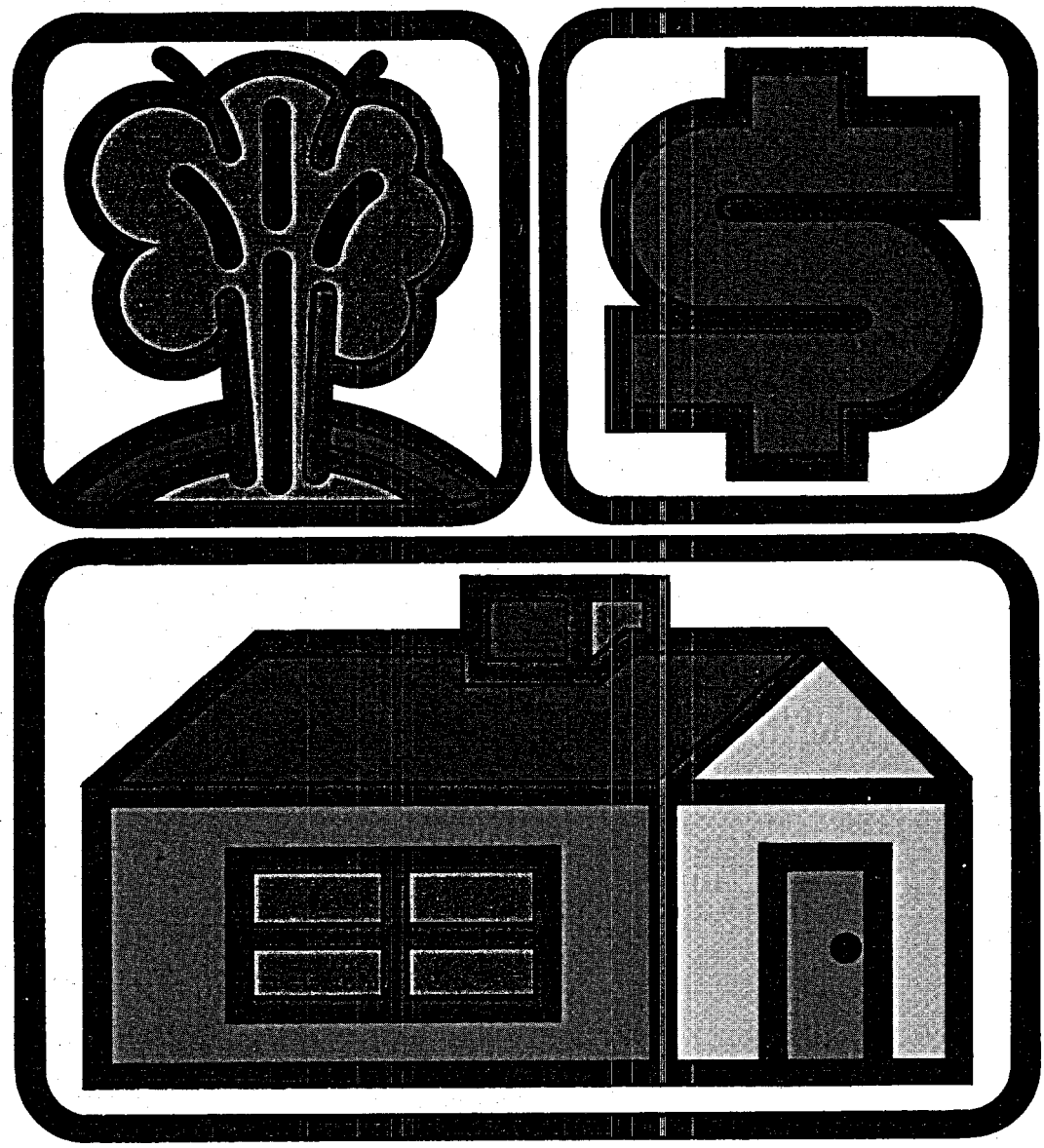
IDAHO GEOTHERMAL HANDBOOK



PUBLISHED BY
THE IDAHO
OFFICE OF ENERGY

DISCLAIMER

IDAHO GEOTHERMAL HANDBOOK

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Geothermal Program

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JOHN V. EVANS
GOVERNOR

OFFICE OF THE GOVERNOR
STATE CAPITOL
BOISE 83720

My fellow Idahoans:

I am pleased to have published through the Idaho Office of Energy this guide to geothermal development.

The years of inexpensive readily available conventional energy sources are quickly coming to an end. Idahoans must now look to the future and develop our own alternatives for home heating, industrial processing and agriculture.

Idaho's geothermal waters have historically served us on a limited basis. We must now seriously consider an increased effort to develop this resource to its full potential. Individually and collectively we can take advantage of this unique resource and help make Idaho a leader in alternative energy development.

Sincerely,

JOHN V. EVANS
GOVERNOR

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INTRODUCTION

Idaho's energy problems have increased at alarming rates due to our dependency on imports of gas and oil. The large hydroelectric base developed in Idaho has for years kept our electric rates relatively low and supplied us with energy on a consumer demand basis. However, this resource cannot be expected to meet our growing demands in the years to come.

Energy alternatives, in whatever form, are extremely important to the future welfare of the State of Idaho. This handbook addresses the implications, uses, requirements and regulations governing one of Idaho's most abundant resources, geothermal energy.

The intent of the Idaho Geothermal Handbook is to familiarize the lay person with the basis of geothermal energy in Idaho.

The potential for geothermal development in the State of Idaho is tremendous. The authors hope this handbook will both increase your knowledge of geothermal energy and speed you on your way to utilizing this renewable resource.

CHAPTER ONE

GEOTHERMAL RESOURCES IN IDAHO

GEOTHERMAL RESOURCES IN IDAHO

Geothermal energy is derived from the natural heat of the earth. Observations in mines and wells indicate that temperatures increase with depth to between 390 degrees F and 1,830 degrees F at the base of the Earth's crust. In some places on the Earth's surface, the natural heat flow is much greater than other places. These are areas of high geothermal (crustal movement) activities. In these areas, heat is transferred toward the Earth's surface from geologically recent intrusive flows of molten rock (magma) through fractures in the Earth's crust.

Four types of geothermal systems are known to occur in nature: geopressured, hydrothermal (hot water), vapor dominated, and hot dry rock. In Idaho, the hot water or hydrothermal resources are the most common. In fact, nearly all commercially important geothermal water resources in the United States are west of the Rocky Mountains and are hydrothermal resources.

In Idaho, most hot water systems are thermally driven; that is, groundwater from rain and snow is heated by a local heat source and moves upward. This upwelling of hot water often reaches the surface as hot springs, geysers and other surface phenomena. Temperatures of the water vary in range from about 90 degrees F to more than 300 degrees F.

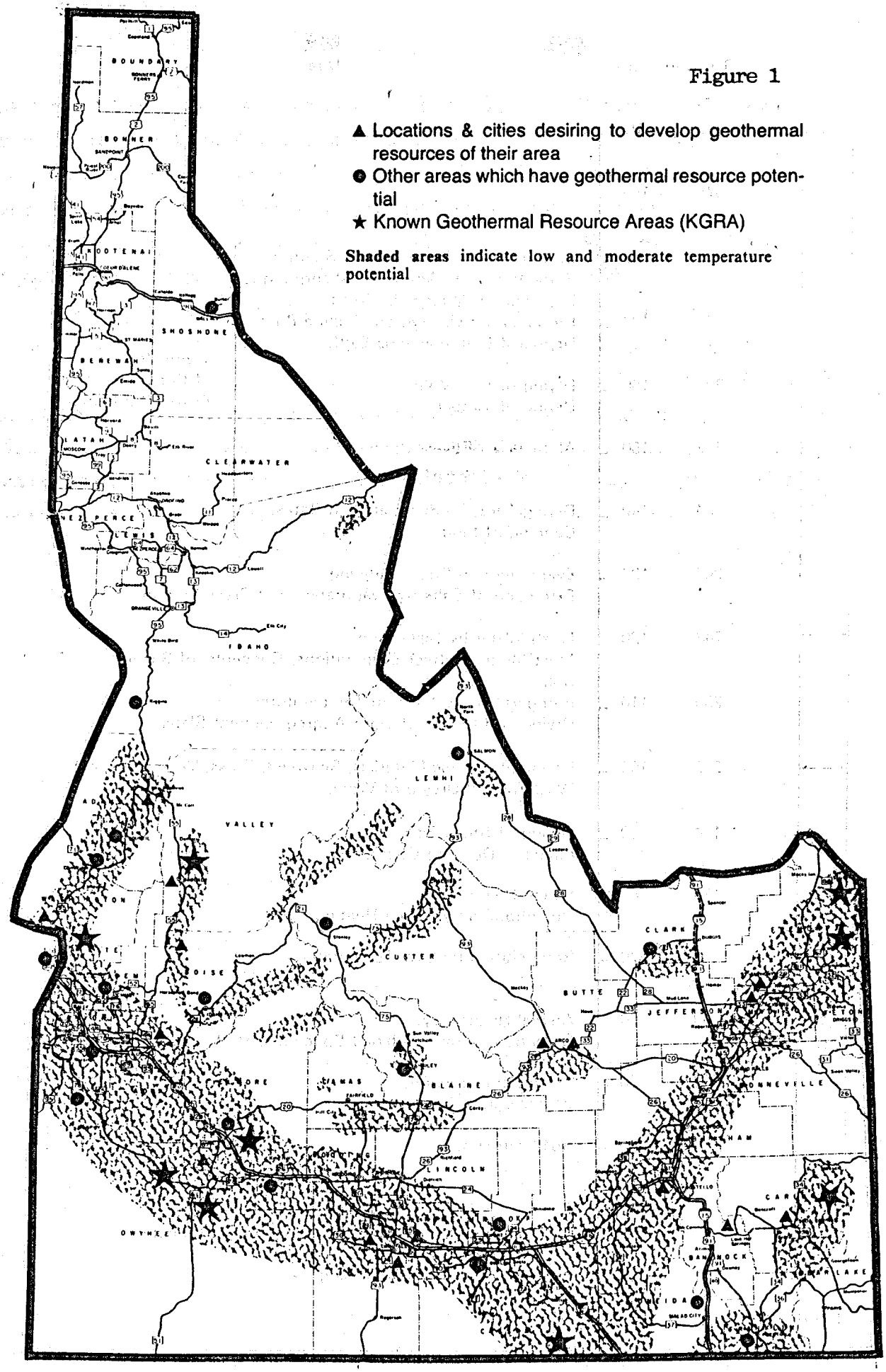
Idaho has for many years benefited from hot water springs and wells for home heating, bathing and recreation. As early as 1879, surveys of the region have mentioned Idaho's hot water springs. Studies to identify and evaluate Idaho's geothermal potential have been periodically published since 1925, and with the increased cost of oil, gas and electricity, these studies have taken on a new importance in the search for alternative energy supplies.

