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EVALUATION OF GEOTHERMAL ENERGY IN ARIZONA

Arizona Geothermal Planning/Commercialization Team

Quarterly Topical Progress Report
January 1, 1980 - March 31, 1981

Prepared by: Don H. White - Principal Investigator
Larry A. Goldstone - Project Manager
Lani Malysa - Group Leader

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1700 West Washington
Phoenix, Arizona 85007

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Region IX

Subcontract 114-80 with
University of Arizona
Tucson, Arizona 85721

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1.0 Introduction

Dwindling oil supplies and dependence on foreign oil have encouraged a more intensive review of alternative energy resources. Geothermal energy reserves are abundant in the western U.S. and may be able to supplement this country's energy supply. Consequently, planning efforts have been directed toward estimating the potential of geothermal energy utilization in Arizona, and for providing information necessary for its prospective commercialization.

The Department of Energy (DOE) through its San Francisco Operations Office has delegated responsibilities for the industrialization of geothermal energy in Arizona to the Arizona Solar Energy Commission (ASEC) via a cooperative agreement. The ASEC assumed authority for monitoring the progress of the project through its director James Warnock and its associate director Frank Mancini. The ASEC in turn subcontracted the commercialization and planning activities to the University of Arizona.

The Arizona Geothermal Commercialization Team consists of three key personnel, one support person and additional temporary personnel. Key personnel are: (1) Frank Mancini, PhD, Project Administration; (2) Don H. White, PhD, Team Leader; and (3) Larry Goldstone, Project Manager. The support person is Lani Malysa, Group Leader. Their tasks are listed in the organization chart of the Arizona Geothermal Commercialization Team (Figure 1-1).

Efforts during the first years of the Geothermal Team were characterized as planning. Planning activities included the identification and delineation of geothermal prospects, the comparison of conventional energy use patterns with geothermal sources, the preparation of area

development plans and the compilation of detailed economic and energy data for each area.

During 1980 and continuing on through 1981, the Geothermal Team changed their emphasis from planning to commercialization. During 1981 the main emphasis for this project is to produce plans and provide information for geothermal energy commercialization. The technical approach for achieving this goal is to characterize geothermal resources and possible users. A program of direct interaction with business and community leaders has been undertaken. Several approaches have been taken, including the publication of a monthly newsletter, to increase awareness of geothermal resources and uses and to open channels for further communication.

Figure 1-1: Organizational Chart

Arizona Geothermal Commercialization Team

2.0 Tasks and Objectives

The overall objectives of the Arizona Geothermal Commercialization Team have been to produce geothermal development plans to be used by the private sector and to provide a source of information for interested parties in the state. These objectives have been met through a balanced planning, commercialization, and outreach program. Each task has played a significant role in providing assistance to potential geothermal developers. Examples of tasks performed in the past include the following:

- 1) The formulation of Area Development Plans involved the compilation and analysis of detailed energy and economic data for seven areas in the state. The result of these studies are a determination of potential market penetration of geothermal energy in each of the areas investigated. Also, potential developers were identified from the residential, commercial, industrial and agricultural sectors.
- 2) The evaluation of geothermal applications (formerly referred to as Site Specific Development Analyses) involved preliminary engineering and economic analyses for selected applications for geothermal energy in Arizona. Particular emphasis was placed on space cooling and heating, geothermal power plants, direct thermal use for food and industrial processing, geothermal energy utilization in cattle feedlots, and satellite urban development.
- 3) The evaluation of geothermal resources provided information of Arizona geothermal resource locations and characteristics.
- 4) In certain instances, more complete engineering and economic analyses were performed and technical assistance provided. The most important instances were on geothermal energy utilization for gasohol production and

geothermal energy for space heating/cooling for John F. Long, a Phoenix developer.

- 5) Growth pattern impacts were studied to provide a better understanding of the role of geothermal energy in a fast-growing state such as Arizona.
- 6) An outreach program for the purpose of providing information has been conducted over the past two years.

