPENDIX B

BTHERM Model, Sensitivity Analysis

9.2 Table 1

BTHERM MODEL
Sensitivity Analysis

- Large Impact on Cost
 - Grants (City Share of Money)
 - Distance
 - Resource Depth
 - Population
 - Industrial Demand and Annual Hours of Operation
 - Retrofit and Hookup Costs
 - Time (Years), Duration of Investment
 - Rate of Return on Investment
 - Flow Rate
 - Research Investment
- Moderate Impact on Cost
 - Population and Industrial Growth Rates
 - Heating Degree Days
 - Resource Temperature
 - Well Life
 - Investment Tax Credit
 - Royalty Rate (Within Normal Limits)
- Low Impact on Cost
 - Bond Rate (Within Normal Limits)
 - Depletion Allowance
 - State Tax Rate
 - Property Tax Rate

(a)

City Share of Money (CSM)

<u>CSM</u>	<u>PRICE</u>	<u>% CHANGE</u>
.5	3.21	
.6	4.38	36.4
.7	5.55	26.7
.8	6.72	21.0
.9	7.89	17.4
1.0	9.06	14.08

CSM (City Share of Money) is a variable which allows the BTherm model to take into account the possibility of a grant. At CSM = 1.0 the private or city developer covers all investment costs himself and the price per million BTU's charged to consumer is indicative of this. At CSM = 0.5, it is assumed that 50 percent of the required investment is obtained from grants, and therefore the price charged will drop accordingly. The example shown above is of Avondale, Arizona, a city which because of its depressed economic state, has been indicated by H.U.D. as being eligible for an Urban Development Action Grant. At a 50 percent matching grant, the city of Avondale could get geothermal energy at a price competitive with current natural gas prices.

For the High Case (10-State Region), CSM was set at 0.75, which is the case in which one dollar of Federal money is granted for three dollars of private or city funds.

9.2 Graph 1 CSM vs Price Per MMBTU

THE DATE IS 20 DEC 1979, TIME 0139
 ENTER THE MULTIVALUED VARIABLE AND ITS VALUES
 ...CSM+.5 .6 .7 .8 .9 1.0
 ENTER ANY CHANGES TO THE BASE CASES DESIRED
 ...AVONDALE

CSM	PRICE PER MMBTU
0.5	9.21
0.6	4.30
0.7	5.55
0.8	6.72
0.9	7.89
1	9.06

*TEMP+60 * DEPTH+3000 * POP+6900 * DIST+0 * LT+36 * DEGD+1550 *
 PHDI+.02E10 * POPG1+.032 * POPG2+.020 * STXRT+0
 GRAPH OF CSM VERSUS PRICE PER MMBTU ?? YES

(b) PSS (Production Well Success Ratio)

<u>PSS</u>	<u>Price</u>	<u>% Increase</u>
.3	8.82	
.5	6.44	27.0
.7	5.43	15.6
.9	4.86	10.4

The price per MMBTU's charged to consumers in a geothermal district space heating system is highly dependent on the success ratio of drilling efforts. The policy conclusions are that, if through reservoir confirmation programs or resource assessment programs, the number of dry holes out of every 10 that are drilled can be reduced from 7 to 1 in the case mentioned above, a 45 percent reduction in the price per MMBTU's could be achieved.

9.2 Graph 2 PSS vs Price Per MMBTU

```

RUN
  RUN
THE DATE IS 20 DEC 1979, TIME 8:34
ENTER THE MULTIVALUED VARIABLE AND ITS VALUES
...PSS+.3 .5 .7 .9
ENTER ANY CHANGES TO THE BASE CASES DESIRED
...TUCSON
...NG+1
...
  PSS      PRICE PER MMBTU
  0.3      8.82
  0.5      6.44
  0.7      5.43
  0.9      4.86

  * TEMP+60 * DEPTH+2000 * POPG1+.019 * POPG2+.011 * POPI+.03 * SYN+20 *
  DIST+0 * DEGD+1705 * LT+38 * POP+3000 * PHDI+3E10 * NG+1
GRAPH OF    PSS      VERSUS PRICE PER MMBTU ?? YES
  
```

(c)

Investors Research Investment

vs.

Investors Rate of Return on Investment (ROR)

One of the many considerations which a developer must take into account when considering an investment is what the rate of return requirements will be for a given investment level. In theory, the higher the investment for a particular developer, the higher the perceived risk, and hence the higher the required rate of return. The output here shows the possible impact on the price charged given that an increasing research investment induces a higher rate of return requirement. The policy conclusion is that, if through publicly financed reservoir confirmation a lower return on investment to the developer can be effected, the required price may drop by as much as 290 percent.

The MFRNV multiplier is used to act on a preset research investment of \$1.0 million per site. Thus, a 0.5 value is translated into an investment of \$500,000, and 1.0 is \$1.0 million. For some of the sites we analyzed, we used as much as \$2.5 million for the research investment.

<u>MRFNV</u>	<u>ROR</u>	<u>PRICE \$ IMMBTU</u>
.0	.15	2.716
.5	.25	5.239
1.0	.35	10.615

9.2 Graph 3 ROR vs Price Per MMBTU

...ROR=.15 .2 .25 .3 .35
 ENTER ANY CHANGES TO THE BASE CASES DESIRED
 ...OURAY
 ...
 ENTER THE VARIABLE TO RANGE OVER, AND ITS VALUES
 ...MFRNV=0 .25 .5 .75 1.0
 .150 2.716
 .200 3.722
 .250 5.239
 .300 7.484
 .350 10.615
 GRAPH ?? YES

(d) GEOCRED (Geothermal)

<u>Tax Credit</u>	<u>Price \$/MBTU</u>	<u>% Increase</u>
.1	9.60	
.2	8.79	8.4
.3	8.19	6.8
.4	7.49	8.5
.5	6.82	8.9

GEOCRED is defined in BTHERM as the tax credit rate which applies to the geothermal investment. The obvious policy conclusion is that public sector adjustments or increments in this tax credit rate would serve to diminish the effective price to consumers and thereby maximize the potential savings to consumers.

9.2 Graph 4 GEOCRE vs Price Per MMBTU

RUN
THE DATE IS 20 DEC 1979, TIME 8:10
ENTER THE MULTIVALUED VARIABLE AND ITS VALUES
...GEOCRED+.1 .2 .3 .4 .5
ENTER ANY CHANGES TO THE BASE CASES DESIRED
...GLOBE

GEOCRE	PRICE PER MMBTU
0.1	9.6
0.2	8.79
0.3	8.19
0.4	7.49
0.5	6.82

TEMP+80 DEPTH+4200 POP+7800 DIST+21 LT+29 DEGD+3010
PHDJ+.961E10 POPG1+.008 POPG2+0 POPI+.015
GRAPH OF GEOCRE VERSUS PRICE PER MMBTU ?? YES

(e) RI (Real Price Increase)

<u>RI</u>	<u>2020 Savings (000)</u>	<u>% Increase</u>
.04	21,992	
.05	36,366	65.3
.06	55,536	52.7
.07	76,450	36.6
.08	97,523	27.5

The savings which accrue to consumers is a function of the price of geothermal energy, the price of the alternate fuel, the rate of real increase in the price of the alternate fuel and the quantity consumed. At a slower real growth rate in the price of alternate fuels, the savings which accrue as a result of the price differential are much smaller than they would be at a higher growth rate. Where,

$$\text{Savings 2020} = (\text{PALT}_{2020} \times Q_{2020}) - (\text{PGEO}_{2020} \times Q_{2020})$$

and PALT_{2020} is a direct function of R.I.