The range of uses for developing geothermal energy are tremendous. For the home owner, farmer, food processor, and numerous commercial busi-

nesses, the geothermal resource can be an economically and environmentally sound choice. Since most of the known temperatures of geothermal fluids in Idaho are in the low to intermediate temperature range (80 degrees F to 200 degrees F), space heating is the largest target area for direct uses. Idahoans are extremely fortunate that a large portion of the geothermal resource in the state lies close to populated areas. (Generally along the Snake River Plain, as shown in Figure 1). Technologies for utilizing geothermal energy for space heating, such as heat exchangers, are easy to understand and economically attractive.

Other potential uses for geothermal energy in the State of Idaho include industrial processing, aquaculture and greenhouse operations, and the possible production of electrical power, if the resource temperature exceeds 300 degrees F. Figure 2 lists the required temperature of geothermal fluids for a number of possible processes.

Figure 1



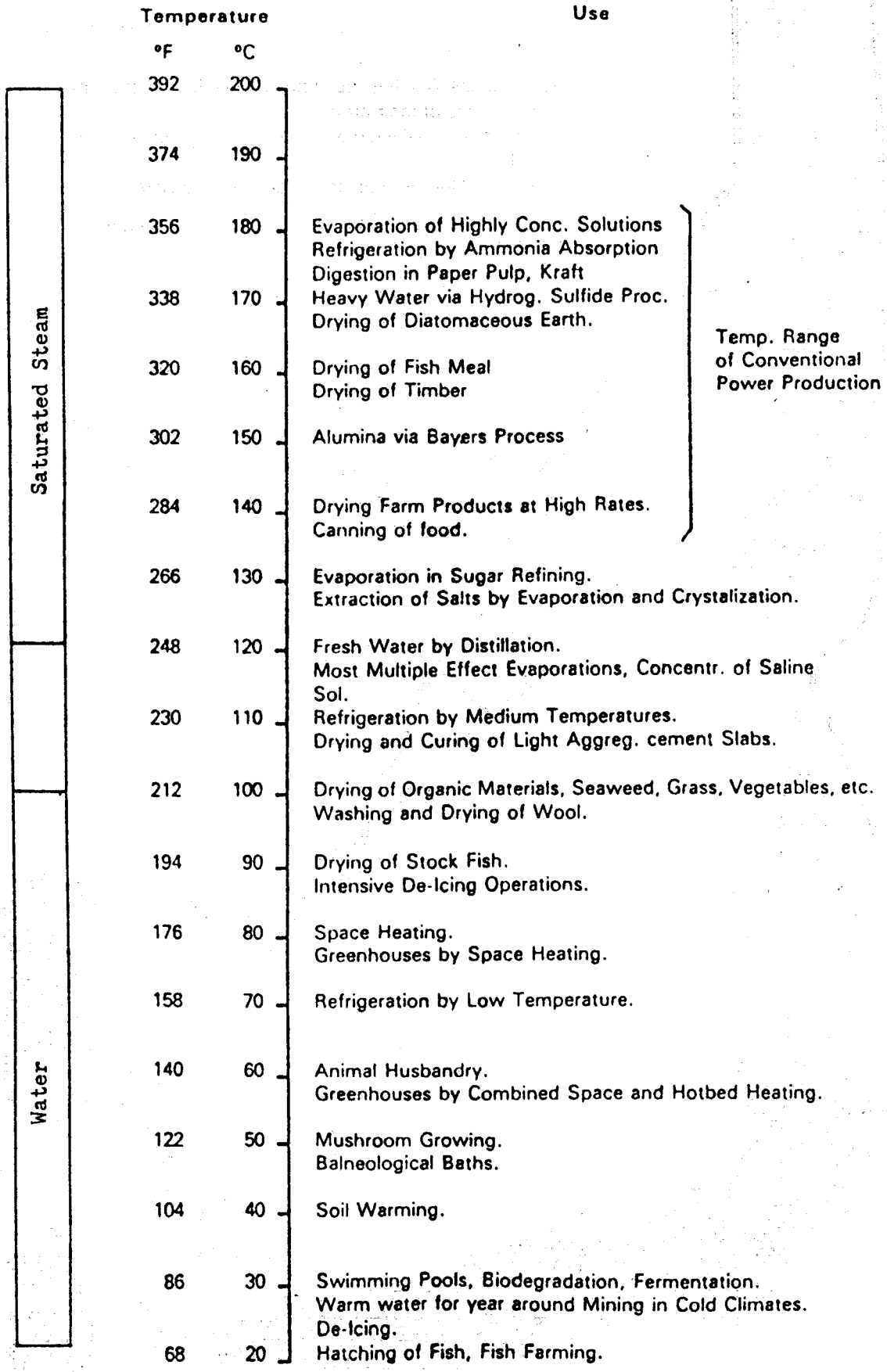
▲ Locations & cities desiring to develop geothermal resources of their area

● Other areas which have geothermal resource potential

★ Known Geothermal Resource Areas (KGRA)

Shaded areas indicate low and moderate temperature potential

Figure 2



Lindal Unesco 1973.

CHAPTER TWO

MARKET ASSESSMENT

MARKET ASSESSMENT

The viability of any geothermal development outside of personal use will depend on the marketing of the resource or products grown or produced in conjunction with the resource. The use of geothermal for recreation such as hot baths, swimming, or for greenhouses, aquaculture, space heating and industrial processing all require differing market approaches. A comprehensive market study of your intended end use or product will be a key factor in the project's economic success.

While preliminary market research is something you may choose to undertake on your own, any project, especially one bringing new or different products into an area will need a professional market survey. All government and private funding will require a well-documented market analysis.

Knowing your market, your competition, and your own strengths and weaknesses is a valuable tool which should be useful in all phases of geothermal development.

CHAPTER THREE

COMMUNITY NEEDS ASSESSMENT

COMMUNITY NEEDS ASSESSMENT

When selecting the best possible use for your resource, one of the prime considerations in dealing with the various government agencies will be the impact on the local community.

Increased employment and the corresponding need for services such as housing, schools, transportation and recreation will affect not only yourself but your neighbors and your community. While most people view increased employment opportunities as a benefit, your neighbors may not view increased pressure on roads and land in your area as a beneficial trade-off for employment.

Therefore, any development which may change the traditional life styles in your community should be studied carefully. Use of a consultant trained in evaluating the impact of a large scale development will save the resource owner/developer a great deal of time and money. However small geothermal resource projects such as aquaculture, greenhouses or on-site space heating will generally not call for a community needs assessment. The Idaho State Office of Energy can assist you in this determination.

CHAPTER FOUR

PRIVATE GEOTHERMAL LEASING PROCEDURES
PRIVATE LANDS

PRIVATE LEASES

In obtaining leases from private owners or an entity seeking to lease your resource, consult an attorney and an accountant. There are various leasing, royalty payments, and other mechanisms used for leases and most of these are based on oil and gas procedures.

Be cautious, however, and insist on performance criteria, minimal disturbance to your land or to the land you are leasing, and consider how drilling equipment and well heads may interfere with farming or other development. It would be wise to have your attorney consult the Idaho State Office of Energy for factors to consider in leasing a geothermal resource. Also your accountant might need to have copies of the geothermal tax laws. Your attorney and accountant fees will be money well spent.

CHAPTER FIVE

IDAHO STATE GEOTHERMAL LEASING PROCEDURES
STATE LANDS

IDAHO STATE GEOTHERMAL LEASING PROCEDURES

STATE LANDS

The State Board of Land Commissioners (Land Board), through the Idaho Department of Lands, is authorized to issue leases for geothermal resources underlying state and school lands of the State of Idaho. The term of a geothermal lease is ten years and can be continued as long as the geothermal resource is producing "in paying quantities" or as long as the lessee shows diligent good faith in drilling and development.

The lease area is limited to an area no greater than one section in size, but there is no limit on the number of leases that any one person may hold. The annual rental is set at a minimum of twenty-five cents (25¢) per acre and the royalty is a minimum of ten percent of the gross value of the resource produced from the lands under lease. These are minimum assessments of royalty and rental, and the state can set higher figures if it will "maximize the public benefits".

In issuing a geothermal lease, the state does reserve the right to issue leases for agriculture and other purposes for the same land. The geothermal lease will have paramount rights to as much of the surface area as it needs to accomplish the purpose of the lease. This provision indicates the state's intention for a multipurpose use of its lands, particularly with respect to agriculture. Present and future agriculture leases are subordinate to a geothermal lease in terms of access, but in no way are other uses excluded from a geothermal area.

A minimum one thousand dollar ($1,000) bond is required with the initial lease and an additional six thousand dollar ($6,000) bond is required before the construction of any geothermal well. The State of Idaho, through the Land Board, reserves the right to cancel or modify any geothermal lease. This provision gives the state the authority to manage geothermal resource development on lands under its jurisdiction in an efficient and conservation oriented manner.

The following summation is added to show the filing fee, term of lease, annual fees and royalties.

Filing Fee

In making application for a state geothermal lease, a twenty-five dollar ($25) nonrefundable filing fee is mandatory. Check with the Minerals Division of the Department of Lands in your area for lands available for lease. When you file, ask how long it will take to process your application.

Terms of Lease

All leases shall be for a primary term of ten (10) years, with continued renewal for a maximum of forty (40) years as long as the geothermal resources are produced or utilized in paying quantities. An additional forty (40) year lease may be awarded by the Land Board provided the lease holder meets the terms and conditions at that time.

Annual Fees

Annual fees for each acre or fraction of an acre leased from the state are as follows:

$1.00 per acre per year-for the first five (5) years
$2.00 per acre per year-for the second five (5) years
$3.00 per acre per year-thereafter

The fees are deducted from production royalties in any given year. The fees are not, however, recoverable in terms of future production royalties.

Royalties

A royalty of ten percent (10%) of the value of the geothermal resource or any other form of heat or energy derived from the leased premises and five percent (5%) royalty of an associated by-product derived from production under the lease agreement is to be paid to the State of Idaho. However, the geothermal resource utilized or consumed in the production operation is not subject to royalty fees.

INFORMATION

The rules and regulations governing geothermal energy were issued under authorization of Idaho Code 47-1601, Chapter 16, Geothermal Resources. For a copy of and information pertaining to the rules and regulations governing the issuance of State of Idaho leases contact:

Department of Lands-Minerals Division
Statehouse
Boise, Idaho 83720
(208) 384-3280

STATE OF IDAHO

SAMPLE

APPLICATION FOR GEOTHERMAL RESOURCE LEASE

See Reverse Side for Instructions

1. APPLICANT INFORMATION (AS TO APPEAR ON LEASE):

Name_____

P.O. Box or Street_____

City, State, Zip_____

Phone No. (optional)_____
Area Code and Number

2. DESCRIPTION OF LAND APPLIED FOR:

Applicant applies for all of the State-owned land which is available for lease in the following section:

TOWNSHIP_____ RANGE_____ SECTION_____, B.M.

