IWRRI

GEO-HEAT CENTER

UURI

Unsolicited Technical Proposal for

Geothermal Resource Assessment and Direct-Heat Utilization Evaluation

submitted to:

U.S. Department of Energy
Office of Conservation and Renewable Energy
Geothermal Division
Washington, D.C. 20585

U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

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Oregon Institute of Technology
University of Utah Research Institute
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Geothermal energy is the nation's third largest energy reserve, and low- and moderate-temperature resources are widely distributed through out 15 western states. Although there has been increased interest in developing these resources since the energy crisis of the 1970's, the enormous potential of these resources is greatly under-utilized. Geothermal energy is essentially non-polluting and offers one alternative to the environmental problems associated with the burning of fossil fuels.

The proposal submitted here presents an integrated strategy of research, resource evaluation, engineering, and technical assistance which will stimulate the conversion to, and utilization of, low- and moderate-temperature geothermal resources throughout the western United States. Individual state-designated teams will develop basic resource data with the assistance of the University of Utah Research Institute (UURI) and the Idaho Water Resources Research Institute (IWRRI). The Oregon Institute of Technology (OIT) Geo-heat Center will play a lead role in identifying the collocation of resources and potential users, and in providing engineering evaluations and stimulating development. A three of four year program funded at a level of approximately 1.9 million dollars per year, would provide a substantial increase in the utilization of these plentiful, non-polluting resources.

geothermal power can quickly come on line when local power oversupplies are eliminated by increased demand.

While there has been a substantial increase in direct heat utilization during the last decade, the large resource base of low- to moderate-temperature resources is greatly under-utilized. The thermal energy of these resources must be beneficially used near the source of the thermal fluids and hence requires the collocation of the resource and the user, or development of a user facility at the site of a hydrothermal resource. Direct heat quality resources are typically used by small businesses, various types of local industry, communities, and individuals. These users rarely have, and cannot afford to hire, the technical expertise required to delineate and develop geothermal resources from scratch. To obtain a more complete utilization of the direct-heat resource, a current inventory of the resource must be made available to potential users, together with the information necessary to evaluate the geothermal reservoir and the economics of potential utilization types. It is necessary to further reduce the risk of resource development for municipalities and small business, until the use of these widespread, nonpolluting resources becomes more established.

Increased utilization of low- and moderate-temperature resources addresses two major national goals: 1) the reduced consumption of diminishing fossil fuel reserves, and the dependence on imported petroleum; and 2) reduced emission of greenhouse gases, acid rain-producing gases, and particulate matter into the atmosphere. In addition, the conservative use of geothermal fluids for space heating could be very important in reducing air pollution on a community or local scale, especially in intermountain basins of the west which are subject to atmospheric temperature inversions. Any reduction of fossil fuel burning in the western U. S. will also reduce the effect of acid rain problems in the eastern tier states.

2.0 OBJECTIVE

The objective of the proposed direct-heat geothermal program is to reduce the consumption of fossil fuels, and the attendant environmental problems, by achieving greater utilization of the nation's widely distributed low- to moderate-temperature geothermal energy resources. We propose to effect this by identifying those resources collocated with population centers, and by characterizing the resources to reduce the economic risk associated with development. Promising resources not collocated with population centers will also be evaluated for the potential for future development. Many industries needing thermal energy may be willing to convert their process and relocate as an alternative to cleaning up hazardous air emissions. Feasibility studies will be completed for various uses, and the resulting information will be made public to stimulate development. As part of an outreach component, the targeted uses will be matched to existing industries and contacts made to work with these industries to have them consider geothermal energy as an alternative fuel.

3.0 BACKGROUND

Man has made use of direct heat from geothermal resources for thousands of years, and many tribal villages or early communities were built around surface thermal features. A number of cities and villages in the United States now include" Hot Springs" as part of the community name. The United States falls behind Japan, Hungary, Iceland, the Soviet Union, and China in the direct use of geothermal energy.