Also, given that RI is the main determinant of PALT in time period t ($\text{PALT}_t = \text{PALT} \times (1 + \text{RI})^t$) the RI is the main determinant of the year in which geothermal will become price competitive and hence "on line".

Note: "Year on Line" in the Cost and Benefit Summaries.

9.2 Graph 5 2020 Savings vs Real Price Increase

RUN

THE DATE IS 20 DEC 1979, TIME 8:57
ENTER THE MULTIVALUED VARIABLE AND ITS VALUES

...RI+.04 .05 .06 .07 .08

ENTER ANY CHANGES TO THE BASE CASES DESIRED

...DURANGO

...PALT+2.80

PENALTY FACTOR FOR LOW TEMPERATURE IS: 1.226

COST AND BENEFIT SUMMARY (1980 - 2020), DISCOUNTED AT COST OF CAPITAL.

FED TAX	TAX CREDIT	ROYALTY	STATE TAX	ST SALES TAX	PROPERTY TAX
\$5,868,000	\$2,028,000	\$2,425,000	\$617,000	\$0	\$2,014,000

NET SAVINGS THROUGH YEAR:	1990	2000	2020
	\$0	\$5,991,000	\$21,992,000

PRICE OF GEO: \$3.94 PRICE OF ALT FUEL: \$2.80 YEAR ON LINE: 1991

PENALTY FACTOR FOR LOW TEMPERATURE IS: 1.226

COST AND BENEFIT SUMMARY (1980 - 2020), DISCOUNTED AT COST OF CAPITAL.

FED TAX	TAX CREDIT	ROYALTY	STATE TAX	ST SALES TAX	PROPERTY TAX
\$6,554,000	\$2,256,000	\$2,733,000	\$690,000	\$0	\$2,249,000

NET SAVINGS THROUGH YEAR:	1990	2000	2020
	\$499,000	\$10,784,000	\$36,366,000

PRICE OF GEO: \$3.94 PRICE OF ALT FUEL: \$2.80 YEAR ON LINE: 1990

PENALTY FACTOR FOR LOW TEMPERATURE IS: 1.226

COST AND BENEFIT SUMMARY (1980 - 2020), DISCOUNTED AT COST OF CAPITAL.

FED TAX	TAX CREDIT	ROYALTY	STATE TAX	ST SALES TAX	PROPERTY TAX
\$8,166,000	\$2,790,000	\$3,460,000	\$860,000	\$0	\$2,801,000

NET SAVINGS THROUGH YEAR:	1990	2000	2020
	\$2,042,000	\$17,270,000	\$55,536,000

PRICE OF GEO: \$3.94 PRICE OF ALT FUEL: \$2.80 YEAR ON LINE: 1988

PENALTY FACTOR FOR LOW TEMPERATURE IS: 1.226

COST AND BENEFIT SUMMARY (1980 - 2020), DISCOUNTED AT COST OF CAPITAL.

FED TAX	TAX CREDIT	ROYALTY	STATE TAX	ST SALES TAX	PROPERTY TAX
\$8,166,000	\$2,790,000	\$3,460,000	\$860,000	\$0	\$2,801,000

NET SAVINGS THROUGH YEAR:	1990	2000	2020
	\$3,133,000	\$24,049,000	\$76,450,000

PRICE OF GEO: \$3.94 PRICE OF ALT FUEL: \$2.80 YEAR ON LINE: 1988

(f) SYN (Synthetic Price Limit)

The price competitiveness of synfuels is highly dependent upon the price of oil. Speculations indicate that when the price of oil reaches \$50 per barrel then the synfuel will become economically competitive, and hence on line. The model BTHERM makes provision for the introduction of synfuels into current energy markets and assumes that whatever value that a particular user desires as a "synfuel limit," thereafter, the savings growth rate ceases for geothermal users. Also, at the interception in time of the price growth rate of oil and the assumed price floor where synfuels become competitive, retrofitting and conversion to utilize geothermal energy will cease.

Savings 2020 (\$000)

	<u>Synfuel Costs Per Year Per/MBTU</u>			
RI	10	20	30	40
.03	4,795	5,407	5,410	5,410
.04	5,095	6,346	6,508	6,510
.05	5,305	7,203	7,676	7,820
.06	5,456	7,958	8,799	9,179

(h) 2020 Savings, RI Versus Syn

Given a very high real growth rate in the price of conventional fuels, the savings to consumers of geothermal energy will also be very high. These savings, however, will be checked by the introduction of synfuels into energy markets. Savings being equal to

$$\text{Savings} = P \times Q_{(\text{Alt}, t)} - P \times Q_{(\text{GEO}, t)}$$

$$\text{and } P \times Q_{(\text{Alt}, t)} = P \times Q_{(\text{Alt}, o)} \times (1 + \text{RI})^t$$

where Alt is the conventional or alternate fuel. The simplifying assumption is made that Q is relatively inelastic with respect to P. At some point in time after PALT is grown at some real rate, a less expensive synfuel may enter the market. At this point, savings to geothermal users are assumed to cease.

9.2 Graph 6 Savings Through Year 2020

9.2 Graph 7 Sample Investment Output

```

      RUN
THE DATE IS 17 JAN 1980, TIME 16:00
ENTER THE MULTIVALUED VARIABLE AND ITS VALUES
...
ENTER ANY CHANGES TO THE BASE CASES DESIRED
...TAMH
...RR+.12*HFRNV+.5*R1+R2+.3*DEV-DPO+1*GR+.025*PCRHE+30
...
PENALTY FACTOR FOR LOW TEMPERATURE IS: 1.035
PRICE OF ALTERNATE FUEL $10.00
      CATEGORY      INVESTMENT COSTS      NET PRESENT VALUE
                        DISCOUNTED AT COST OF CAPITAL
-----
RESEARCH INVESTMENT  $      420,148
DESIGN                26,400
MANAGEMENT FEE        0
WELLS                103,181
TRANSMISSION          114,211
DISTRIBUTION:
  RESIDENTIAL RETROFIT  32,927
  RESIDENTIAL HOOKUP    11,525
  COMMERCIAL CONVERSION  0
  INDUSTRIAL CONVERSION  0
  HEAT EXCHANGERS      15,490
  CENTRAL SYSTEM        32,561
TOTAL                 $      756,483
PRICE PER MILLION BTU: $9.55

* TEMP+60 * DEPTH+1750 * DIST+2 * PA+1 * PH+0 * POP+750 * POPG1+.1 *
POPG2+.03 * T+D+20 * PHDI+CF+0 * HFC+.25 * HFDINV+.075 * PCRHE+40 *
DEGD+0300 * LT+10 * RR+.12 * HFRNV+.5 * R1+R2+.3 * DEV-DPO+1 *
GR+.025 * PCRHE+30

```

9.2 Graph 8 Sample Cost-Benefit-Analysis Output

CBA

COST AND BENEFIT SUMMARY (1980 - 2020), DISCOUNTED AT COST OF CAPITAL.

