DOE/RA/50076--T13

EVALUATION OF GEOTHERMAL ENERGY IN ARIZONA

MASTER

Arizona Geothermal Team

Quarterly Topical Progress Report

July 1, 1981 - September 30, 1981

DOE/RA/50076--T13

DE82 010969

Prepared by:

Don H. White, Ph.D., Principal Investigator

Larry A. Goldstone, Project Manager

Other Contributors:

Cherif Balamane
Ronda Bitterli
Wei-hsin (Alex) Chung
David Wolf, Ph.D.
Tom Young

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Arizona Solar Energy Commission 951 4058
James F. Warnock, Jr., Director
Frank Mancini, Ph.D., Associate Director
1700 West Washington
Phoenix, Arizona 85007

Work performed under
Contract No. DE-FC03-80RA50076
Modification No. A-001
U.S. Department of Energy
San Francisco Operations Office
Region IX

Subcontract 114-80 with 950 3464
Department of Chemical Engineering
University of Arizona
Tucson, Arizona 85721

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1.0 Introduction

Dwindling oil supplies, dependence on foreign oil and steadily rising energy prices 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 Dr. 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, Ph.D., Project Administration; (2) Don H. White, Ph.D., 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

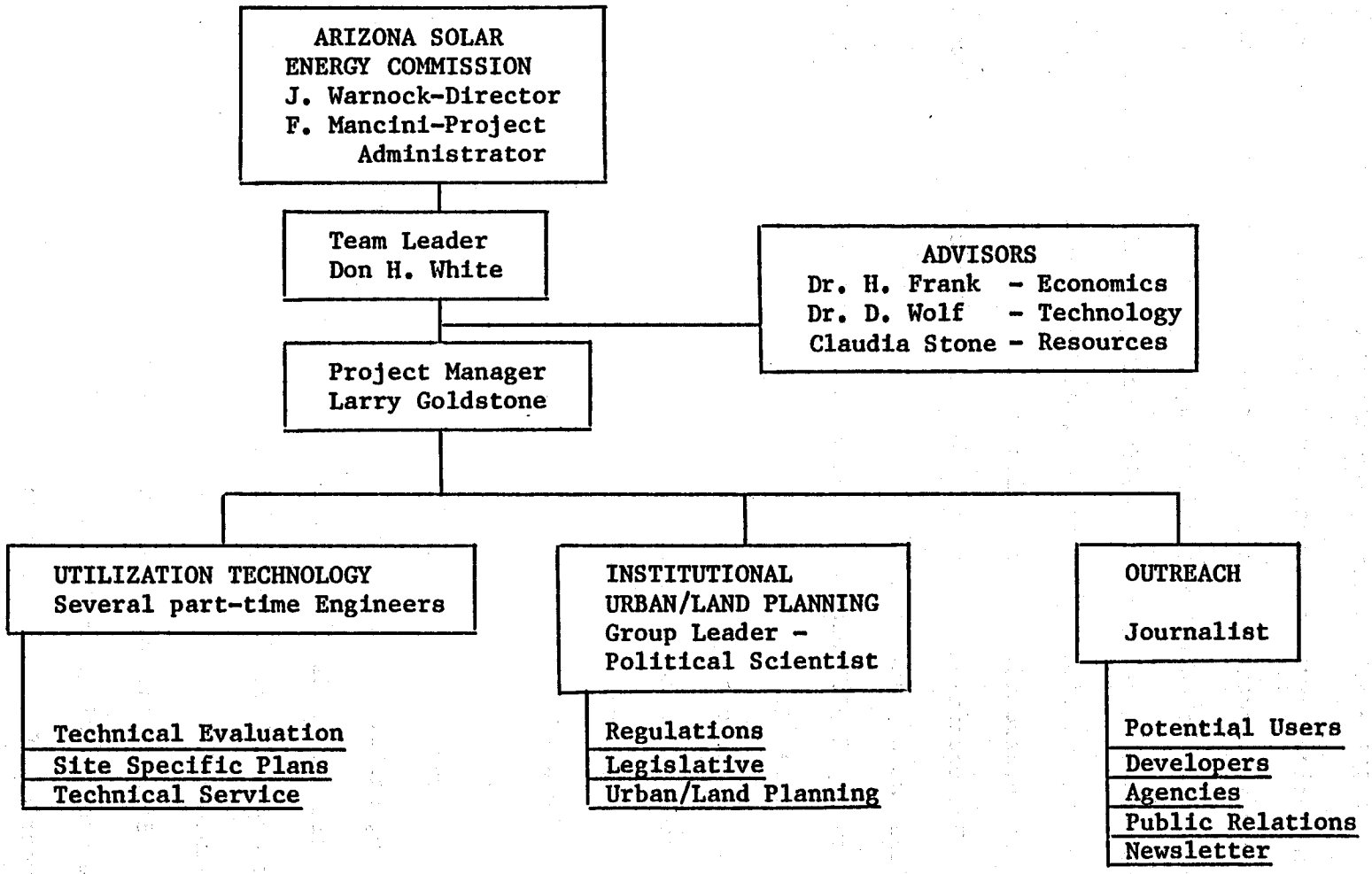

Figure 1-1: Organizational Chart
Arizona Geothermal Commercialization Team

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

During 1980 and continuing on through 1981, the Geothermal Team changed its emphasis from planning to commercialization. During 1981 the main emphasis for this project was 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.

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 is 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 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 were included in 1980 reports. These three tasks will be completed during 1981 and will 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 industries. 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