3.1 Geothermal Resource Base

Low- to moderate-temperature geothermal resources are widely distributed throughout the western United States (Reed, 1983) in contrast to the distribution of the highest grade geothermal resources, as summarized by Muffler (1978). The distribution of these resources is shown in a general manner in Figure 1. While numerous resources may occur in the areas indicated, individual reservoir areas where the fluid may be beneficially used may be as small as one square kilometer or less. In the northern Great Plains, stratabound resources of major aquifers with fluid temperatures exceeding 50°C may extend in a continuous manner for thousands of square kilometers (Gosnold, 1987; 1990). While high-temperature resources are relatively rare, the number of low- and moderate-temperature resources increases exponentially as the reservoir temperature decreases, as shown in Figure 2, and the resources become much more widely distributed.

A single hydrothermal resource in Boise, Idaho has been producing fluids for a district heating system since 1892, and has recently been expanded to include a major portion of the state and federal complex as well as businesses in the downtown portion of Boise. In contrast, a hidden resource discovered as recently as 1975 near Newcastle, Utah has been rapidly developed to provide heating for three large greenhouses, a church, and several community residences.

Much of the recent interest in developing direct heat resources may be attributed to a Department of Energy initiative, the State Coupled Program, which began in 1977. As a result of this program, geothermal resource maps were compiled and distributed for 18 western states. The maps, typically printed at a scale of 1:500,000, identify wells and springs

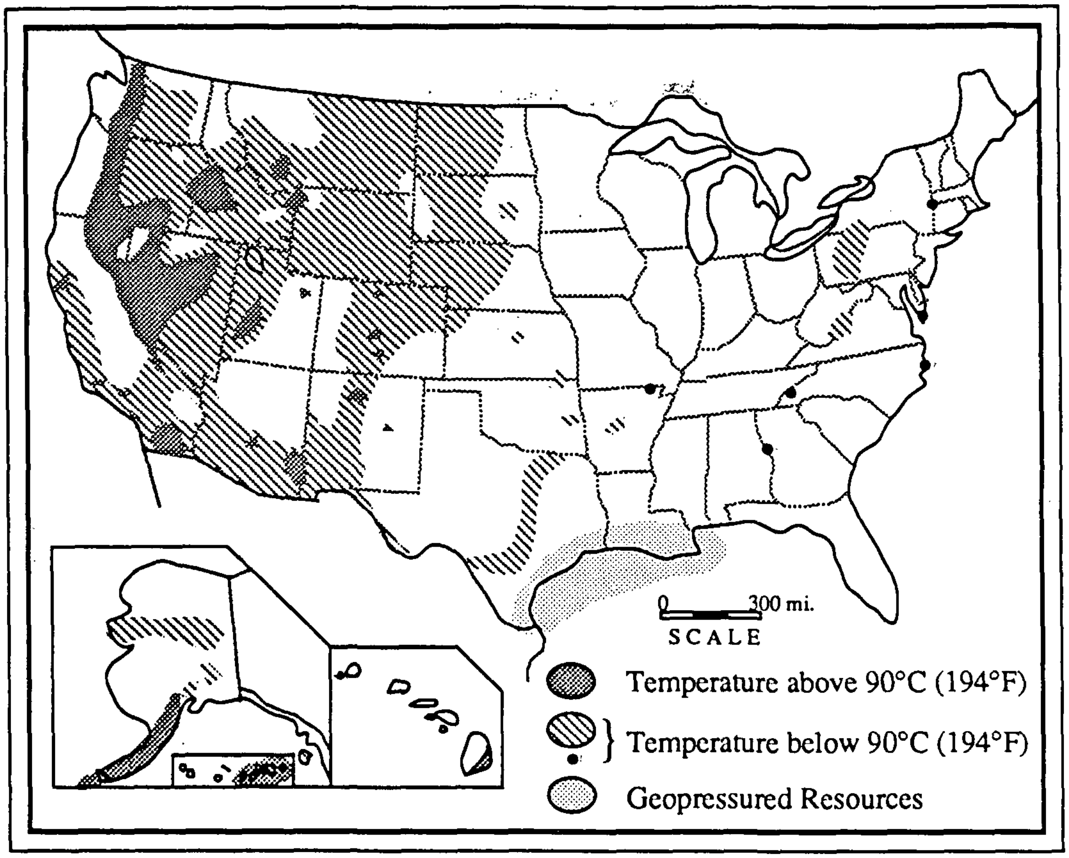

Figure 1. Generalized distribution of geothermal resources in the United States.