3. COUNTY APPLIED SECTION LIES IN: _____

4. SIGNATORY

Applicant applies for this land in accord with the State of Idaho Rules and Regulations Governing the Issuance of Geothermal Leases. Applicant assumes the risk that the land applied for may have already been leased or applied for, or that this application may be filed simultaneously with others, as defined by the Rules, which will necessitate a drawing. Basic term is for ten (10) years. Rental will be $1.00 per acre per year. Should a lease be approved, first year rental will be payable concurrent with the return of the lease sent for signature. Application fee is $25.00, which is non-refundable and must accompany this application.

Dated _____ .

_____
Signature of Applicant or Representative

* * * * * * * * * * * * * * * * * * * *

FOR IDAHO DEPARTMENT OF LANDS USE ONLY

Acreage Determined and Platted ☐

Legal Description: _____

_____

_____

Application No.: GRLA-_____

Tract No. (if applicable):_____

Fee Paid: _____

Receipt No._____

Fund_____ Acres_____

Fund_____ Acres_____

Fund_____ Acres_____

TOTAL: _____

(Date Stamp)

INSTRUCTIONS

THE FOLLOWING INSTRUCTIONS AND INFORMATION ARE PROVIDED FOR PROPER COMPLETION OF AN "APPLICATION FOR STATE OF IDAHO GEOTHERMAL RESOURCE LEASE."

Item 1. Applicant Information -- Complete name and address must be listed. Either print or type. Phone number is optional. More than one (1) person may be entered as applicant. However, one person must be designated as the lessee of record for purposes of correspondence and lease accountability. Lease address will be the address of lessee of accountability.

Item 2. Description of Land Applied For -- The Rules stipulate that a lease will include all state-owned lands in a section, unless such lands are presently leased or otherwise not available for lease. Hence, enter only the township, range, and section of interest. Acreage will be determined by the Department of Lands staff and, if a lease is approved, will be entered with the complete legal description on the lease documen

Item 3. County Applied Section Lies In -- Enter here the county that applied for section is located in.

Item 4. Signature -- Read carefully and sign and date where indicated. A copy of the Rules are available from the Department of Lands. Notarization of this application is not required.

Submission of Application -- Mail one copy of application and required fee to:

IDAHO DEPARTMENT OF LANDS
STATEHOUSE
BOISE, ID 83720

Check to be made payable to State of Idaho -- Department of Lands. Application may also be filed at the Statehouse Office of the Department in Boise, between the hours of 8:00 A.M. and 5:00 P.M., other than holidays and week-ends.

NOTE:

Only one section per application permitted. $25.00 fee must be filed with the application.

CHAPTER SIX

FEDERAL GEOTHERMAL LEASING PROCEDURES
FEDERAL LANDS

FEDERAL GEOTHERMAL LEASING PROCEDURES

FEDERAL LANDS

The Geothermal Steam Act of 1970 (P.L. 91-581) authorized the Secretary of the Interior to issue leases for the development of geothermal resources. Lands available for leasing include:

(1) Public, withdrawn and acquired lands administered by the Secretary of the Interior;
(2) National forest and other lands administered by the U. S. Department of Agriculture through the U. S. Forest Service; and
(3) Lands which have been conveyed by the United States subject to reservation of the geothermal steam and associated geothermal resources therein.

Lands excluded from leasing include national recreation areas; lands in a fish hatchery administered by the Secretary of the Interior, wildlife refuge, game refuge, wildlife management area, waterfowl production area; lands acquired or reserved for the protection and conservation of fish and wildlife that are threatened with extinction; and tribally or individually owned Indian trust or restricted lands, within or without the boundaries of Indian reservations.

RESPONSIBLE FEDERAL AGENCIES

The Bureau of Land Management (BLM) through the U. S. Department of the Interior has jurisdiction over mineral and related subsurface resources on public lands. The BLM role includes:

(1) Receiving and processing lease applications for non-competitive leases.
(2) Publishing lease sale notices for competitive bid lands.
(3) Awarding leases.

(4) Administering leases (except those functions assigned to the U. S. Geological Survey of the U. S. Forest Services as outlined below).

The Conservation Division, U. S. Geological Survey (Department of the Interior) has expertise in geothermal geology and engineering, deep-well drilling and other technical aspects of geothermal development operations. Their role in the leasing program is:

(1) Supervising activity inside the area of operation on leased lands including enforcement of regulations covering all aspects of exploration, development and utilization.
(2) Preparing post-lease environmental studies on specific development proposals. The Forest Service or Bureau of Land Management provides input on surface management environmental considerations.
(3) Providing input on geothermal geology and geothermal operations for pre-lease environmental studies.
(4) Issuing Geothermal Resource Operational Orders.
(5) Concurring to special stipulations proposed (by the land managing agency) to mitigate or control situations peculiar to the lease area.

On national forest land, the U. S. Forest Service, through the Department of Agriculture is responsible for:

(1) Preparing environmental assessments on suitability of national forest lands for geothermal leasing purposes. (Geological Survey provides input.)
(2) Providing input to the Conservation Division, U. S. Geological Survey, on surface environmental considerations of post-lease environmental studies. (Conservation Division has primary responsibility.)

(3) Preparing lease stipulations covering special surface management problems.

(4) Issuing special use permits for occupancy of leased lands needed for development purposes.

(5) Supervising land uses on leased lands outside areas of operation.

PRE-LEASE EXPLORATION

Examination of Federal lands which involves only "casual use" requires no permits and may be conducted after notifying the Geothermal Supervisor of Geological survey. Casual use involves activities which do not appreciably disturb the land, improvements or other resources, which do not require heavy equipment or explosives, and which confine vehicles to established roads.

To drill temperature holes, construct roads and perform other intensive exploration, an operator must first secure approval under a "Notice of Intent and Permit to Conduct Exploration Operations". Geochemical and geophysical surveying and test drilling up to 152 meters (500 feet) may be conducted under this permit. Core drilling and geothermal development wells are not included; these are authorized only under a geothermal lease. Casual use and explorations under a Notice of Intent are not exclusive rights and do not confer any preferential right to a geothermal lease.

KNOWN GEOTHERMAL RESOURCE AREA (KGRA)

Competitive Leasing

A Known Geothermal Resource Area (KGRA) is a region in which the geology, nearby discoveries, competitive interests, or other indications

would, in the opinion of the Secretary of the Interior, lead experts to believe the prospects for extracting geothermal resources are sufficient to warrant spending money for the purpose (Geothermal Steam Act of 1970). A "discovery" is a well capable of producing geothermal resources in commercial quantities, which means quantities sufficient to provide a return after all variable costs of production have been met. If the geologic structure is not known, all land within five miles of the discovery is "nearby". If the extent of the producing structure is known, all land in the structural area, regardless of distance from the discovery well, is designated a KGRA.

All of the lands covered by a geothermal lease application are designated KGRA if 50% or more of the lands overlap another application of the same filing period. If less than half of the application is overlapping, the competitive portion alone may be designated KGRA.

In order to qualify for competitive bidding under a KGRA, an application (nomination) must be filed with the proper BLM office stating:

(1) The person's (company's) name and address.
(2) Statement of citizenship and qualifications for leasing.
(3) Site description.
(4) Declaration of interests in any other Federal geothermal leases within the same state.

The notice of competitive bid for the KGRA will be published once a week for four (4) consecutive weeks in the area where lands are located. The notice will include all pertinent information including terms and conditions of the sale, royalty and rental terms. Each bidder must submit a sealed bid which includes a certified or cashier's check for one-half the amount bid. The right to reject any and all bids is reserved by the Federal government, however all monies on rejected bids will be returned to the applicant.

Regulations governing KGRA status and access to Federal lands appear as Title 43, Chapter II of the Code of Federal Regulations (43 CFR Part 3200).

Non-Competitive Leasing

Federal lands which have not been declared a KGRA or reserved from mineral leasing by the Secretary of the Interior are available to the public for geothermal leasing without competitive bidding. The director of the local BLM office should be contacted for the appropriate application and guidelines submittal. However, the application should include a complete and accurate description of the lands applied for, a proposed plan including maps, and a statement that the applicant does not hold over 20,480 acres of Federal geothermal leases in the same state.

Each application must be in sealed envelope marked "Application for a Lease Pursuant to 43 CFR subpart 32" and be accompanied by payment of fifty dollars ($50.00), a service charge.

RULES AND REGULATIONS

Before lands may be offered for lease, the Director of Geological Survey first secures a description of the lands and the effects on the area which might accompany geothermal development. If issuance of leases may significantly affect the quality of the human environment, an environmental impact statement must be prepared under the National Environmental Policy Act of 1969. The statement must consider effects on fish and other aquatic resources, wildlife habitats, populations, aesthetics, and the area's recreational values.

In selecting tracts for lease, the Director of Geological Survey is to request the views and recommendations of appropriate Federal agencies, business and industry, and private organizations. Public hearings may be held. If a decision to lease is made, the director is to include in the lease any special conditions necessary to protect the environment, to permit use of the land for other purposes, and to protect other natural resources. *

*Code of Federal Regulations Title 43 Chapter II

Terms of Lease

Lease Terms:

(a) 10-year term
(b) renewal as long as commercial production occurs
(c) 40-year maximum for automatic renewal
(d) preferential right to second 40-year term

Acreage Limitations:

(a) 640 minimum
(b) 2560 maximum
(c) 20,480 acres/state maximum total holdings
(d) acreage committed to cooperative development plans is excepted when calculating total holdings within a state

Rental:

(a) $1/acre minimum (exact amount set in lease)
(b) $1/acre escalation each year after the fifth, until commercial production begins
(c) exploration expenditures during the first five years, and those exploration expenditures in excess of the minimum for subsequent years, may be credited to the escalated portion of rent due
(d) $2/acre during periods of production

Royalties:

(a) at least 10% and no more than 15% on the "value of steam, or any other forms of heat or energy"
(b) no more than 5% of the value of by-products sold, utilized or reasonably susceptible to utilization; except
(c) any by-product which is a mineral named in Section 1 of the

Mineral Leasing Act of 1920, as amended (20 USC 181), has a royalty as set in that act

(d) $2 acre minimum royalty commencing the year production in commercial quantities begins; this royalty is paid in lieu of rent

(e) 22½% maximum royalty

Lease Adjustments:

(a) rentals and royalties may be adjusted every 20 years, beginning 35 years after production of geothermal steam; maximum increase for any interval is 50%

(b) other terms and conditions may be adjusted at 10-year intervals, beginning 10 years after production of geothermal steam

Bonds:

(a)	lease compliance	$10,000
(b)	surface protection	$ 5,000
(c)	in lieu of the above bonds, statewide or nationwide bonds may be filed	
	----statewide	$50,000
	----nationwide	$150,000

Note: At the present time, the Idaho Department of Water Resources requires all Federal lessees to acquire a geothermal resource permit before drilling operations can begin.