Tasks for 1981 consist of six specific contractual tasks plus the completion of three tasks that were started during CY 1980. In addition to these tasks, the Arizona Geothermal Commercialization Team plans to make modifications in order to broaden the scope of work for CY 1981. Due to some positive results and findings during CY 1980, four additional tasks are being added for CY 1981. The six main contractual tasks for 1981 are as follows:

Task 1. Integrated Alcohol/Feedlot/Geothermal Operation

The Contractor shall evaluate the integration of alcohol production by fermentation with a cattle feedlot, utilizing geothermal energy as much as it is practical. Specific locations will be considered where agricultural crops and cattle feedlots overlap high potential geothermal energy resources, especially (a) in the Safford/Willcox area and (b) in the Casa Grande/Chandler area, to the south of Phoenix. The drilling of at least one exploratory geothermal well in these areas will be encouraged.

Task 2. Geothermal Energy in Mining Industry

The Contractor shall work with a subcontractor knowledgeable of and serving the mining industry of Arizona, to utilize low- and medium-temperature geothermal energy in such applications as copper dump leaching, solvent extraction plants of bulk leaching, flotation plants and in-situ

mining of copper, uranium and other metals. Special attention will be paid to the Clifton/Morenci area and to interactions with Phelps Dodge of that area, where extensive copper operations and potential geothermal resources overlap. The drilling of at least one exploratory well in this area will be encouraged and assisted from resource and use standpoints.

Task 3. Geothermal Space Cooling/Heating

The Contractor shall continue the evaluation of using geothermal energy for absorption cooling and heat pumps in order to back out electricity during the heavy summer peak load of May-September, and will attempt to interest certain major corporations and/or subdivision developers to participate in one or more exploratory wells in both the Phoenix and Tucson areas.

Task 4. Identification of Suitable Industry for a Remote Geothermal Resource

The Contractor shall evaluate and make preliminary technical and economic studies of the feasibility of attracting a new industry to the remote San Bernardino Valley of Southeast Arizona, which is believed to have one of the best geothermal resources in the state.

Task 5. Food Processing/Irrigation Pumping/Biosalinity Agriculture/Geothermal

The Contractor shall study the feasibility of utilizing geothermal energy in agricultural areas, especially the Yuma and Hyder Valley areas, where some of the higher food and food processing crops, fruits and vegetables could be expanded. Certain practices of the Imperial and San Joaquin Valleys of California will be considered for adaption to Arizona soils and climate to mutually assist in the development of these two agricultural areas which appear to have geothermal resources.

Task 6. Coal-Fired Geothermal-Assisted Power Plant

The Contractor shall assist Arizona Public Service and other utility companies of Arizona in making engineering and economic studies on the possible benefits of utilizing geothermal energy (a) to reduce the quantity of coal that must be slurried and pumped to the plant site and (b) to reduce the total water requirements of the power plant.

During 1980 a supplemental proposal with three tasks was funded by DOE. Work on the three tasks was started immediately and some of the findings included in 1980 reports. These three tasks will be completed during 1981 and include the following:

Task 1. District Cooling/Heating of a Satellite Community

The Contractor shall investigate the feasibility of a district absorption cooling and space heating system in a satellite community or new growth area with geothermal potential. Cooling and heating loads and equipment necessary to meet these needs will be defined. Important community factors will also be defined. A cost study, possibly with the assistance of New Mexico Energy Institute (NMEI), will be done. The resulting product will be an informational packet detailing cost-effectiveness, feasibility, energy saved, and financial incentives.

Task 2. Space Cooling/Heating of a Large Industrial or Commercial Facility

The Contractor shall interact with owners of large industrial and commercial facilities in Phoenix and Tucson in order to define a system using geothermal energy to meet their cooling and heating loads. Of particular interest are large facilities in the electronics, computer, and solid state industry. A cost study, possibly with the assistance of NMEI,

will be done. The resulting product will be an informational packet detailing cost-effectiveness, feasibility, and energy saved.

Task 3. Alcohol Production for Gasohol

The Contractor shall interact with persons interested in the production of alcohol to provide technical assistance in evaluating the use of geothermal energy as a major energy source in the distillation process. Energy balance and cost studies shall be performed for a specific site in Arizona. The final product shall be a package of information on the legal, institutional, financial, and engineering aspects of gasohol production using geothermal energy.

