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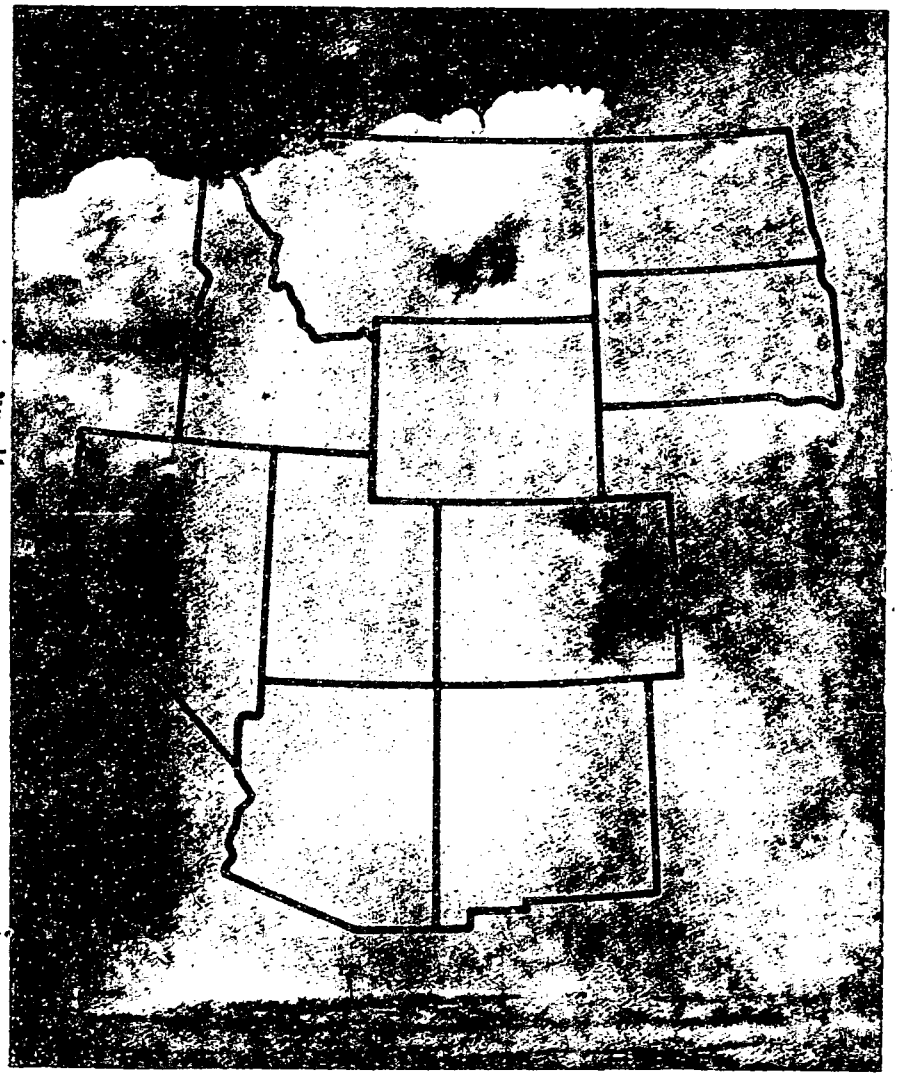

EG&G Idaho, Inc.

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DRAFT

REGIONAL HYDROTHERMAL MARKET PENETRATION ANALYSIS

OCTOBER 1978

ROCKY MOUNTAIN BASIN
AND RANGE REGION

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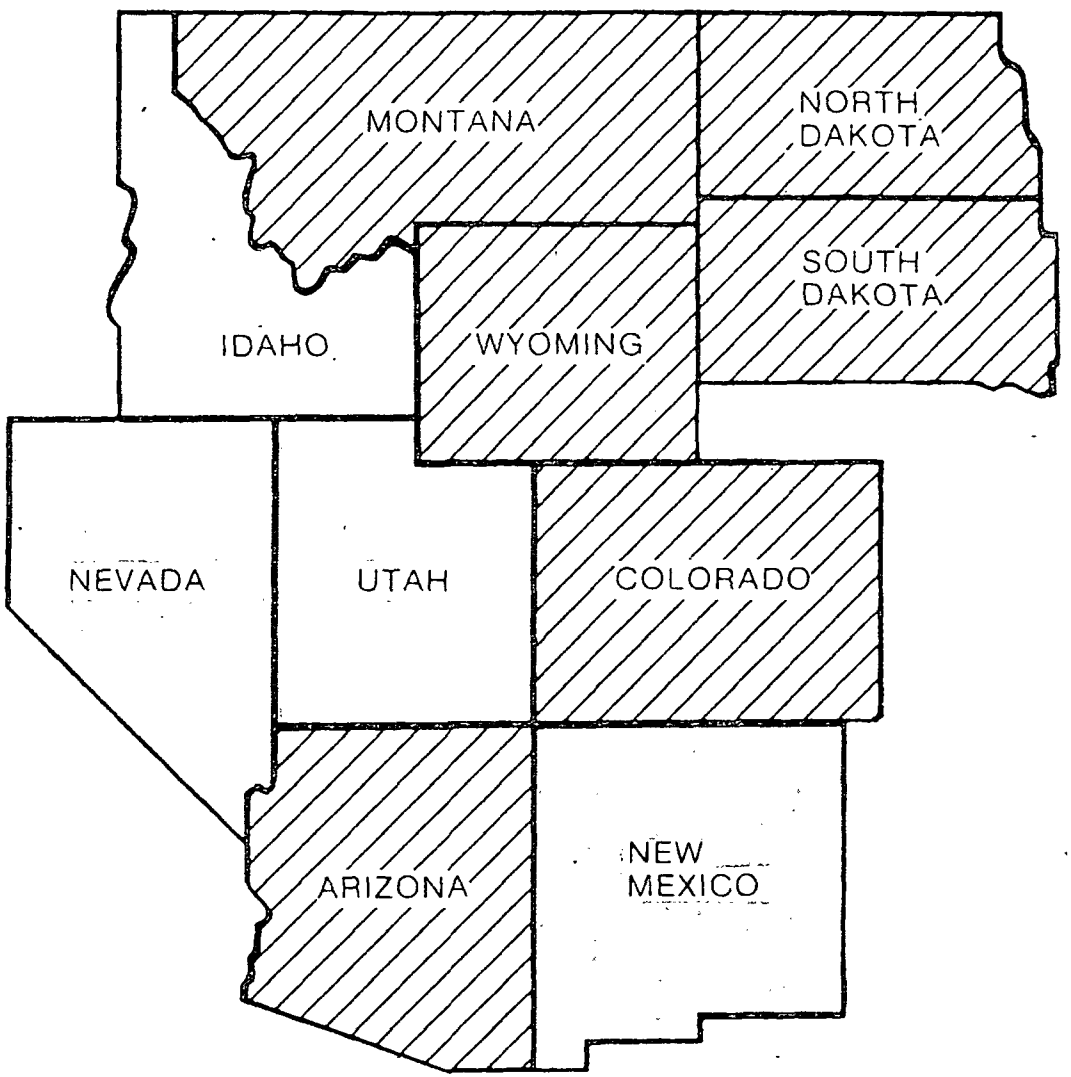
STATES IN THE RMB&R REGION



STATES WITH DIRECT HEAT RESOURCES MATCHED WITH POTENTIAL USERS

STATES WITH DIRECT HEAT AND HIGH TEMPERATURE ($\geq 200°C$) PROVEN, POTENTIAL, OR INFERRED ELECTRIC GENERATION RESOURCES MATCHED WITH POTENTIAL USERS.

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I. EXECUTIVE SUMMARY

DIRECT HEAT APPLICATIONS

- ALL 10 STATES HAVE POTENTIALLY ECONOMICAL HYDROTHERMAL RESOURCES.
- MOST INDUSTRIAL AND POPULATION CONCENTRATIONS ARE COLOCATED WITH HYDROTHERMAL RESOURCES.
- CURRENT HYDROTHERMAL MARKET POTENTIAL WITHIN THE REGION FOR DIRECT HEAT APPLICATIONS IS APPROXIMATELY 0.4 QUAD. MARKET POTENTIAL FOR DIRECT HEAT WILL BE APPROXIMATELY 5-6 QUADS BY THE YEAR 2020.
- ESTIMATED POTENTIAL MARKET CAPTURE BY HYDROTHERMAL ENERGY IS 0.2 QUAD IN 1985, INCREASING TO 2.5 QUADS IN THE YEAR 2020.
- THE MAJOR DIRECT HEAT MARKETS ARE CURRENTLY RESIDENTIAL/COMMERCIAL, SPACE CONDITIONING AND INDUSTRIAL PROCESS HEAT APPLICATIONS. THE INDUSTRIAL MARKET SECTOR HAS THE GREATER POTENTIAL FOR NEAR-TERM PENETRATION.
- A MAJOR BARRIER TO DIRECT HEAT MARKET PENETRATION IS LACK OF AN INFRASTRUCTURE, EARLY FORMATION OF WHICH IS A PRINCIPAL PROGRAM GOAL.

I. EXECUTIVE SUMMARY

ELECTRIC APPLICATIONS

- MORE THAN 25% OF THE ADDITIONAL ELECTRICAL ENERGY REQUIRED IN THE REGION BY THE YEAR 2000 COULD BE SUPPLIED FROM HYDROTHERMAL RESOURCES.

- ADVANCED TECHNOLOGY FOR UTILIZATION OF 150°C RESOURCE FOR ELECTRIC POWER GENERATION MUST BE AVAILABLE BY THE LATE 1980'S TO PROVIDE A SUBSTANTIAL PORTION OF THE REGIONAL NEEDS BEYOND THE YEAR 2000.

- RESOURCES SUITABLE FOR ELECTRIC POWER GENERATION APPEAR TO BE ABUNDANT IN THE REGION, BUT A MAJOR NEAR-TERM RESERVOIR CONFIRMATION EFFORT IS REQUIRED TO ALLOW SUBSTANTIAL COMMERCIAL DEVELOPMENT BY THE YEAR 2000.

- ELECTRIC POWER GRID SYSTEMS ARE COLOCATED WITH POTENTIAL HYDROTHERMAL SITES, BUT SOME UPGRADING MAY BE REQUIRED.

II. INTRODUCTION

Outlined herein are the results of a survey of the potential applications of hydrothermal energy in the RMB&R region of the United States. The DOE goal is to foster accelerated commercialization of the substantial hydrothermal resources of the region. This document provides a summary of the market analysis and is intended to serve as a guide in the future preperation of the comprehensive DOE Implementation Plan to accomplish the desired commercialization.

A major portion of this survey has been devoted to estimating the size of the current as well as potential future markets. While current use of the region's hydrothermal resources is limited, there are in fact numerous established process industries in the region which can use hydrothermal energy for process heat. In addition the region's residential and commercial sectors are fortunately largely co-located with hydrothermal resources. This provides a major opportunity for space conditioning and water heating applications. In addition, several known potential resources in the region provide reservoir temperatures suited to electric power generation with today's technology.

The current state-of-the art is adequate to undertake design of installations with assurance that necessary reliability, safety, cost and environmental considerations can be met. In addition, hydrothermal energy is expected to be economically competitive and relatively benign environmentally. Achievment of substantial commercialization of the region's abundant and widespread hydrothermal resources will allow reduced dependence on fossil fuels and provide the region with an enhanced economic base.

A comprehensive program has been outlined. Detailed planning is continuing, by which DOE commercialization objectives will be achieved. Regional planning will continue to include program coordination, policy development, and state profile development to provide an element for formation of a strong hydrothermal energy commercialization infrastructure.

Resource definition is likewise a major aspect of the program.

Technology applications for both electric and direct heat options are also important program elements required to penetrate the commercial market. Barrier mitigation, power plant development incentives, various direct heat field projects, and timely technology transfer are required.

Environmental control regional support and technology transfer will continue to assure that commercialization is accomplished in an environmentally acceptable manner.

Finally, rounding out the program is the on-going work at the Raft River Facility. From this facility it is intended to demonstrate economical power production from 150°C reservoir temperatures, corrosion/scaling prevention, and similar technologies for industrial use.

The potential markets considered in the survey include both the projected growth of markets currently implaced, as well as new industries which would be expected to be attracted to the region by the availibility of a stable energy supply. However, regional industrial growth, as well as associated residential/commercial development, must also consider legal, regulatory, environmental and financial aspects, as well as other related factors. Such factors have not yet been fully evaluated for the region. Detailed consideration of these factors remains a major necessary activity yet to be accomplished to carry out the overall commercialization planning for the region. This document will require periodic updating as state profiles are developed by state operational teams, potential users are further defined and as scenarios for electric power generation become available.

The methodology and assumptions used for this analysis are presented in Section III.

III. METHODOLOGY AND ASSUMPTIONS - DIRECT HEAT

A. BASELINE MARKET SIZE DEVELOPMENT

The region's hydrothermal resources, as defined by the University of Utah Research Institute, were mapped in each of the ten states. Next, the counties overlying the resource areas were identified. Each of these counties was reviewed to identify the industries that operate processes having potential for hydrothermal energy use. The potential was established by reviewing the listing of Standard Industrial Classification (S.I.C.) industries and selecting those S.I.C. categories having processes operating in the temperature range of 40°C to 260°C. County level data on the number of employees for each industry was multiplied by an energy intensity coefficient (millions of Btu per year per employee) developed by a Rocket Research Inc. study to establish energy consumption by those industries having processes compatible with hydrothermal energy. This latter value was multiplied by a selected factor for each S.I.C. category to exempt such energy consumptions as product sizing, packaging, handling, transportation, etc. While this factor is based mainly on engineering judgment, several cases were correlated with data developed in a solar energy application study performed for DOE by Intertechnology Corporation, and found to be generally consistent.

Since the Rocket Research Inc. "energy intensity coefficient" did not consider waste heat, a simplifying assumption of a 50% cycle efficiency was applied to all processes, in effect increasing their total energy consumption by a factor of two. Energy use and employment data were available for the time span of 1972 to 1975. For this survey, a further simplifying (and conservative) assumption is made that all data would be assumed to be representative of 1975 data. The 1975 data were set as the base year for growth projections.

An additional factor is necessary to account for counties showing surface manifestations of potential hydrothermal resources, but not fully evaluated on an industry by industry basis. This

III. METHODOLOGY AND ASSUMPTIONS - DIRECT HEAT

BASELINE (1975) MARKET ESTIMATE

- CONSIDERED ONLY COUNTIES COLOCATED WITH HYDROTHERMAL RESOURCES.
- ESTABLISHED INDUSTRIAL ENERGY USE IN 40℃ TO 260℃ RANGE (PROCESS HEAT).
- ESTABLISHED RESIDENTIAL/COMMERCIAL ENERGY USE FOR ONLY SPACE CONDITIONING AND WATER HEATING PURPOSES.

MARKET GROWTH FORECASTS

- APPLIED NATIONAL INDUSTRIAL GROWTH RATES BY SIC CATEGORY.
- ASSUMED 3% ANNUAL INCREASE PER CAPITA CONSUMPTION.
- ASSUMED 5% ANNUAL NEW INDUSTRY SPIN-OFF WITHIN THE REGION, 1985 AND BEYOND.
- ASSUMED 4% PER YEAR REGIONAL POPULATION GROWTH (1.4 X NATIONAL AVERAGE).
- APPLIED FACTORS FOR POTENTIAL NEW DISCOVERIES BY THE YEAR 2000 AND BEYOND.
- APPLIED FACTORS FOR NEW INDUSTRIES RELOCATED TO THE REGION.

MARKET CAPTURE ESTIMATE ASSUMPTIONS

- 1% PER YEAR, BASELINE MARKET RETROFIT, 1980 AND BEYOND, TO 25% MAXIMUM RETROFIT.
- LINEAR INCREASE IN PERCENT CAPTURE OF NEW GROWTH MARKET, 1980 TO 1985.
- 80% OF NEW ANNUAL INDUSTRIAL GROWTH CAPTURED, 1985 AND BEYOND.
- 70% OF NEW ANNUAL RESIDENTIAL/COMMERCIAL GROWTH CAPTURED, 1985 AND BEYOND.
- 40% OF RELOCATED INDUSTRY GROWTH 1990 AND BEYOND.

factor varied from state to state, depending upon the number of such counties, frequency of resource evidence, and current populations of the counties in question. For residential/commercial (R/C) energy use, county population was multiplied by an energy use factor, chosen specifically for the climatic region, and adjusted to account for non-geothermal potential uses such as cooking, lighting, electrical appliances, etc. This county-level detail was summed by state and region to establish the current (1975) hydrothermal market size for the industrial as well as the combined residential/commercial sectors.

B. MARKET GROWTH PROJECTION DEVELOPMENT

Growth rates for each of the selected SIC categories were developed from a Ford Foundation report on industrial growth patterns in the United States, and projected at these rates to the year 2020. These basic projects were amplified by a compounded 3% per year increase in per capita energy consumption, following the usual forecasting practice of the electric power industry.

It was anticipated that, by 1985, the stimulated industrial growth resulting from the availability of an economical, stable hydrothermal energy resource base would attract new allied suppliers and service industries not currently part of the baseline market. To account for these new enterprises, a factor of 5% per year was added to the predicted market size for 1985 and beyond. In addition, a factor was added to account for new large industrial firms which, because of economics, would relocate to the region's hydrothermal resources, or would choose to adapt processes to accommodate hydrothermal energy characteristics. It was estimated that 68% of the basic industrial growth of the region, less that specifically identified as having potential for direct hydrothermal applications, would reasonably approximate the likely extent of such industry relocations and process modifications. (Sixty-eight percent is roughly the fraction of industrial energy consumption used as steam or process heat.)