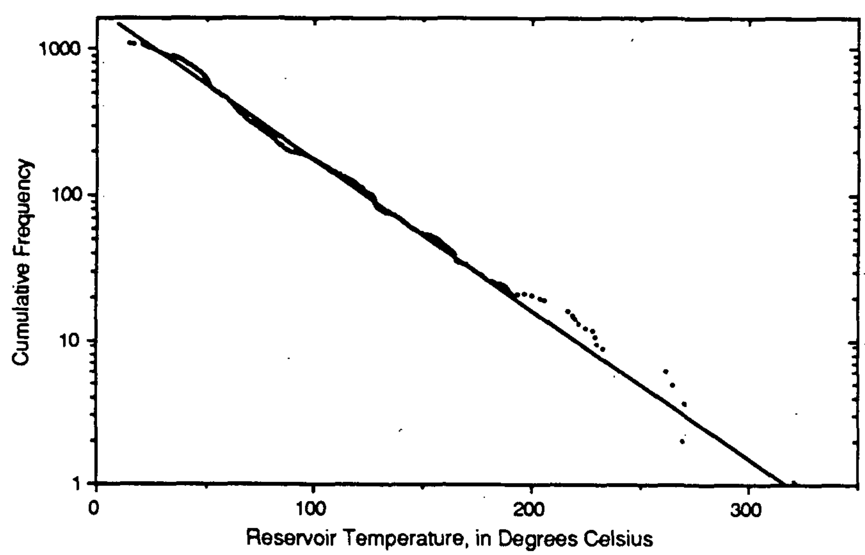

Figure 2. Cumulative frequency versus reservoir temperature for 1,346 hydrothermal-convection systems in the United States, including 1,125 low-temperature geothermal systems and 220 intermediate-and high-temperature systems (from Reed, 1982).

with anomalous temperatures, and were released from 1980 to 1983. The maps have been extremely useful to the more aggressive developers, and form an important starting point for the proposed study.

The Oregon Institute of Technology authorized a study of the collocation of geothermal resources and communities for eight western states (Eliot Allen & Associates, 1980). The criteria used in this study included incorporated cities located within five miles of a thermal well or spring having a temperature of 50°F or greater. This inventory identified a total of 1,277 hydrothermal sites within five miles of 373 cities in the eight states, with a combined population of 6,720,347 persons. The combined heat load for all cities (exclusive of industrial loads) was estimated at 132,556.0 E9 Btu/yr.

While the 1980 study was quite instructive and arrived at impressive population and heat load estimates, it was limited in scope (only eight states), and did not account for the low-temperature use loads of agriculture, greenhousing, or aquaculture. It considered wells and springs with temperatures as low as 50°F, and predated the publication of results from the DOE State Coupled Program for 17 western States. Clearly the 1980 study is outdated. We propose, as the initial part of our new study, a collocation inventory to address cities and established communities located within five miles (8 km) of a thermal well or spring having a confirmed temperature of 120°F (50°C) or greater. The study will also address the collocation of geothermal resources and major agricultural areas which are potential users of direct heat.

As an indication of the difference which might result from an update of the inventory, we consider two states where a current inventory is in progress. A 1990 collocation study for Alaska lists 13 communities with a total population estimated at 6,500 compared to the 1980 estimates of 5 communities with a total population of 3,408. Alaska may be atypical; it is a state with many hydrothermal resources and great heating requirements, but a limited and well-scattered population. Our 1990 review of collocated resources and population for Montana includes 17 communities with a total population of approximately 84,000. Montana was not included in the 1980 inventory.

We believe a complete inventory of collocated resources and population centers will indicate a potential heat load for 17 western states, exclusive of industrial loads, more than 10 times the 1980 heat load estimated for eight states. The total heat load which could be addressed by low- to moderate-temperature geothermal resources is even greater, should we consider industrial utilization and low-temperature heat pump utilization. It is apparent that geothermal energy can make a much more substantial contribution to our energy picture, but the private sector needs the necessary information and stimulation.

3.2 Potential Uses

Enormous potential exists in the United States for geothermal heat pumps and direct-heat projects to make a significant contribution to our national energy needs by offsetting electricity and replacing conventional fuels. Implementation of these projects will reduce emission of greenhouse gases that impact our environment from combustion of fossil fuels .