FED TAX	TAX CREDIT	ROYALTY	STATE TAX	ST SALES TAX	PROPERTY TAX
\$343,000	\$62,000	\$50,000	\$35,000	\$0	\$17,000
NET SAVINGS THROUGH YEAR:					
	1990	2000	2000		
	\$594,000	\$1,329,000	\$1,329,000		

EVALUATION OF INVESTMENT (NET PRESENT VALUE)

INVESTORS RETURN ON INVESTMENT:	\$520,043
EQUITY INVESTMENT:	\$105,080 (EQUITY PORTION = 0.3)
ECONOMIC JUDGEMENT:	\$342,955
PRICE OF GEO:	\$9.55
PRICE OF ALT FUEL:	\$10.00
YEAR ON LINE:	1983

9.3 APPENDIX C

Description of CASH Program

Description of CASH Program

The CASH program was developed in order to aggregate economic potential geothermal energy heat-on-line by year from 1980 through 2020. Our requirement was to develop the tool, so that we could display data:

- ° By industrial sector.
- ° By residential/commercial sector.
- ° By year.
- ° By site.
- ° By groups of sites.
- ° By county.
- ° By groups of counties (state regions).
- ° By state.
- ° By groups of states.
- ° By private or city-utility.
- ° By potential or inferred Sites.

The following samples depict tabular and graphical data for each of the primary routines (site-by-city, region-by site, state-by-region). The site-by-city data is an example of combined industrial, residential, and commercial, with heat-on-line based on private development. The region-by-site is an example of residential and commercial usage, for city-owned utilities at each of the four sites in that region. These four sites include one in the proven/ potential category, and three in the inferred resource category.

The state-by-region is an example of the industrial application for city owned utilities, with separate aggregations for proven/potential sites, and for inferred sites.

Header data on these various CASH output includes a description of the site, the city, and for the site-by-city, the values assigned to input parameters in order to calculate the price.

9.3 Sample 1 Cash Output SBYC

STATE: NEW MEXICO REGION: 3 COUNTY: TAOS
SITE: POCOT DE LEON RAG (25670) TEMP-60 LEPTB-25CC
APPLICATION: COMBINED INDUSTRIAL AND RESIDENTIAL

NOTE: ALL VALUES SHOWN ARE BILLION BTU PER YEAR
ALL PRICES ARE DOLLARS PER MILLION BTU

CITY NAME	PRIVATE DEVELOPER PRICE	YR ON LINE	CITY DEVELOPER PRICE	YR ON LINE	FALL
(25569) TAOS	5.56	1989	4.45	1984	\$ 4.13
(25670) RANCHES DE TAOS	5.98	1990	4.77	1985	\$ 4.13

CITY SPECIFIC INFORMATION:

25569 T867-C.54 POP-3050 DIST-3 LT-17 BEGD-6800 PHEI-2.412510 POPG1-FCFG2-.01 DIST-S POPG1-.023 POPG2-.1
25670 T867-C.54 POP-900 DIST-3 LT-17 BEGD-6800 PHEI-0 FCIG1-FCFG2-.01 PCFG1-.023 POPG2-.021

PRIVATELY OWNED UTILITY:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
YEARS -											
CITY IDS 1											
25569	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	4.20E2
25670	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
TOTALS	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	4.20E2
YEARS -	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	
CITY IDS 1											
25569	4.16E2	4.16E2	4.56E2	4.66E2	4.76E2	4.87E2	4.98E2	5.09E2	5.21E2	5.31E2	
25670	1.24E2	1.27E2	1.30E2	1.33E2	1.36E2	1.39E2	1.42E2	1.45E2	1.49E2	1.52E2	
TOTALS	5.70E2	5.72E2	5.85E2	5.98E2	6.12E2	6.27E2	6.40E2	6.54E2	6.69E2	6.83E2	
YEARS -	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
CITY IDS 1											
25569	5.12E2	5.53E2	5.65E2	5.76E2	5.85E2	6.00E2	6.13E2	6.25E2	6.38E2	6.51E2	
25670	1.55E2	1.58E2	1.62E2	1.65E2	1.68E2	1.72E2	1.76E2	1.79E2	1.83E2	1.87E2	
TOTALS	6.67E2	7.12E2	7.27E2	7.42E2	7.53E2	7.72E2	7.89E2	8.05E2	8.21E2	8.38E2	
YEARS -	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
CITY IDS 1											
25569	6.65E2	6.79E2	6.92E2	7.07E2	7.21E2	7.36E2	7.51E2	7.67E2	7.82E2	7.99E2	
25670	1.91E2	1.95E2	1.99E2	2.03E2	2.07E2	2.12E2	2.16E2	2.21E2	2.26E2	2.30E2	
TOTALS	8.56E2	8.73E2	8.91E2	9.10E2	9.28E2	9.48E2	9.67E2	9.88E2	1.01E3	1.03E3	

9.3 Sample 2 Cash Output SBYC

9.3 Sample 3 Cash Output RBYS

STATE: NEW MEXICO
 REGION NUMBER: 2
 COUNTIES IN REGION: BERNALILLO, VALENCIA, TORRENCIA
 APPLICATION: RESIDENTIAL
 CITY (WABO UTILITY)
 THE DATE IS 12 AUG 1979, TIME 19:10
 SITES IN REGION 2
 25124 25027 25062 25061