Growth projections for the residential/commercial sector were based on the federal Project Independence Report indication of a residential/commercial growth projection of approximately 4% per year. In addition, per capita consumption was assumed to increase at a 3% per year factor for the residential/commercial consumer sector, as it was for the industrial sector.

Because the foregoing market size was based only upon those counties overlying currently identified potential resources, a "new discovery" factor was applied to the market projections values for the year 2020 and beyond. This factor varies from zero, in states such as Nevada where virtually all counties were encompassed by the baseline assessments, to on the order of 15 to 20% in states like the Dakotas, Arizona, and New Mexico, where there are reasons to anticipate some additional discoveries in counties not heretofore considered.

C. MARKET CAPTURE POTENTIAL ESTIMATE DEVELOPMENT

Starting in 1980, a linear 1% per year hydrothermal energy retrofit of the total 1975 baseline industrial plus R/C market was assumed, and assumed to continue until a maximum of 25% of the 1975 market had converted to hydrothermal energy. (The identified total baseline market was only those sectors uniquely able to adapt to hydrothermal usage.)

Capture of the projected market new growth by hydrothermal energy was assumed to be zero in 1979, increasing linearly to 70% and 80% by 1985 for the residential/commercial and industrial sectors, respectively. Continued growth market capture beyond 1985 was assumed to remain at the 70% and 80% values through the year 2020.

Capture of the industry choosing to relocate or convert processes to hydrothermal use was assumed at 40%, starting in the year 2000, and continuing beyond.

III. METHODOLOGY AND ASSUMPTIONS - ELECTRIC

A. ELECTRICAL FORECAST

Data from the September 15, 1977, issue of Electrical World were used to determine the planned generating capacity net addition in the RMB&R region to 1995. A linear extrapolation was applied to obtain the projected new capacity for the year 2020. The ratio of planned regional to national installed energy capacity in 1980 was assumed to maintain through the period, since only limited regional planning data was available beyond the 1980 time frame.

B. RESOURCE PROJECTED DEVELOPMENT

The location of the proven, potential and inferred potential resources were identified and overlaid with the region's existing electrical power grids to verify that there are power grids in the vicinity of most resources, although some upgrading may be necessary.

Typical commercialization scenarios were developed for high as well as moderate temperature prospective resources to develop approximate time scales. Preliminary scenarios were also developed for the number of wells and drill rigs required for confirmation of a reservoir, as well as for reservoir development to assure that unreasonable demands upon drilling resources were not implied by the goals established.

Prospective resources with potential temperatures above 200°C were considered for the year 2000 power-on-line projections. It was assumed that technology will be developed by the early 1990's for the economical use of resources down to 150°C. Actual power-on-line from such reservoirs would commence in about the year 2000. Proven resources in Utah and New Mexico, and only a small fraction of the potential resources in Utah and Nevada, were used for the near-term (1985) goal projections.

C. MARKET CAPTURE POTENTIAL

Since most of the known prospective resources for electrical power generation are in the vicinity of an existing power grid, it was assumed that all of the electrical power that could be generated would be utilized. In some cases, this power would potentially be wheeled from one state to another depending on the load factors.

III. METHODOLOGY AND ASSUMPTIONS - ELECTRIC

BASELINE REGIONAL ELECTRIC POWER MARKET ESTIMATE

- MCGRAW-HILL ANNUAL ELECTRIC INDUSTRY SURVEY DATA
- MCGRAW-HILL (ELECTRICAL WORLD) FORECAST OF NEW POWER-ON-LINE THROUGH 1990
- ASSUMED LINEAR EXTRAPOLATION, 1990 TO YEAR 2020

RESOURCE POTENTIAL ESTIMATE (THIS TASK CURRENTLY IN PROCESS)

- CORRELATE POTENTIAL RESOURCE AREAS WITH REGIONAL POWER GRID SYSTEM
- COMPILE UNIVERSITY OF UTAH RESEARCH INSTITUTE RESOURCE DATA AS MADE AVAILABLE
- DEVELOP SITE-SPECIFIC RESOURCE DEVELOPMENT/PRODUCTION SCENARIOS
- ASSUME ONLY $\geq$ 200°C RESOURCES ECONOMICAL TO YEAR 2000, $\geq$ 150°C RESOURCES THEREAFTER
- DEVELOP APPROXIMATE TOTAL CAPACITY ESTIMATES FOR EACH PROMISING PROSPECTIVE RESOURCE

HYDROTHERMAL ELECTRIC POWER-ON-LINE ESTIMATE (THIS TASK TO BE INITIATED)

- ESTABLISH POSSIBLE RATES OF INDEPENDENT, AS WELL AS GOVERNMENT-ASSISTED, RESOURCE DEVELOPMENT
- NEAR-TERM (1985) GOALS INCLUDE:
  - UTAH PROSPECTS - 220 MWe (REQUIRES UTILITY COMMITMENT OF 110 MWe AT COVE FORT PROSPECT)
  - NEW MEXICO PROSPECTS - 55 MWe
  - NEVADA PROSPECTS - 55 MWe
- TENTATIVE LONG-TERM GOALS (YEAR 2000 - 2020) 9500 MWe AND 35,000 MWe, RESPECTIVELY, IN REGION

IV. RESOURCE OVERVIEW - DIRECT HEAT

Normal groundwater at shallow depth has a temperature roughly equal to the mean annual air temperature, which ranges from about 17°C to 25°C in the Rocky Mountain/Basin and Range Region. Geothermal water is groundwater which has a higher temperature than that of normal groundwater. Heating of groundwater results from contact with warm or hot rocks within the earth either by circulation to depths where the natural earth temperature is higher, or by coming near or into contact with rocks that are now cooling from a former molten state or have been heated up by natural radioactive decay. Geothermal waters range in temperature from just slightly above ~~near~~ mean annual air temperature to more than 300°C. In general hotter geothermal fluids are associated with recently molten intrusive igneous rocks whereas cooler geothermal systems. High-temperature hydrothermal systems are widespread in the Region but are far less numerous than are low- and moderate-temperature systems. This is presently interpreted to indicate that the low- and moderate-temperature geothermal waters most useful for direct heat applications form a very sizeable resource base whose exploration has hardly begun.

Warm and hot springs and shallow wells are known in each of the ten states in the Region. Low- and moderate-temperature geothermal water is known to occur at or near most of the major population centers in the Region: examples are Tucson, Phoenix, Albuquerque, Las Vegas, Reno, Provo-Salt Lake City-Ogden, Boise, and Sheridan. Because interest in geothermal resources as an energy alternative in the United States is very recent, knowledge of the ultimately available resources base is scanty. Little exploration has been done, expecially for low-and moderate-temperature resources. The U.S. Geological Survey estimates that three times the known number of intermediate-temperature hydrothermal systems may ultimately be discovered. The primary exploration effort by industry is for discovery of high-temperature resources suitable for electrical power generation, and so a vigorous federal program aimed at confirming lower temperature reservoirs is warranted.

Geothermal water, like normal groundwater, generally contains dissolved salts and gasses. The highest brine concentrations are usually found in the higher-temperature systems. Scale and corrosion problems may occur but are amenable to solution using today's technology.

IV. RESOURCE OVERVIEW - DIRECT HEAT

AVAILABILITY

- RESOURCES ARE AVAILABLE IN ALL OF THE TEN STATES
- ALMOST ALL OF THE LARGER POPULATION CENTERS IN THE REGION HAVE SOME RESOURCES IN THEIR VICINITY.
- AS THE NUMBER OF RESOURCE OCCURENCES INCREASE THE RESOURCE TEMPERATURES DECREASE.
- RESERVOIR CONFIRMATION PROGRAM REQUIRED.

QUALITY

- OFTEN POTABLE, BUT A WIDE RANGE OF SCALE/CORROSION POTENTIAL MAY BE ENCOUNTERED.
- TEMPERATURES ARE SUITED TO MANY PROCESS APPLICATIONS AND TO SPACE CONDITIONING USES.

OTHER CONSIDERATIONS

- TRANSPORT COST IS A SIGNIFICANT ECONOMIC FACTOR.
- A COMMERCIALIZATION INFRASTRUCTURE NEEDS TO BE ESTABLISHED.
- CURRENT TECHNOLOGY IS ADEQUATE FOR INITIATING COMMERCIAL USE.
- NEW TECHNOLOGIES ARE NEEDED FOR FULL MARKET PENETRATIONS.

IV. RESOURCE OVERVIEW - ELECTRIC

Electric applications of geothermal fluids require temperatures in excess of 200°C using today's technology and economics. Efforts are being made under the Raft River project to extent the temperature limit downward to 150°C. The technology could then be applied to many more resources.

Within the Rocky Mountain/Basin and Range Region, all known resources with temperatures greater than 200°C are believed to be associated with still-cooling intrusive rocks at anomalously shallow depth (1500-500 m) in the earth's crust. Such resources are generally small (10-50 sq km) in areal extent and occur in specific geologic settings. Most of the known resources, at least a portion, are federal land. The possibility of other types of high-temperature resources in the Region is good.

Within the Region, two areas have been proven to have both quality and quantity of resources needed for electrical power generation. These are Roosevelt Hot Springs, UT and Valles Caldera, NM. Numerous other excellent prospects exist, but drilling has not been intensive or extensive enough to establish a proven capacity for power generation. Due to the high cost of deep drilling in the adverse geothermal environment, ($1 million per hole is not unusual) and the large number of producing holes needed to confirm the reservoir sufficiently to interest utility companies to consider plant construction, the number of holes being drilled by industry is inadequate to ensure the electrical power the U.S. will need from geothermal resources. An aggressive program by the federal government of cost-sharing exploration and confirmation expenses is needed.

The ultimate high-temperature resource base is large--it is estimated by the U.S. Geological Survey to be five times the presently known resource base. Exploration drilling, confirmation, and reservoir engineering technologies have never been developed specifically for geothermal resources. Rather, technologies developed for the petroleum and mining industries are being applied. In some areas these technologies are not even appropriate, and in no area are they optimum. Therefore federal support for a broad range of research and technology development is strongly indicated.

IV. RESOURCE OVERVIEW - ELECTRIC

AVAILABILITY	RESOURCES MW(e) >200°C	RESOURCES MW(e) >150°C<200°C
• PROVEN	150	-
• POTENTIAL	2,250	-
• INFERRED	5,600	9,000
• UNDISCOVERED	8,000	10,000
SUBTOTAL	16,000	19,000
GRAND TOTAL		35,000

QUALITY

TOTAL DISSOLVED SOLIDS (AVG.)

≥ 200°C = 7000 PPM

150°C-200°C = 2000-4000 PPM

OTHER CONSIDERATIONS

- RESOURCES ARE PRIMARILY ON GOVERNMENT LAND.
- SPECIAL DOWNHOLE EQUIPMENT REQUIRED TO DEAL WITH FORMATION & TEMPERATURES (TECHNOLOGY UNDER DEVELOPMENT).
- EXPLORATION/DEVELOPMENT EFFORT HAS BEEN MINIMAL TO DATE. TENFOLD INCREASE REQUIRED.
- EXPLORATION AND CONFIRMATION TECHNOLOGY IMPROVEMENTS NEEDED.
- CONTINUED RESOLUTION OF INSTITUTIONAL BARRIERS IS REQUIRED.

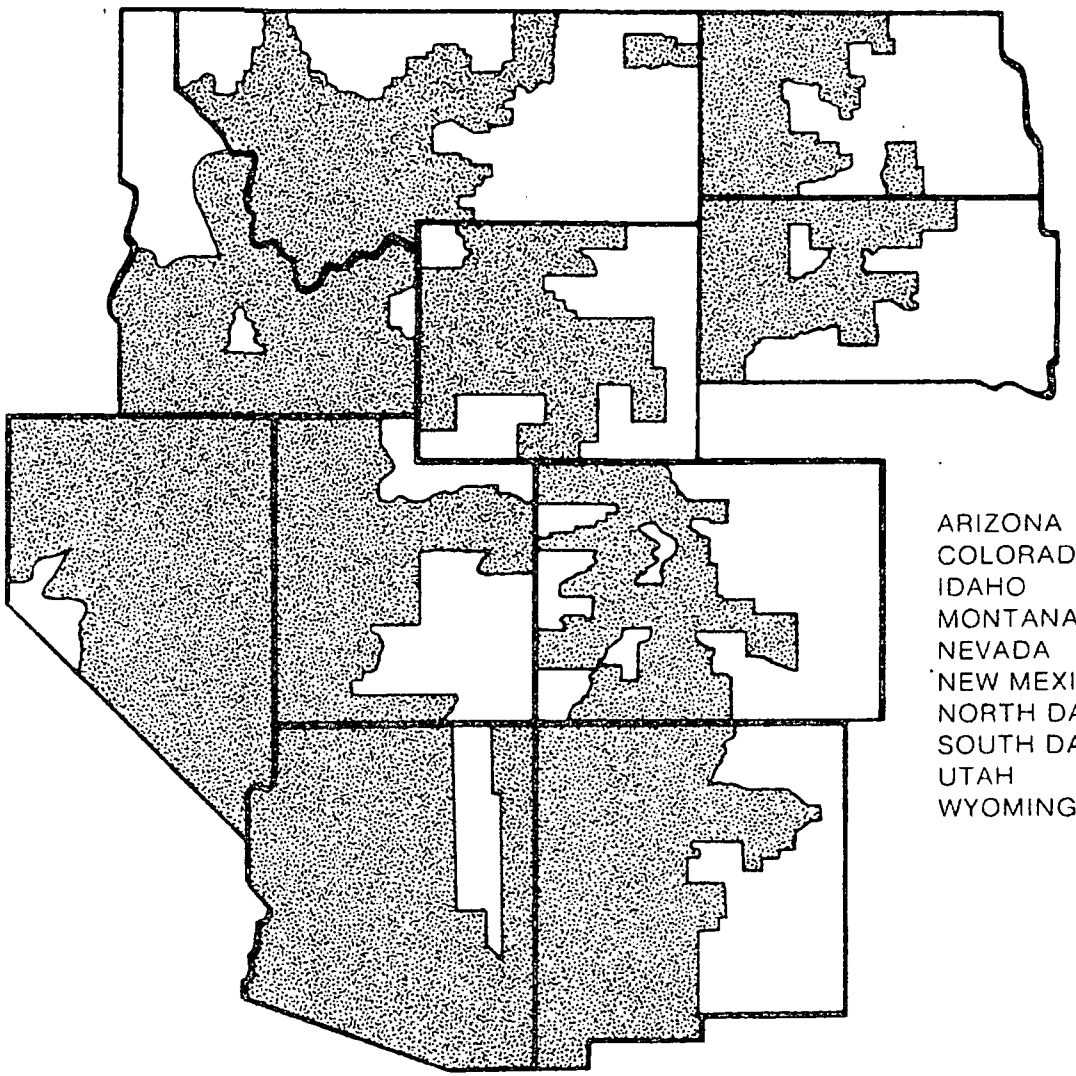
V. MARKET OVERVIEW - DIRECT HEAT

Hydrotheraml energy, in direct applications, has the potential of replacing significant amounts of fossil energy and often providing a more appropriate matching of the energy to required working temperature. The direct heat use of geothermal energy is currently being economically marketed to a number of process industries in several countries, including the United Stated, although its application in the U.S. is mainly directed to spaceheating. Industries currently being served by this energy source are pulp and paper processing, timber-drying, confectionary preparation, diatomaceous earth processing, brewing and distillation, sea weed processing, washing and drying of wool, cement curing and dairy products processing. On a world wide basis approximately 5500 $MW_{(th)}$ of geothermal energy is being utilized by direct application, while current U.S. use of this energy source is less than 50 $MW_{(th)}$.

Analysis of current energy use within the RMB&R region indicates that the prime market sectors for the direct use of geothermal energy are in space conditioning, (both cooling and space/water heating) and in low-to-moderate temperature industrial processing. Currently greater than 75% of these market sections are being served by fossil fuels, with electricity claiming the majority of the remianing sales. Energy competition projections for the RMB&R region indicate a higher dependence upon coal in the future which may encounter environmental or growth constraints. A cross matching of the hydrothermal resources, as known today and projected in the future, on a county-by-county geographical basis with the potential user sectors was defined the prime areas to be developed. This analysis reveals that all 10 states within the RMB&R region have significant amounts of resources which correlate with potential market areas and that the majority of the industrial and population centers are colocated with hydrothermal resources. The largest potential user segment is the space cooling and space/water heating segment. The current energy use for this sector is 288×10^{12} Btu/yr with a growth potential by the year 2020 of $2,504 \times 10^{12}$ Btu/yr.