As previously mentioned, the Arizona Geothermal Team plans to modify their scope of work for 1981 by adding an additional four tasks. These tasks are seen as a natural ongoing progression of work performed during 1980 but more specific in nature. The four additional tasks are detailed in Figure 2-1 and include the following: (1) Legislative and Institutional Program; (2) Cities Program; (3) Geothermal Applications Utilization Technology Program; and (4) an Outreach Program.

2.1 Legislative and Institutional Program

During the past two years, the Arizona Geothermal Commercialization Team has completed an in-depth study of state and local rules and regulations relating to geothermal development in Arizona. It is clearly evident that some of these rules and regulations on the state level will act to deter geothermal development. Examples of these include how the royalty rate is calculated for leased state land, unitization, lack of tax incentives for geothermal development, lack of municipality bonding authority, lack of state funding and most important, the conflict between groundwater

Figure 2-1: Arizona Geothermal Program for 1981

laws and geothermal development laws.

Inasmuch as the Geothermal Commercialization Team will not exist next year, it is imperative that the Arizona State Legislature be made aware of these barriers in legislation. Therefore, work for CY 1981 will consist of participating with the newly established ad hoc Senate Subcommittee on Geothermal Energy. The Arizona Geothermal Team in conjunction with the National Conference of State Legislatures will suggest legislative changes and possible types of funding programs (similar to other western states) to help pave the way for geothermal development in Arizona.

2.2 Cities Program

During 1980, the Arizona Geothermal Team supported Dr. Mike Pasqualetti of Arizona State University and his work in collecting data on how geothermal energy might be utilized in certain areas of Arizona. According to Dr. Pasqualetti, it would be counterproductive and unnecessary to allow land use to add to the burden faced by developers of geothermal energy. The aim should be at removing as many land use barriers as possible. Early land use planning can be a relatively inexpensive step, especially when compared to the benefits. As his methodology, Dr. Pasqualetti used Scottsdale as a model city type in order to determine the land use factors involved in geothermal development.

During 1981, the Arizona Geothermal Team will continue to support Dr. Pasqualetti's work on land use planning. In addition, the Geothermal Team will work to organize local geothermal expertise in other towns such as Safford, Chandler, Willcox, Clifton, Papago Farms and others by providing cost data (in conjunction with NMEI), preliminary feasibility

studies, assistance in writing proposals, and planning assistance.

2.3 Geothermal Applications Utilization Technology

During 1980, a study on Arizona's industries and the potential of incorporating geothermal energy was undertaken. This was the beginning of our understanding of industry in Arizona.

During 1981, further research will be done on the cottonseed oil, ready-mix concrete, soft drink, and animal feeds industries in order to better understand how geothermal energy can be utilized for their industrial processes. Technical assistance services such as institutional and regulatory, resource, engineering, and economic expertise will be provided in order to help industry realize their geothermal potential and help them in utilizing the resource.

In addition, the geothermal team will take known technologies such as greenhousing, aquaculture, alcohol production and space heating and assist persons in better understanding how geothermal energy could be utilized. For those technologies that are not yet fully understood (mining applications, space cooling, geothermal power plants, food processing, etc.), additional planning and research on how to integrate geothermal will be done.

2.4 Outreach

During 1980, the Geothermal Team began publishing a monthly newsletter on relevant geothermal topics. With a mailing list now over 500 persons, it has proved to be a most effective means of outreach.

During 1981, the Arizona Geothermal Team will continue to publish the monthly newsletter The Geothermal Resource. In addition, the Team

will continue other effective outreach activities including information dissemination and exhibiting the geothermal display at energy fairs.

3.0 Work Completed

The following work has been completed under each task during the first quarter of 1981.

3.1 Maryvale Terrace

During the first quarter of 1981, work was completed and reviewed on a report detailing a district heating/cooling system for a new growth area with geothermal potential. The John F. Long Realty Company of Phoenix, Arizona, supplied information regarding Maryvale Terrace, a development which began construction in the fall of 1980. In the report, cooling and heating loads and equipment necessary to meet the demands were defined. Also defined were important community factors involved in such a system. In addition, promising new technologies such as the Organic Rankine Cycles System, Ammonium Nitrate-Water Absorption Refrigeration Systems, geothermally powered pumps, and heat pumps were examined. The following is an abstract from the report:

Maryvale Terrace will be a development of 557 single-family homes. Its shape will be basically square, one-half mile (0.8 km) on each side. This development will be located on the northwest side of Phoenix, Arizona, on land which was formerly farmland. This area is quite level and would have a maximum elevation change of only 10 ft (3.0 m).