Applications for geothermal leases on Federal Lands can be obtained by writing the State office of the Bureau of Land Management, as follows:

Bureau of Land Management
Idaho State Office
550 West Fort Street
Boise, Idaho 83702

TIME FRAMES FOR PERMITS WITHIN ALL FEDERAL AGENCIES

FEDERAL AGENCIES	PERMIT	REQUIRED PRIOR TO:	ESTIMATED TIME FOR ISSUANCE	NOTES
Bureau of Land Management	Permit for Pre-Lease Operation	Non-surface disturbing exploratory activities on lands not leased by applicant	30 days	Includes geophysical/ geological exploration, temperature gradient surveys, etc., 30 day time limit for approval
	Issue Lease-BLM Lands			
	Conducts EAR Conducts KGRA Lease Sales Issues Lease		About 5 months Total: about 8 months	
	Plant Siting Permit	Plant Construction	Not known	
	Post-Lease Joint Approval with USGS of Plans & Operations			Site Specific
U.S. Forest Service	Special Use Permit for Pre-Lease Operations	Before exploratory activities on lands not leased by applicant	30 days	Includes geophysical/ geological exploration, temperature gradient surveys, etc., 30 day time limit for approval

FEDERAL AGENCIES	PERMIT	REQUIRED PRIOR TO:	ESTIMATED TIME FOR ISSUANCE	NOTES
U.S. Forest Service cont.	Issue Lease-Forest Service Lands	Before major exploratory activities	About 17 months or longer	Lease obtains rights to the resource
	Conducts EAR KGRA Land Sales Approves Lease			
	Joint Approval with USGS of Plans of Operation			
U.S. Geological Survey	Administers Terms of Lease			
	Approves Permit for Exploratory Activities	Before non-surface disturbing activities	30 days	Includes geophysical/ geological activities, temperature gradient surveys, etc., 30 day time limit for approval
	Conducts Site-Specific Environmental Analysis and Approval of Plans & Operations			
	Exploration	Before non-surface disturbing activities	About 1 year	

FEDERAL AGENCIES	PERMIT	REQUIRED PRIOR TO:	ESTIMATED TIME FOR ISSUANCE	NOTES
U.S. Geological Survey cont.	Environmental Baseline Data	Gathering of required 1-year's environmental baseline data	About 3 to 5 months	Must be completed at least one year before Plan of Production is submitted
	Development	Drilling and development of production wells	About 3 to 5 months	Define extent of field
	Injection	Drilling and development of injection system	About 3 to 5 months	
	Utilization	Construction of power plant	About 3 to 5 months	Sundry notices submitted for each phase. Includes contract and royalty breakdown.
	Production	Use of the resource for power production	About 3 to 5 months	Includes production data from wells and target date for completion
	Changes in Plans of Operation	Before implementation of changes in plans of operation	A few months	Sundry notices
U.S. Environmental Protection Agency	Certify Air Discharge Permit		About 90 days	

FEDERAL AGENCIES	PERMIT	REQUIRED PRIOR TO:	ESTIMATED TIME FOR ISSUANCE	NOTES
U.S. Environmental Protection Agency cont.	Issue Water Permit		About 90 days	Air, water, solid waste permits are in conjunction with State Environmental Health Agencies
	Issue Solid Waste Disposal Permit		About 90 days	
	Review of EIS			
U.S. Fish and Wildlife Service	Advisory			Consults on lease sales (competitive abd non-competitive), pre-lease and post-lease environmental analysis

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

FORM APPROVED
OMB NO. 42–R1688

Serial Number

APPLICATION TO LEASE GEOTHERMAL RESOURCES
(Sec. 4 Noncompetitive Lease)

The undersigned hereby makes application to lease all or any of the lands described herein that are available for lease pursuant and subject to the terms and provisions of the Act of December 24, 1970 (84 Stat. 1566, 30 U.S.C. Sec. 1001), or any amendments hereafter enacted, hereinafter referred to as the Act, and to all applicable regulations now or hereafter in force when not inconsistent with any express and specific provisions herein, which are made a part hereof.

1. Name *(Last, First, Middle initial, print or type)*	Address *(include zip code)*

Social Security or Taxpayer Number

2. Legal description

State	County
NATIONAL RESOURCE LANDS	ACQUIRED LANDS
Total area Acres	Total area Acres

	YES	NO
3. Service charge enclosed		
4. Rental enclosed		
5. Compliance bond enclosed		
6. Are you the sole party in interest?		
7. Are you a citizen of the United States?		
8. Have you reached the age of majority?		
9. Is application made for a corporation or other legal entity?		
10. Has a statement of qualifications been filed?		

I CERTIFY That my interests, direct or indirect, in geothermal resources leases in the above State do not exceed 20,480 acres. That the statements made herein are true, complete, and correct to the best of my knowledge and belief and are made in good faith.

(Signature of Applicant) (Signature of Applicant)

(Date) (Attorney-in-Fact)

Title 18 U.S.C. Section 1001 makes it a crime for any person knowingly and willfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

(Instructions on reverse) Form 3200–8 (December 1973)

GENERAL INSTRUCTIONS

Submit copies of application typewritten or printed plainly, and signed in ink. Application *must* be filed in the proper BLM Office for the State in which the lands are located, in *duplicate* for national resource lands and in *triplicate* where acquired lands are involved. Applications for lands in the following States which have no proper BLM Office should be filed in the office indicated below.

North Dakota, South Dakota
State Office, BLM
Billings, Montana 59101

Kansas, Nebraska
State Office, BLM
Cheyenne, Wyoming 82001

Oklahoma
State Office, BLM
Santa Fe, New Mexico 87501

Eastern States
Eastern States Office, BLM
7981 Eastern Avenue
Silver Spring, Maryland 20910

If additional space is needed in furnishing any of the required information, it should be prepared on additional sheets, initialed, and attached to your application.

Item 1 - Give last name, first name, middle initial, and Social Security or Taxpayer Number. Give street and number (P.O. Box), City, State, and Zip Code.

Item 2 - *Land Description* - Give complete and accurate description of lands for which lease is desired. If lands have been surveyed under the public land rectangular system, each application *must* describe lands by legal subdivision, section, township, and range. When protracted surveys have been approved and effective date thereof published in the Federal Register, all applications to lease lands shown on such protracted surveys, filed on or after such effective date, *must* describe lands only according to section, township, and range shown on approved protracted surveys. If lands have neither been surveyed on the ground nor shown on records as protracted surveys, each application *must* describe lands by metes and bounds, giving courses and distances between successive angle points on the boundary of tract, in cardinal directions except where boundaries of lands are in irregular form, and connected by courses and distances to an official corner of the public land surveys. In Alaska, descriptions of unsurveyed lands *must* be connected by courses and distances to either an official corner of the public land surveys or to a triangulation station established by any agency of the United States *(such as the United States Geological Survey, the Coast and Geodetic Survey, or the International Boundary Commission)*, if the record position thereof is available to the general public. For description of unsurveyed public lands adjacent to tidal waters in Louisiana and Alaska, see 43 CFR 3203.4(d).

Total area of land requested should be shown, in acres, in space provided. That area, except where the rule of approximation applies, must not exceed 2560 acres. All of the land applied for, must be within a six (6) mile square or an area of six (6) surveyed or protracted sections in length or width. In instances where the United States does not own a 100 percent interest in the mineral deposits in any particular tract, the offeror should indicate the percentage of Government ownership.

Item 3 - *Service Charge* - Nonrefundable service charge of fifty dollars ($50) must accompany application.

Item 4 - *Rental* - Advance rental at rate of not less than one dollar ($1) per acre, or fraction thereof, must be submitted at time of filing application.

Item 5 - *Bonding* - A single copy of the bonds on forms approved by the Director *must* be filed in the proper BLM Office. Bonds may be filed with application or *must* be filed within thirty (30) days after receipt of notice from Authorized Officer.

Item 6 - *Party in Interest* - Indicate whether sole party in interest or not. If not, submit, at the time application is filed, a signed statement setting forth names of other interested parties and the nature of the agreement between them. All interested parties *must* furnish evidence of their qualifications to hold an interest in the lease when application is filed.

Item 8 - *Age of Majority* - Indicate whether or not the age of majority. If application is made by a guardian or trustee for a person who has not reached the age of majority, the application *must* be accompanied by evidence required by Section 3202.2-2 of the Regulations.

Item 9 - *Application by Corporation or Association* - If the applicant is a corporation, or an association, it must submit a statement containing the following information: (1) State in which it is incorporated or formed; (2) that it is authorized to hold geothermal leases; (3) that the officer executing this application is authorized to act on behalf of corporation or association in such matters; and, (4) the percentage of voting stock and all stock owned by aliens or for those having addresses outside the United States. If 10 percent or more of the stock of any class is owned or controlled by, or on behalf of, any one stockholder, a separate showing as to his name, citizenship, and holdings *must* be furnished.

Item 10 - *Statement of Qualifications Filed* - If qualification statement has been previously filed indicate and identify by serial number the record in which such statements were filed together with a statement as to any amendments thereof.

Submit application in a sealed envelope. Envelope *must* be plainly identified that it is an application for a lease pursuant to 43 CFR 3210. *(Items not listed are self-explanatory).*

GPO 851-310

CHAPTER SEVEN

ENVIRONMENTAL AND REGULATORY PROCESSES

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

The National Environmental Policy Act (NEPA) became law on January 1, 1970. It has been stated that NEPA has become the "major statutory lever for environmental quality in Federal Government". This is because it imposes a broad responsibility on Federal agencies to take environmental values into account in their planning and decision making.

NEPA boils down to a body of Federal legislation requiring the inclusion of environmental impacts into cost/benefit analyses determining project feasibilities. The Council of Environmental Quality (CEQ) was also established by this legislation to implement NEPA requirements. Basically, NEPA requires in-depth reports to be written describing projects and their impact on the environment. These reports are called Environmental Impact Statements (EIS) and are required of all projects that are "major Federal actions significantly affecting the quality of the human environment". This phrase is intended to relay:

(1) The overall cumulative impact of the action proposed and further actions contemplated;

(2) The potential that the environment may be significantly affected even if the action is localized in impact; and

(3) Any action in which the environmental impact is likely to be highly controversial.