V. MARKET OVERVIEW — DIRECT HEAT

COUNTIES WITH DIRECT HEAT RESOURCES CO-LOCATED WITH POTENTIAL USERS



	Number Of Counties	Counties With Resources/ User Match	Counties With Some Potential Resource/ User Match	Counties With No Known Resources
ARIZONA	14	7	6	1
COLORADO	63	17	9	37
IDAHO	44	20	11	13
MONTANA	56	20	7	29
NEVADA	17	15	0	2
NEW MEXICO	32	14	4	14
NORTH DAKOTA	53	19	1	33
SOUTH DAKOTA	67	21	7	39
UTAH	29	18	0	11
WYOMING	24	12	0	12
	399	163	45	191

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FORTY "BEST MATCH"[1] COUNTIES IN THE REGION

COUNTY	STATE	1975 INDUSTRIAL Btu/yr x 10^{12}	1975 RESIDENTIAL/ COMMERCIAL Btu/yr x 10^{12}	1975 TOTAL POTENTIAL GEOTHERMAL Btu/yr x 10^{12}
MARICOPA	ARIZONA	.98	17.12	47.02
SALT LAKE	UTAH	8.50	20.80	29.30
CLARK	NEVADA	13.95	3.75	17.70
UTAH	UTAH	2.13	11.00	13.13
PIMA	ARIZONA	10.15	2.57	12.72
WEBER	UTAH	3.34	9.20	12.54
BERNALILLO	NEW MEXICO	10.80	1.63	12.43
BOULDER	COLORADO	8.60	3.48	12.08
DAVIS	UTAH	.68	10.90	11.58
WASHOE	NEVADA	9.20	1.78	10.98
ADA	IDAHO	9.00	.56	9.56
BONNEVILLE	IDAHO	2.80	3.97	6.77
CASSIA	IDAHO	.60	5.30	5.90
CANYON	IDAHO	.25	5.64	5.89
NATRONA	WYOMING	.14	5.55	5.69
TWIN FALLS	IDAHO	1.80	3.35	5.15
PENNINGTON	SOUTH DAKOTA	1.04	4.10	5.14
CACHE	UTAH	1.94	2.90	4.84
MINIDOKA	IDAHO	.45	3.73	4.18
WARD	NORTH DAKOTA	.25	3.52	3.77
BANNOCK	IDAHO	3.20	.43	3.63
BINGHAM	IDAHO	1.40	2.09	3.49

FORTY "BEST MATCH"[1] COUNTIES IN THE REGION (cont'd)

COUNTY	STATE	1975 INDUSTRIAL Btu/yr x 10^{12}	1975 RESIDENTIAL/ COMMERCIAL Btu/yr x 10^{12}	1975 TOTAL POTENTIAL GEOTHERMAL Btu/yr x 10^{12}
MISSOULA	MONTANA	3.10	.31	3.41
BIGHORN	WYOMING	2.25	2.76	2.76
LEWIS & CLARK	MONTANA	.34	2.74	2.74
SAN PETE	UTAH	.69	2.56	2.56
FREMONT	WYOMING	2.25	2.34	2.34
DONA ANA	NEW MEXICO	.33	2.08	2.08
CARBON	WYOMING	2.00	2.05	2.05
SANTA FE	NEW MEXICO	.20	1.95	1.95
POWER	IDAHO	1.46	1.76	1.76
WILLIAMS	NORTH DAKOTA	1.49	1.66	1.66
LINCOLN	WYOMING	1.48	1.66	1.66
STARK	NORTH DAKOTA	1.48	1.60	1.60
JEFFERSON	IDAHO	1.30	1.48	1.48
COCONINO	ARIZONA	.28	1.26	1.26
HUGHES	SOUTH DAKOTA	.90	1.22	1.22
FREMONT	COLORADO	.12	1.12	1.12
CONVERSE	WYOMING	.99	1.07	1.07
LAPLATA	COLORADO	.16	1.04	1.04

(1) Best match of user and hydrothermal resources, based upon colocation, suitable resource temperatures and quantity of energy replaceable by hydrothermal direct heat use in the county.

IV. MARKET OVERVIEW - DIRECT HEAT

Many of the major industrial energy consumers in the region can use low-to-moderate heat sources to meet a portion if not all of their energy needs. These industries include food and kindred products processing, wood and lumber products, mining and minerals, chemical processing and the concrete industry. The energy supply requirements for these elements of the industrial sector are some what smaller than the energy needs for residential/commercial space conditioning, but the region's growth potential is excellent and it appears that penetration can more readily be made in the industrial sector. Current energy use in the low-to-moderate heat processing sector which can be served by hydrothermal energy is 74 x 10^{12} Btu/yr with a growth pattern of 177 x 10^{12} Btu/yr by 1985, 480 x 10^{12} Btu/yr by 2000 and 1,476 x 10^{12} Btu/yr by the year 2020.

From the foregoing considerations it can reasonably be observed that substantial long-term markets for hydrothermal energy exist in the RMB&R region; that commonly found coincidence of resource occurrance with user locations promise favorable economics in competition with other energy supplies; and that hydrothermal energy can, with appropriate stimulation and encouragement, be a near-term partial solution to the regions's energy needs. The principal barrier to the rapid transition to hydrothermal energy application is that the present market place lacks the infrastructure necessary to develop and deliver hydrothermal energy to the user sectors.

V. MARKET OVERVIEW - DIRECT HEAT

TOP 20 INDUSTRIAL PROCESS HEAT APPLICATIONS DIRECTLY MATCHED[1] FOR GEOTHERMAL ENERGY REPLACEMENT IN THE ROCKY MOUNTAIN BASIN & RANGE REGION ($\times 10^{12}$ BTU/YR)*

INDUSTRY	MATCHED 1975 ENERGY USE[2]	INDUSTRY	MATCHED 1975 ENERGY USE[2]
DEHYDRATED FRUITS & VEGETABLES	11.80	INORGANIC CHEMICALS	1.06
CONCRETE BLOCK	7.10	READY-MIX CONCRETE	.98
FROZEN FRUITS & VEGETABLES	5.24	GYPSUM	.97
POULTRY DRESSING	4.82	CANNED FRUITS & VEGETABLES	.97
MEAT PACKING	4.45	BEET SUGAR	.82
PREPARED FEEDS	3.65	TREATED MINERALS	.69
PLASTIC MATERIALS	3.63	COTTON SEED OIL MILLS	.34
DAIRY INDUSTRY	3.24	PREPARED MEATS	.34
SOFT DRINKS	2.91	PHARMACEUTICALS	.25
SOAPS	1.24	FURNITURE	.21

(1) INDUSTRIES MATCHED BY COLOCATION WITH RESOURCES AND COMPATIBLE PROCESS TEMPERATURES IN THOSE COUNTIES HAVING HYDROTHERMAL RESOURCES.

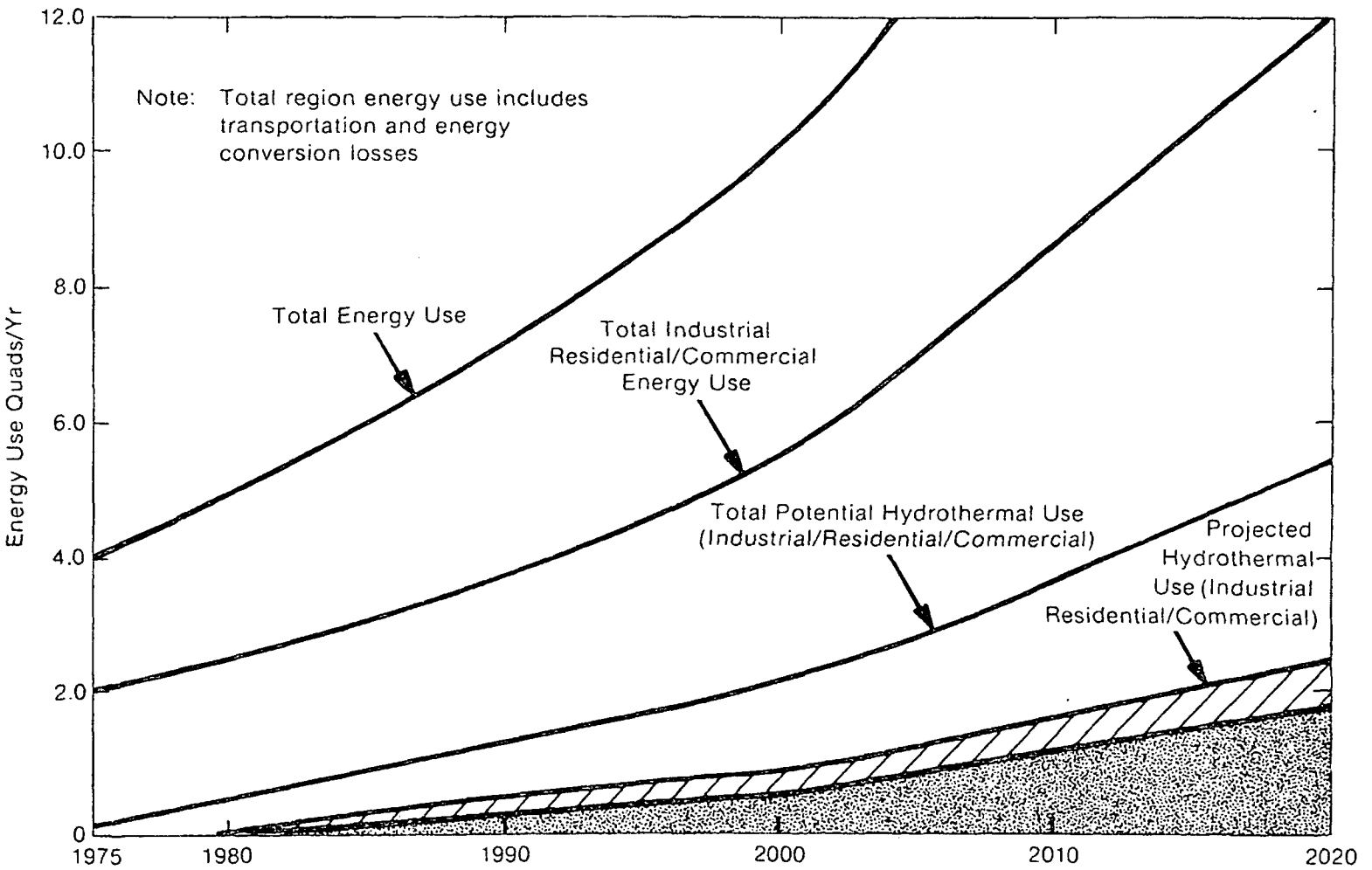
(2) REGIONAL CONSUMPTION OF DIRECT HEAT ENERGY IN 1975 REPLACEABLE BY HYDROTHERMAL ENERGY FROM COLOCATED AND TEMPERATURE-MATCHED RESOURCES.

V. MARKET OVERVIEW - DIRECT HEAT

Market growth projections for hydrothermal energy in the RMB&R region present an attractive profile. From the illustration on Page 24, it is evident that a substantial protion of the region's energy needs could be satisfied by hydrothermal energy, as shown by the potential Hydrothermal use Market Curve. Competition from conventional energy sources, as well as other alternative energy types (solar, biomass, etc.), result in choosing conservative market penetration objectives as shown by the estimated penetration (bottom) curve.

Resource uncertainty, lack of proven economics, and absence of an established infrastructure, as well as general reluctance to accept an unfamiliar resource, are factors which are expected to minimize significant market penetration until post-1985. These factors are among those which will receive major DOE emphasis in the commercialization program.

ENERGY CONSUMPTION PROJECTIONS FOR THE RMB&R REGION



V. HYDROTHERMAL MARKET OVERVIEW - ELECTRIC

The electrical energy produced in the RMB&R region in 1975 was approximately 1.1×10^8 MWh, of which about 0.2×10^8 MWh was exported. Average per customer residential use was 8700 kWh in 1977, showing an annual increase of approximately 3%. Industrial consumption data shows a similar per capita increase. This coupled with a 4% regional overall growth rate results in a net annual demand increase in the region of about 7%. Industrial users in the region consumed approximately 0.3×10^8 MWh of electricity in 1975, while the residential/commercial sector electrical consumption amounted to about 0.8×10^8 MWh, for a total of 0.9×10^8 MWh.

Electric utility capital spending in the region exceed $1.8 billion in 1977, and is predicted to be greater than $2.2 billion in 1978, for generation, transmission, distribution, and miscellaneous purposes. In early 1978, there were 158 utilities operating a total of 396 generating plants in the region. Hydro, fossil steam, gas turbine and diesel (no nuclear) plants, were operational with an installed capacity of approximately 35,000 MW. Ownership of these plants included investor-owned, municipal, state and PPDs, cooperatives, and federal agencies. A breakdown of electric capacity or sales by ownership is not directly at hand, but will be developed in continuing studies.

VI. MARKET OVERVIEW — ELECTRIC

CURRENT INSTALLED CAPACITIES WITHIN THE REGION

- Investor Owned Companies
- Municipal & State Agencies
- Cooperatives
- Federal Agencies (BPA, etc.)

UTILITIES	PLANTS	MWe
Hydropower	166	9,349
Fossil Fuels	231	26,067
Nuclear	0	0
158 Total Utility Companies	397	35,416

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IV MARKET OVERVIEW - ELECTRIC

The regional goal for the year 2020 is 35,000 $MW_{(e)}$, (2.9 Quads/yr) which is approximately 30% the region's projected requirements (45% of additional generating capacity). This goal is dependent upon reservoir confirmation of prospective resources and the technology development for the economic utilization of resources as low as 150°C.

There are three confirmed reservoirs and an excellent prospect, located in the RMB&R region, which are within the current economic electric production temperature range. Concensus is that there is high confidence that state-of-the-art technology allows for economic use of hydrothermal resources to temperatures approaching 200°C. It is currently expected that such resources can meet the regional goal of 300 $MW_{(e)}$ on line by 1985.

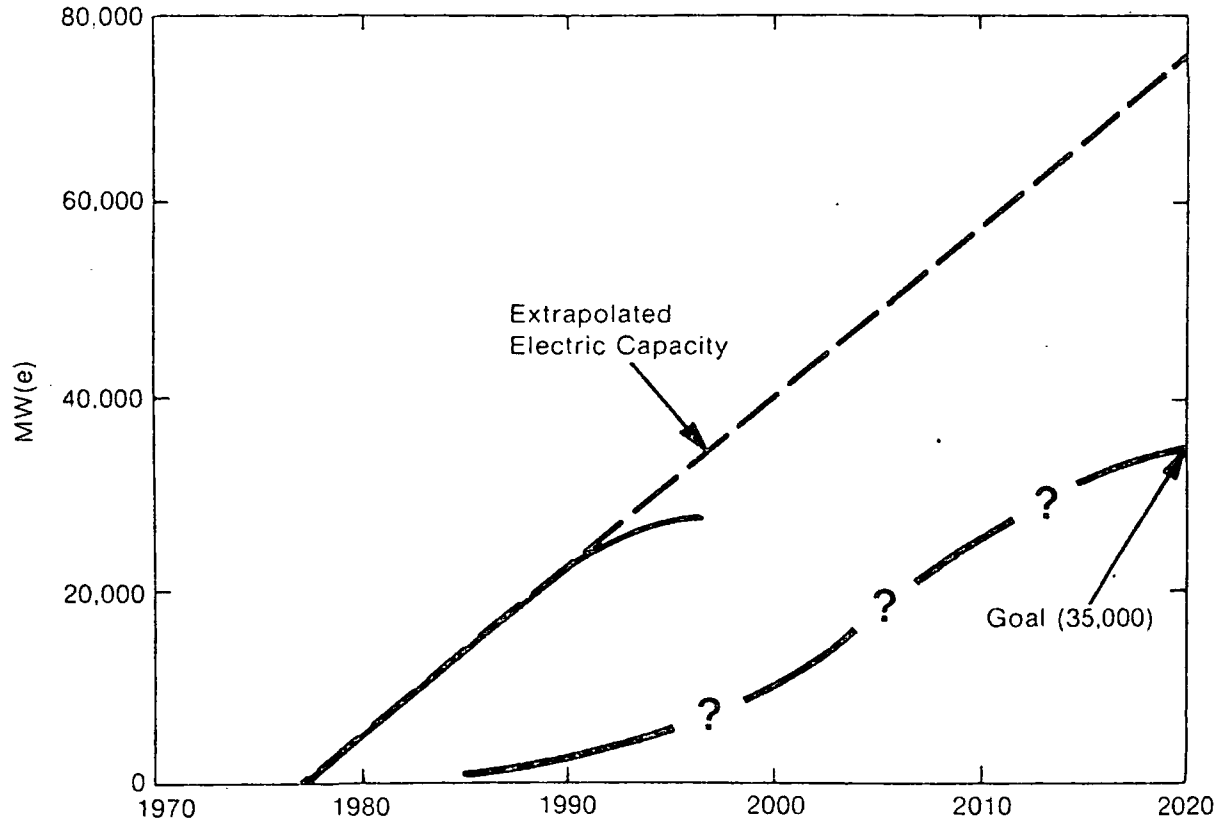
The tentative mid-term (year 2000) goal is to achieve 9,500 $MW_{(e)}$ on line. This is based upon the asumption that 8,000 $MW_{(e)}$ can be derived from presently know or inferred resources, and 1,500 $MW_{(e)}$ are obtained from presently unconfirmed resources. This goal will require three areas of major DOE involvement. These are: exploration for new high-grade resources, technology development for economical electrical energy recovery from intermediate-moderate temperature resources, well stimulation development and a continuation of incentives and barrier removals to simulate strong growth. In effect, the DOE program to meet intermediate goals is a continuation and expansion of work already underway, supported by the experience, economic findings, and industry acceptance inherent in achieving the near term (1935) goals.

The principal assumption concerning the long term (year 2020) goal is that the econmic reservoir temperature can be lowered to 150°C. This achievement opens the extensive moderate temperature hydrothermal resources to exploitation. Two factors support this possibility. The energy cost spiral will continue to move the economic cross-over point to higher and higher values, allowing cooler (as well as deeper) reservoirs to compete, and very major technology advancements can be anticipated by that time frame.