The type of system investigated for Maryvale Terrace is capable of delivering heating or cooling water to each home but not both at the same time. It also cannot supply domestic hot water.

This system uses geothermal energy to heat or cool the water circulated to each home for heating or cooling. The circulated water is heated by

passing through a heat exchanger where it absorbs some of the energy of the geothermal brine. It is cooled by passing through a lithium bromide water absorption chiller which is a device that uses the geothermal heat to cool the water. The heating or cooling water is then pumped to each home via a piping system.

Within each home a fan coil combination heating and cooling unit will do the actual heating or cooling of the home. In the heating mode, the fan coil unit extracts heat from the water circulating through it. In the cooling mode, heat from the home is added to the circulating water, thereby cooling the home.

The water is then returned to either the heat exchanger or the absorption chiller via the district piping system. If water treatment to prevent fouling is necessary, it will occur at this time.

Maximum heating and cooling loads for the average home in Maryvale Terrace were 30,000 Btu/hr (8.82 KW) and 26,300 Btu/hr (7.71 KW) respectively. It was assumed that there would be times when every home in the development would be needing its entire maximum heating or cooling load. This was done to create an overdesign. Therefore, the total maximum heating and cooling loads for Maryvale Terrace are 16.77 MBtu/hr (4920 KW) and 14.65 MBtu/hr (4290 KW) respectively.

To provide the average home with its maximum cooling or heating load would require a flow rate of 6.575 gpm or 5.02 gpm respectively.

The selection of the in-home fan coil units was made for this system. The Yazaki 304 Mini Handler would be the recommended unit for the average home. Each would require 215 W of electric power and would

provide more than the design heating capacity. The design cooling capacity would be fully met by these units.

A two-pipe distribution system was chosen to carry the heating or cooling water to the homes. While a two-pipe system has more inherent disadvantages than a four-pipe system, the lower cost of the two-pipe system made it more attractive.

The major disadvantages of two-pipe systems are their inability to supply heating and cooling water at the same time, and the time it takes to change over from one mode of operation to the other. Four-pipe systems do not have these disadvantages but they are expensive.

The location of the central heating and cooling plant was chosen to be in the center of the western boundary because it would not be surrounded by Marvale Terrace homes. It was assumed that most home buyers do not want to be located near large buildings of any kind. In addition, the cooling towers located at the central plant would make some noise which also dictated locating the plant on the development's perimeter.

The piping system would run along easements wherever possible and along streets where easements were not available. The diameters of the mains were chosen on the basis of a maximum fluid velocity of 8 ft/sec (2.4 m/sec) and the maximum flow rate that they would carry. Insulated, heavy wall, PVC pipe was chosen for this system due to its thermal and mechanical properties.

The maximum working pressure and temperature would be 80 psig (550 hPa) and 160°F (71°C). The minimum working temperature would be 45°F (7°C). All of the piping would be insulated with urethane foam covered by a sheath of sheet metal aluminum. Heat transfer would be

reduced to $0.5 \text{ Btu}/(\text{hr ft}^2)$ at 150°F ($1.58 \text{ W}/\text{m}^2$ at 66°C) by the insulation.

Table 3-1 summarizes the length of each diameter pipe the system would require and its cost. One inch, insulated, heavy wall, PVC pipe would be used to connect the homes to the mains. Each house was assumed to be an average of 60 ft (18.3 m) away from the mains.

Lithium bromide water absorption chillers would be used to chill the cooling water. No other types of absorption chillers were available in the size required by Maryvale Terrace.

Two Trane ABSC11A Single Stage Absorption Chillers were chosen to chill the cooling water. They would provide the entire cooling load of 14.65 MBtu/hr (4290 KW) but no excess capacity. The cost of these machines would be \$420,000. The absorption machines would require 30.0 MBtu/hr (10.27 KW) of cooling tower capacity. The cooling towers would need to supply 7200 gpm of 85°F (29.4°C) cooling water. A Marley 454-302 two-cell cooling tower was selected to meet this need. This machine would require 153.2 KW of electrical power to run at full capacity and could be installed on an already-existing concrete pad for approximately \$80,000.