Responsibility for EIS preparation falls to the "lead agency" of a project; the agency having the greatest legal authority in the matter. The EIS, if required, can be prepared by either the planning "lead agency" or a contractor, but will be prepared at the developer's expense.

INFORMATION

For further information on NEPA requirements:

U. S. Environmental Protection Agency
442 South Washington
Boise, Idaho 83702
(208) 384-1450

DEPARTMENT OF HEALTH AND WELFARE

STATE OF IDAHO

The Idahó Department of Health and Welfare, Division of the Environment, is responsible under the 1973 Water Quality Act to administer standards for water quality in wastewater treatment.

The Department works with the Department of Water Resources in the area of geothermal disposal. A permit must be obtained from the Department of Water Resources for injection fo disposal waters into a "re-injection" well. Prior to issuing such a permit, the Department of Water Resources does ask the Environmental division for comment.

Should the owner/developer anticipate the disposal of waste water from the geothermal project into Idaho's waterways, a copy of the Water Quality Standards and Wastewater Treatment Requirements should be obtained from the Department of Health and Welfare. A discharge permit will be required from Health and Welfare with concurrence of the Environmental Protection Agency.

INFORMATION

Department of Health and Welfare
Statehouse
Boise, Idaho 83720
(208) 384-2392

CHAPTER EIGHT

LOCAL GOVERNMENT REGULATIONS

ROLE OF LOCAL GOVERNMENT

In Idaho, a geothermal drilling permit and a water right permit from the Department of Water Resources is mandatory by state law. Local units of government are not charged with any responsibility for the drilling of geothermal wells. However, individual city and county codes may be in effect or implemented in the near future, and it would be wise to check with the local permitting agency, i.e., public works director, city engineer, or building inspector, to insure that an additional permit is not required at the local level.

Idaho State law does require local units of government to adopt building, plumbing and electrical codes. The geothermal owner/developer must obtain the necessary permits from officials at the local level before proceeding with the construction of a geothermally heated project.

Should the geothermal project require a change in land use, the local zoning ordinance and rules for applying for a land use change, e.g., from agriculture to residential, must be followed. State and Federal agencies as well as lending institutions will require the owner/developer to meet local zoning laws and permitting requirements.

CHAPTER NINE

GEOTHERMAL EXPLORATION

GEOTHERMAL EXPLORATION

Exploring for geothermal resources, both hydrothermal and hot rock anomalies, has become extremely technical and complex. The historical method of stumbling upon a hot spring, geyser, boiling mud pool or other surface activity is being replaced by more scientific approaches. Unfortunately, surface manifestations do not always depict subsurface conditions.

However technical or complex the method of exploration, the important phrase to remember is "geothermal exploration is essentially a matter of teamwork". Geothermal exploration techniques have incorporated a multitude of disciplines including geological, geotechnical and geophysical studies at a particular region to locate possible geothermal production sites. The purpose of this teamwork is to pool the necessary information and capsulate the results as final evidence for drilling.

The Aims of Exploration

The aims of the geothermal explorer, of whatever discipline, are as follows:

(1) To locate a geothermal field;
(2) To decide whether such a field, if found, is semi-thermal or hyper-thermal (mixing of cool and warm or hot water);
(3) To decide whether a hyper-thermal field, if located, is steam-or-water dominated;
(4) To define as closely as possible the location, area, depth and probable range of temperatures of any located field; and
(5) From all this, to estimate the order of magnitude of the heat or power potential of any located field, and the grade of heat obtainable therefrom.

The initial stage of any exploration program is a reconnaissance of the field geology and geologic mapping. Review all existing literature to identify prospective areas in your concern. All recorded data such as topography, meteorology, geology, hydrogeology, observations of hot springs, geysers and fumaroles, geochemistry and geophysical measurements should be carefully collected and reviewed. Structural geology is of primary importance in determining geothermal anomalies. From the data mentioned in may be possible to select promising regions, or even more narrowly defined regions, that are likely prospects for closer investigation. Geological data from surrounding "non-thermal" areas may also provide valuable information. All the data from "thermal" and "non-thermal" areas will help you to deduce the true thermal anomaly.

The second stage of your geothermal exploration program should involve an interpretation of the aerial photography of the site in question. Photographic surveys aid in structural analysis and geologic mapping, and in areas of poor topographic control are essential for geographic location during geophysical surveys.

Field work involving geologic and hydrologic surveys are the third stage in your exploration program. To understand these technologies, we must first look at the function of your principal investigator, the geologist.

The role of the geologist in your exploration program is to start the framework of a "hypothetical" model which will pinpoint your drilling area. The geologic model is only part of the total picture that will aid you in determining the best site for drilling. (Remember, the functions of the geologist, hydro-geologist, geophysicist, and geochemist are all dependent on one another.

GEOLOGIST

The geologist must rely heavily upon deductions to complete his/her part of the model. The geologist's job is to relay to you suggestions of what zones may be permeable and contain hot fluids, and to pinpoint promising drill sites. He/she accomplishes this by studying surface geo-

logical mapping; by studying the tilt of outcrops; by examining the results of any cored surroundings which may have been obtained by previous investigators or by their own exploratory drilling; by observing faults and surface thermal manifestations; and by the presence of "cap rock" formations that sometimes may serve to prevent the wholesale escape of steam into the atmosphere. The geologist may also suggest where geothermal zones are recharged with water and where the source of heat originates.

HYDRO-GEOLOGIST

The hydro-geologist follows the path of the geologist model to deduce the probable zones along which water will flow underground. The hydro-geologist should be able to answer the following questions to further your exploration program. (1) How the geothermal fluids reach the permeable zones; (2) How the geothermal fluids escape to the surface structures; (3) How the geothermal fluids are contained from escaping elsewhere; and (4) How the geothermal fluids may be expected to react once drilling has begun.

GEOPHYSICIST

The next step in your geothermal exploration model pertains to the function of the geophysicist. The task of the geophysicist in geothermal exploration is to measure as accurately as possible the physical parameters of underground formations. The existence of a geothermal reservoir can be further explained from the indirect measurement of various physical parameters at depth. These physical parameters include temperature, electrical conductivity, density, and magnetic-susceptibility.

Many techniques are available to the geophysicist, varying widely in reliability and cost. Fortunately, some of the most useful techniques are the cheapest; and it is on these that the geophysicist should first concentrate.

Perhaps the most inexpensive method is that of thermal techniques. Thermal-exploration techniques can provide the size and potential of a

geothermal system. By using special thermometers, the geophysicist can deduce temperature gradients and heat flow rates. Again, relating to cost, the geophysicist can: (1) take surface and shallow temperature measurements, generally at depths of 6 meters or less; (2) take geothermal gradient surveys at depths of 15 to 100 meters, and (3) make heat flow determinations, generally requiring hole depths of at least 100 meters.

Temperature measurements of under 5 meters can be used to detect hot areas, but should be taken lightly, as the temperature may be influenced by cross-flows of cool ground waters. Once a chemical analysis has been developed on the reservoir, a more conclusive answer can be given on the true temperature.

Another method available to the geophysicist is that of electrical resistivity measurements. This method is achieved by injecting current into the ground through suitably spaced electrodes, and measuring the voltages between those electrodes. In general, a hot water field will tend to produce a zone of low resistivity, mainly because of the dissolved salts, whereas a steam field will tend to show up as a high resistivity zone. Thus, without exploratory drilling, it can be determined through an electrical resistivity method whether a geothermal resource exists and if it is significantly large enough for practical applications.

Other techniques available to the geophysicist are more costly, but are worth listing:

(1) gravity measurements
(2) seismic measurements, reflective and refractive
(3) micro-wave techniques
(4) electro-magnetic techniques
(5) radio frequency interference
(6) ground noise measurements
(7) micro-seismicity
(8) audio-magneto-tellurics
(9) aerial scanning of infra-red radiation

GEOCHEMIST

The last link in the model before exploratory drilling is the function of the geochemist. The correlation between chemical and thermal actions of the Earth's crust are extremely important in tracing geothermal analomies. Geochemical analysis should include:

(1) fundamental water chemistry
(2) identification of chemical constituents relative to reservoir temperatures
(3) dissolved gas content
(4) geochemical indicators of various processes associated with high temperature reservoirs

There is a direct relationship between a geothermal water's chemistry and its original reservoir temperature. Geochemical analysis of surface thermal activity can lead to the following information:

(1) temperatures
(2) hydrostatic pressures
(3) gas pressures
(4) rock types
(5) flow pressures

Although the geochemist's job becomes highly technical, the geothermal explorer should know that silica, magnesium and sodium/potassium are the three principal factors in determining reservoir temperatures. The geochemist's interpretation of the minerals will help deduce the quality and temperature of deep thermal fluids.

If the preceding exploratory techniques indicate a likelihood that the geothermal resource may indeed be present, a suitable site should be chosen for exploratory drilling. The object of exploratory drilling is to seek proof of the technical deductions raised earlier in your model.

Exploratory drilling is important for the following reasons:

(1) to confirm and revise the previous information obtained on the geothermal resource;
(2) to prove whether or not a site is economically and technically feasible for full-scale geothermal exploitation;
(3) to provide the information necessary for the location of drill sites, for the design of production equipment, and for the calculation of probable useful life.

It must be noted that the geothermal explorer must always weigh the cost of these services with the benefits to be gained. Any one of the aforementioned techniques may lead toward drilling an exploratory well. It is not necessary to follow step-by-step everything mentioned in this Chapter. The authors merely wanted to give you an understanding of the many facets of an exploration program. In other words, if the cost of geophysical exploration is greater than a couple of shallow wells, then drilling may be the best exploration technique. Remember, the final answer is always obtained by drilling.

It is important for the geothermal explorer to be cautious in selecting a technical geothermal team. Exploring and drilling for geothermal fluids must be precise and include the teamwork mentioned earlier. Try to select individuals who have extensive technical backgrounds in your geographic area and individuals in whom you personally feel confidence.

CHAPTER TEN

GEOTHERMAL DRILLING

GEOTHERMAL DRILLING

WELL DRILLING

The most important phase of geothermal development is well drilling. The drilling of the first well and subsequent wells defines the resource limits, temperature and quality.

Until the completion of one or more wells, the geophysical, geochemical and hydrological data will give you information based on percentage of probability for a successful production well. While this data is an integral part of the process, any geothermal project viability hinges on the final step of actual water flowing from the production well.

In light of this, selection of a well driller with the expertise and equipment to bring in the maximum producing well is critical. The following information is designed to give you not only a working knowledge of drilling regulations and procedures, but also to aid in the selection of a driller.

Before talking to any drillers, thoroughly familiarize yourself with the information presented and proceed with caution when selecting a driller.

RULE #1 Not every well driller can drill a geothermal well! Few drillers have had experience drilling anything but domestic and irrigation wells. Do not base your selection on previous domestic or irrigation experience. If you (or your friends or relatives) know a driller, do not base your selection only on personal relationships.