VI. MARKET OVERVIEW — ELECTRIC

PROJECTED ELECTRIC DEMAND AND POTENTIAL MARKET PENETRATION

• ELECTRICAL WORLD (SEPT. 15, 1977)



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V. MARKET OVERVIEW - ELECTRIC

There is proven potential for hydrothermal electric power production in the RMB&R region. While only a limited number of KGRAs show temperatures of 200°C or higher needed for today's technology, planned future ability to utilize economically reservoirs with temperatures as low as 150°C will provide a major increase in electric power potential.

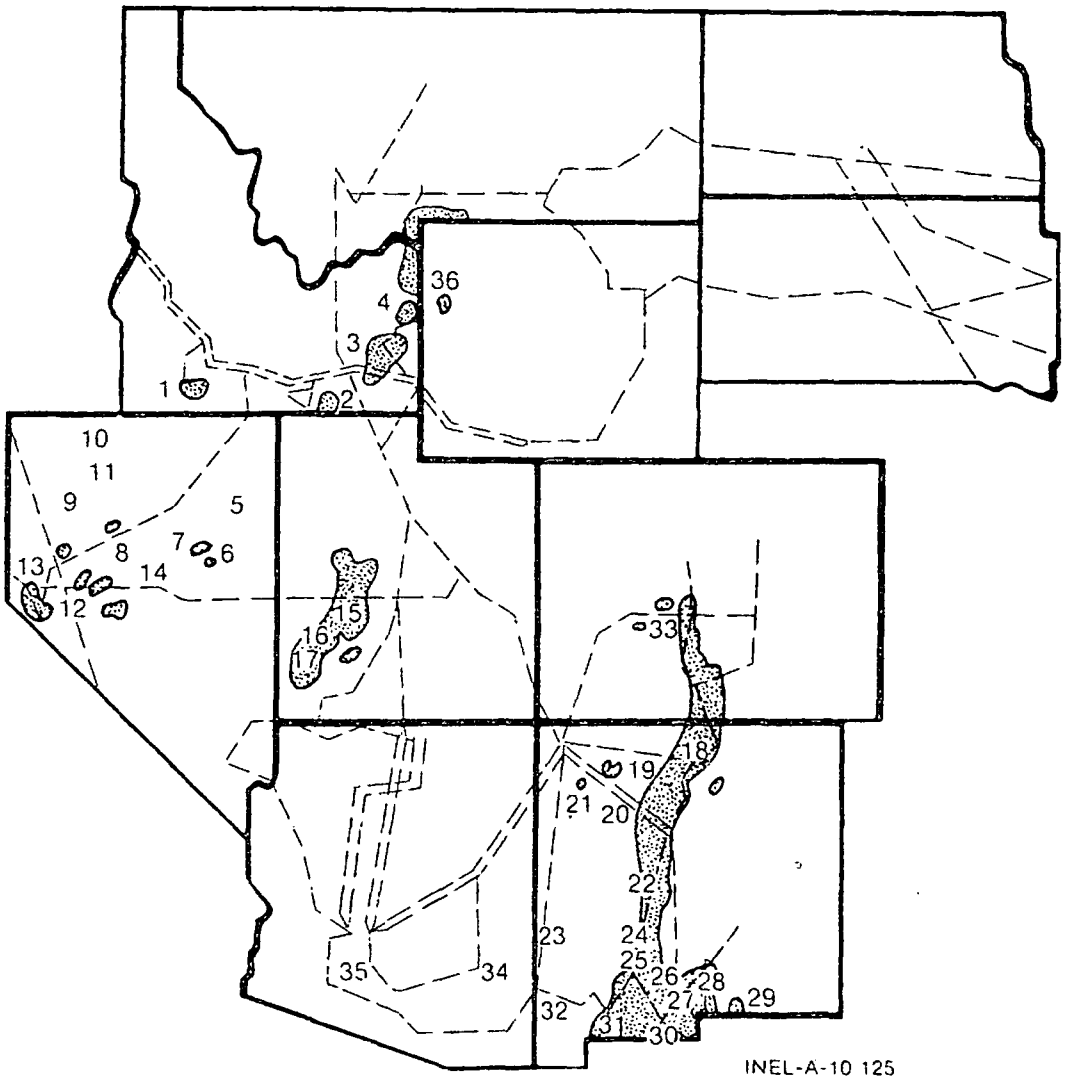
The regional map shows the location of a number of reservoirs possibly having electric generation potential, with an overlay of the existing electric power grid of the region. In general, a good colocation of the power grid with reservoirs is found, although in some instances grid transmission capacity may be insufficient. However, existence of the power line right-of-ways is a significant advantage, and grid capacity can be upgraded, if necessary, to accommodate the resource output.

Among the specific factors that require consideration for DOE support to foster accelerated resource development are:

- Reservoir confirmation programs
- Industry-coupled well stimulation programs
- Financial incentives such as loan guaranty, equitable taxation, and reservoir insurance
- Simplified and faster leasing, siting, permitting, and licensing practices
- Development of approved codes and standards
- Promotion and public education programs
- Continued development of other incentives and barrier removal actions.

MAJOR POWER LINES AND PROSPECTIVE POWER PRODUCTION RESOURCES[1]

1. Bruneau-Grandview
2. Raft River
3. East Snake River Plain
4. Island Park
5. Ruby Valley
6. Beowawe
7. Leach Hot Springs
8. Humbolt House
9. Double Hot Springs, Gerlach/Fly Ranch
10. Baltazor
11. Pinto Hot Springs
12. Brady Hazen/Desert Peak & Stillwater/Soda Lake
13. Steamboat Springs
14. Dixie Valley
15. Cove Fort/Sulphurdale
16. Roosevelt Hot Springs
17. Thermo Hot Springs, Newcastle
18. Mamby's Hot Spring
19. Valles Caldera, Baca Location No. 1
20. Guadalupe Area, Jemez Reservoir
21. Prewitt Area
22. North of Socorro
23. Lower Frisco Hot Springs
24. Derry Spring
25. Radium Spring
26. San Diego Mountain
27. Mesquite-Berino, Las Alturas
28. White Sands (Town)
29. Southern Tulsarosa Basin
30. Kilbourne Hole
31. Columbus Area
32. Lightning Dock, Lordsburg
33. Poncha, Mt. Princeton, Valley View Hot Springs
34. Clifton/Gillard
35. Chandler
36. Huckleberry Hot Springs, Auburn Hot Springs



(1) 150°C and above prospective resources.

VII. MARKET PENETRATION OBJECTIVES AND REGIONAL GOALS

The hydrothermal market penetration objectives include both electric power generation as well as direct heat applications. A survey of the region's electric power generation and energy consumption profiles together with growth projections through the year 2020 has verified a major potential for hydrothermal energy application. Aggressive, but achievable, goals have been chosen for guidance in the future development and justification of commercialization implementation plans. The goals assume a maximum of 25% retrofit, and 70% and 80% capture, respectively, of residential/commercial and industrial growth in the specifically applicable markets. The electric power goals represent reasonable fractions of the projected new power-on-line, but require resource verification to assure that they can be achieved.

Specifically, it is necessary to establish an additional 150 MW of high grade (>200°C) proven reserves by 1980, since probable output of the Roosevelt prospect and Valles Caldera will be only about 150 MW by 1985. The year 2000 goal assumes commercialing 8000 MW of proven potential, and inferred resources, as well as 1500 MW of high grade resources yet to be discovered. Beyond the year 2000, it is assumed that technology developed during the 1980's, and brought to commercial status during the 1990's, will allow economic exploitation of reservoirs with temperatures as low as 150°C.

In developing the megawatt equivalency of direct heat, it was roughly approximated that 1 MW of hydrothermal energy on-line equals 5100 barrels of oil per year for direct heat applications, and 14,200 barrels of oil per year for electric generation applications. On this basis, achievement of the 1985 goals would reduce fossil fuel demand by the equivalent of over 100,000 barrels of oil per day, while the 2020 goals would save over 2,500,000 barrels per day!

VII. REGIONAL MARKET PENETRATION GOALS

Hydrothermal Energy Application	Present Hydrothermal Use	Hydrothermal Energy Goals 1985	2000	2020
Electric Generation (MWe)	— 0 —	300 (1)	9,500 (2)	35,000 (3)
Direct Heat Uses, Quads (Megawatts Equivalent)	<0.001 (< 25)	0.2 (≈8000)	1.0 (≈25,000)	2.5 (≈67,000)
ENERGY EQUIVALENTS				
Electric Generation (4) (Equivalent Fossil Fuel Energy, Quads per Year)	— 0 —	0.03	0.8	2.9
Direct Heat Uses (Expressed directly in Quads per Year)	<0.001	0.2	1.0	2.5
Total Equivalent Energy, Quads/yr (5)	<0.001	0.23	1.8	5.4
Barrels of Oil Equivalent	$< 1 \times 10^6$/yr	40×10^6/yr	304×10^6/yr	910×10^6/yr

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(1) Assuming additional 150 MW of proven reserves established by 1980.

(2) Assuming commercialization of 8000 MW of proven, potential and inferred resources and 1500 MW of high grade undiscovered resources.

(3) Assuming the economically competitive reservoir temperature is lowered to 150°C.

(4) 35% cycle efficiency applied to obtain fossil fuel equivalents for electric power generation.

(5) A quad is a unit of energy defined as 10^{15} BTU's or 1 quadrillion BTU's.

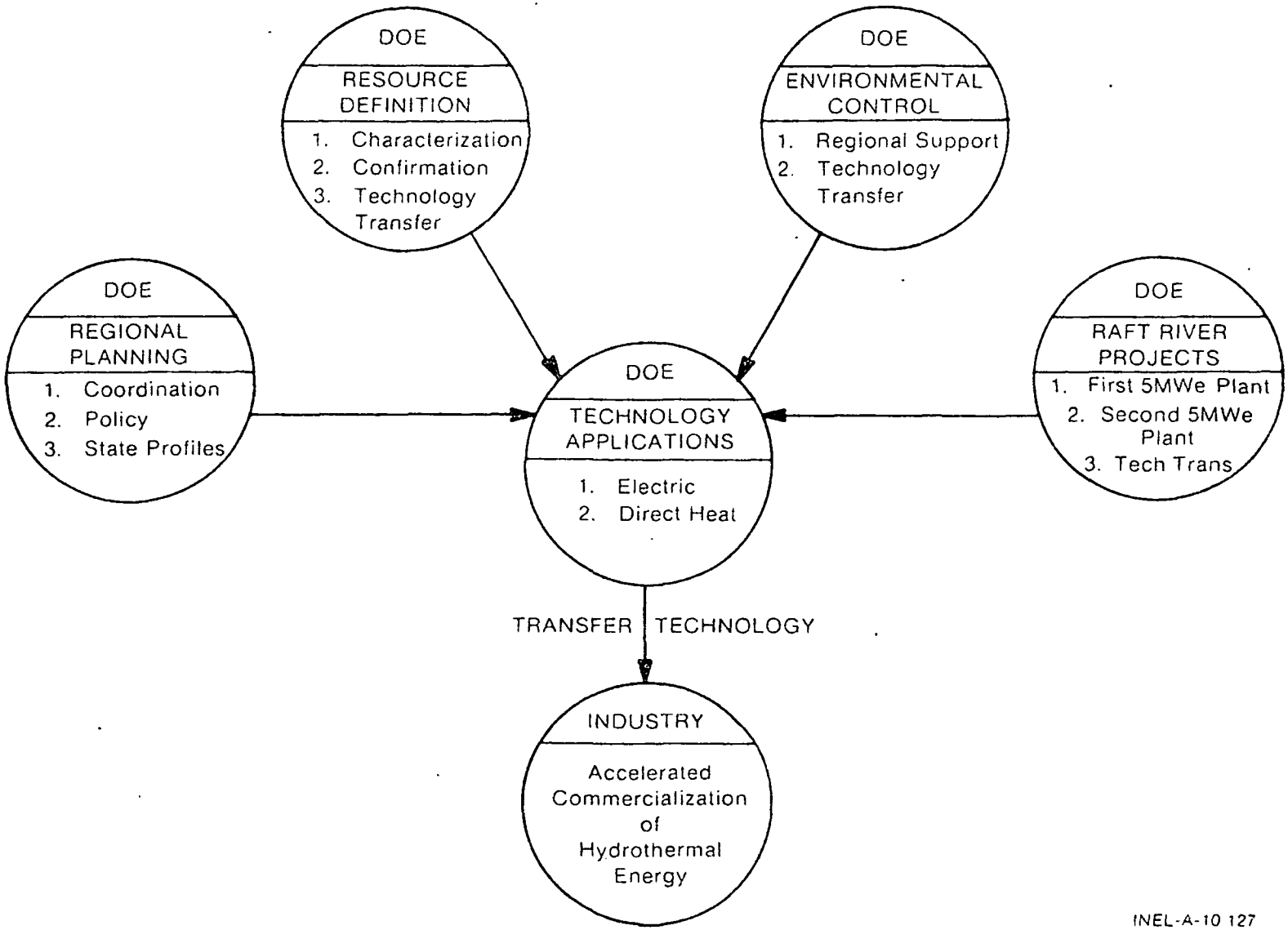
II. REGIONAL PROGRAM SUMMARY

Five essential components of the DOE program are required to fully penetrate the hydrothermal energy market. Four elements of the DOE program (Regional Planning, Resource Definition, Environmental Control and Raft River Projects) lead to support the Electric and Direct Heat Applications and Transfer of Technology to Industry. The DOE program elements are designed to stimulate the market by minimizing the risks that investors will face in utilizing hydrothermal energy. The five essential DOE program elements are detailed in the commercialization plan and summarized as follows:

Regional Planning -
- ° Analysis of economic, environmental, institutional, legal and technological factors effecting commercialization.
- ° Identification of federal initiatives required.
- ° Preparation of state development profiles.
- ° Preparation and implementation of educational programs for state, industry and other related parties.

Resource Definition -
- ° Industry coupled case study program (shared costs).
- ° Disseminate resource data to industry.
- ° Assess low and moderate temperature resources.
- ° Produce state by state resource maps.
- ° Initiate heat-flow and lava flow mapping.

VIII. REGIONAL PROGRAM SUMMARY



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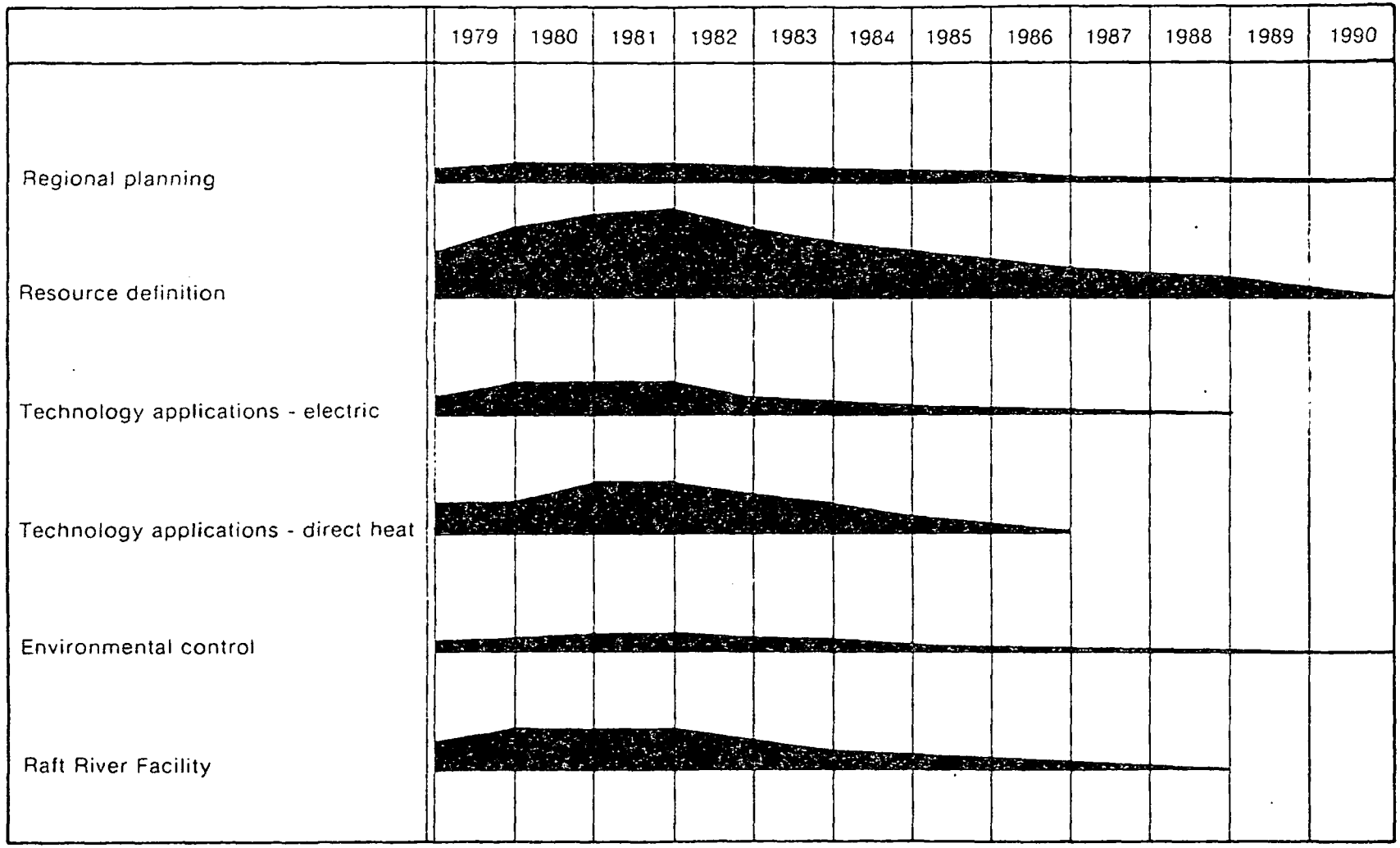
VIII. REGIONAL PROGRAM SUMMARY

Technology Applications -
- ° Encourage direct heat use through support of direct heat cost shared demonstrations.
- ° The production of electricity from high-grade reservoirs in the region.
- ° Develop and pursue new catalytic initiatives to bring together resource developers, utilities and in some cases an intermediate risk-taker.
- ° Incorporate well stimulation technique developments into the Regional
- ° Commercialization Program through the Industry-Coupled Well Stimulation Program.