Geothermal heat pump potential exists in all states with an estimated 110,000 units currently installed (5.65 trillion Btu per year or 1,200 MWt) and 15,000 to 25,000 units being installed annually. If technical and economic advances were instituted, it is believed that installations of geothermal heat pumps could increase to between 240,000 to 400,000 annually. This would amount to an increase of 12.3 trillion Btu per year or approximately 1.0 Quad by the year 2010. Geothermal heat pumps use either closed-loop ground heat exchangers or wells, and are 30 percent more efficient than air-source units.

Geothermal space and district heating systems, other than geothermal heat pumps, need to be collocated with resources of greater than 50°C, which occur primarily in 15 western states. It is estimated that the space and district heating potential load is 54.2 trillion Btu per year corresponding to a thermal capacity of 7,850 MWt. These cities are within 5 miles (which is estimated to be an economical transmission distance) of a resource with a temperature greater than 50°C. Technically, transmission distances of greater than 25 miles are possible, which would certainly increase the potential heat load. In Iceland, geothermal fluids have been economically transported 39 miles to a city with a population of only 5,000. This study will identify resource potential and potential heat loads for the region 5 to 20 miles from a resource, where there is the likelihood of district space heating for an entire new subdivision, such as the area outside Reno, Nevada.

Other direct heat applications include industrial process heat, greenhouse heating, aquaculture and swimming pool heating. Industrial processes require the highest application temperatures, ranging from 80 to 150°C. Existing industrial applications include enhanced oil recovery, heap leaching of gold, food and grain drying, to mention a few. Figure 3 shows application temperature ranges for industrial processes and agricultural applications.

Greenhouses are one of the fastest growing applications in the direct-use industry. A number of commercial crops can be raised in greenhouses, making geothermal resources in cold climates particularly attractive. Crops include vegetables, spices, flowers (potted and cut), house plants and tree seedlings.