RULE #2 When talking or visiting with a well driller, the main area of concern will be the equipment to be used. Do not be swayed by the size or price of drill rig or appearance. Some drillers have top equipment but still have no geothermal experience; while another well driller with poor-looking equipment could be the right person for the job.

RULE #3 If you use a consultant, engineer, and/or architect,

let them select the driller for you, BUT make certain that your contractual agreement with them specifies the use of a qualified geothermal well driller.

Now that we have the three basic rules on well driller selection outlined, the following discussion is on well drilling, drilling equipment, and drilling rules and regulations. Armed with the following information, selection of a qualified well driller for a successful project should be much easier.

GEOTHERMAL WELLS

There are four basic types of wells:

(1) Slim hole/exploratory wells.
These are used mainly by large development companies and/or wildcatters in areas where no previous drilling has taken place and limited geological information is available.

(2) Observation wells.
These wells are used only for monitoring purposes. In a geothermal field observation wells are often drilled to see what impact, if any, one production well may have on another. A well drilled as an observation well may NOT be used as a Production or Injection well.

(3) Injection wells.
An injection well is used to dispose of the geothermal waters after they have been used. Any well drilled especially as an injection well, a converted producing well, or reactivated or converted abandoned well used for injecting material (water, steam) into a geothermal area or adjacent area to maintain pressures in a geothermal reservoir, pool or other source, fits this catagory.

(4) Production wells.

This includes any well that is commercially producing water, steam, or heat--or is intended for commercial production of a geothermal resource.

DRILLING EQUIPMENT

There are two basic types of drill rigs. The most common rig is a cable tool, and the second is a rotary rig, which uses three basic mediums to drill: mud, air, and reverse circulation.

CABLE TOOLS

Cable tooling uses a series of components; sockets, jars, drill stems which weigh from 1,500 to 2,500 pounds attached to a drill bit which drives this combination, called a "drill string" down into the earth. Most common steel cable has a right hand lay. Cable tools use left hand lay cable to give a twist as the tool drops, deepening and keeping the well bore uniform. The left lay cable keeps the drill string, which has standard right hand threads, from coming loose in the hole. Cuttings and debris are removed periodically, depending on the strata being drilled through, by means of a bailer. The bailer works by means of a dart and pop door which closes once the cuttings have entered the bailer and the driller starts to remove it from the hole.

Cable tool rigs have a limited depth. Generally, in Idaho, most cable tool rigs cannot drill deeper than 1,500 feet; however, in other parts of the country cable tool rigs have been known to drill to depths up to 6,000 feet. The major problem of cable drilling is the limited capacity of different types of equipment to hoist the weight of the drill string and cable.

ROTARY RIGS

Most rotary rigs found in Idaho are small mobile units similar to the larger derrick type oil and gas rigs. Rotary rigs, as the name im-

plies, turn the drill stem in the hole with a tricone bit attached to the bottom of the stem. The drill stem is hollow to allow the drilling medium (mud, air, water) to be forced down it, and then in turn carry the cuttings up and around the stem and out of the hole.

Most rotary rigs are diesel powered to turn the mechanical drive for the drill stem, compressors, pulley arrangements for lowering and raising the stem in the hole, pumps for circulating the drilling mediums in the hole, and pumps to circulate, cool-screen, settle and store the cooling mediums.

Rotary rigs are divided into three basic drilling methods, and most are easily interchangeable:

Mud Rotary: Mud drilling is by far the most common and usually the easiest drilling method. The mud is forced down the hollow drill stem, lubricating the tricone bits, and then rises to the surface carrying the drilling cuttings and excessive heat. This method works in sand, gravel and hard rock. The one drawback to drilling with mud is that if the drilling proceeds into high temperature areas, the mud can have a sealing effect on the hole. This wall cake, as it is commonly called, can turn a high producing well into a dry hole. This must be a consideration in drilling, and the driller would be wisest in most cases to switch to air or water in a hard rock producing zone or any zone with high temperatures. Experienced geothermal well drillers are now drilling with water from start to finish, with mud being used only in zones where there is difficulty holding the formation.

Air Rotary: The air drilling method uses compressed air forced down the hollow drill stem. The air carries heat and drill cuttings to the surface. The drawback to air drilling is that it is not effective in drilling through formations that might cave in, such as sand or gravel, and air drilling will not be successful with high volumes of water. For most geothermal wells mud has been used until the

driller reaches the producing zone; he will then case the hole on down to that level and then switch to air or water to finish the well.

Another air method is a down hole hammer which operates similar to the standard jackhammer seen at construction sites. Air, or air mixed with foam, powers the hammer and then carries the debris from the hole. The foam is introduced as a liquid substance which foams when driven by the air.

Water Drilling or Reverse Circulation Drilling: This method utilizes water as the drilling medium with the water forced down around the drill stem, and the debris and cuttings flowing up the drill stem, (hence the name, reverse circulation), and into a cooling and settling pond. Most experienced geothermal well drillers are now starting to use water to drill the entire well. This, however, may be limited by the type of formation and the availability of water. If the formations hold and a sufficient supply of water is available, it is advisable to drill with water.

WELL SIZE

Sizing the well or bore hole depends on a number of factors:

(1) Available data from existing wells in the area, if any.
(2) Information gathered by the geologists/hydrologists.
(3) Intended end use and quantity of water needed.
(4) Depth of drilling.

In sizing the well the above factors all contribute to determining well size. Another factor that should not be overlooked in sizing the well is that higher temperature (160^{o}F plus) water plays havoc with pumps that can fit only in the smaller casing sizes, i.e., eight inches and

smaller. If the area has sufficient artesian head, pumping (depending on the use) may not be necessary; but if a pump is needed, consideration to pumping requirements and water temperature should play an important role in selecting bore hole size. This is where the use of a consultant and/or engineer is most critical. Do not leave this for the driller to determine for you.

BLOWOUT PREVENTION EQUIPMENT

When drilling in areas with known high pressure, blowout prevention equipment will be necessary. As discussed in the previous section, cementing of the casing to prevent damage to the environment, groundwaters, geothermal resource, etc. is necessary. The surface casing should be of adequate size, strength and depth to allow anchoring of the blowout prevention equipment.

Blowout prevention equipment consists of a series of hydraulic rams. The first set is commonly called a shaffer hydril. These rubber gasket-like devices can be closed quickly to hold the stem in place. The next set is a pipe ram which has two semicircular rams that fit snugly around the drill stem. This allows for a stronger hold on the rubber hydril. The next set is the blind ram. This device is used to actually cut through the drill stem and seal the well completely,and is viewed as the last line of resistance and would be used only in the worst circumstances.

All these rams are hooked to what is called an accumulator wagon, which supplies the power needed to effectively use the rams in case of an emergency.

Blowout prevention equipment is required by Idaho law for drilling in high pressure areas. Your well driller should be familiar with this equipment, its use, and the Idaho law that addresses its use.

WELL CASING AND CEMENTING

Well casing standards are set on a well-by-well basis by the Director of the Idaho Department of Water Resources. Your well driller or whoever files for the drilling permit will have to work out the details with this department.

Cementing of casing, again, is determined by the Director of the Department of Water Resources. Cementing is performed to prevent blowouts and seal other water-bearing formations from the geothermal producing zones.

There are five basic types of casings:

(1) Conductor pipe - This is the first and largest diameter string of casing to be installed. This extends from the surface to a minimum of 40 feet or greater if necessary.

(2) Intermediate string or casing is the casing installed in the well to seal out the brackish water producing zones, and to prevent caving below the bottom of the conductor pipe or surface casing.

(3) Production string is the casing that extends from the production zone to the surface through which the resource is produced.

(4) Surface casing is the first string of casing run after the conductor pipe to which the blowout prevention equipment is anchored for sealing out groundwater zones.

(5) Screening is used in the production zone to prevent caving and to keep the production zone open.

COST OF DRILLING

Drilling costs vary from driller to driller. Cost factors that contribute to drilling costs are:

(1) Bore hole size
(2) Type of casing
(3) Amount of cementing
(4) Types of geological formations encountered (hard rock, gravel, clay, etc.)
(5) Set up time and availability of support systems
(6) Depth of well
(7) Type of equipment used
(8) Need for blowout prevention equipment

To try to give a cost range in this time of inflated prices for fuel, casing and overall price increases is extremely difficult. Oral bids on well costs for a 12" 1,000 foot well ranged from $50,000 to $90,000, depending on the factors listed above. Some costs are truly impossible for the driller to accurately predict in advance. Per foot and per pound quotes, however, should be secured for differing formations, casings, drilling muds, and cementing.

Securing the services of an experienced reputable driller is your best protection against unreasonable drilling costs.

IDAHO STATE DRILLING REQUIREMENTS

A drilling permit must be obtained from the Idaho Department of Water Resources before the drilling of any geothermal well. This regulation (Idaho Code 42-4006) covers all private land owners and holders of a State or Federal lease.

The Idaho Code

Because of possible conflicts between geothermal resource development and state water appropriations, the Idaho legislature through the Idaho Geothermal Resources Act of 1972 placed the regulatory powers for geothermal development in the Department of Water Resources. Drilling permits, fees, construction bonds, and appropriations of water for geothermal development is the responsibility of this department.

Filing Fees

The cost for filing a geothermal well permit, to either drill or alter an existing well for production purposes, is one hundred dollars ($100.00). This fee covers paperwork and handling by the Department of Water Resources.

Bonds

Every permit requires a bond of an amount not less than $10,000 to ensure compliance with the rules and regulations of geothermal development as set forth by the department.

INFORMATION

Idaho Department of Water Resources
373 West Franklin Street
Boise, Idaho 83720
(208) 384-2215

CHAPTER ELEVEN

GOVERNMENT FUNDING

U. S. DEPARTMENT OF ENERGY

PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA)

The purpose of the Program Research and Development Announcement (PRDA) is to provide an opportunity for interested parties to propose engineering and economic feasibility studies of direct applications of geothermal resources. PRDA solicitations are part of the U. S. Department of Energy's (DOE) national geothermal energy program plan which places emphasis on the near-term commercialization by the private sector of hydrothermal resources for direct purposes.

Proposals for any PRDA announcement may be submitted by individuals, corporations, companies, educational institutions, non-profit and not-for-profit organizations, and others, individually or as proposed teams. Proposals from Federal agencies and/or laboratories owned, operated, or under the cognizance of the Federal Government cannot be considered for selection.