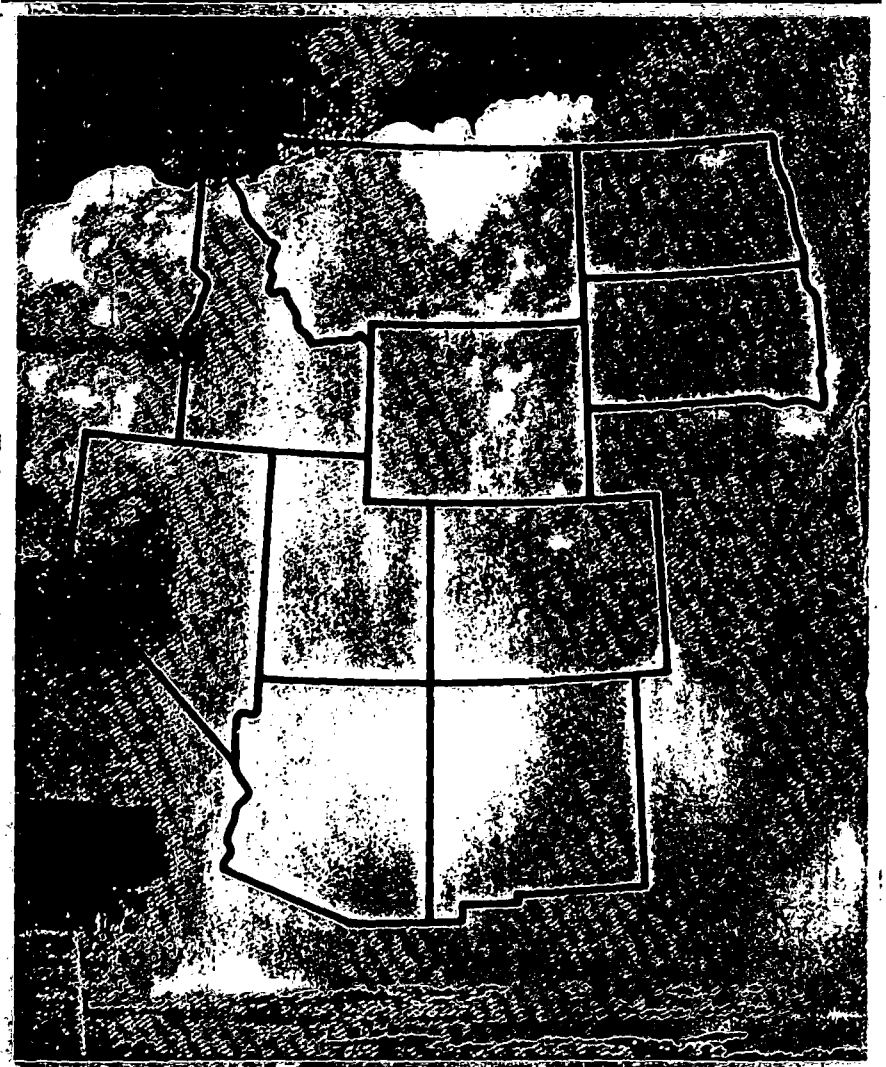
Environmental Control -
- ° Provide support to environmental impact assessment/environmental impact statement preparation, PON/PRDA reviews, and institutional activities.
- ° Gather subregional environmental data and perform site-specific monitoring
- ° Prepare preplans for gathering baseline environmental data as needed for preparation of EIA/EIS documents.

Raft River Facility. -
- ° Test the economics of utilizing moderate temperature (150°C) reservoirs.
- ° Construct and evaluate the first 5 MW thermal loop with conventional hardware.
- ° Construct and evaluate a second 5 MW thermal loop with advanced systems hardware.
- ° Compare economics of first and second thermal loop systems.
- ° Utilize the facility as a showcase for technology transfer for electric and direct heat applications.
- ° Evaluate direct applications of moderate temperature resources (low temperature drying, low temperature processing and beneficial uses of geothermal fluids).
- ° Invite industry to participate and review results of experiments.

VIII. REGIONAL PROGRAM SUMMARY



Department of Energy



EG&G Idaho, Inc.

Earth Science Laboratory
UURI

DRAFT

REGIONAL HYDROTHERMAL MARKET PENETRATION ANALYSIS

OCTOBER 31, 1978

ROCKY MOUNTAIN BASIN
AND RANGE REGION

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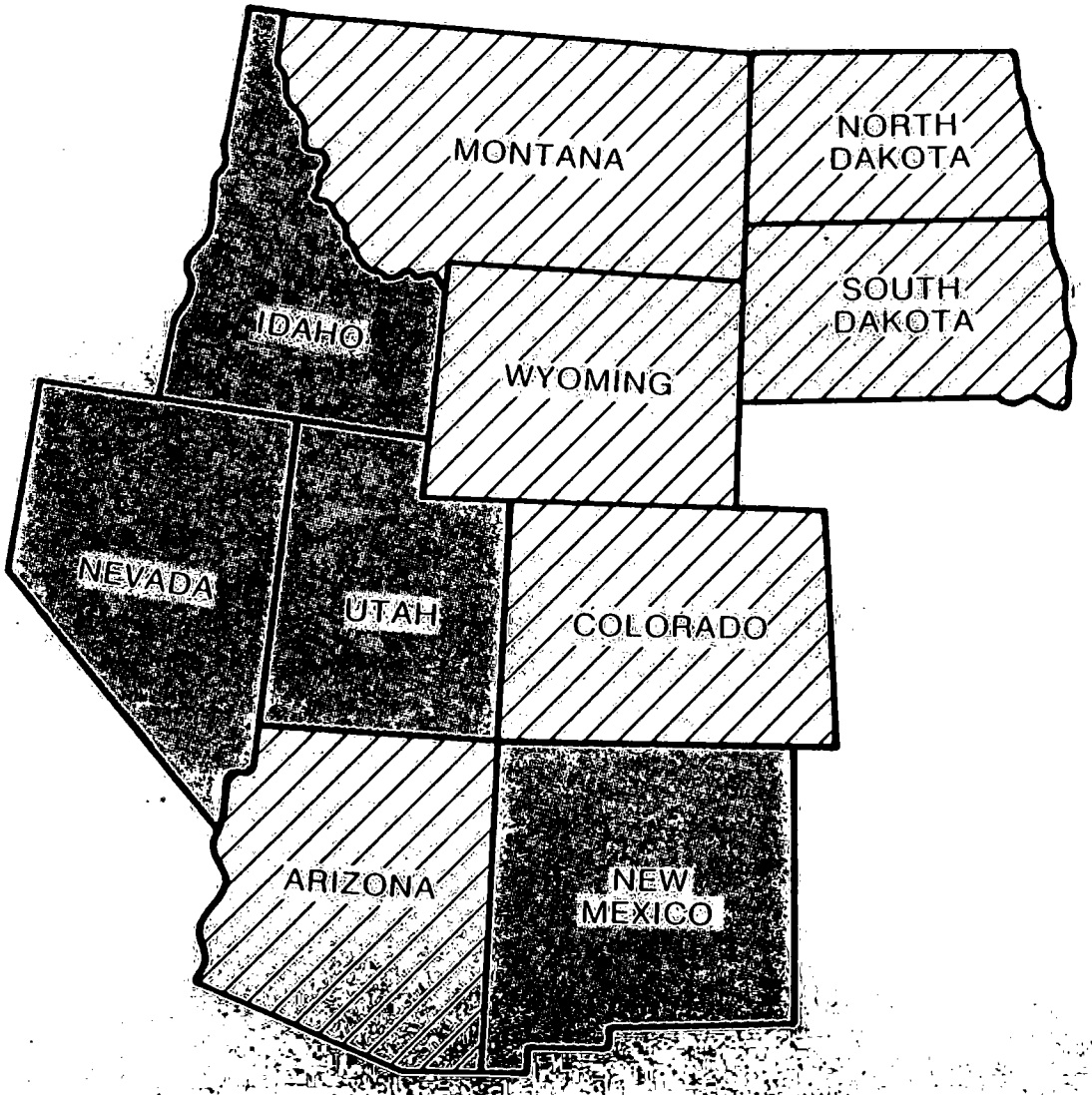
STATES IN THE RMB&R REGION



STATES WITH DIRECT HEAT RESOURCES MATCHED WITH POTENTIAL USERS

STATES WITH DIRECT HEAT AND HIGH TEMPERATURE ($\geq 200°C$) PROVEN, POTENTIAL, OR INFERRED ELECTRIC GENERATION RESOURCES MATCHED WITH POTENTIAL USERS

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I. EXECUTIVE SUMMARY

DIRECT HEAT APPLICATIONS

- ALL 10 STATES HAVE POTENTIALLY ECONOMICAL HYDROTHERMAL RESOURCES.
- MOST INDUSTRIAL AND POPULATION CONCENTRATIONS ARE COLOCATED WITH HYDROTHERMAL RESOURCES.
- CURRENT HYDROTHERMAL MARKET POTENTIAL WITHIN THE REGION FOR DIRECT HEAT APPLICATIONS IS APPROXIMATELY 0.4 QUAD. MARKET POTENTIAL FOR DIRECT HEAT WILL BE APPROXIMATELY 5-6 QUADS BY THE YEAR 2020.
- ESTIMATED POTENTIAL MARKET CAPTURE BY HYDROTHERMAL ENERGY IS 0.2 QUAD IN 1985, INCREASING TO 2.5 QUADS IN THE YEAR 2020.
- THE MAJOR DIRECT HEAT MARKETS ARE CURRENTLY RESIDENTIAL/COMMERCIAL, SPACE CONDITIONING AND INDUSTRIAL PROCESS HEAT APPLICATIONS. THE INDUSTRIAL MARKET SECTOR HAS THE GREATER POTENTIAL FOR NEAR-TERM PENETRATION.
- A MAJOR BARRIER TO DIRECT HEAT MARKET PENETRATION IS LACK OF AN INFRASTRUCTURE, EARLY FORMATION OF WHICH IS A PRINCIPAL PROGRAM GOAL.

I. EXECUTIVE SUMMARY

ELECTRIC APPLICATIONS

- MORE THAN 25% OF THE ADDITIONAL ELECTRICAL ENERGY REQUIRED IN THE REGION BY THE YEAR 2000 COULD BE SUPPLIED FROM HYDROTHERMAL RESOURCES.

- ADVANCED TECHNOLOGY FOR UTILIZATION OF 150°C RESOURCE FOR ELECTRIC POWER GENERATION MUST BE AVAILABLE BY THE LATE 1980'S TO PROVIDE A SUBSTANTIAL PORTION OF THE REGIONAL NEEDS BEYOND THE YEAR 2000.

- RESOURCES SUITABLE FOR ELECTRIC POWER GENERATION APPEAR TO BE ABUNDANT IN THE REGION, BUT A MAJOR NEAR-TERM RESERVOIR CONFIRMATION EFFORT IS REQUIRED TO ALLOW SUBSTANTIAL COMMERCIAL DEVELOPMENT BY THE YEAR 2000.

- ELECTRIC POWER GRID SYSTEMS ARE COLOCATED WITH POTENTIAL HYDROTHERMAL SITES, BUT SOME UPGRADING MAY BE REQUIRED.

II. INTRODUCTION

Outlined herein are the results of a survey of the potential applications of hydrothermal energy in the RMB&R region of the United States. The DOE goal is to foster accelerated commercialization of the substantial hydrothermal resources of the region. This document provides a summary of the market analysis and is intended to serve as a guide in the future preperation of the comprehensive DOE Implementation Plan to accomplish the desired commercialization.

A major portion of this survey has been devoted to estimating the size of the current as well as potential future markets. While current use of the region's hydrothermal resources is limited, there are in fact numerous established process industries in the region which can use hydrothermal energy for process heat. In addition the region's residential and commercial sectors are fortunately largely co-located with hydrothermal resources. This provides a major opportunity for space conditioning and water heating applications. In addition, several known potential resources in the region provide reservoir temperatures suited to electric power generation with today's technology.

The current state-of-the art is adequate to undertake design of installations with assurance that necessary reliability, safety, cost and environmental considerations can be met. In addition, hydrothermal energy is expected to be economically competitive and relatively benign environmentally. Achievment of substantial commercialization of the region's abundant and widespread hydrothermal resources will allow reduced dependence on fossil fuels and provide the region with an enhanced economic base.

A comprehensive program has been outlined. Detailed planning is continuing, by which DOE commercialization objectives will be achieved. Regional planning will continue to include program coordination, policy development, and state profile development to provide an element for formation of a strong hydrothermal energy commercialization infrastructure.

Resource definition is likewise a major aspect of the program.

Technology applications for both electric and direct heat options are also important program elements required to penetrate the commercial market. Barrier mitigation, power plant development incentives, various direct heat field projects, and timely technology transfer are required.

Environmental control regional support and technology transfer will continue to assure that commercialization is accomplished in an environmentally acceptable manner.

Finally, rounding out the program is the on-going work at the Raft River Facility. From this facility it is intended to demonstrate economical power production from 150°C reservoir temperatures, corrosion/scaling prevention, and similar technologies for industrial use.

The potential markets considered in the survey include both the projected growth of markets currently implaced, as well as new industries which would be expected to be attracted to the region by the availibility of a stable energy supply. However, regional industrial growth, as well as associated residential/commercial development, must also consider legal, regulatory, environmental and financial aspects, as well as other related factors. Such factors have not yet been fully evaluated for the region. Detailed consideration of these factors remains a major necessary activity yet to be accomplished to carry out the overall commercialization planning for the region. This document will require periodic updating as state profiles are developed by state operational teams, potential users are further defined and as scenarios for electric power generation become available.

The methodology and assumptions used for this analysis are presented in Section III.

III. METHODOLOGY AND ASSUMPTIONS - DIRECT HEAT

A. BASELINE MARKET SIZE DEVELOPMENT

The region's hydrothermal resources, as defined by the University of Utah Research Institute, were mapped in each of the ten states. Next, the counties overlying the resource areas were identified. Each of these counties was reviewed to identify the industries that operate processes having potential for hydrothermal energy use. The potential was established by reviewing the listing of Standard Industrial Classification (S.I.C.) industries and selecting those S.I.C. categories having processes operating in the temperature range of 40°C to 260°C. County level data on the number of employees for each industry was multiplied by an energy intensity coefficient (millions of Btu per year per employee) developed by a Rocket Research Inc. study to establish energy consumption by those industries having processes compatible with hydrothermal energy. This latter value was multiplied by a selected factor for each S.I.C. category to exempt such energy consumptions as product sizing, packaging, handling, transportation, etc. While this factor is based mainly on engineering judgment, several cases were correlated with data developed in a solar energy application study performed for DOE by Intertechnology Corporation, and found to be generally consistent.

Since the Rocket Research Inc. "energy intensity coefficient" did not consider waste heat, a simplifying assumption of a 50% cycle efficiency was applied to all processes, in effect increasing their total energy consumption by a factor of two. Energy use and employment data were available for the time span of 1972 to 1975. For this survey, a further simplifying (and conservative) assumption is made that all data would be assumed to be representative of 1975 data. The 1975 data were set as the base year for growth projections.

An additional factor is necessary to account for counties showing surface manifestations of potential hydrothermal resources, but not fully evaluated on an industry by industry basis. This

III. METHODOLOGY AND ASSUMPTIONS - DIRECT HEAT

BASELINE (1975) MARKET ESTIMATE

- CONSIDERED ONLY COUNTIES COLOCATED WITH HYDROTHERMAL RESOURCES.
- ESTABLISHED INDUSTRIAL ENERGY USE IN 40℃ TO 260℃ RANGE (PROCESS HEAT).
- ESTABLISHED RESIDENTIAL/COMMERCIAL ENERGY USE FOR ONLY SPACE CONDITIONING AND WATER HEATING PURPOSES.

MARKET GROWTH FORECASTS

- APPLIED NATIONAL INDUSTRIAL GROWTH RATES BY SIC CATEGORY.
- ASSUMED 3% ANNUAL INCREASE PER CAPITA CONSUMPTION.
- ASSUMED 5% ANNUAL NEW INDUSTRY SPIN-OFF WITHIN THE REGION, 1985 AND BEYOND.
- ASSUMED 4% PER YEAR REGIONAL POPULATION GROWTH (1.4 X NATIONAL AVERAGE).
- APPLIED FACTORS FOR POTENTIAL NEW DISCOVERIES BY THE YEAR 2000 AND BEYOND.
- APPLIED FACTORS FOR NEW INDUSTRIES RELOCATED TO THE REGION.