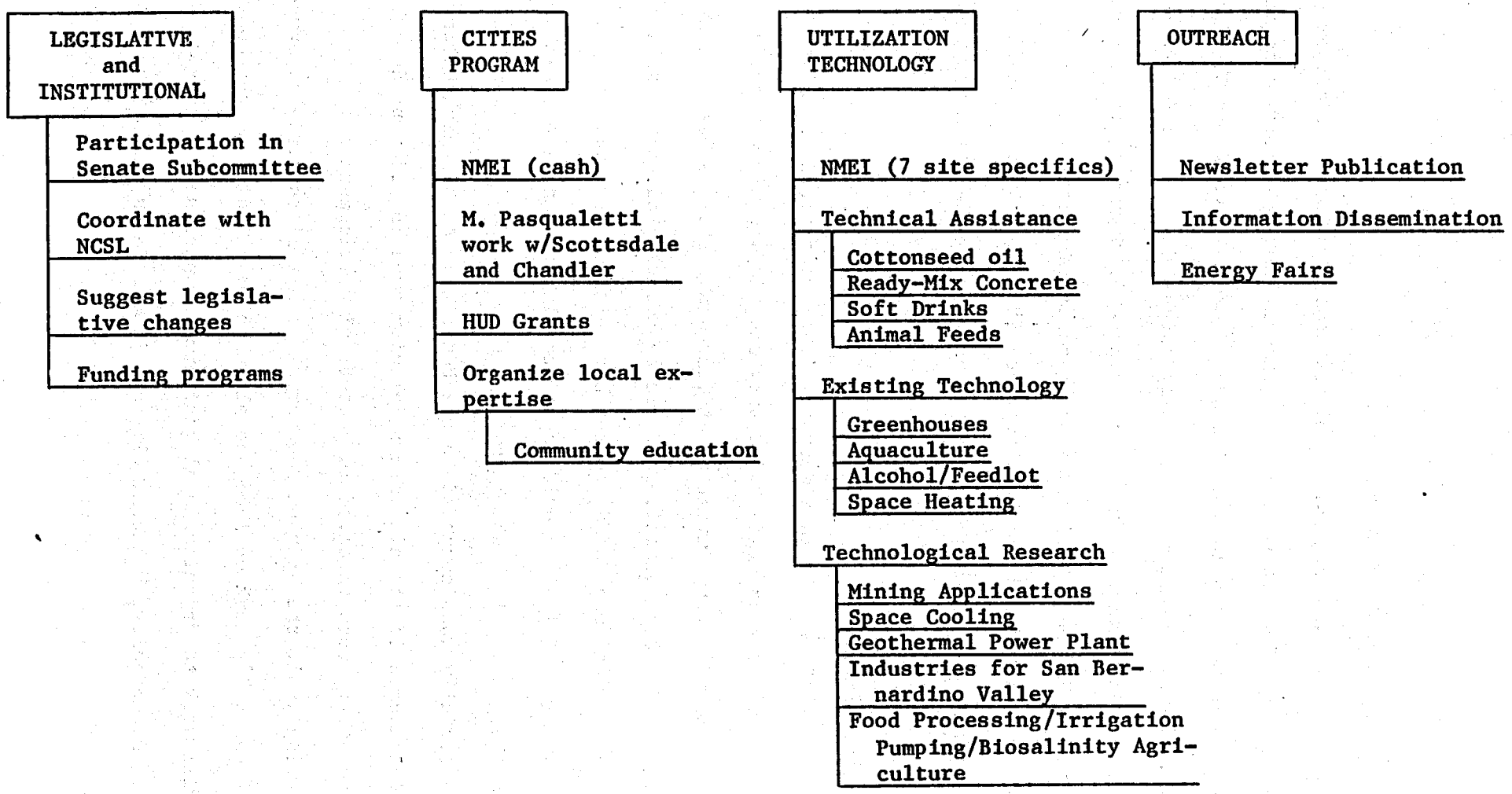

Figure 2-1: Arizona Geothermal Program for 1981

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 industries 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 is a summary of work completed during the third quarter of 1981.

3.1 Integrated Alcohol/Feedlot/Geothermal Operation

At the outset of 1981, it was believed that a number of ethanol production facilities would be constructed in Arizona for the purpose of manufacturing alcohol for use in gasohol (blends of gasoline and anhydrous alcohol). Federal legislation had created a scheme to subsidize the more expensive alcohol fuels so that after blending they could be priced competitively with gasoline. Through a series of blenders credits and excise tax exemptions, such subsidies were made available. Further, the federal government offered low-cost loans for the construction of alcohol production facilities. As a result of this federal action, a number of groups in Arizona had plans underway to construct and operate ethanol production facilities.

Since January of 1981, several occurrences have slowed (if not stopped) the plans to manufacture alcohol in Arizona. First, many of the sources of federal funding for alcohol fuels have dried up or have been curtailed. In addition, discussions suggesting that the tax breaks available to alcohol fuel producers and blenders may be curtailed have created a cautionary environment amongst alcohol fuel producers. Further, the actual market for gasohol has been very slow in developing, particularly in Arizona. Gasohol sales are much lower than what was initially anticipated. Lastly, the long-term availability of conventional starch feedstocks such as corn and potatoes has been questioned as well as the price at which the feedstocks may be available. Clearly, a number of factors have contributed to the slowdown of alcohol production.

The Arizona Geothermal Team believed that geothermal energy could play a significant role in alcohol production. The Team closely monitored the activities of the Arizona alcohol industry and received several inquiries during the course of the year from alcohol producers interested in using low-temperature geothermal heat. In addition, the Team believed that the growth of the alcohol industry could be accompanied by growth in the cattle feedlot industry in Arizona. However, declining interest in alcohol production from starch feedstocks has caused a change in emphasis.

During the third quarter the Arizona Geothermal Team began researching the possibility of using geothermal energy in an advanced process design for ethanol production from cellulosics, in particular, wood waste. Further, using geothermal energy to pretreat the wood waste coupled with molecular sieve drying columns to remove the last 10 percent of water from the alcohol could result in significant cost reductions. It is possible that the envisioned process could enhance the economics of ethanol production. To date, the initial research and reporting has been completed. The final paper is now in review and should be completed during January of 1982.

3.2 Geothermal Energy in the Mining Industry

During the past several years, the Arizona Geothermal Team has been researching the feasibility of integrating geothermal energy into the copper extraction and processing industries in Arizona. In particular, in situ solution mining of various minerals (mostly uranium) and the dump leaching of copper have been researched. In both cases, preliminary results were promising enough to warrant further work.