YEARS - SITE I P/I/I	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
25124 P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25027 I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25062 I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25061 I	0.00E0	0.00E0	0.00E0	6.63E2	1.18E3	1.76E3	2.15E3	2.31E3	2.47E3	2.64E3
POT TOTALS	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
IAF TOTALS	0.00E0	0.00E0	0.00E0	6.63E2	1.18E3	1.76E3	2.15E3	2.31E3	2.47E3	2.64E3
TOTALS	0.00E0	0.00E0	0.00E0	6.63E2	1.18E3	1.76E3	2.15E3	2.31E3	2.47E3	2.64E3
YEARS - SITE I P/I/I	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
25124 P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25027 I	0.00E0	0.00E0	0.00E0	0.00E0	4.15E2	5.59E2	5.81E2	6.03E2	6.27E2	6.52E2
25062 I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	2.91E2
25061 I	2.82E3	3.02E3	3.23E3	3.30E3	3.36E3	3.43E3	3.50E3	3.57E3	3.64E3	3.71E3
POT TOTALS	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
IAF TOTALS	2.82E3	3.02E3	3.23E3	3.30E3	3.78E3	3.99E3	4.06E3	4.17E3	4.27E3	4.66E3
TOTALS	2.82E3	3.02E3	3.23E3	3.30E3	3.78E3	3.99E3	4.06E3	4.17E3	4.27E3	4.66E3
YEARS - SITE I P/I/I	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
25124 P	0.00E0	0.00E0	0.00E0	2.35E2	4.29E2	4.43E2	4.57E2	4.72E2	4.87E2	5.02E2
25027 I	6.77E2	7.04E2	7.31E2	7.60E2	7.76E2	7.92E2	8.08E2	8.24E2	8.40E2	8.56E2
25062 I	3.01E2	3.13E2	3.24E2	3.36E2	3.49E2	3.61E2	3.75E2	3.89E2	4.03E2	4.17E2
25061 I	3.79E3	3.86E3	3.94E3	4.02E3	4.10E3	4.18E3	4.27E3	4.35E3	4.44E3	4.53E3
POT TOTALS	0.00E0	0.00E0	0.00E0	2.35E2	7.28E2	7.43E2	7.57E2	7.72E2	7.87E2	8.02E2
IAF TOTALS	4.77E3	4.88E3	5.00E3	5.12E3	5.22E3	5.34E3	5.45E3	5.57E3	5.68E3	5.81E3
TOTALS	4.77E3	4.88E3	5.00E3	5.35E3	5.65E3	5.78E3	5.91E3	6.04E3	6.17E3	6.32E3
YEARS - SITE I P/I/I	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
25124 P	5.18E2	5.35E2	5.52E2	5.69E2	5.87E2	6.05E2	6.23E2	6.41E2	6.59E2	6.77E2
25027 I	8.95E2	9.14E2	9.34E2	9.54E2	9.74E2	9.94E2	1.01E3	1.03E3	1.05E3	1.08E3
25062 I	4.20E2	4.29E2	4.38E2	4.47E2	4.56E2	4.66E2	4.76E2	4.86E2	4.96E2	5.06E2
25061 I	4.62E3	4.71E3	4.80E3	4.90E3	5.00E3	5.10E3	5.20E3	5.30E3	5.41E3	5.52E3
POT TOTALS	5.18E2	5.35E2	5.52E2	5.69E2	5.87E2	6.05E2	6.23E2	6.41E2	6.59E2	6.77E2
IAF TOTALS	5.93E3	6.05E3	6.18E3	6.30E3	6.43E3	6.56E3	6.69E3	6.83E3	6.97E3	7.11E3
TOTALS	6.45E3	6.59E3	6.70E3	6.84E3	7.00E3	7.20E3	7.38E3	7.53E3	7.76E3	7.92E3

9.3 Sample 4 Cash Output RBYS

9.3 Sample 5 Cash Output STBYR

STATE OF NEW MEXICO
8 REGIONS
26 POTENTIAL SITES
16 INFERRED SITES
INDUSTRIAL APPLICATION WITH CITY UTILITY

8/12/79
ALL VALUES ARE BILLION BTU

YEARS - REGION	P/I	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	I	0.00E0	0.00E0	0.00E0	6.04E3	6.42E3	6.50E3	6.55E3	6.67E3	6.70E3	7.20E3
2	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
3	I	0.00E0	0.00E0	0.00E0	6.58E3	6.91E3	7.26E3	7.62E3	8.00E3	8.40E3	8.82E3
4	P	0.00E0	0.00E0	0.00E0	2.53E1	2.01E1	2.12E1	1.71E2	1.73E2	1.74E2	1.76E2
5	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
6	P	0.00E0	0.00E0	0.00E0	4.10E0	4.14E0	4.18E0	4.22E0	4.27E0	4.31E0	5.66E1
7	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
8	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	2.42E2	2.45E2	2.47E2
9	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
10	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
11	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
12	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
13	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
14	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
15	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
16	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
17	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
18	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
19	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
20	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
21	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
22	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
23	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
24	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
26	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
PCT TOTALS		0.00E0	0.00E0	0.00E0	6.10E3	6.50E3	6.55E3	6.81E3	7.14E3	7.23E3	8.01E3
INF TOTALS		0.00E0	0.00E0	0.00E0	6.62E3	7.25E3	7.60E3	7.97E3	8.35E3	8.75E3	9.18E3
TOTALS		0.00E0	0.00E0	0.00E0	1.30E4	1.37E4	1.42E4	1.48E4	1.55E4	1.60E4	1.72E4

YEARS - REGION	P/I	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	F	7.20E3	7.38E3	7.48E3	7.57E3	7.67E3	7.77E3	7.87E3	7.98E3	8.08E3	8.19E3
2	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
3	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
4	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
5	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
6	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
7	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
8	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
9	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
10	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
11	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
12	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
13	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
14	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
15	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
16	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
17	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
18	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
19	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
20	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
21	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
22	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
23	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
24	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
25	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
26	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
PCT TOTALS		8.11E3	8.21E3	8.36E3	8.47E3	8.66E3	8.77E3	8.88E3	8.99E3	9.11E3	9.23E3
INF TOTALS		0.65E3	1.01E4	1.09E4	1.14E4	1.20E4	1.25E4	1.31E4	1.38E4	1.45E4	1.52E4
TOTALS		1.78E4	1.83E4	1.93E4	1.99E4	2.06E4	2.13E4	2.20E4	2.28E4	2.36E4	2.44E4