A production well, reinjection well piping system was then designed using the following assumptions as concrete data was unavailable. It was assumed that:

- a) each production well could produce 500 gpm of 220°F (104.4°C) geothermal brine and would be approximately 6000 ft (1800 m) deep;

Table 3-1: Cost of District Piping System

Diameter		Length		Cost per unit length		Cost
in	cm	ft	m	\$/ft	\$/m	\$
1	3	66,840	20,378	3.25	10.66	217,230
2	5	24,360	7,427	3.90	12.79	95,004
3	8	15,960	4,866	4.45	14.93	72,618
4	10	9,720	2,963	6.50	21.32	63,180
5	13	940	287	8.45	27.72	7,943
6	15	2,400	732	9.10	29.85	21,840
7	18	3,360	1,024	11.70	38.38	39,312
8	21	3,540	1,079	13.00	42.64	46,020

Total = \$563,147

To this total, the cost of 557 water meters at a cost of \$50 each was added. This sum was increased by 50% to cover the cost of the large number of hook-ups. The total estimated cost of the piping is \$887,000 and does not include installation costs.

- b) each reinjection well would be approximately 4000 ft (1200 m) deep and could handle approximately 1100 gpm.
- c) a minimum distance of 1320 ft (400 m) would be required between production wells;
- d) a minimum distance of 1320 ft (400 m) would be required between reinjection wells;
- e) no minimum distance would be required between production wells and reinjection wells;
- f) wells and pipelines could be placed wherever needed without regard to land ownership or right-of-ways.

Nine production wells and four reinjection wells would be needed to supply the energy required to meet the maximum load.

3.2 Legislative Program

In January the Arizona Geothermal Commercialization Team and the National Conference of State Legislatures (NCSL) met with the Arizona Senate Committee on Natural Resources to discuss geothermal energy legislation in Arizona. On the basis of the presentation, a subcommittee was established (under Senator James Mack) to address current legislative problems concerning geothermal energy.

A public subcommittee meeting to discuss current legislative issues was scheduled for February 9. Interested persons from both the public and private sectors attended and gave their ideas on current geothermal issues. The Arizona Geothermal Team gave a general overview presentation on the issues we would like the legislature to address in order to help pave the way for geothermal development in Arizona. The following is an

abstract from that presentation. Work on a more detailed specific document, detailing specific, relevant issues and various options for changing them, is currently underway.

3.2.1 Legislative Issues

Many direct uses of the resource have been proposed for the State of Arizona, given its current economic climate. Residential uses include space heating, heating for hot water, and space cooling. Commercial uses follow along the same lines. Industry, in addition to space conditioning and hot water needs, may find geothermal resources useful in their industrial processes. Key industries include agriculture and agricultural processing, copper mining and processing and, to a lesser extent, the bottling industry and the ready-mix concrete industry.

Whether geothermal energy development becomes a reality in the State of Arizona depends in large part on the attitude of the State Legislature. It is critical that the State of Arizona create an environment in which free enterprise can develop geothermal energy. Past geothermal legislation provides a sound basis on which to build; however, the statutory environment in Arizona is still not well defined and conducive for geothermal development. Further, with the impending removal of federal funding, the creation of a positive state environment becomes all the more important. Investment in geothermal energy typically requires large front-end capital investment and long-term security of tenure. For this reason, investor certainty in the law is imperative.

Currently, three barriers to the development of geothermal resources exist within the state. The first are legislative issues which relate to existing geothermal statutes. In the opinion of the Geothermal Com-

mercantilization Team, certain provisions within existing legislation may require clarification while other provisions appear to provide disincentives to development. The second and third perceived barriers relate to the novelty of geothermal energy use within Arizona and competition with other alternative energy sources' favorable tax treatment.

The most important issue within existing legislation involves the possible conflict between water law and geothermal law. Current definitions appear to inadequately distinguish between the two types of resources, water and geothermal. Further, geothermal development in active management areas may not be possible. Other legislative issues include the role of unitization, the effect of a royalty rate, and jurisdiction over planning for the utilization of geothermal resources. In addition, future data collection needed to identify geothermal resources could be improved by requiring temperature logs on all oil, gas, and water wells drilled in the state.