During the third quarter of 1981, assistance was received from Mr.

Tom Young, Research Metallurgist in the Mineral Technology Branch of the Bureau of Geology and Mineral Technology, in evaluating results of work performed over the past years. Mr. Young's 18 years of experience in metallurgical processing proved most helpful. It was learned that the in situ solution mining process using geothermal energy, though a promising idea, probably would never be commercialized in Arizona mainly due to the unknown long-term environmental impacts of utilizing such technology.

It was also learned that geothermal energy may have limited applications in copper recovery from dump leaching operations. A majority of the state's 15 leach dumps rely on bacterial action in the overall leaching process. Although increased temperatures of the leaching fluids improve the rate of copper extraction, geothermal fluids with temperatures greater than 40°C (104°F) may have adverse effects on the bacteria essential to the leaching process. However, by using geothermal water at a temperature of 40°C, significant amounts of copper can be recovered in dump leaching operations without harming the bacteria. Preliminary results indicate that increasing the leaching fluid temperature from 30°C (86°F) to 40°C can increase copper recovery by 10 percent.

As a preliminary example of the economic returns which are possible, consider the following analysis. Assume that a typical leach dump in Arizona contains 200 million tons of low-grade (0.15 percent) copper ore. Potentially recoverable copper from such a dump amounts to approximately 300,000 tons. By using 30°C (86°F) leaching solutions, approximately 58 percent of the total available copper, or 174,000 tons, would be recovered over the life of the dump leach operation. At $0.50 per pound (unrefined), the gross value of this copper over 30 years would be $174,000,000. By raising the leaching fluid temperature to 40°C (104°F), recovered copper

would increase to 68 percent, or 204,000 tons, over the same time period. The gross value over 30 years at $0.50 per pound (unrefined) would increase to $204,000,000. Thus, using warm, geothermal water increases the value of the leach dump by $30,000,000.

From the simple economic calculations above, it is clear that the introduction of geothermal energy into the dump leaching process can provide significant benefits. Further, the majority of the cash benefit is available in the earlier years of the dump leach operation, if geothermal energy is used. Note that the benefits alluded to in the above analysis do not include investment costs for the geothermal system. However, the magnitude of the benefit is great enough to suggest that the investment would be a favorable one.

Research was also begun on integration of geothermal energy into the flotation extraction process in order to improve copper recovery. A tour of the Phelps Dodge Morenci Mine was arranged in September in order to view the flotation process and to formulate ideas for ways to integrate geothermal energy into the process. Preliminary results of work to date suggest that a 10°F increase in temperature will increase copper recovery by one percent.

Two reports on the use of geothermal energy in copper dump leaching and the flotation extraction process are being completed and should be available in January, 1982.

3.3 Geothermal Space Heating and Cooling

Much of the work over the past several years has dealt with the problem of space conditioning using geothermal energy. Studies have been performed to analyze the technology and economics of space conditioning at various locations in Arizona. Some of these results were reported in

the Second Quarterly Report, 1981, while others, such as the Maryvale Terrace district heating and cooling analysis, still await final typing.

During the third quarter, two new studies were initiated. One report, a preliminary economic analysis of both a heating system and a heating and cooling system for large buildings located in Scottsdale, Arizona, has been completed. Although the report is still in the review process by city officials, some general conclusions can be stated. It appears that space heating for large city buildings is currently feasible. However, the city would need to undertake the development. If the private sector were to develop the same resource, the investment would not be profitable until 1985. Under both types of development, a resource temperature of 140°F at a depth of 3500 ft was assumed.

For the heating and cooling system, a resource temperature of 200°F at a depth of 6000 ft was assumed. Absorption refrigeration using geothermal energy to fire the absorption chiller was the preferred cooling method. However, study results indicate that even under city development, such a system would not be economic for at least ten years since natural gas could be used more inexpensively than geothermal energy to fire the absorption chiller. The major reason for the poor economic results of the geothermal system was the temperature of the geothermal resource. A temperature of 250°F would have greatly improved the performance of the geothermal cooling system.