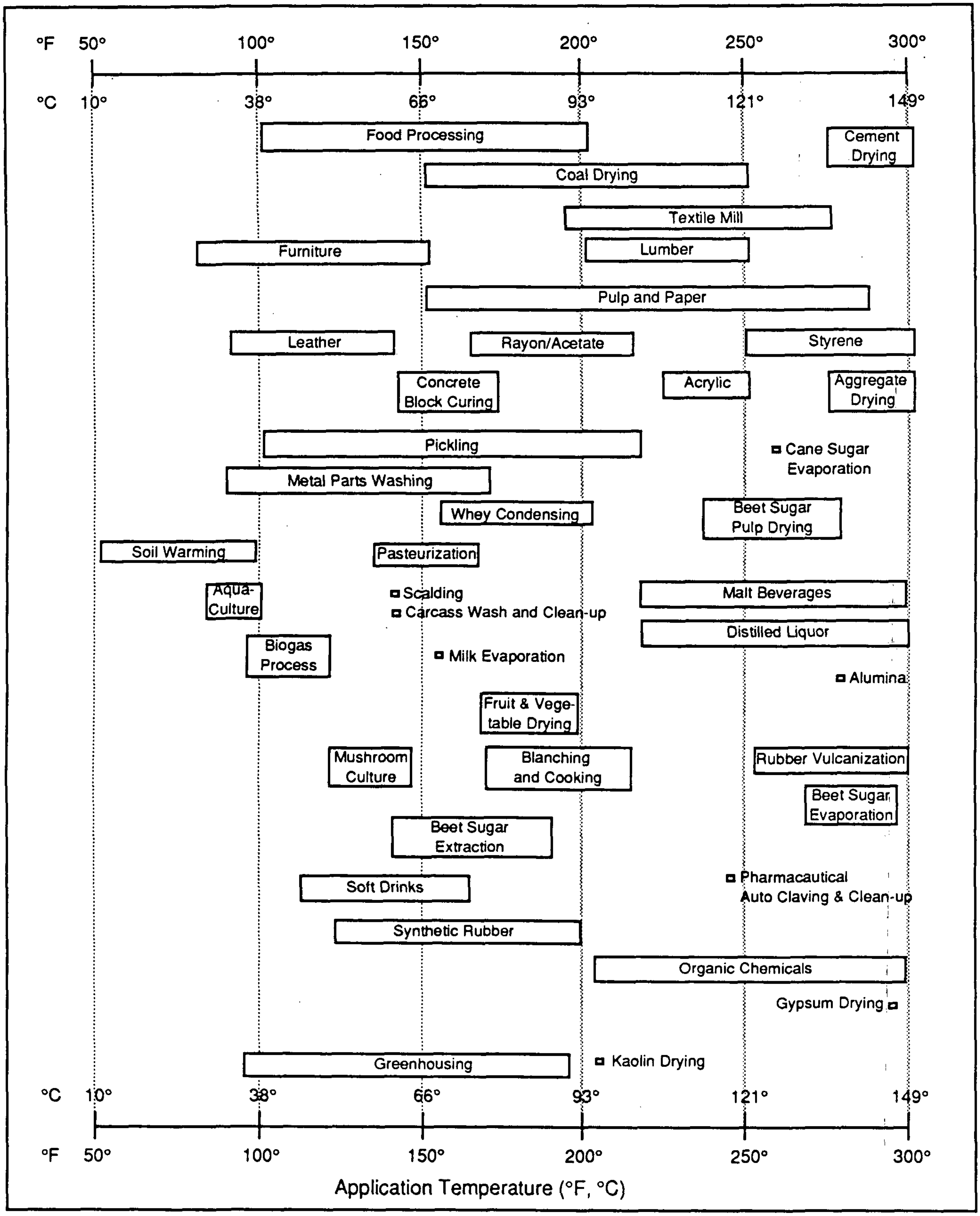

Figure 3. Application temperature range from some industrial processes and agricultural applications.

Aquaculture involves the raising of freshwater or marine organisms in a controlled environment to enhance production rates. The principal species raised include catfish, bass, tilapia, sturgeon, shrimp, alligators, and tropical fish. The benefit of controlled rearing temperature in aquaculture operations can increase growth rates by 50 to 100 percent, and thus, increase the number of harvests per year.

The total installed capacity of direct-use projects is 7.2 billion Btu/hr (2,100 MWt), with an annual energy use of 18.7 trillion Btu/yr (5 million barrels of oil energy equivalent). Approximately 44% of this use is due to geothermal heat pumps. The relative energy used in the six major direct use applications is shown in Figure 4. Enhanced oil recovery is not shown due to its large value.