9.3 Sample 6 Cash Output STBYR (Con't)

YEARS - REGION	P/T	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	P	8.30E3	8.41E3	8.52E3	8.63E3	8.75E3	8.87E3	8.99E3	9.11E3	9.24E3	9.36E3
1	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
2	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
2	I	1.51E4	1.58E4	1.66E4	1.75E4	1.84E4	1.93E4	2.02E4	2.12E4	2.23E4	2.34E4
3	P	1.96E2	1.98E2	2.00E2	2.02E2	2.04E2	2.06E2	2.08E2	2.10E2	2.12E2	2.14E2
3	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
4	P	6.54E1	6.60E1	6.67E1	6.74E1	6.80E1	6.87E1	6.94E1	7.01E1	7.08E1	7.15E1
4	I	2.93E1	2.96E1	2.99E1	3.02E1	3.05E1	3.08E1	3.11E1	3.15E1	3.18E1	3.21E1
5	P	2.80E2	2.83E2	2.86E2	2.91E2	2.94E2	2.97E2	3.00E2	3.04E2	3.07E2	3.10E2
5	I	2.70E1	2.72E1	2.75E1	2.78E1	2.80E1	2.83E1	2.86E1	2.89E1	2.92E1	2.95E1
6	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
6	I	7.35E2	7.42E2	7.49E2	7.57E2	7.64E2	7.72E2	7.80E2	7.88E2	7.95E2	8.03E2
7	P	4.53E2	4.56E2	4.61E2	4.65E2	4.70E2	4.75E2	4.79E2	4.84E2	4.89E2	4.94E2
7	I	1.98E1	2.00E1	2.02E1	2.04E1	2.06E1	2.08E1	2.10E1	2.13E1	2.15E1	2.17E1
8	P	5.98E1	6.04E1	6.10E1	6.17E1	6.23E1	6.29E1	6.35E1	6.42E1	6.48E1	6.55E1
8	I	3.66E0	3.70E0	3.73E0	3.77E0	3.81E0	3.85E0	3.88E0	3.92E0	3.96E0	4.00E0
POT TOTALS		9.35E3	9.47E3	9.59E3	9.72E3	9.85E3	9.98E3	1.01E4	1.03E4	1.04E4	1.06E4
INF TOTALS		1.59E4	1.67E4	1.75E4	1.83E4	1.92E4	2.01E4	2.11E4	2.21E4	2.32E4	2.43E4
TOTALS		2.52E4	2.61E4	2.70E4	2.80E4	2.90E4	3.01E4	3.12E4	3.24E4	3.36E4	3.48E4

YEARS - REGION	P/T	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	P	9.49E3	9.63E3	9.76E3	9.90E3	1.00E4	1.02E4	1.03E4	1.05E4	1.06E4	1.08E4
1	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
2	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
2	I	2.46E4	2.58E4	2.71E4	2.85E4	3.00E4	3.14E4	3.28E4	3.42E4	3.56E4	3.71E4
3	P	2.17E2	2.19E2	2.21E2	2.23E2	2.25E2	2.28E2	2.30E2	2.32E2	2.34E2	2.37E2
3	I	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
4	P	7.22E1	7.29E1	7.37E1	7.44E1	7.52E1	7.59E1	7.67E1	7.74E1	7.82E1	7.90E1
4	I	3.24E1	3.27E1	3.31E1	3.34E1	3.37E1	3.41E1	3.44E1	3.47E1	3.51E1	3.54E1
5	P	3.58E2	3.61E2	3.65E2	3.68E2	3.72E2	3.76E2	3.80E2	3.83E2	3.87E2	3.91E2
5	I	2.98E1	3.01E1	3.04E1	3.07E1	3.10E1	3.13E1	3.16E1	3.19E1	3.22E1	3.26E1
6	P	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0	0.00E0
6	I	8.11E2	8.19E2	8.28E2	8.36E2	8.44E2	8.53E2	8.61E2	8.70E2	8.79E2	8.87E2
7	P	4.99E2	5.04E2	5.09E2	5.14E2	5.19E2	5.24E2	5.30E2	5.35E2	5.40E2	5.46E2
7	I	2.19E1	2.21E1	2.23E1	2.26E1	2.28E1	2.30E1	2.33E1	2.35E1	2.37E1	2.40E1
8	P	6.61E1	6.68E1	6.74E1	6.81E1	6.88E1	6.95E1	7.02E1	7.09E1	7.16E1	7.23E1
8	I	4.04E0	4.08E0	4.12E0	4.16E0	4.21E0	4.25E0	4.29E0	4.33E0	4.38E0	4.42E0
POT TOTALS		1.07E4	1.08E4	1.10E4	1.11E4	1.13E4	1.15E4	1.16E4	1.18E4	1.19E4	1.21E4
INF TOTALS		2.55E4	2.67E4	2.80E4	2.94E4	3.08E4	3.23E4	3.38E4	3.53E4	3.70E4	3.87E4
TOTALS		3.62E4	3.75E4	3.90E4	4.05E4	4.21E4	4.37E4	4.55E4	4.73E4	4.92E4	5.12E4

9.3 Sample 7 Cash Output STBYR

9.4 APPENDIX D
Description of HYPOT Program

Description of HYPOT Program

The HYPOT program was developed in order to provide a quick estimation of the recoverable, useable heat energy contained in potential or inferred geothermal reservoirs. This Hydrothermal Potential (HYPOT) program is required, because many of the geothermal sites contained in the working file of geothermal resources (termed SITEX) are not listed in USGS Circular 790, or subsequent research and exploration by state resource assessment teams has resulted in values different from USGS Circular 790. Note that HYPOT represents a possible geophysical potential, which does not necessarily represent an engineering or economic potential. This geophysical potential is vastly larger than current engineering or economic systems can recover.

The computerized HYPOT program computes the beneficial (recoverable, useable) electricity or direct heat potentially available from a given geothermal site based on reservoir size and temperature. This calculation is consistent with USGS Circulars 726 and 790, but is not an estimate of the economical potential. In order to determine the economically potential energy, use is made of the BTHERM computer simulation and CASH models. Following is a detailed sample of HYPOT output.

9.4 Sample 1 Hypot Output

Arizona Hydrothermal Sites,
Beneficial Energy Available

SITE	TEMP	VOL	ELECTRIC			DIRECT THERMAL	
			MWE	MWO	MWP	(VTS E13)	(GMD BTU)
20001	188	2.80	23	50	0	5.36E-2	0.1237
20002	148	3.30	0	0	0	7.00E-2	0.2213
20003	180	3.00	21	50	0	5.31E-2	0.2039
20004	137	3.00	0	0	0	5.37E-2	0.2077
20005	35	3.30	0	0	0	5.31E-2	0.1382
20006	120	3.00	0	0	0	5.14E-2	0.1633
20007	120	3.00	0	0	0	5.14E-2	0.1525
20008	115	3.00	0	0	0	4.90E-2	0.1548
20009	110	3.00	0	0	0	4.85E-2	0.1470
20010	110	3.00	0	0	0	4.85E-2	0.1470
20011	108	3.00	0	0	0	4.81E-2	0.1393
20012	105	3.00	0	0	0	4.81E-2	0.1383
20013	61	3.00	0	0	0	2.25E-2	0.0712
20028	150	3.00	21	50	0	5.31E-2	0.2039
20036	150	3.00	21	50	0	5.31E-2	0.2039
20037	150	3.00	21	50	0	5.31E-2	0.2039
20038	150	3.00	21	50	0	5.31E-2	0.2039
20039	150	3.00	21	50	0	5.31E-2	0.2039
20040	150	3.00	21	50	0	5.31E-2	0.2039
20041	150	3.00	21	50	0	5.31E-2	0.2039
20042	150	3.00	21	50	0	5.31E-2	0.2039
20043	150	3.00	21	50	0	5.31E-2	0.2039
20044	150	3.00	21	50	0	5.31E-2	0.2039
20045	135	2.80	0	0	0	4.80E-2	0.1224
20046	139	3.00	0	0	0	5.32E-2	0.1901
20047	64	3.00	0	0	0	2.40E-2	0.0733
20048	147	3.00	0	0	0	5.46E-2	0.2043
20049	37	3.00	0	0	0	3.53E-2	0.1114
20050	113	3.00	0	0	0	4.90E-2	0.1517
20051	110	3.00	0	0	0	4.85E-2	0.1470
TOTALS						1.55E0	5.2235

(Resource Temperature ≥60°C)

9.5 APPENDIX E

Methodology for Estimating Industrial Heat Demand

Methodology For Estimating Heat Demand

At the site specific level the estimation of industrial process heat demand is difficult. In many cases, even though some data exists, it is usually highly generalized and the frequency of its updating is sparse. For example, the Department of Commerce has just released in magnetic tape format the 1977 Census of Manufacturers. This Census is not site specific. As these data are updated it is expected that the results of this particular exercise should improve.