The other area of research initiated during the third quarter was a heat pump analysis for heating and cooling a large commercial building. McKale Center, a large activity center on the University of Arizona campus, was selected as the model building. This choice was based on several reasons. First, a thermal well (86°F) is located within two blocks of

the facility. Second, the building was easily accessible so researchers could collect accurate energy-use data on the facility. Work is expected to be completed in December, 1981, with a final report available in January, 1982.

One other heating analysis completed during the third quarter involved the design and economic feasibility of space heating 7.4 acres of greenhouse at the Environmental Research Laboratory. Tables 3-1 - 3-4 summarize the findings of the study. It is anticipated that once a final report is completed, the results will be turned over to the University of Arizona in hopes that it will pursue the project.

3.4 Identification of a Suitable Industry for a Remote Geothermal Site

An area in southeast Arizona known as the San Bernardino Valley is suspected to contain at least low-temperature geothermal energy in large quantities. Reasons for this belief stem from private-sector leasing in the area as well as preliminary geologic assessments which indiate that the region may contain just low- to moderate-temperature resources suitable for direct-use applications rather than the high-temperature resources required for power production.

The Arizona Geothermal Team initiated studies to find a suitable industry for this area. The analysis began with the identification of the ideal industry. First, an ideal industry would need to require large amounts of low-temperature heat or energy. Second, the industry should be capital intensive as very little labor is available in the area due to its remote location. Lastly, a highly mechanized or computerized process would be ideal. An industry which would manufacture heavy water for nuclear reactors could meet these criteria. From preliminary research, it appears that the United States will require at least one new heavy water

TABLE 3-1: BASIC PROJECT DATA

* GREENHOUSE AREA	7.4 ACRES
* NATURAL GAS PURCHASE PRICE	$2.71 PER MBTU
* NATURAL GAS CONSUMPTION	37,825 MBTU
* ANNUAL NATURAL GAS COST	$102,506
* GEOTHERMAL CAPITAL COST	$687,509
* ANNUAL ELECTRICAL COST	$ 17,354
* ANNUAL MAINTENANCE COST	$ 6,500
* PROJECT LIFE	20 YEARS
* INTEREST RATE	15%
* DEBT SERVICE	$109,837

TABLE 3-2: CAPITAL COST SUMMARY - ENVIRONMENTAL RESEARCH LAB

PRODUCTION WELLS (2)	$360,000
PRODUCTION WELL PUMPS (2)	49,800
ADDITIONAL PIPING	132,000
CIRCULATION PUMPS (2)	6,034
UNIT HEATERS (25)	32,175
WATER STORAGE TANK	70,000
TOTAL CAPITAL EQUIPMENT	$650,009
ENGINEERING (10%)	65,000
CONTINGENCY (5%)	32,500
TOTAL SYSTEM COST	$747,509
LESS BOILER RESALE	60,000
NET SYSTEM COST	$687,509

TABLE 3-3: ANNUAL CASH FLOW ANALYSIS - GREENHOUSE HEATING

YEAR	ANNUAL NATURAL GAS COST	ANNUAL MAINTENANCE COST	ANNUAL ELECTRICAL COST	ANNUAL SAVING	PRESENT VALUE OF SAVINGS
1	$ 102,506	$ 6,500	$17,354	$ 78,652	$ 78,652
2	121,982	7,085	18,916	95,981	85,697
3	145,159	7,723	20,618	116,818	93,126
4	172,739	8,418	22,474	141,847	100,963
5	205,559	9,175	24,497	171,887	109,237
6	244,615	10,001	26,701	207,913	117,975
7	291,092	10,901	29,104	251,087	127,208
8	346,400	11,882	31,724	302,794	136,969
9	412,216	12,952	34,579	364,685	147,290
10	490,537	14,117	37,691	438,729	158,210
11	544,496	15,388	41,083	488,025	157,131
12	604,391	16,773	44,781	542,837	156,053
13	670,874	18,282	48,811	603,781	154,975
14	744,670	19,928	53,204	671,538	153,899
15	826,583	21,721	57,992	746,870	152,824
16	917,508	23,676	63,212	830,620	151,751
17	1,018,434	25,807	68,901	923,726	150,680
18	1,130,461	28,130	75,102	1,027,229	149,610
19	1,254,812	30,661	81,861	1,142,290	148,543
20	1,392,842	33,421	89,228	1,270,193	147,478
				$10,417,502	$2,678,271