MARKET CAPTURE ESTIMATE ASSUMPTIONS

- 1% PER YEAR, BASELINE MARKET RETROFIT, 1980 AND BEYOND, TO 25% MAXIMUM RETROFIT.
- LINEAR INCREASE IN PERCENT CAPTURE OF NEW GROWTH MARKET, 1980 TO 1985.
- 80% OF NEW ANNUAL INDUSTRIAL GROWTH CAPTURED, 1985 AND BEYOND.
- 70% OF NEW ANNUAL RESIDENTIAL/COMMERCIAL GROWTH CAPTURED, 1985 AND BEYOND.
- 40% OF RELOCATED INDUSTRY GROWTH 1990 AND BEYOND.

factor varied from state to state, depending upon the number of such counties, frequency of resource evidence, and current populations of the counties in question. For residential/commercial (R/C) energy use, county population was multiplied by an energy use factor, chosen specifically for the climatic region, and adjusted to account for non-geothermal potential uses such as cooking, lighting, electrical appliances, etc. This county-level detail was summed by state and region to establish the current (1975) hydrothermal market size for the industrial as well as the combined residential/commercial sectors.

B. MARKET GROWTH PROJECTION DEVELOPMENT

Growth rates for each of the selected SIC categories were developed from a Ford Foundation report on industrial growth patterns in the United States, and projected at these rates to the year 2020. These basic projects were amplified by a compounded 3% per year increase in per capita energy consumption, following the usual forecasting practice of the electric power industry.

It was anticipated that, by 1985, the stimulated industrial growth resulting from the availability of an economical, stable hydrothermal energy resource base would attract new allied suppliers and service industries not currently part of the baseline market. To account for these new enterprises, a factor of 5% per year was added to the predicted market size for 1985 and beyond. In addition, a factor was added to account for new large industrial firms which, because of economics, would relocate to the region's hydrothermal resources, or would choose to adapt processes to accommodate hydrothermal energy characteristics. It was estimated that 68% of the basic industrial growth of the region, less that specifically identified as having potential for direct hydrothermal applications, would reasonably approximate the likely extent of such industry relocations and process modifications. (Sixty-eight percent is roughly the fraction of industrial energy consumption used as steam or process heat.)

Growth projections for the residential/commercial sector were based on the federal Project Independence Report indication of a residential/commercial growth projection of approximately 4% per year. In addition, per capita consumption was assumed to increase at a 3% per year factor for the residential/commercial consumer sector, as it was for the industrial sector.

Because the foregoing market size was based only upon those counties overlying currently identified potential resources, a "new discovery" factor was applied to the market projections values for the year 2020 and beyond. This factor varies from zero, in states such as Nevada where virtually all counties were encompassed by the baseline assessments, to on the order of 15 to 20% in states like the Dakotas, Arizona, and New Mexico, where there are reasons to anticipate some additional discoveries in counties not heretofore considered.

C. MARKET CAPTURE POTENTIAL ESTIMATE DEVELOPMENT

Starting in 1980, a linear 1% per year hydrothermal energy retrofit of the total 1975 baseline industrial plus R/C market was assumed, and assumed to continue until a maximum of 25% of the 1975 market had converted to hydrothermal energy. (The identified total baseline market was only those sectors uniquely able to adapt to hydrothermal usage.)

Capture of the projected market new growth by hydrothermal energy was assumed to be zero in 1979, increasing linearly to 70% and 80% by 1985 for the residential/commercial and industrial sectors, respectively. Continued growth market capture beyond 1985 was assumed to remain at the 70% and 80% values through the year 2020.

Capture of the industry choosing to relocate or convert processes to hydrothermal use was assumed at 40%, starting in the year 2000, and continuing beyond.

III. METHODOLOGY AND ASSUMPTIONS - ELECTRIC

A. ELECTRICAL FORECAST

Data from the September 15, 1977, issue of Electrical World were used to determine the planned generating capacity net addition in the RMB&R region to 1995. A linear extrapolation was applied to obtain the projected new capacity for the year 2020. The ratio of planned regional to national installed energy capacity in 1980 was assumed to maintain through the period, since only limited regional planning data was available beyond the 1980 time frame.

B. RESOURCE PROJECTED DEVELOPMENT

The location of the proven, potential and inferred potential resources were identified and overlaid with the region's existing electrical power grids to verify that there are power grids in the vicinity of most resources, although some upgrading may be necessary.

Typical commercialization scenarios were developed for high as well as moderate temperature prospective resources to develop approximate time scales. Preliminary scenarios were also developed for the number of wells and drill rigs required for confirmation of a reservoir, as well as for reservoir development to assure that unreasonable demands upon drilling resources were not implied by the goals established.

Prospective resources with potential temperatures above 200°C were considered for the year 2000 power-on-line projections. It was assumed that technology will be developed by the early 1990's for the economical use of resources down to 150°C. Actual power-on-line from such reservoirs would commence in about the year 2000. Proven resources in Utah and New Mexico, and only a small fraction of the potential resources in Utah and Nevada, were used for the near-term (1985) goal projections.

C. MARKET CAPTURE POTENTIAL

Since most of the known prospective resources for electrical power generation are in the vicinity of an existing power grid, it was assumed that all of the electrical power that could be generated would be utilized. In some cases, this power would potentially be wheeled from one state to another depending on the load factors.

III. METHODOLOGY AND ASSUMPTIONS - ELECTRIC

BASELINE REGIONAL ELECTRIC POWER MARKET ESTIMATE

- MCGRAW-HILL ANNUAL ELECTRIC INDUSTRY SURVEY DATA
- MCGRAW-HILL (ELECTRICAL WORLD) FORECAST OF NEW POWER-ON-LINE THROUGH 1990
- ASSUMED LINEAR EXTRAPOLATION, 1990 TO YEAR 2020

RESOURCE POTENTIAL ESTIMATE (THIS TASK CURRENTLY IN PROCESS)

- CORRELATE POTENTIAL RESOURCE AREAS WITH REGIONAL POWER GRID SYSTEM
- COMPILE UNIVERSITY OF UTAH RESEARCH INSTITUTE RESOURCE DATA AS MADE AVAILABLE
- DEVELOP SITE-SPECIFIC RESOURCE DEVELOPMENT/PRODUCTION SCENARIOS
- ASSUME ONLY $\geq$ 200°C RESOURCES ECONOMICAL TO YEAR 2000, $\geq$ 150°C RESOURCES THEREAFTER
- DEVELOP APPROXIMATE TOTAL CAPACITY ESTIMATES FOR EACH PROMISING PROSPECTIVE RESOURCE

HYDROTHERMAL ELECTRIC POWER-ON-LINE ESTIMATE (THIS TASK TO BE INITIATED)

- ESTABLISH POSSIBLE RATES OF INDEPENDENT, AS WELL AS GOVERNMENT-ASSISTED, RESOURCE DEVELOPMENT
- NEAR-TERM (1985) GOALS INCLUDE:
  - UTAH PROSPECTS - 220 MWe (REQUIRES UTILITY COMMITMENT OF 110 MWe AT COVE FORT PROSPECT)
  - NEW MEXICO PROSPECTS - 55 MWe
  - NEVADA PROSPECTS - 55 MWe
- TENTATIVE LONG-TERM GOALS (YEAR 2000 - 2020) 9500 MWe AND 35,000 MWe, RESPECTIVELY, IN REGION

IV. RESOURCE OVERVIEW - DIRECT HEAT

Normal groundwater at shallow depth has a temperature roughly equal to the mean annual air temperature, which ranges from about 17°C to 25°C in the Rocky Mountain/Basin and Range Region. Geothermal water is groundwater which has a higher temperature than that of normal groundwater. Heating of groundwater results from contact with warm or hot rocks within the earth either by circulation to depths where the natural earth temperature is higher, or by coming near or into contact with rocks that are now cooling from a former molten state or have been heated up by natural radioactive decay. Geothermal waters range in temperature from just slightly above near annual air temperature to more than 300°C. In general hotter geothermal fluids are associated with recently molten intrusive igneous rocks whereas cooler geothermal systems. High-temperature hydrothermal systems are widespread in the Region but are far less numerous than are low- and moderate-temperature systems. This is presently interpreted to indicate that the low- and moderate-temperature geothermal waters most useful for direct heat applications form a very sizeable resource base whose exploration has hardly begun.

Warm and hot springs and shallow wells are known in each of the ten states in the Region. Low- and moderate-temperature geothermal water is known to occur at or near most of the major population centers in the Region: examples are Tucson, Phoenix, Albuquerque, Las Vegas, Reno, Provo-Salt Lake City-Ogden, Boise, and Sheridan. Because interest in geothermal resources as an energy alternative in the United States is very recent, knowledge of the ultimately available resources base is scanty. Little exploration has been done, expecially for low-and moderate-temperature resources. The U.S. Geological Survey estimates that three times the known number of intermediate-temperature hydrothermal systems may ultimately be discovered. The primary exploration effort by industry is for discovery of high-temperature resources suitable for electrical power generation, and so a vigorous federal program aimed at confirming lower temperature reservoirs is warranted.

Geothermal water, like normal groundwater, generally contains dissolved salts and gasses. The highest brine concentrations are usually found in the higher-temperature systems. Scale and corrosion problems may occur but are amenable to solution using today's technology.

IV. RESOURCE OVERVIEW - DIRECT HEAT

AVAILABILITY

- RESOURCES ARE AVAILABLE IN ALL OF THE TEN STATES
- ALMOST ALL OF THE LARGER POPULATION CENTERS IN THE REGION HAVE SOME RESOURCES IN THEIR VICINITY.
- AS THE NUMBER OF RESOURCE OCCURENCES INCREASE THE RESOURCE TEMPERATURES DECREASE.
- RESERVOIR CONFIRMATION PROGRAM REQUIRED.

QUALITY

- OFTEN POTABLE, BUT A WIDE RANGE OF SCALE/CORROSION POTENTIAL MAY BE ENCOUNTERED.
- TEMPERATURES ARE SUITED TO MANY PROCESS APPLICATIONS AND TO SPACE CONDITIONING USES.

OTHER CONSIDERATIONS

- TRANSPORT COST IS A SIGNIFICANT ECONOMIC FACTOR.
- A COMMERCIALIZATION INFRASTRUCTURE NEEDS TO BE ESTABLISHED.
- CURRENT TECHNOLOGY IS ADEQUATE FOR INITIATING COMMERCIAL USE.
- NEW TECHNOLOGIES ARE NEEDED FOR FULL MARKET PENETRATIONS.

IV. RESOURCE OVERVIEW - ELECTRIC

Electric applications of geothermal fluids require temperatures in excess of 200°C using today's technology and economics. Efforts are being made under the Raft River project to extent the temperature limit downward to 150°C. The technology could then be applied to many more resources.

Within the Rocky Mountain/Basin and Range Region, all known resources with temperatures greater than 200°C are believed to be associated with still-cooling intrusive rocks at anomalously shallow depth (1500-500 m) in the earth's crust. Such resources are generally small (10-50 sq km) in areal extent and occur in specific geologic settings. Most of the known resources, at least a portion, are federal land. The possibility of other types of high-temperature resources in the Region is good.

Within the Region, two areas have been proven to have both quality and quantity of resources needed for electrical power generation. These are Roosevelt Hot Springs, UT and Valles Caldera, NM. Numerous other excellent prospects exist, but drilling has not been intensive or extensive enough to establish a proven capacity for power generation. Due to the high cost of deep drilling in the adverse geothermal environment, ($1 million per hole is not unusual) and the large number of producing holes needed to confirm the reservoir sufficiently to interest utility companies to consider plant construction, the number of holes being drilled by industry is inadequate to ensure the electrical power the U.S. will need from geothermal resources. An aggressive program by the federal government of cost-sharing exploration and confirmation expenses is needed.

The utlimate high-temperature resource base is large--it is estimated by the U.S. Geological Survey to be five times the presently known resource base. Exploration drilling, confirmation, and reservoir engineering technologies have never been developed specifically for geothermal resources. Rather, technologies developed for the petroleum and mining industries are being applied. In some areas these technologies are not even appropriate, and in no area are they optimum. Therefore federal support for a broad range of research and technology development is strongly indicated.

IV. RESOURCE OVERVIEW - ELECTRIC

AVAILABILITY	RESOURCES MW(e) >200°C	RESOURCES MW(e) >150°C<200°C
• PROVEN	150	-
• POTENTIAL	2,250	-
• INFERRED	5,600	9,000
• UNDISCOVERED	8,000	10,000
SUBTOTAL	16,000	19,000
GRAND TOTAL		35,000

QUALITY

TOTAL DISSOLVED SOLIDS (AVG.)

≥ 200°C = 7000 PPM

150°C-200°C = 2000-4000 PPM

OTHER CONSIDERATIONS

- RESOURCES ARE PRIMARILY ON GOVERNMENT LAND.
- SPECIAL DOWNHOLE EQUIPMENT REQUIRED TO DEAL WITH FORMATION & TEMPERATURES (TECHNOLOGY UNDER DEVELOPMENT).
- EXPLORATION/DEVELOPMENT EFFORT HAS BEEN MINIMAL TO DATE. TENFOLD INCREASE REQUIRED.
- EXPLORATION AND CONFIRMATION TECHNOLOGY IMPROVEMENTS NEEDED.
- CONTINUED RESOLUTION OF INSTITUTIONAL BARRIERS IS REQUIRED.

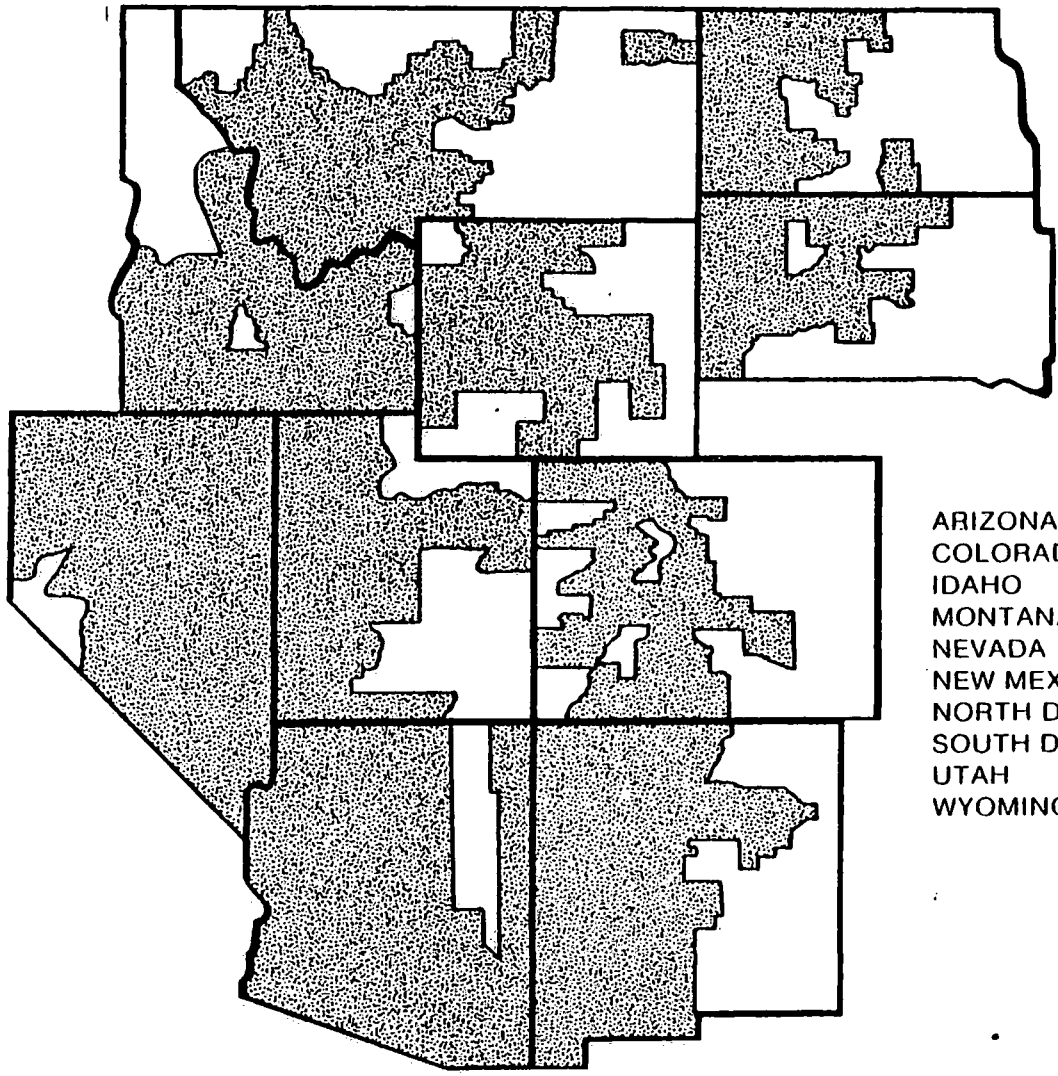
V. MARKET OVERVIEW - DIRECT HEAT

Hydrotheraml energy, in direct applications, has the potential of replacing significant amounts of fossil energy and often providing a more appropriate matching of the energy to required working temperature. The direct heat use of geothermal energy is currently being economically marketed to a number of process industries in several countries, including the United Stated, although its application in the U.S. is mainly directed to spaceheating. Industries currently being served by this energy source are pulp and paper processing, timber-drying, confectionary preparation, diatomaceous earth processing, brewing and distillation, sea weed processing, washing and drying of wool, cement curing and dairy products processing. On a world wide basis approximately 5500 $MW_{(th)}$ of geothermal energy is being utilized by direct application, while current U.S. use of this energy source is less than 50 $MW_{(th)}$.