Notwithstanding the data constraints, the NMEI calculation of industrial heat demand for a given city is calculated in the following manner.

where

$$PHDI = \frac{AD/SIC_t}{AE/SIC_t \times E_t}$$

PHDI = Annual Industrial Energy Demand
AD/SIC_t = Average Annual Energy Demand for the tth SIC¹
AE/SIC_t = Average number of employees' for the tth SIC classified manufacturer²
E_t = Number of employees' in the firm under observation³

- 1 Solar Energy Information Data Bank (4 digit SIC)
- 2 1977 Census of Manufacturers, General Statistics for Establishments by Industry Group and Industry: 1977 and 1972
- 3 State Manufacturers Directory (Different Actual Title for Each State Analyzed)

Following is a sample which displays the estimated or actual industrial heat demand potentially replaceable by geothermal energy, aggregated by city.

9.5 Sample 1 Estimated or Actual Industrial
Heat Demand Potentially Replaceable by Geothermal Energy

UTAH					P1
CITY	COUNTY	NO. OF INDUSTRY	ENERGY USE 1E10 BTU/YR (1977)	ESTIMATED ENERGY USE 1E10 BTU/YR (2020)	
BEAVER	BEAVER	7	1.0616	1.6592	
MILFORD	"	3	0.0880	0.1350	
BEAR RIVER CITY	BOX ELDER	1	0.0640	1.0126	
BRIGHAM CITY	"	18	12.1171	18.5873	
GARLAND	"	0	0.0000	0.0000	
HONEYVILLE	"	1	3.4725	5.3267	
PROMONTORY PT	"	1	0.1925	0.2953	
TREMONTON	"	5	0.6835	1.0484	
CACHE JUNCTION	CACHE	0	0.0000	0.0000	
COVE	"	1	3.2042	4.9152	
HYRUM	"	5	3.6499	13.2687	
LEWISTON	"	0	0.0000	0.0000	
LOGAN	"	34	58.6837	90.0195	
MENDON	"	2	0.1695	0.2600	
PROVIDENCE	"	1	0.0323	0.0495	
RICHMOND	"	4	22.0325	35.1779	
SMITHFIELD	"	4	51.3140	78.7145	
TRENTON	"	0	0.0000	0.0000	
WELLSVILLE	"	3	22.0055	33.7559	
HELPER	CARBON	1	0.1454	0.2231	
PRICE	"	10	1.9143	2.9365	
WELLINGTON	"	2	3.1500	4.8320	
BJUNTIFUL	DAVIS	14	2.2991	3.5268	
CENTERVILLE	"	5	1.4621	2.2428	
CLEARFIELD	"	13	11.1093	17.0414	
FARMINGTON	"	0	0.0000	0.0000	
KAYSVILLE	"	2	9.1810	14.0835	
LAYTON	"	6	1.7385	2.5668	

9.6 APPENDIX F

Computerized Energy Demand Forecasting

Computerized Energy Demand Forecasting

This is a sample of the computerized energy demand forecasting which accepts as input a wide variety of factors, including real compound growth rate in price, and computes forecasted energy demand output.

Output terms are defined as:

RDF	Residential Distillate Fuel
RLPG	Residential Liquid (Program)
RNG	Residential Natural Gas
RE	Residential Electricity
CDF	Commercial Distillates
CLPG	Commercial Liquid
CNG	Commercial Natural Gas
CE	Commercial Electricity
IDF	Industrial Distillates
ING	Industrial Natural Gas
IE	Industrial Electricity

Models have been developed for each of the ten states, and for sub-state regions.

Detailed methodology and description of results are contained in NMEI Reports 30-1 (July, 1979) and 30-7 (September, 1979).