A second barrier to the development of geothermal resources appears to center on the novelty of direct-use geothermal applications within Arizona. Large front-end capital investments, perceived risks in discovering the resource and a general lack of information and experience with direct-use application appear to effectively deter utilization of geothermal resources. State support for development of geothermal resources in the form of state-funded drilling projects or demonstration projects similar to other surrounding western states could help to foster the necessary infrastructure and experience which is currently lacking. One possible source of funds for such programs may be revenues received from lands under federal and state geothermal lease.

A third barrier may be the lack of tax incentives for those who choose to develop geothermal resources. Current tax law tends to favor solar development at the expense of possible geothermal development; yet geothermal development may be more advantageous in certain instances. It is true that existing tax law offers geothermal developers deductions for exploration and development expenses; however, additional incentives may be necessary and desirable. Proposed incentives include property tax exemptions, rapid amortization, income tax credits and a geothermal drilling credit. Further, tax incentives should include cooling devices which utilize geothermal energy and some other energy source. A well-balanced incentive program could improve the pace of geothermal development in Arizona.

3.3 Outreach

During January 27-29, two members of the Arizona Geothermal Commercialization Team attended the State/Federal Geothermal Contractor's meeting in Seattle. A presentation on geothermal energy in Arizona was given at the meeting.

In February Margaret Rice of Farmer's Home Administration and Larry Goldstone of the Arizona Geothermal Team met with town leaders from Clifton, Safford, and Chandler to discuss the federal HUD program which identifies potential heating and cooling systems. All three towns are thought to be located near good geothermal resources which could be used for district heating and cooling systems.

On March 11 a presentation on geothermal energy and its role in small urban communities was given to the South Eastern Arizona Governments Organization (SEAGO) by Larry Goldstone. Jim Witcher of the Arizona Bu-

reau of Geology and Mineral Technology identified the state's geothermal resource areas.

During March, a new three-panel geothermal display was constructed by the Arizona Geothermal Team. This display was exhibited for a week at the Southern Arizona Energy Show at a local shopping mall.

During the first quarter, the Arizona Geothermal Team has been working closely with two groups of investors interested in utilizing low-temperature geothermal energy in large-scale greenhouse operations. The first proposed project would be a tomato greenhouse operation in Bisbee. The second proposed project involves growing roses using the geothermal energy to heat the greenhouse and possibly irrigate the flowers. This operation would be located in Pinal County.

In addition to these outreach activities, the monthly newsletter, The Geothermal Resource, was mailed to approximately 500 persons in both the public and private sectors in Arizona and other states. This newsletter serves to keep interested persons abreast of all current geothermal issues in Arizona. During the first quarter of 1981, major articles detailed the following: (1) the goals and objectives of the Arizona Geothermal Program for 1981; (2) the monthly Arizona geothermal highlights; (3) the Arizona Senate Natural Resources Subcommittee on geothermal energy; and (4) the role of the Arizona Corporation Commission in developing geothermal energy for district heating and cooling. A monthly series on the steps to geothermal use was started. Each month one of the steps to get geothermal energy out of the ground and into actual use will be detailed.

3.4 Cities Program

As a result of work completed during 1980 by Dr. Mike Pasqualetti of Arizona State University, two papers have been written. These papers address the electrical and nonelectrical development of geothermal energy in terms of the interrelationships with land and land use. The following are abstracts from those two papers.

3.4.1 The Site Specific Nature of Geothermal Energy:

Its Effects on Land Use Planning

The site specific nature of geothermal energy is manifest most strongly in such possible nonelectric applications as space conditioning. Inasmuch as electrical geothermal developments have encountered land use problems with regard to geothermal energy development, the more restricted nature of nonelectric resources suggest even closer relationships. In order to investigate these ties, nine sites of nonelectric geothermal development were studied in five western states. Land use was identified as important as the geothermal resource itself in future developmental potential. In this light, it is suggested that land use planning begin for nonelectric geothermal development at several dozen sites in the western U.S. prior to efforts at the expensive phase of full resource identification. The continuation of the present "resource-first" program which is standard throughout the country will maintain the current slow pace of commercialization, while a shift of emphasis toward a primary role for land use planning will "protect" the potential of the resource and bring it to more rapid useful application.