Background

One of the major objectives in the DOE Geothermal Program is to work with industry, state and local governments, the academic community, individuals, companies and other concerned groups to provide the nation with an economically and environmentally acceptable energy resource to substitute for or supplement present energy sources. The DOE feels that working with these groups will permit the timely exploitation of our nation's substantial geothermal energy resources. To provide early momentum and development of the geothermal industry, DOE announced the initiation of the PRDA program to stimulate rapid exploitation of liquid-dominated hydrothermal resources. The DOE feels that this class of geothermal energy resource is considered most likely to make a significant impact in the national energy problem in the near-to-intermediate future.

Requirements

To be considered for any PRDA announcement, proposers must demonstrate their total ability to carry out the project through completion. The proposers must be familiar with the economics, energy utilization technology, and institutional requirements of the various representative direct applications.

The proposer should remember that the application will receive closer consideration if the proposal incorporates a well-rounded technical team. Engineering and economic backgrounds should be highlighted for your proposal to be considered.

Additional requirements are stipulated under each particular PRDA announcement. However, it should be noted that under most PRDA announcements, proposals must be for site-specific studies; that is, analysis of use at a specific geothermal reservoir for a single-purpose application or multi-use application. On the same note, the proposer must either own the resource area in study, or have the authority to enter or gain access to the resource area from the owners.

Scope of Studies

The engineering and economic studies of interest vary with each PRDA announcement. The following are areas in which DOE has had interest in the past:

* Industrial - Process steam and moderate to low temperature heat for industrial plants.

* Agricultural - Space, water, and soil heating for greenhouses; grain drying; irrigation pumping; and extraction of chemicals from agricultural products (starches, acetic acid, acetone/butanol, ethanol, etc.).

* Space/Water Heating and Cooling - Space heating and cooling, water heating (especially district heating and/or cooling systems) for commercial-sized buildings or business complexes and residential developments.

* Mineral Extraction - Process steam and moderate to low temperature heat for ore concentrating, leaching, flotation processes, etc.

Evaluation

All proposals undergo a Preliminary Review and a Comprehensive Review as described below. The Preliminary Review is conducted from a technical and business standpoint to determine whether the proposal:

(1) contains sufficient cost, technical, management, and other information to permit a meaningful, comprehensive evaluation;

(2) has been signed by a responsible official of the proposing organization or a person authorized to obligate such organization;

(3) provides a proposed site which could be available for commercial exploitation;

(4) contains a letter from facility owners assuring contractor access to study area;

(5) is valid for at least 150 days; and

(6) clearly addresses the purpose of the PRDA.

If the proposal does not meet these requirements, DOE will discontinue evaluation and the offeror will be notified in writing.

Proposals which pass the preliminary review then undergo a comprehensive review which categorizes the proposals according to:

(1) type of application (single-purpose or multi-purpose applications); and

(2) industry sector (industrial processing, and space/water heating and cooling, etc.).

This review rates proposals according to the established evaluation criteria described below. The review is conducted by a Government Evaluation Panel composed of government personnel, supplemented as necessary with technical advisors from DOE laboratories and/or DOE consultants.

Evaluation Criteria

* Quality of the technical plan, including discussion of study objectives, background, study plan for producing the information required as the final product of the effort, statement of work and implementation plan.
* Adequacy of the proposed organizational structure and project management plan, including provisions for financial control.
* The capabilities, related experience and facilities which the proposer offers and which are considered to be integral factors for achieving the objectives of the proposal, including the qualifications, capabilities and experience of the project manager and other key personnel.

Number and Value of Awards

Under each PRDA announcement the DOE reserves the right to make any number of awards, or none at all. The dollar amount per proposal follows these same principles. However, in past issuances, the DOE placed a $100,000 to $125,000 lid on proposals and awarded approximately six to twelve grants.

It is important to get on the DOE mailing list so that you will receive the PRDA notices when they are released. You can assume that DOE will have at least one PRDA announcement per year. Expect approximately 90 days for the DOE to review your proposal and another 60 days to negotiate if you are selected. (These times have been known to be longer).

INFORMATION

To receive further information on the PRDA program and to get your name on the DOE mailing list, write:

U.S. Department of Energy
Idaho Operations Office
Geothermal Program
550 Second Street
Idaho Falls, Idaho 83401

or

U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

U. S. DEPARTMENT OF ENERGY

PROGRAM OPPORTUNITY NOTICE (PON)

The purpose of the Program Opportunity Notice (PON) is to provide an opportunity for interested parties to propose direct heat utilization or combined electric/direct use projects demonstrating single or multiple uses of geothermal energy. The PON solicitation is part of DOE's national geothermal program plan which places emphasis on the near-term commercialization by the private sector of hydrothermal resources for nonelectric purposes.

Proposals for any PON announcement may be submitted by individuals, corporations, companies, educational institutions, and state and local agencies. Like the PRDA announcement, proposals from Federal agencies and/or laboratories owned, operated, or under the cognizance of the Federal Government cannot be considered for selection.

The background and requirements of the PON announcement follows the same course as the PRDA. The initial purpose of the PON is to follow, through construction, the research and development learned from the PRDA studies, and other research being completed by the government and private sectors.

Scope of Studies

The demonstrations of interest to DOE vary with each PON announcement. However, the following are general areas in which DOE has had interest in the past:

* Space/water heating and cooling for residential and commercial building complexes.
* Agribusiness (agricultural and aquacultural uses).
* Industrial processing.

Evaluation

The evaluation process of the PON application is much the same as the PRDA. The main criteria the DOE uses in evaluating the PON are:

(1) Overall feasibility of the proposed project, including quality and adequacy of the technical and cost data submitted and reasonable evidence of the existence of suitable geothermal resources and availability of facilities, site, equipment and other project-related needs for duration of field experiment.

(2) Suitability of match-up between prospective geothermal energy user(s) and the proposed application, including potential for alternative energy savings and degree of transferability of project results to other potential users of geothermal energy.

(3) Evidence that the proposed application is likely to promote new or expanded use of geothermal resources, consistent with overall goals of the DOE geothermal program, adequate economic analysis of the user and application area, and the ability to begin operations of the proposed application at an early date.

(4) Adequacy and quality of a Management Plan including adequacy of the organizational structure and provisions for technical and administrative controls.

(5) Qualifications, capabilities, and relevant technical experience of project personnel, including proposed prime contractor, sub-contractor(s), and consultants, if any.

Number and Value of Awards

Under the PON announcement the DOE reserves the right to make any number of awards or none at all. The dollar amount per proposal follows the same principles as the PRDA. Heavier emphasis is placed upon a cost-shared proposal under the PON, and this cost share can be in actual dollar contributions or "in-kind" matches.

It is important to get on the DOE mailing list so that you will receive the PON notices as they are released. There are no guidelines as to when PON notices are released. Expect approximately three to five months for the DOE to review your proposal and another two to four months to negotiate if you are selected.

INFORMATION

To receive further information on the PON program and to get your name on the DOE mailing list, write:

U.S. Department of Energy
Idaho Operations Office
Geothermal Program
550 2nd Street
Idaho Falls, Idaho 83401

or

U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

U. S. DEPARTMENT OF ENERGY

GEOTHERMAL LOAN GUARANTY PROGRAM

The Geothermal Loan Guaranty Program (GLGP) became effective on June 25, 1976 under Title II of the Geothermal Research, Development and Demonstration Act of 1974.

The outlined objectives of the GLGP as stated under this Act are:

(1) To encourage and assist the private and public sectors to accelerate development of geothermal resources in an environmentally acceptable manner by minimizing a lender's financial risk.

(2) To develop normal borrower-lender relationships in order that financing be made available without guarantees at some future time.

Under the terms of the Act, loan guarantees will be granted for up to 75% of project costs, with the Federal government guaranteeing up to 100% of the amount borrowed, and the applicant contributing 25% equity. The amount to be guaranteed is limited to $100 million per project and $200 million per borrower.

The life of the program is 10 years, to terminate on September 3, 1984, but all loans guaranteed up to that time will be honored according to the terms of the loan agreement. The maximum term for any loan guaranty is 30 years or the expected average useful life of any major physical asset to be financed by such loan, whichever is less.

Priorities assigned to different types of projects are as follows:

(1) Projects with promise of rapid energy production from geothermal resources.

(2) Projects designed to demonstrate or utilize new technologies or produce advanced technology components.

(3) Projects that will demonstrate or exploit the commercial potential of new geothermal resource areas.

(4) Lowest priority is given to projects initially proposing geological and geophysical exploration, or the acquisition of lands or leases.

In addition, priority within each of these categories is given first to projects from which the Federal government receives royalty payments and second, to projects undertaken by small companies and private utilities.

INFORMATION

For further information about the Geothermal Loan Guaranty Program, write:

U.S. Department of Energy
Idaho Operations Office
Geothermal Program
550 2nd Street
Idaho Falls, Idaho 83401

or

U.S. Department of Energy
San Francisco Operations Office
1333 Broadway
Oakland, California 94612

ECONOMIC DEVELOPMENT ADMINISTRATION

Technical Assistance Grants

The Economic Development Administration has technical assistance grants available for pilot or demonstration projects. Those eligible for such monies must show projected employment gains to the community and leadership capability. The owner/developer of the geothermal project must have the financial resources to cost share twenty-five percent (25%) of the gross project costs to qualify for these demonstration funds. The amount of monies varies from $25,000 to $80,000.

Public Works Grants and Loans

Funds for geothermal development under this Economic Development program must be used for public services and/or facilities. The applicant may be a public or private non-profit organization, but must have the approval and support of the local government entity as well as regional economic development support. The extent of funds available is generally sixty percent (60%) of total project cost.

INFORMATION

Economic Development Administration
2404 Bank Drive
Boise, Idaho 83705
(208) 384-1521

APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM

Congress authorized the U. S. Department of Energy (DOE) in 1977 to undertake a small grants program to support small-scale energy related technologies referred to as appropriate technologies because they are "appropriate" to local needs, skills, and available energy resources. Grant applications for this program are usually available in September of each year and it takes approximately five to eight months before the DOE releases award winners. Grant funds are available for:

* Concept Development Projects for the development of an idea, concept or investigative finding up to $10,000.
* Development Projects for studies, investigations, models, hardware development, experimental tests, or operational tests up to $50,000.
* Demonstration Projects for the testing of technology or system under actual operational conditions up to $50,000.

The Appropriate Technology Small Grants Program is designed to:

* Make more energy related technology options available in the United States.
* Provide access to DOE for individuals and groups who would not otherwise have access.
* Make available technology not otherwise accessible to DOE.
* Further national efforts to promote the use of renewable resources and the conservation of non-renewable resources.

Eligible projects can come from:

* Individuals
* Local non-profit organizations and institutions
* State and local agencies
* Indian tribes and nations
* Small businesses

One stipulation to this grant program is that no grant recipient can be awarded more than $50,000 in a two year consecutive period.