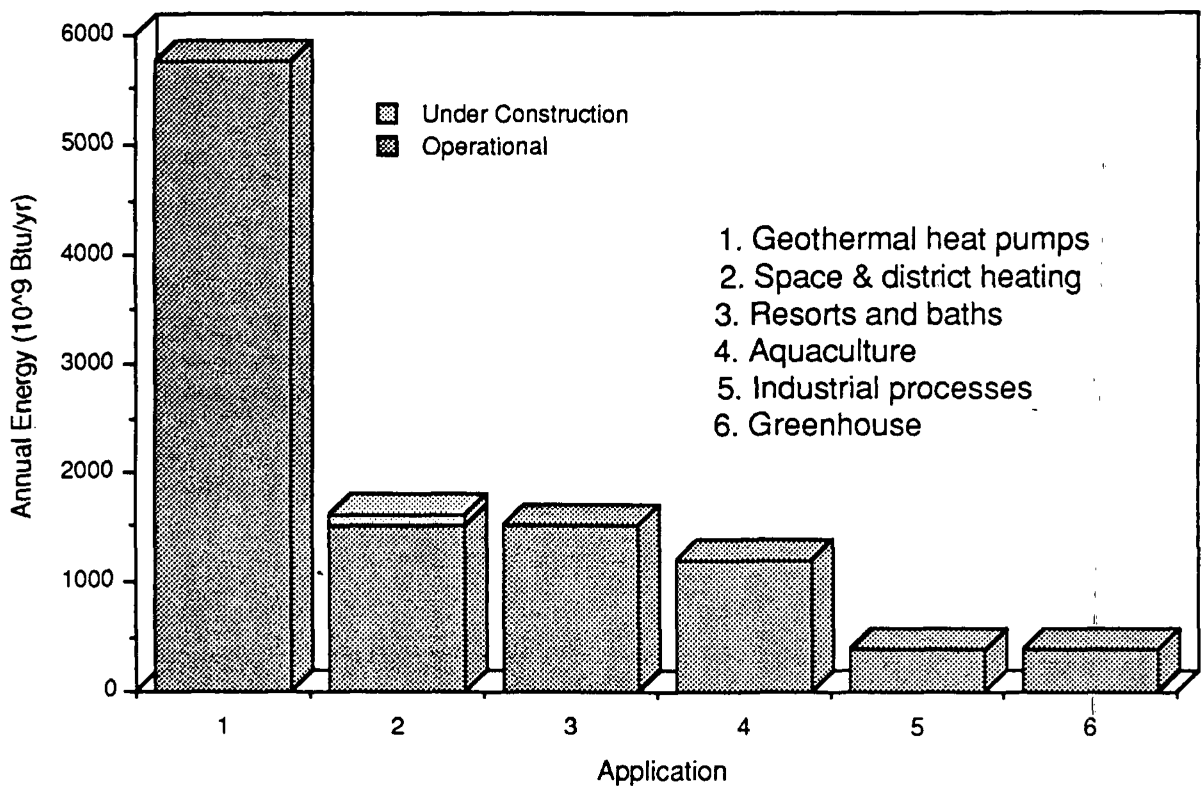

Figure 4. Relative energy need for the six major direct use applications.

Three main factors result in direct applications having a significant potential in geothermal energy use. First, although electricity generation is technically feasible at low- to moderate-temperatures, there is a definite economic limit on the resource temperature suitable for power generation. Second, the supplying of low- to moderate-temperature heating from high-grade fossil fuels results in poor thermodynamic performance. Matching geothermal resources to meet these heating requirements would result in much better use of U.S. energy resources and reduce emissions from combustion of fossil fuels. Third, a large portion of the basic energy needs of modern industrial society is for low- to moderate-temperature heating. The energy used in the United States below 250°C represents 50 percent of the total energy. Space heating at 50 to 75°C application temperature is by far the largest single use, representing 45 percent of the total at temperatures below 250°C. Therefore, space heating is the most important application.

4.0 PROPOSED PROJECT

A multiphase project, which would extend over a period of 3 or 4 years, would be required to produce the desired increase in utilization of the direct heat resource base. The project would require expertise in geothermal resource exploration, development, and reservoir research. Because of the broad distribution of resources, much of the resource assessment would best be addressed by existing or former State Cooperative Program teams, or by a state agency or university group designated (authorized) to carry out this research on behalf of a given state. UURI would coordinate resource assessment activities with the state teams and provide technical review, and geologic, geophysical and geochemical expertise to the state teams as required. OIT would update demographic information, develop user information requirements, conduct utilization feasibility studies and provide engineering for development. IWRRI would undertake the research necessary to evaluate reservoir parameters and to assess potential reservoir problems. IWRRI and UURI would jointly evaluate the use of geochemical tracers in reservoir assessment. Reservoir information is essential in providing sufficient information about the reservoir to gain the confidence of lending institutions to invest in geothermal projects.

4.1 Phase 1

The principal Phase I activity would be to update information on the low- and moderate-temperature resource base. The state teams would revise and update the 1980-1983 State Geothermal Resource Maps and inventories, especially with regard to new drill-hole information and present direct-heat utilization. Additional geoscience information would be acquired to perform a preliminary evaluation of resource potential. This effort would take place over two years. UURI would coordinate and support this effort.

OIT would simultaneously update the demographic data and begin an evaluation of potential heat loads, fossil-fuel displacement, and environmental benefits. The state teams, UURI and OIT would prioritize resources with respect to potential for near-term utilization on a yearly basis. OIT would conduct detailed feasibility studies on collocated resources with a high priority or obvious development potential.

IWRRI would establish reservoir requirements for a variety of direct-heat uses and load factors, identify the research needs and reservoir testing required, and initiate the research activities. Throughout Phase 1 and Phase 2, OIT, UURI, and IWRRI will provide technical assistance and support to all the participating state teams.

4.2 Phase 2

UURI and the state teams would undertake geological, geochemical and geophysical work on selected resources which had been prioritized from the results of Phase I. These activities would lead to a better understanding of the resource and the formation of a preliminary resource (reservoir) model. High-priority targets from Phase 1 could be based on a single warm well or hot spring, certainly too little information on which to base a feasibility study or to plan a reservoir test. The end stage of this work would be shallow confirmation drill testing, and reservoir testing and analysis by IWRRI, OIT, and UURI.