3.4.2 Geothermal Energy, Site Specificity, and Resource Reserves

The site specific nature of geothermal energy places a great emphasis on land use and land use planning. A survey of the operating geothermal generating stations around the world reveals many different approaches to this relationship. In Italy, agricultural use of the land proceeds concurrently with geothermal development. In Mexico, on the other hand, no multipurpose use of the geothermal field is attempted whatsoever. Just north of the primary Mexican site, in the Imperial Valley of California, land use considerations have long delayed tapping one of the largest geothermal fields in the U.S. In Japan, concern over development in national parks has threatened the future of geothermal development. In the largest field, the Geysers of Northern California, conflicts between desires to develop the land both for recreation and also for electricity have slowed development and raised costs. If geothermal energy is to meet its generating potential "resource reserves" must be established to protect the resource.

3.5 NMEI

During the first quarter of 1981, the Arizona Geothermal Commercialization Team and the New Mexico Energy Institute completed a joint effort to evaluate all available information on the geothermal resources in Arizona as well as the colocated population centers. The effort was designed to assist the state in planning and implementation of geothermal policy and subsequent development. The product was the aggregation of city/geothermal site pairs on a site, county, regional and state level. The aggregation is the best possible estimate of geothermal direct use available today. The following is a summary of the methodology and re-

sults.

CASH is a computer process for aggregating geothermal heat-on-line potential from many sites. The process begins with collocating cities for the nearest resource. Each city/site pair is evaluated using the BTHERM computer model for economic viability. The results of this analysis predict the year in which geothermal energy is economic for a site and the amount of heating potential which could be supplied by year after construction. Each city/site pair is then summed according to which year it comes on line to arrive at a total aggregation on a regional and state level. The results of the aggregation were as follows.

Low Case

If the system development is done by private business, two potential and one inferred pair are economic within the year 2000 time frame.

Existing on line capacity for the state is 3.00×10^9 Btu/yr.

Significant growth in quantity of geothermal heat which is economic begins in 1994. This increases through the year 2000. The economic heat potential for the year 2000 is 1.12×10^{12} Btu/yr.

With the city as the developer, economic heat-on-line increases much faster. Major increases begin in 1983 and rise steadily through the year 2000. The economic heat potential for the year 2000 is 3.02×10^{13} Btu/yr. The potential heat-on-line can be compared to the present energy use in the residential/commercial sector which could be penetrated if resources were available everywhere. This total state demand is 14.4×10^{13} Btu/yr of which geothermal could supply 21%. For the city developer 45 potential and eight inferred sites become economic by

the year 2000. A graph of geothermal energy potential by year (low case) is presented in Figure 3-1.

The industrial energy supply potential with a private developer begins with significant increases in 1995. It increases to 2.39×10^{13} Btu/yr by the year 2000.

High Case

The high case, a more optimistic case for geothermal development, is quite similar but with higher figures. These results are presented below in tabular form along with the results for low case for comparison. A graph of geothermal energy potential by year (high case) is also presented in Figure 3-2.

		<u>Low Case</u>	<u>High Case</u>
Pairs economic by year 2000			
Private Developer	Potential	2	66
	Inferred	1	17
City Developer	Potential	48	77
	Inferred	8	21
Year major growth in potential begins			
	Private developer	1994	1984
	City developer	1983	1983
Economic heat potential in 2000			
	Private developer	1.12×10^{12}	3.81×10^{13}
	City developer	3.02×10^{13}	4.70×10^{13}
Industrial heat potential in 2000			
	Private developer	2.39×10^{13}	6.13×10^{13}
Percentage of state space heat demand*		21%	33%

* That portion of the residential and commercial space heating and hot water demand which could be supplied with direct use geothermal, if it were available everywhere.

Figure 3-1: Arizona Geothermal Direct Use Potential Heat-On-Line, Low Policy Case

Figure 3-2: Arizona Geothermal Direct Use Potential Heat-On-Line, High Policy Case

In addition to the computer runs for all communities in Arizona colocated with a geothermal resource, work was done on modelling a power plant and seven site specifics on heat pumps and district heating. The results have not yet been analyzed thoroughly.