Analysis of current energy use within the RMB&R region indicates that the prime market sectors for the direct use of geothermal energy are in space conditioning, (both cooling and space/water heating) and in low-to-moderate temperature industrial processing. Currently greater than 75% of these market sections are being served by fossil fuels, with electricity claiming the majority of the remianing sales. Energy competition projections for the RMB&R region indicate a higher dependence upon coal in the future which may encounter environmental or growth constraints. A cross matching of the hydrothermal resources, as known today and projected in the future, on a county-by-county geographical basis with the potential user sectors was defined the prime areas to be developed. This analysis reveals that all 10 states within the RMB&R region have significant amounts of resources which correlate with potential market areas and that the majority of the industrial and population centers are colocated with hydrothermal resources. The largest potential user segment is the space cooling and space/water heating segment. The current energy use for this sector is 288 x 10^{12} Btu/yr with a growth potential by the year 2020 of 2,504 x 10^{12} Btu/yr.

V. MARKET OVERVIEW — DIRECT HEAT

COUNTIES WITH DIRECT HEAT RESOURCES CO-LOCATED WITH POTENTIAL USERS



	Number Of Counties	Counties With Resources/ User Match	Counties With Some Potential Resource/ User Match	Counties With No Known Resources
ARIZONA	14	7	6	1
COLORADO	63	17	9	37
IDAHO	44	20	11	13
MONTANA	56	20	7	29
NEVADA	17	15	0	2
NEW MEXICO	32	14	4	14
NORTH DAKOTA	53	19	1	33
SOUTH DAKOTA	67	21	7	39
UTAH	29	18	0	11
WYOMING	24	12	0	12
	399	163	45	191

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FORTY "BEST MATCH" (1) COUNTIES IN THE REGION

COUNTY	STATE	1975 INDUSTRIAL Btu/yr x 10^{12}	1975 RESIDENTIAL/ COMMERCIAL Btu/yr x 10^{12}	1975 TOTAL POTENTIAL GEOTHERMAL Btu/yr x 10^{12}
MARICOPA	ARIZONA	17.12	29.90	47.02
SALT LAKE	UTAH	8.50	20.80	29.30
CLARK	NEVADA	3.75	13.95	17.70
UTAH	UTAH	2.13	11.00	13.13
PIMA	ARIZONA	2.57	10.15	12.72
WEBER	UTAH	3.34	9.20	12.54
BERNALILLO	NEW MEXICO	1.63	10.80	12.43
BOULDER	COLORADO	3.48	8.60	12.08
DAVIS	UTAH	.68	10.90	11.58
WASHOE	NEVADA	1.78	9.20	10.98
ADA	IDAHO	1.56	9.00	10.56
BONNEVILLE	IDAHO	3.97	2.80	6.77
CASSIA	IDAHO	5.30	.60	5.90
CANYON	IDAHO	5.64	2.50	5.89
NATRONA	WYOMING	.14	5.55	5.69
TWIN FALLS	IDAHO	3.35	1.80	5.15
PENNINGTON	SOUTH DAKOTA	1.04	4.10	5.14
CACHE	UTAH	1.94	2.90	4.84
MINIDOKA	IDAHO	3.73	.45	4.18
WARD	NORTH DAKOTA	.25	3.52	3.77
BANNOCK	IDAHO	.43	3.20	3.63
BINGHAM	IDAHO	2.09	1.40	3.49

FORTY "BEST MATCH" (1) COUNTIES IN THE REGION (cont'd)

COUNTY	STATE	1975 INDUSTRIAL Btu/yr x 10^{12}	1975 RESIDENTIAL/ COMMERCIAL Btu/yr x 10^{12}	1975 TOTAL POTENTIAL GEOTHERMAL Btu/yr x 10^{12}
MISSOULA	MONTANA	.31	3.10	3.41
BIGHORN	WYOMING	.51	2.25	2.76
LEWIS & CLARK	MONTANA	.34	2.40	2.74
SANPETE	UTAH	1.87	.69	2.56
FREMONT	WYOMING	.09	2.25	2.34
DONA ANA	NEW MEXICO	.33	1.75	2.08
CARBON	WYOMING	.05	2.00	2.05
SANTA FE	NEW MEXICO	.20	1.75	1.95
POWER	IDAHO	1.40	.36	1.76
WILLIAMS	NORTH DAKOTA	.17	1.49	1.66
LINCOLN	WYOMING	.18	1.48	1.66
STARK	NORTH DAKOTA	.12	1.48	1.60
JEFFERSON	IDAHO	1.30	.18	1.48
COCONINO	ARIZONA	.28	.98	1.26
HUGHES	SOUTH DAKOTA	.32	.90	1.22
FREMONT	COLORADO	.12	1.00	1.12
CONVERSE	WYOMING	.08	.99	1.07
LAPLATA	COLORADO	.08	.88	1.04

(1) Best match of user and hydrothermal resources, based upon colocation, suitable resource temperatures and quantity of energy replaceable by hydrothermal direct heat use in the county.

IV. MARKET OVERVIEW - DIRECT HEAT

Many of the major industrial energy consumers in the region can use low-to-moderate heat sources to meet a portion if not all of their energy needs. These industries include food and kindred products processing, wood and lumber products, mining and minerals, chemical processing and the concrete industry. The energy supply requirements for these elements of the industrial sector are some what smaller than the energy needs for residential/commercial space conditioning, but the region's growth potential is excellent and it appears that penetration can more readily be made in the industrial sector. Current energy use in the low-to-moderate heat processing sector which can be served by hydrothermal energy is 74 x 10^{12} Btu/yr with a growth pattern of 177 x 10^{12} Btu/yr by 1985, 480 x 10^{12} Btu/yr by 2000 and 1,476 x 10^{12} Btu/yr by the year 2020.

From the foregoing considerations it can reasonably be observed that substantial long-term markets for hydrothermal energy exist in the RMB&R region; that commonly found coincidence of resource occurrance with user locations promise favorable economics in competition with other energy supplies; and that hydrothermal energy can, with appropriate stimulation and encouragement, be a near-term partial solution to the regions's energy needs. The principal barrier to the rapid transition to hydrothermal energy application is that the present market place lacks the infrastructure necessary to develop and deliver hydrothermal energy to the user sectors.

TOP 20 INDUSTRIAL PROCESS HEAT APPLICATIONS DIRECTLY MATCHED[1] FOR GEOTHERMAL ENERGY REPLACEMENT IN THE ROCKY MOUNTAIN BASIN & RANGE REGION ($\times 10^{12}$ BTU/YR)*

INDUSTRY	MATCHED 1975 ENERGY USE[2]	INDUSTRY	MATCHED 1975 ENERGY USE[2]
DEHYDRATED FRUITS & VEGETABLES	11.80	INORGANIC CHEMICALS	1.06
CONCRETE BLOCK	7.10	READY-MIX CONCRETE	.98
FROZEN FRUITS & VEGETABLES	5.24	GYPSUM	.97
POULTRY DRESSING	4.82	CANNED FRUITS & VEGETABLES	.97
MEAT PACKING	4.45	BEET SUGAR	.82
PREPARED FEEDS	3.65	TREATED MINERALS	.69
PLASTIC MATERIALS	3.63	COTTON SEED OIL MILLS	.34
DAIRY INDUSTRY	3.24	PREPARED MEATS	.34
SOFT DRINKS	2.91	PHARMACEUTICALS	.25
SOAPS	1.24	FURNITURE	.21

(1) INDUSTRIES MATCHED BY COLOCATION WITH RESOURCES AND COMPATIBLE PROCESS TEMPERATURES IN THOSE COUNTIES HAVING HYDROTHERMAL RESOURCES.

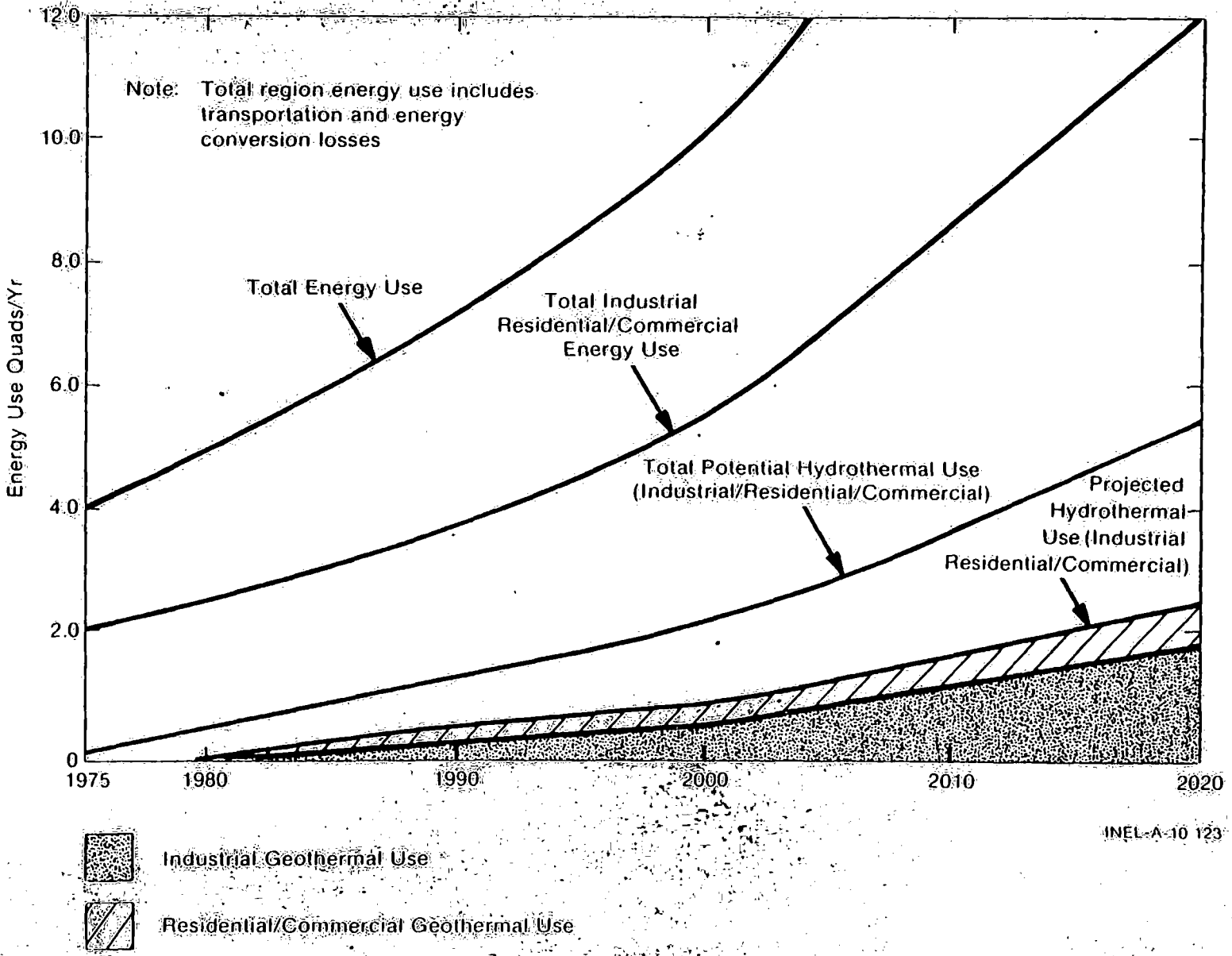
(2) REGIONAL CONSUMPTION OF DIRECT HEAT ENERGY IN 1975 REPLACEABLE BY HYDROTHERMAL ENERGY FROM COLOCATED AND TEMPERATURE MATCHED RESOURCES.

V. MARKET OVERVIEW - DIRECT HEAT

Market growth projections for hydrothermal energy in the RMB&R region present an attractive profile. From the illustration on Page 24, it is evident that a substantial protion of the region's energy needs could be satisfied by hydrothermal energy, as shown by the potential Hydrothermal use Market Curve. Competition from conventional energy sources, as well as other alternative energy types (solar, biomass, etc.), result in choosing conservative market penetration objectives as shown by the estimated penetration (bottom) curve.

Resource uncertainty, lack of proven economics, and absence of an established infrastructure, as well as general reluctance to accept an unfamiliar resource, are factors which are expected to minimize significant market penetration until post-1985. These factors are among those which will receive major DOE emphasis in the commercialization program.

ENERGY CONSUMPTION PROJECTIONS FOR THE RMB&R REGION



V. HYDROTHERMAL MARKET OVERVIEW - ELECTRIC

The electrical energy produced in the RMB&R region in 1975 was approximately 1.1×10^8 MWh, of which about 0.2×10^8 MWh was exported. Average per customer residential use was 8700 kWh in 1977, showing an annual increase of approximately 3%. Industrial consumption data shows a similar per capita increase. This coupled with a 4% regional overall growth rate results in a net annual demand increase in the region of about 7%. Industrial users in the region consumed approximately 0.3×10^8 MWh of electricity in 1975, while the residential/commercial sector electrical consumption amounted to about 0.8×10^8 MWh, for a total of 0.9×10^8 MWh.

Electric utility capital spending in the region exceed $1.8 billion in 1977, and is predicted to be greater than $2.2 billion in 1978, for generation, transmission, distribution, and miscellaneous purposes. In early 1978, there were 158 utilities operating a total of 396 generating plants in the region. Hydro, fossil steam, gas turbine and diesel (no nuclear) plants, were operational with an installed capacity of approximately 35,000 MW. Ownership of these plants included investor-owned, municipal, state and PPDs, cooperatives, and federal agencies. A breakdown of electric capacity or sales by ownership is not directly at hand, but will be developed in continuing studies.

VI. MARKET OVERVIEW — ELECTRIC

CURRENT INSTALLED CAPACITIES WITHIN THE REGION

- Investor Owned Companies
- Municipal & State Agencies
- Cooperatives
- Federal Agencies (BPA, etc.)

UTILITIES	PLANTS	MWe
Hydropower	166	9,349
Fossil Fuels	231	26,067
Nuclear	0	0
158 Total Utility Companies	397	35,416

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IV MARKET OVERVIEW - ELECTRIC

The regional goal for the year 2020 is 35,000 $MW_{(e)}$, (2.9 Quads/yr) which is approximately 30% the region's projected requirements (45% of additional generating capacity). This goal is dependent upon reservoir confirmation of prospective resources and the technology development for the economic utilization of resources as low as 150°C.

There are three confirmed reservoirs and an excellent prospect, located in the RMB&R region, which are within the current economic electric production temperature range. Concensus is that there is high confidence that state-of-the-art technology allows for economic use of hydrothermal resources to temperatures approaching 200°C. It is currently expected that such resources can meet the regional goal of 300 $MW_{(e)}$ on line by 1985.

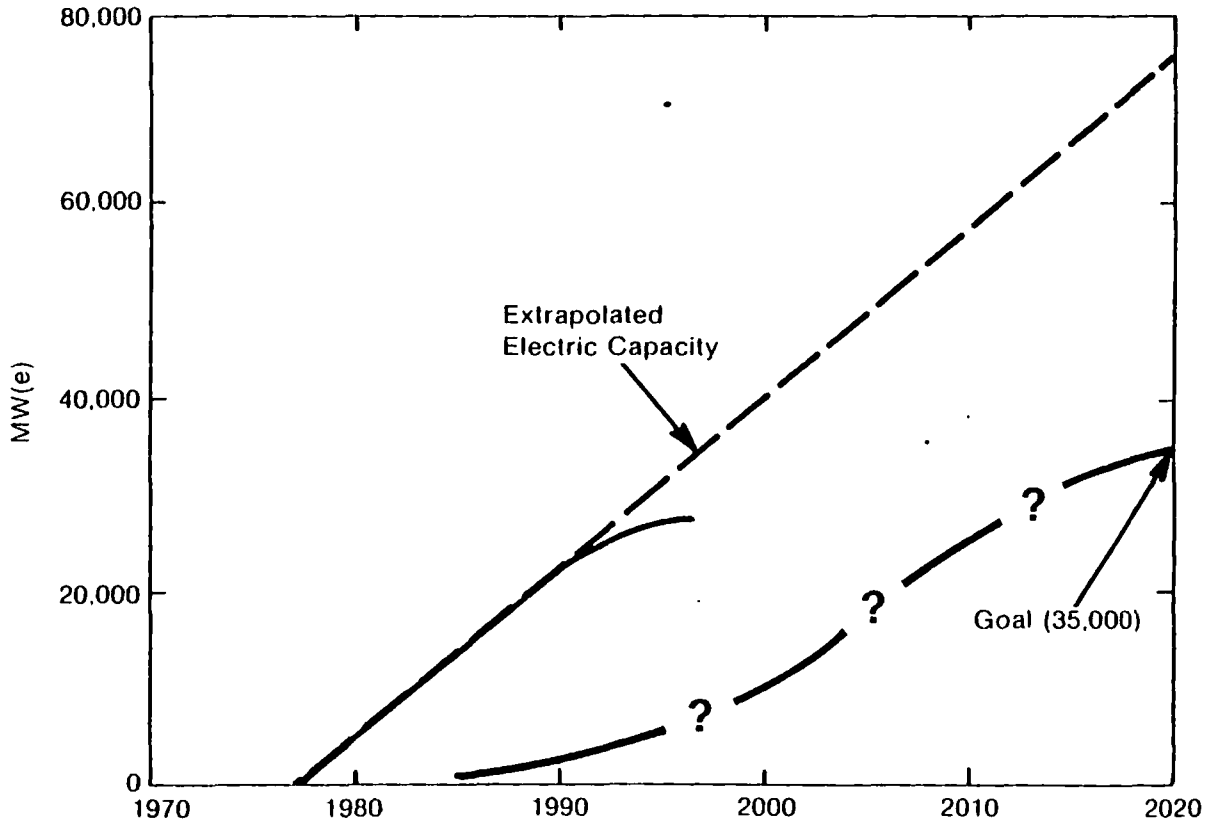
The tentative mid-term (year 2000) goal is to achieve 9,500 $MW_{(e)}$ on line. This is based upon the asumption that 8,000 $MW_{(e)}$ can be derived from presently know or inferred resources, and 1,500 $MW_{(e)}$ are obtained from presently unconfirmed resources. This goal will require three areas of major DOE involvement. These are: exploration for new high-grade resources, technology development for economical electrical energy recovery from intermediate-moderate temperature resources, well stimulation development and a continuation of incentives and barrier removals to simulate strong growth. In effect, the DOE program to meet intermediate goals is a continuation and expansion of work already underway, supported by the experience, economic findings, and industry acceptance inherent in achieving the near term (1935) goals.