Using the results of specific exploration/evaluation studies, OIT would complete site-specific utilization feasibility studies. As these studies are completed, resource utilization possibilities would be prioritized within each state, and, as a group, for all states. If the project is judged successful, additional funding to cost-share drilling with private sector developers may be requested in the outyears. The distribution of results would be effected throughout Phase 2 by presentations at the state level, and presentations and publications to technical societies. Presentations would be made to: realtors, developers, state and local economic development representatives, state energy and conservation representatives, architects and engineers, local or state planners, aquaculture and greenhouse operators, and prison officials. The results of collocation would be published in magazines and journals such as: the Bulletin of the Geothermal Resources Council, Consulting-Specifying Engineer, ASHRAE Journal, Scientific American, National Geographic, Aquaculture Journal, Greenhouse Journals and others.

5.0 SCHEDULE

A preliminary schedule for various work tasks, on a yearly basis, is given below, and is summarized in Table 2.

Year 1

- Negotiations and contracts or grants with state teams, to be done by DOE
- Review state geothermal resource inventory, begin update.
- Review demographics, potential uses; begin update.
- Identify and prioritize research problems necessary to better evaluate low- and moderate- temperature reservoirs.

Year 2

- Continue resource inventory; verify data; begin resource prioritization.
- Complete demographic database. Determine additional data needs for collocation priorities. Prioritize resource areas for potential development.
- Pursue reservoir research topics; develop model programs and requirements. Develop reservoir test plans.
- Begin site-specific resource evaluation for some states.

Year 3

- Begin site-specific resource evaluation, field studies.
- Conduct site-specific feasibility studies; prioritize.
- Begin drilling, reservoir testing, and modeling.

Year 4

- Continue detailed resource and reservoir testing.
- Finalize feasibility studies; note potential fuel conversion, and environmental benefits.
- Distribute resource/reservoir/utilization information.
- Presentation, publication, users assistance.

Table 2

Task Performance Schedule

Task	Description	Year 0	1	2	3	4
1	Negotiation/contracts					
2	Review state resource inventory, begin update					
3	Review demographics; update					
4	Identify/prioritize reservoir research problems					
5	New resource inventory					
6	Collocation studies; prioritize resources, cities					
7	Reservoir research, develop model programs					
8	Site-specific resource evaluation, field studies					
9	Feasibility studies, drilling, reservoir testing, modeling					
10	Presentation, publication, users assistance					

6.0 BUDGET

Funding requested for the proposed project is $1.9 million per year, for each of four years. The distribution of funds among the program participants may vary from year to year. The state teams will have different potential, numbers of resources, and funding requirements. Our present evaluation of the distribution of funds assumes a near constant level of effort for IDWRRI, OIT, and UURI, and is shown below. As the program develops it may become apparent that this distribution of funds should be changed.

Participant	Year 1	Year 2	Year 3	Year 4
IWRRI	$150 K	$150 K	$200 K	$200 K
OIT	$350 K	$350 K	$350 K	$350 K
UURI	$300 K	$300 K	$250 K	$200 K
State Teams (total) (distributed to individual states)	$1,100 K	$1,100 K	$1,100 K	$1,100 K

7.0 REFERENCES

Eliot Allen & Associates, Inc., 1980, Preliminary inventory of western U. S. cities with proximate hydrothermal potential, v. 1, report: prepared for the U. S. Departments of Energy and Housing and Urban Development: Salem, OR, 54 p.

Gosnold, W. D., 1987, Geothermal resource assessment - South Dakota; Univ. North Dakota-Mining and Mineral Resources Research Institute final rept. to DOE, Cont. No. DE-FG07-85ID12602, 37p.

Gosnold, W. D., 1990, Heat flow in the Great Plains of the United States; J. Geophys. Res., v. 91, 353-374.

Meridian Corporation, 1989, Characterization of U. S. energy resources and reserves: prepared for U. S. Department of Energy: Alexandria, VA.

Muffler, L. J. P., ed, 1979, Assessment of geothermal resources of the United States-1978: U. S. Geological Survey Circular 790, 163 p.

Reed, M. J., ed, 1982, Assessment of low-temperature geothermal resources of the United States-1982: U. S. Geological Survey Circular 892, 73 p.