9.6 Sample of Energy Demand Forecast Output

CASE 2

YEAR	EDF	RIFC	RNG	NE	CDF	CLIG	CNG	CE	IDF	ING	IE	TRILLION
												BTU
												TOTAL
1975	3.2500	12.1600	103.1300	17.3800	10.1500	1.3500	78.7300	24.7000	6.0100	77.3300	11.3800	345.5700
1976	3.2476	11.9500	102.1972	18.2252	9.2607	2.8162	73.7477	24.8537	6.2656	76.3093	11.1484	340.2216
1977	3.2453	11.8049	105.2008	18.7214	8.7322	3.3251	73.7083	24.3751	6.4097	75.3007	11.0817	341.9052
1978	3.2430	11.6994	108.0812	19.1127	8.4393	3.8816	73.6689	23.5873	6.5413	74.3054	11.0153	343.1775
1979	3.2407	11.6181	111.0405	19.4762	8.3082	3.5593	73.6296	22.6653	6.6735	73.3234	10.9494	344.4843
1980	3.2384	11.5518	114.0808	19.8356	8.2431	3.6175	73.5902	21.6997	6.8082	72.3543	10.8818	345.9535
1981	3.2361	11.4949	117.2044	20.1983	8.3643	3.6725	73.5509	20.7354	6.9455	71.3980	10.8187	347.6189
1982	3.2338	11.4437	120.4134	20.5666	8.5018	3.7276	73.5116	19.7940	7.0856	70.4543	10.7539	349.4864
1983	3.2316	11.3962	123.7104	20.9413	8.6920	3.7832	73.4724	18.8855	7.2286	69.5241	10.6896	351.5537
1984	3.2293	11.3511	127.0976	21.3227	8.9251	3.8397	73.4331	18.0137	7.3744	68.6042	10.6256	353.8164
1985	3.2270	11.3074	130.5775	21.7110	9.1945	3.8970	73.3939	17.1797	7.5211	67.6975	10.5620	356.2706
1986	3.2247	11.2647	134.1527	22.1064	9.4952	3.9551	73.3547	16.3811	7.6749	66.8028	10.4987	358.9130
1987	3.2224	11.2226	137.8258	22.5090	9.8236	4.0141	73.3155	15.6228	7.8297	65.9198	10.4359	361.7415
1988	3.2201	11.1811	141.5995	22.9190	10.1774	4.0740	73.2763	14.8975	7.9877	65.0486	10.3734	364.7546
1989	3.2179	11.1399	145.4765	23.3364	10.5547	4.1348	73.2372	14.2057	8.1488	64.1889	10.3115	367.9520
1990	3.2156	11.0989	149.4597	23.7614	10.9545	4.1965	73.1980	13.5460	8.3172	63.3405	10.2496	371.3338
1991	3.2133	11.0582	153.5519	24.1941	11.3759	4.2591	73.1589	12.9168	8.4809	62.5033	10.1882	374.9008
1992	3.2110	11.0177	157.7562	24.6348	11.8187	4.3227	73.1198	12.3169	8.6520	61.6772	10.1272	378.6541
1993	3.2088	10.9773	162.0756	25.0834	12.2826	4.3872	73.0808	11.7448	8.8265	60.8620	10.0666	382.5956
1994	3.2065	10.9371	166.5132	25.5402	12.7679	4.4526	73.0417	11.1993	9.0045	60.0576	10.0063	386.7271
1995	3.2042	10.8971	171.0723	26.0054	13.2747	4.5191	73.0027	10.6791	9.1862	59.2639	9.9464	391.0511
1996	3.2020	10.8572	175.7563	26.4790	13.8035	4.5865	72.9637	10.1831	9.3715	58.4806	9.8869	395.5703
1997	3.1997	10.8175	180.5685	26.9612	14.3549	4.6549	72.9247	9.7101	9.5605	57.7076	9.8277	400.2875
1998	3.1974	10.7779	185.5175	27.4523	14.9294	4.7244	72.8858	9.2591	9.7534	56.9449	9.7689	405.2060
1999	3.1952	10.7385	190.5919	27.9522	15.5278	4.7949	72.8468	8.8290	9.9501	56.1923	9.7104	410.3291
2000	3.1929	10.6992	195.8103	28.4613	16.1509	4.8664	72.8079	8.4189	10.1509	55.4496	9.6523	415.6006
2001	3.1906	10.6593	200.5873	29.0586	16.7945	4.9391	72.7690	8.0279	10.3556	54.7507	9.5945	420.5391
2002	3.1884	10.6198	205.4707	29.6925	17.4745	5.0128	72.7301	7.6550	10.5645	54.0057	9.5371	425.6296
2003	3.1861	10.5821	210.4781	30.3477	18.1771	5.0875	72.6913	7.2994	10.7776	53.2545	9.4800	430.9215
2004	3.1839	10.5442	215.6076	31.0197	18.9081	5.1635	72.6524	6.9604	10.9950	52.0167	9.4232	436.4147
2005	3.1816	10.5053	220.8622	31.7072	19.6687	5.2405	72.6136	6.6371	11.2168	51.1922	9.3688	442.1120
2006	3.1794	10.4659	226.2447	32.4101	20.4601	5.3187	72.5748	6.3248	11.4431	50.3808	9.3107	448.0171
2007	3.1771	10.4264	231.7585	33.1287	21.2834	5.3981	72.5361	6.0349	11.6739	49.5822	9.2550	454.1342
2008	3.1749	10.3870	237.4066	33.8632	22.1400	5.4786	72.4973	5.7546	11.9093	48.7963	9.1996	460.4674
2009	3.1726	10.3476	243.1924	34.6141	23.0311	5.5604	72.4586	5.4873	12.1497	48.0228	9.1445	467.0210
2010	3.1704	10.3086	249.1191	35.3815	23.9581	5.6433	72.4199	5.2324	12.3948	47.2616	9.0898	473.7995
2011	3.1681	10.2698	255.1904	36.1660	24.9225	5.7275	72.3812	4.9894	12.6448	46.5125	9.0354	480.8075
2012	3.1659	10.2312	261.4095	36.9679	25.9257	5.8130	72.3425	4.7576	12.8999	45.7753	8.9813	488.0498
2013	3.1637	10.1926	267.7803	37.7876	26.9693	5.8937	72.3039	4.5366	13.1601	45.0497	8.9275	495.5314
2014	3.1614	10.1540	274.3063	38.6255	28.0550	5.9777	72.2652	4.3259	13.4255	44.3356	8.8741	503.2575
2015	3.1592	10.1154	280.9913	39.4819	29.1894	6.0771	72.2266	4.1250	13.6964	43.6329	8.8210	511.2334
2016	3.1570	10.0769	287.8393	40.3571	30.3593	6.1678	72.1880	3.9334	13.9727	42.9413	8.7681	519.4645
2017	3.1547	10.0384	294.8541	41.2522	31.5815	6.2599	72.1495	3.7507	14.2545	42.2606	8.7157	527.9568
2018	3.1525	10.0000	302.0399	42.1668	32.8529	6.3532	72.1109	3.5765	14.5421	41.5908	8.6635	536.7160
2019	3.1503	9.9617	309.4008	43.1018	34.1755	6.4480	72.0724	3.4104	14.8354	40.9315	8.6116	545.7484
2020	3.1480	9.9248	316.9412	44.0575	35.5513	6.5442	72.0339	3.2520	15.1347	40.2827	8.5601	555.0693

9.7 APPENDIX G

. Sample SITEX File

Sample SITEX File

This is a sample page from the current SITEX file, which is the repository for geothermal site information. This computerized file is backed-up by other computerized and manual files which provide additional information for those sites for which flow rates, depths, water chemistry, and other information are available.

All temperature values are recorded in degress Celsius.