The principal assumption concerning the long term (year 2020) goal is that the econmic reservoir temperature can be lowered to 150°C. This achievement opens the extensive moderate temperature hydrothermal resources to exploitation. Two factors support this possibility. The energy cost spiral will continue to move the economic cross-over point to higher and higher values, allowing cooler (as well as deeper) reservoirs to compete, and very major technology advancements can be anticipated by that time frame.

VI. MARKET OVERVIEW — ELECTRIC

PROJECTED ELECTRIC DEMAND AND POTENTIAL MARKET PENETRATION

• ELECTRICAL WORLD (SEPT. 15, 1977)



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V. MARKET OVERVIEW - ELECTRIC

There is proven potential for hydrothermal electric power production in the RMB&R region. While only a limited number of KGRAs show temperatures of 200°C or higher needed for today's technology, planned future ability to utilize economically reservoirs with temperatures as low as 150°C will provide a major increase in electric power potential.

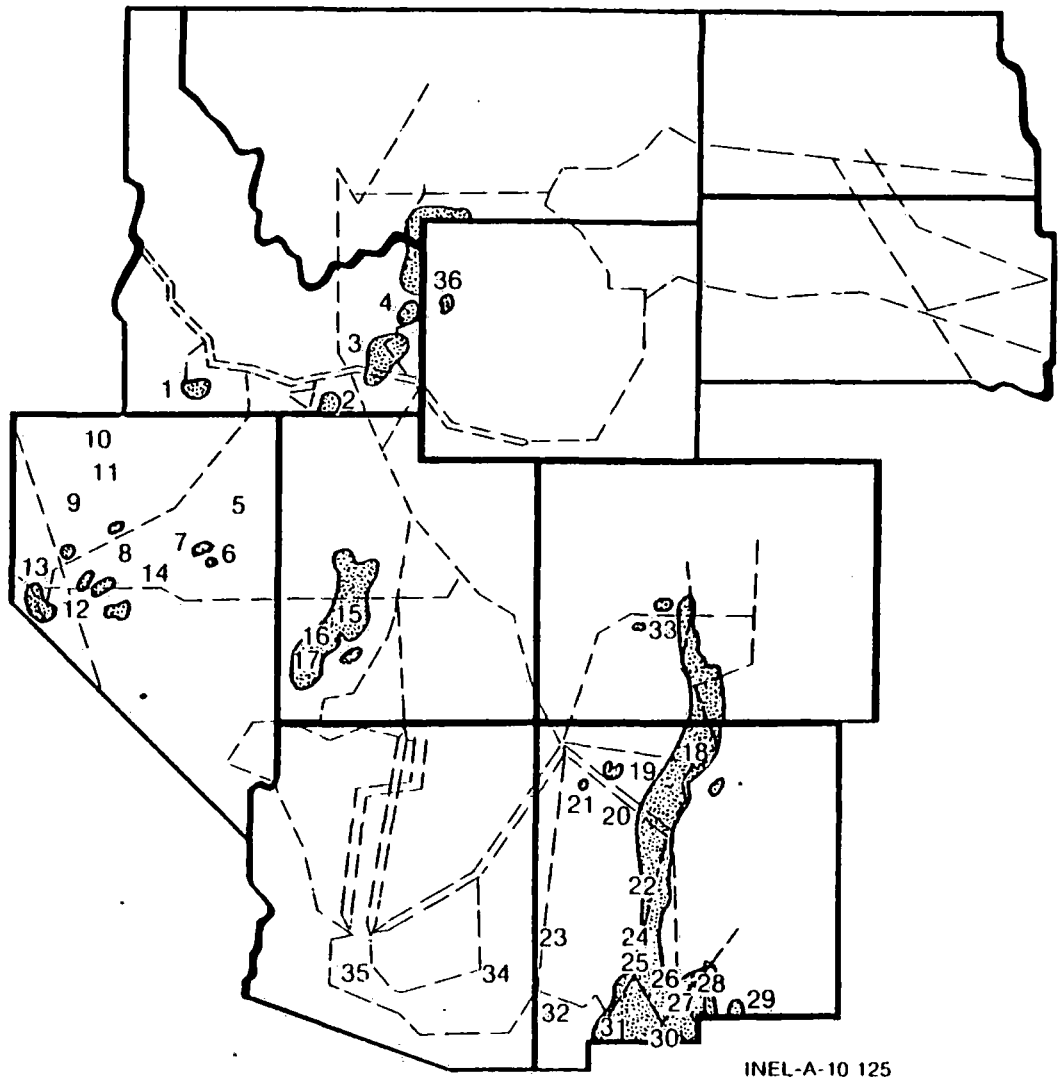
The regional map shows the location of a number of reservoirs possibly having electric generation potential, with an overlay of the existing electric power grid of the region. In general, a good colocation of the power grid with reservoirs is found, although in some instances grid transmission capacity may be insufficient. However, existence of the power line right-of-ways is a significant advantage, and grid capacity can be upgraded, if necessary, to accommodate the resource output.

Among the specific factors that require consideration for DOE support to foster accelerated resource development are:

- Reservoir confirmation programs
- Industry-coupled well stimulation programs
- Financial incentives such as loan guaranty, equitable taxation, and reservoir insurance
- Simplified and faster leasing, siting, permitting, and licensing practices
- Development of approved codes and standards
- Promotion and public education programs
- Continued development of other incentives and barrier removal actions.

MAJOR POWER LINES AND PROSPECTIVE POWER PRODUCTION RESOURCES[1]

1. Bruneau-Grandview
2. Raft River
3. East Snake River Plain
4. Island Park
5. Ruby Valley
6. Beowawe
7. Leach Hot Springs
8. Humboll House
9. Double Hot Springs, Gerlach/Fly Ranch
10. Baltazor
11. Pinto Hot Springs
12. Brady Hazen/Desert Peak & Stillwater/Soda Lake
13. Steamboat Springs
14. Dixie Valley
15. Cove Fort/Sulphurdale
16. Roosevelt Hot Springs
17. Thermo Hot Springs, Newcastle
18. Mamby's Hot Spring
19. Valles Caldera, Baca Location No. 1
20. Guadalupe Area, Jemez Reservoir
21. Prewitt Area
22. North of Socorro
23. Lower Frisco Hot Springs
24. Derry Spring
25. Radium Spring
26. San Diego Mountain
27. Mesquite-Berino, Las Alturas
28. White Sands (Town)
29. Southern Tulsarosa Basin
30. Kilbourne Hole
31. Columbus Area
32. Lightning Dock, Lordsburg
33. Poncha, Mt. Princeton, Valley View Hot Springs
34. Clifton/Gillard
35. Chandler
36. Huckleberry Hot Springs, Auburn Hot Springs



(1) 150°C and above prospective resources.

VII. MARKET PENETRATION OBJECTIVES AND REGIONAL GOALS

The hydrothermal market penetration objectives include both electric power generation as well as direct heat applications. A survey of the region's electric power generation and energy consumption profiles together with growth projections through the year 2020 has verified a major potential for hydrothermal energy application. Aggressive, but achievable, goals have been chosen for guidance in the future development and justification of commercialization implementation plans. The goals assume a maximum of 25% retrofit, and 70% and 80% capture, respectively, of residential/commercial and industrial growth in the specifically applicable markets. The electric power goals represent reasonable fractions of the projected new power-on-line, but require resource verification to assure that they can be achieved.

Specifically, it is necessary to establish an additional 150 MW of high grade (>200°C) proven reserves by 1980, since probable output of the Roosevelt prospect and Valles Caldera will be only about 150 MW by 1985. The year 2000 goal assumes commercialing 8000 MW of proven potential, and inferred resources, as well as 1500 MW of high grade resources yet to be discovered. Beyond the year 2000, it is assumed that technology developed during the 1980's, and brought to commercial status during the 1990's, will allow economic exploitation of reservoirs with temperatures as low as 150°C.

In developing the megawatt equivalency of direct heat, it was roughly approximated that 1 MW of hydrothermal energy on-line equals 5100 barrels of oil per year for direct heat applications, and 14,200 barrels of oil per year for electric generation applications. On this basis, achievement of the 1985 goals would reduce fossil fuel demand by the equivalent of over 100,000 barrels of oil per day, while the 2020 goals would save over 2,500,000 barrels per day!

VII. REGIONAL MARKET PENETRATION GOALS

Hydrothermal Energy Application	Present Hydrothermal Use	Hydrothermal Energy Goals 1985	2000	2020
Electric Generation (MWe)	— 0 —	300 (1)	9,500 (2)	35,000 (3)
Direct Heat Uses, Quads (Megawatts Equivalent)	<0.001 (< 25)	0.2 (≈8000)	1.0 (≈25,000)	2.5 (≈67,000)
ENERGY EQUIVALENTS				
Electric Generation (4) (Equivalent Fossil Fuel Energy, Quads per Year)	— 0 —	0.03	0.8	2.9
Direct Heat Uses (Expressed directly in Quads per Year)	<0.001	0.2	1.0	2.5
Total Equivalent Energy, Quads/yr (5)	<0.001	0.23	1.8	5.4
Barrels of Oil Equivalent	< 1 x 10^6/yr	40 x 10^6/yr	304 x 10^6/yr	910 x 10^6/yr

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(1) Assuming additional 150 MW of proven reserves established by 1980.

(2) Assuming commercialization of 8000 MW of proven, potential and inferred resources and 1500 MW of high grade undiscovered resources.

(3) Assuming the economically competitive reservoir temperature is lowered to 150°C.

(4) 35% cycle efficiency applied to obtain fossil fuel equivalents for electric power generation.

(5) A quad is a unit of energy defined as 10^{15} BTU's or 1 quadrillion BTU's.

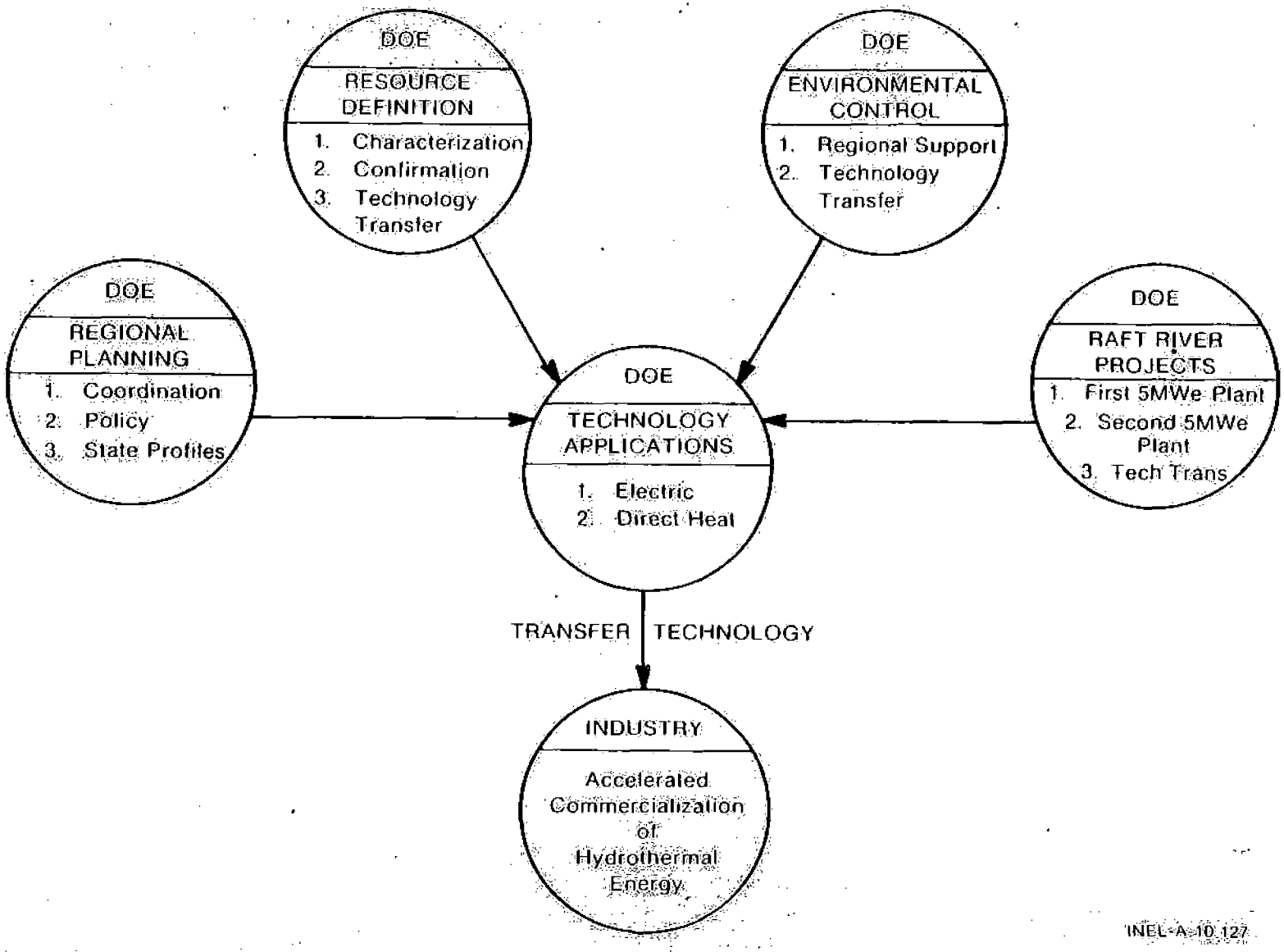
II. REGIONAL PROGRAM SUMMARY

Five essential components of the DOE program are required to fully penetrate the hydrothermal energy market. Four elements of the DOE program (Regional Planning, Resource Definition, Environmental Control and Raft River Projects) lead to support the Electric and Direct Heat Applications and Transfer of Technology to Industry. The DOE program elements are designed to stimulate the market by minimizing the risks that investors will face in utilizing hydrothermal energy. The five essential DOE program elements are detailed in the commercialization plan and summarized as follows:

Regional Planning -
- ° Analysis of economic, environmental, institutional, legal and technological factors effecting commercialization.
- ° Identification of federal initiatives required.
- ° Preparation of state development profiles.
- ° Preparation and implementation of educational programs for state, industry and other related parties.

Resource Definition -
- ° Industry coupled case study program (shared costs).
- ° Disseminate resource data to industry.
- ° Assess low and moderate temperature resources.
- ° Produce state by state resource maps.
- ° Initiate heat-flow and lava flow mapping.

VIII. REGIONAL PROGRAM SUMMARY



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VIII. REGIONAL PROGRAM SUMMARY

Technology Applications -

- ° Encourage direct heat use through support of direct heat cost shared demonstrations.
- ° The production of electricity from high-grade reservoirs in the region.
- ° Develop and pursue new catalytic initiatives to bring together resource developers, utilities and in some cases an intermediate risk-taker.
- ° Incorporate well stimulation technique developments into the Regional
- ° Commercialization Program through the Industry-Coupled Well Stimulation Program.

Environmental Control -

- ° Provide support to environmental impact assessment/environmental impact statement preparation, PON/PRDA reviews, and institutional activities.
- ° Gather subregional environmental data and perform site-specific monitoring
- ° Prepare preplans for gathering baseline environmental data as needed for preparation of EIA/EIS documents.

Raft River Facility. -

- ° Test the economics of utilizing moderate temperature (150°C) reservoirs.
- ° Construct and evaluate the first 5 MW thermal loop with conventional hardware.
- ° Construct and evaluate a second 5 MW thermal loop with advanced systems hardware.
- ° Compare economics of first and second thermal loop systems.
- ° Utilize the facility as a showcase for technology transfer for electric and direct heat applications.
- ° Evaluate direct applications of moderate temperature resources (low temperature drying, low temperature processing and beneficial uses of geothermal fluids).
- ° Invite industry to participate and review results of experiments.

VIII. REGIONAL PROGRAM SUMMARY