TABLE 3-4: PROJECT EVALUATION RESULTS

* TOTAL ANNUAL SAVINGS	$10,417,502
* PRESENT VALUE OF SAVINGS	$2,678,271
* SIMPLE PAYBACK	5.39 YEARS
* PRESENT VALUE PAYBACK	6.80 YEARS
* NET PRESENT VALUE	$1,990,762
* ENERGY COST COMPARISON (FIRST YEAR)	
NATURAL GAS	$3.39 PER MBTU
GEOTHERMAL	$3.53 PER MBTU

manufacturing facility in the future. During the third quarter, research was still continuing into this proposed idea.

As a qualification to the work being performed, a number of sites in the West may be able to use geothermal energy in manufacturing heavy water for reactors. Of all sites available, Arizona sites would probably appear fifth on the list. The ideal sites would be existing military bases in Idaho, Washington or California. However, the results of our work may prove useful in other locations as well.

3.5 Irrigation Pumping

During the third quarter, meetings were held with Sperry in order to obtain additional data related to their power production system and irrigation pump. The principles upon which the Sperry irrigation pump operates are an extension of the principles being applied to their power system. After the meetings, a series of calculations were made in order to assess the applicability of their irrigation pump to conditions known to exist in Arizona. In order to perform the calculations, a series of conditions regarding geothermal temperature and groundwater temperature were necessary. Efficiencies were then calculated given the assumed conditions. As of the end of the third quarter, results were not available due in part to the status of the Sperry test site in Imperial County, California.

3.6 Coal-Fired/Geothermal-Assisted Power Plants

No work was performed on this task during the third quarter.

3.7 Legislative and Institutional Program

During the third quarter, the Arizona Department of Health Services issued for public comment a series of draft regulations for underground injection. Had the regulations passed as proposed, geothermal developers may have encountered serious problems if they tried to reinject. Most

of those problems would have resulted from double-agency jurisdiction over reinjection of spent geothermal fluid. The Commercialization Team submitted a series of comments to try to limit the role of the Department of Health Services in favor of the Oil and Gas Conservation Commission (OGCC). The OGCC currently has regulations for underground injection which are adequate to meet Health Service standards. As of the end of the third quarter, the submitted comments were still under review.

3.8 Area Development Plans (ADPs)

The seven Area Development Plans have been completed. Information concerning population of the counties, description of the resources and identification of potential users was updated and included in the reports. The major headings are:

1. Introduction
2. Area Development Plans
3. Geothermal Resources
4. Economy
5. Land Ownership
6. Energy Use
7. Water
8. Matching Geothermal Resources to Potential Users

Results of space heating feasibility analyses were also included for those areas in which analyses were performed.

3.9 Outreach

The mailing list for the Geothermal Resource is currently just under 640. The readership is varied and includes individuals, chambers of commerce, colleges and universities, federal and state agencies, planning commissions, mining companies, oil companies, engineering firms, utility

companies and state legislators. Responses generated from the newsletters have generally been from energy-related corporations and commissions, engineering firms and oil companies.

Front-page articles for the most recent newsletters have covered "Geothermal Energy as an Income Investment" and "Area Development Plans." The remaining pages of the newsletters continued the discussion of steps to geothermal development. Headings for the articles in the series were "Reservoir Evaluation," "Economic Feasibility" and "Institutional Requirements." Starting with the August issue, a column was devoted to describing geothermal potential in a particular area. The Clifton area was covered in August and the Phoenix area in September. Dr. Don H. White's "As I See It" column and the monthly "Arizona Highlights" have continued to be featured in the newsletters.