9.7 Sample of page from SITEX File

ID	Site Name	County	Lat	Long	Twp	Rng	S	Rsvr Vol	Subs So Temp	So	Surf Temp	E So M
23001	HELENA BROADWATER HS	LEWIS	46.617	112.083	10N	4W	28	3.30	14	118	14	65 1 E
23002	WHITE SULPHUR SPRING	CASCAD	46.533	110.817	8N	7E	18	3.00	14	112	21	46 21 E
23003	ALHAMBRA H S	JEFFER	46.450	111.883	8N	3W	16	2.25	21	114	21	57 21 E
23004	BOULDER H S	JEFFER	46.200	112.083	5N	4W	10	3.30	14	125	21	71 21 E
23005	GREGSON FAIRMONT R S	SILVER	46.033	112.817	3N	10W	2	3.30	14	118	14	70 21 E
23006	PIPESTONE H S	JEFFER	45.900	112.233	2N	5W		3.00	14	97	21	51 21 E
23007	BARKELLS SILVER STAR	MADISO	45.685	112.295	2S	6W	1	3.30	14	131	14	72 1 E
23008	NORRIS HAPGOOD H S	MADISO	45.575	111.683	3S	1W	14	2.25	21	124	21	53 1 E
23009	JACKSON BIG HOLE R S	BEAVER	45.367	113.417	5S	15W		3.00	14	114	21	58 1 E
23010	ELKHORN HOT SPRINGS	BEAVER	45.458	113.108	4S	12W	29	3.00	14	79	21	49 12 E
23011	WARM SPRINGS STATE H	DEER L	46.178	112.784	5N	10W	24	3.00	14	115	21	77 12 E
23012	BOZEMAN HOT SPRINGS	GALLAT	45.661	111.186	2S	4E	14	3.00	14	95	21	54 21 E
23013	POTOSI HOT SPRINGS	MADISO	45.600	111.800	3S	2W	6	3.00	14	79	21	50 12 E
23014	NEW BILTMORE HOT SPR	MADISO	45.461	112.473	4S	7W	28	3.00	14	105	21	53 12 E
23015	CHICO HOT SPRINGS	PARK	45.337	110.691	6S	9E	1	3.00	14	96	21	48 21 E
23016	LA DUKE HOT SPRINGS	PARK	45.093	110.774	8S	8E	32	3.00	14	102	21	65 12 E
23017	HUNTERS HOT SPRINGS	PARK	45.757	110.257	1S	12E	9	3.00	14	82	21	60 12 E
23019	SLEEPING CHILD HOT S	RAVALL	46.083	114.000	4N	19W	7	3.00	14	101	21	52 12 E
23020	CANAS HOT SPRINGS	SANDER	47.616	114.666	21N	24W	3	3.00	14	81	21	45 12 E
23021	ANACONDA HOT SPRINGS	DEER L	46.106	112.803	4N	11W	13	3.00	14	0		22 12
23022	ANDERSONS HOT SPRING	SWEET	45.553	110.142	3S	13E	29	3.00	14	0		25 12
23023	ANDERSONS PASTURE	BEAVER	44.703	111.888	13S	2W	18	3.00	14	52	14	28 12 E
23024	APEX HOT SPRINGS AIR	BEAVER	45.420	112.692	5S	9W	10	3.00	14	0		25 12
23025	AVON WARM SPRING	POWELL	45.610	112.555	10N	8W	24	3.00	14	0		26 12
23026	DEAR CREEK	PARK	45.033	110.664	9S	9E	19	3.00	14	0		22 12
23027	BEARMOUTH WARM SPRIN	GRANIT	46.718	113.306	11N	14W	12	3.00	14	0		15 12
23028	BEAVERHEAD ROCK	MADISO	45.390	112.451	5S	7W	22	3.00	14	0		27 12

9.8 APPENDIX H
Sample CITY2 File

Sample CITY2 File

This is a sample page from the current city file, called CITY2. Population is the 1976 estimated, as listed in Census reports, or more current if available. DEGD is the 30-year mean of annual Heating Degree Days. LT is the 30-year mean lowest temperature.

9.8 Sample of page from CITY2 File

CITY NAME	COUNTY	LAT.	LONG.	POP.	DEGD.	LT.
23552 CULBERTSON	ROOSEV	48.150	104.517	833	9160	-4
23586 CUT BANK	GLACIE	48.633	112.327	4535	9030	5
23510 DARBY	RAVALL	46.017	114.183	543	7360	16
23511 DEER LODGE	POWELL	46.417	112.717	4944	8700	15
23512 DILLON	BEAVER	45.233	112.633	4444	8350	10
23587 DRUMMOND	GRANIT	46.668	113.145	577	8500	15
23588 DUTTON	TETON	47.850	111.713	577	8000	8
23553 EKALAKA	CARTER	45.900	104.517	639	8160	3
23514 ENNIS	MADISO	45.333	111.700	518	8020	11
23590 EUREKA	LINCOL	48.882	115.048	1195	8420	13
23591 EVERGREEN	FLATHE	48.145	114.313	1200	8000	14
23592 FAIRFIELD	TETON	47.617	111.985	752	7840	10
23554 FAIRVIEW	RICHLA	47.867	104.033	902	9100	-1
23515 FLORAL PARK	SILVER	46.000	112.517	5113	9720	4
23555 FORSYTH	ROSEBU	46.250	106.667	2396	7670	6
23594 FT BELKNAP AGENCY	BLAINE	48.485	108.757	500	8730	-2
23596 FT BENTON	CHDUTE	47.818	110.667	1863	7660	5
23597 FT PECK	VALLEY	48.008	106.447	600	8430	1
23589 GLACIER PARK	GLACIE	48.445	113.210	500	10000	9
23556 GLASGOW	VALLEY	48.200	106.617	5050	8970	0
23599 GLASGOW AFB	VALLEY	48.195	106.637	300	8970	0
23557 GLENDALE	DAWSON	47.133	104.700	5797	7770	1
23516 GREAT FALLS	CASCAD	47.500	111.267	60866	7650	12
23517 HAMILTON	RAVALL	46.250	114.167	3111	7190	18
23558 HARDIN	HIGHUR	45.733	107.583	3055	7530	8
23559 HARLEM	BLAINE	48.550	108.783	2205	8730	-2
23518 HARLOWTON	WHEATL	46.433	109.833	1264	8120	9

10.0 Distribution

<u>Organization</u>	<u>Location</u>	<u>Attention</u>	<u>Copies</u>
DOE/IDAHO	Idaho Falls, ID	J. Griffith	10
University of Utah Research Institute	Salt Lake City, UT	Dr. P.M. Wright	1
Western Energy Planners	Denver, CO	Dr. R. Meyer	1
DGE/DOE	Washington, DC	Dr. F. Abel	1
DGE/DOE	Washington, DC	Dr. J. Salisbury	1
DGE/DOE	Washington, DC	R. Stephens	1
DGE/DOE	Washington, DC	B. DiBona	1
Dept. of Energy Region X	Seattle, WA	R. Bendixen	1
Dept. of Energy Region IX	San Francisco, CA	S. Sellars	1
OIT	Olympia, WA	R. Bloomquist	1
EG&G	Idaho Falls, ID	J. Hanny	1
NMEI/NMSU	Las Cruces, NM	Dr. L. Icerman	2
Four Corners Regional Comm.	Albuquerque, NM	K. Dotson	3
<u>FOUR CORNERS ALTERNATES</u>			
Office of the Governor	Phoenix, AZ	R. Lopez	1
State Centennial Building	Denver, CO	R. Romer	1
Four Corners Regional Comm.	Carson City, NV	R. Hill	1
Four Corners Regional Comm.	Santa Fe, NM	L. Griego	1

Dept. of Community Economic Development	Salt Lake City, UT	R. Searle	1
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STATE TEAMS

Solar Energy Research Comm.	Phoenix, AZ	F. Mancini	1
Colorado Geo. Survey	Denver, CO	R. Pearl	1
Dept. of Energy	Carson City, NV	K. Jackson	1
New Mexico Energy & Minerals Dept.	Santa Fe, NM	D. Fedor	1
State Engr's. Office	Salt Lake City, UT	S. Green	1
Idaho Energy Office	Boise, ID	D. McClain	1
Montana Dept. of Natural Resources	Helena, MT	J. Birkby	1
University of Wyoming	Laramie, WY	R. James	1
South Dakota Office of Energy Policy	Pierre, SD	P. Lidel	1
North Dakota Energy Office	Bismarck, ND	B. Kaiser	1