The Appropriate Technology Small Grants Program is unique in that it is designed for the "local", small-scale inventor. Large corporations or laboratories are not allowed to apply for these grants under the guidelines drawn up by the DOE. Keep in mind that projects submitted for this program must be:

* small scale;
* simple to install, operate and maintain;
* low cost;
* environmentally sound;
* able to utilize resources, materials and labor skills;
* for novel applications of existing technologies, or to develop new concepts or technologies.

All projects must make use of available renewable energy resources and/or conserve non-renewable resources.

INFORMATION

For additional information on the Department of Energy Appropriate Technology Small Grants Program contact:

Appropriate Technology Small Grants Program
U.S. Department of Energy, Region X
1992 Federal Building
915 Second Avenue
Seattle, Washington 98174
(206) 442-1746

or

Idaho State Office of Energy
Statehouse
Boise, Idaho 83720
(208) 384-3800

CHAPTER TWELVE

PRIVATE FUNDING

PRIVATE FUNDING

To obtain non-government funds for geothermal development, the owner/developer can look to lending institutions, investment companies and/or individual investors for financial assistance.

The person who has an established business relationship with a lending institution and sufficient collateral to offset the bank's risk will obviously have little, if any, problem in securing development funds. However, the person who wishes to utilize geothermal development in a new business venture should be aware of the preparation necessary to secure venture capital.

In Idaho, banks as well as savings and loan institutions have not had sufficient experience with the economics of alternative energy utilization; therefore the owner/developer should be knowledgeable in all aspects of the geothermal project in order to "sell" a lending institution. While geothermal energy can be a most economically sound investment, the owner/developer should be well prepared with engineering data, marketing studies (if appropriate), a management plan, and financial information before approaching a loan officer. The more clear, concise, and orderly the information you can supply the lending institution, the more likely you are to obtain funding.

Investment companies and private investors may also be skeptical of this non-fossil fuel energy source and therefore the owner/developer who needs to secure front end capital for the engineering, marketing and managment planning should secure the services of a qualified attorney. Interpretation of Idaho law governing corporations, partnerships and the raising of capital by sale of stock can be time consuming and discouraging without the appropriate legal assistance.

The key to selling investors, loan officers and others on your project is by clearly stating the economic potential, and demonstrating your marketing and management capabilities.

The central theme of your approach should emphasize in most cases the clear connection between using geothermal as an energy source which is not subject to fossil fuel inflationary trends.

If you are intending to set up a greenhouse operation, for example, taking the necessary time or hiring someone to project operating costs comparing fossil fuel costs at differing inflated prices to geothermal, can and most likely should, be the key selling point. Also the life cycle cost and effect on operating capital, amortization, and even future expansion should not be overlooked.

CHAPTER THIRTEEN

STATE AND FEDERAL GEOTHERMAL ASSISTANCE PROGRAMS

U. S. DEPARTMENT OF ENERGY
TECHNICAL ASSISTANCE PROGRAM

One part of the growing geothermal program of the U. S. Department of Energy (DOE) is the Technical Assistance program offered to potential geothermal users as an on-call service. The DOE-Idaho Falls Geothermal Office has contracted this authority to EG&G Idaho, Inc.'s geothermal program office and the Earth Science Laboratory at the University of Utah (UURI).

The Technical Assistance program has been available for over two years and has a good team of experts to help you in your endeavors. However, the service is provided on a first-come, first-served basis; therefore it is not unusual to find a waiting list of longer than two months.

The amount of assistance given is limited in order to protect the interests of private engineering organizations and others working in the field. Generally, enough information is provided so that a potential user can make an evaluation as to how and where to proceed.

The limits to the kinds of assistance you can expect to receive are varied. However, technologies dealing with engineering, economics, drilling techniques, and geology are certainly covered within the expertise housed at EG&G and UURI.

INFORMATION

For further information on the Technical Assistance Program:

Idaho National Engineering Laboratory (INEL)
EG&G Idaho, Inc.
Geothermal Program
P. O. Box 1625
Idaho Falls, Idaho 83401

Or

University of Utah Research Institute (UURI)
Earth Science Laboratory
Research Park
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108

IDAHO STATE OFFICE OF ENERGY GEOTHERMAL TEAM

The Idaho Office of Energy, through a contract with the U. S. Department of Energy, administers a state planning program to promote the commercialization of geothermal energy. For the past two years, this geothermal team has worked to build a strong data base of geothermal information and supply the citizens of Idaho with a technical information outreach program.

The diverse nature of this team allows them to investigate many areas of geothermal development thoroughly and professionally. Needless to say, their contract with DOE strictly outlines a "scope of work" but the team is adaptable to carry out many demands of the public.

The most important function this team accomplishes is the technical outreach program. Armed with a resource planner, economist, and the capabilities of contracting qualified engineers, the team is available upon call to provide the public with technical assistance to further geothermal development.

The state outreach program is not intended to infringe upon the integrity of the private engineering community. The outreach purpose is to steer community leaders, businesses, individuals, industry and government officials in the direction of possible applications of geothermal resources.

Should you decide to use this valuable service, you may expect to receive these kinds of assistance:

(1) On-site visit(s) by the outreach team to discuss your concern in geothermal development;

(2) Brief overviews of the geologic parameters of the resource in your area;

(3) Analysis of the economic impacts of using geothermal energy at your site;

(4) Engineering decisions as to the type of system you should consider;

(5) Listing of qualified technical expertise in your area;

(6) Information on the best method for pursuing your geothermal energy project; and

(7) Institutional and planning assistance.

INFORMATION

For further information on the State of Idaho Geothermal Team:

Idaho State Office of Energy
Geothermal Program
Statehouse
Boise, Idaho 83720
(208) 384-3800

STATE COUPLED GEOTHERMAL PROGRAM

The primary importance of mentioning this program is to show the cooperative effort being displayed by the State and Federal governments in fusing geothermal development. In order to develop a well-rounded data base of information, the U. S. Department of Energy established this program to (1) assist the U. S. Geological Survey in its ongoing geothermal resource assessment effort, and (2) to stimulate confirmation of low and intermediate temperature reservoirs at sites with an apparent potential for direct heat application development.

The State Coupled Geothermal Program is a continuing effort among the following agencies: (1) DOE, (2) Idaho Department of Water Resources, (3) the U. S. Geological Survey, (4) the National Atmospheric and Oceanic Administration, and (5) the Earth Science Laboratory at the University of Utah Research Institute.

This Federal and State cooperative effort will accomplish the following objectives:

(1) Phase I, geothermal data compilation, with emphasis on low and intermediate temperature systems, culminating in the publication of state maps and reports on the location and possible viability of geothermal resources.

(2) Phase II, investigation of specific geothermal sites with drilling, to demonstrate reservoir characteristics.

In Idaho, both Phase I and Phase II are well underway with the development of the state resource map to be published in 1979. The Idaho Department of Water Resources has information available on well temperatures throughout the state and will supply you with information upon request. Publications, such as Idaho Department of Water Resources Bulletin 30, will keep you up-to-date on matters pertaining to that department's functions.

INFORMATION

For further information on this program, write:

U. S. Department of Energy-Idaho Operations Office
Geothermal Program
Attention: State Coupled Program
550 2nd Street
Idaho Falls, Idaho 83401

or

Idaho Department of Water Resources
Geothermal State Coupled Program
373 West Franklin Street
Boise, Idaho 83720

INDUSTRY COUPLED GEOTHERMAL PROGRAM

In Idaho, this U. S. Department of Energy (DOE) sponsored program has not received the attention it deserves. The program's purpose is to foster the development of geothermal electrical power generation. Several factors have hindered this program, but as the cost of conventional fossil fuels goes higher, this program may receive more attention in the future.

The Industry Coupled Program is intended to be a cooperative effort between DOE and any industrial organization engaged in geothermal exploration. The program is set up to address: (1) cost-sharing with industry for exploration, reservoir assessment and reservoir confirmation, and (2) releasing to the public geoscience data which will increase our understanding of the geothermal resource.

Under the guidelines of the program, if a successful contract was negotiated with the DOE and a particular industry, the contract would specify: (1) an exploration and/or reservoir confirmation program which industry would perform and manage, (2) a data package which industry would agree to make public, and (3) a certain percentage of total costs (generally in the range of 20 to 50 percent) which DOE would contribute toward funding the work.

INFORMATION

For information on the Industry Coupled Geothermal Program:

U. S. Department of Energy-Idaho Operations Office
Geothermal Program
550 2nd Street
Idaho Falls, Idaho 83401

CHAPTER FOURTEEN

GEOTHERMAL LEGISLATION

FEDERAL LEGISLATION

FEDERAL GEOTHERMAL STEAM ACT OF 1970

PUBLIC LAW 91-581

The purpose of the Federal Geothermal Steam Act of 1970 is to authorize the Secretary of the Interior to make disposition of geothermal steam and associated geothermal resources.

Geothermal steam and associated resources means: (1) all products of geothermal embracing indigenous steam, hot water, and hot brines; (2) steam and other gases, hot water and hot brines resulting from water, gas or other fluids artifically introduced into geothermal formations; (3) heat or other associated energy found in geothermal formations; and (4) any by-products derived from them.

FEDERAL GEOTHERMAL ENERGY RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACT OF 1974

PUBLIC LAW 93-410

The purpose of the Federal Geothermal Energy Research, Development, and Demonstration Act of 1974 are: (1) to further the conduct of research, development and demonstrations in geothermal energy technologies; (2) to develop a geothermal energy coordination and management project; (3) to carry out a program of demonstrations in technologies for the utilization of geothermal resources; (4) to establish a loan guaranty program for the financing of geothermal energy development; and (5) other purposes.

FEDERAL PUBLIC LAW 91-190

The purpose of Federal Public Law 91-190 is to establish a National Policy for the environment; to provide for the establishment of a council on environmental quality, and other purposes.

STATE LEGISLATION

SENATE BILL NO. 1062

Domestic Water Systems (An Amendment)

The purpose of SB 1062 is to explain the terms "Domestic Water Systems" and "Domestic water" by way of example, but not by way of limitation, as a public water system providing water at any temperature for space heating or cooling, culinary, sanitary, recreational or therapeutic uses.

HOUSE BILL 468

The purpose of HB 468 relates to tax incentives for the installation of insulation and alternative energy devices.

Chapter 16 Geothermal Resources Act
Idaho Code 47-1601 - 47-1611

Chapter 40 Geothermal Resources Act
Idaho Code 42-4001 - 42-4015

APPENDIX ONE

GLOSSARY OF ENERGY TERMS

GLOSSARY OF ENERGY TERMS

AQUIFER A water bearing stratum of permeable rock, sand, or gravel.

ARTESIAN Ground water that has sufficient hydrostatic head to rise above its aquifier.

ARTESIAN WATER Ground water that is under sufficient pressure to rise above the level at which it is encountered (by a well), but which does not necessarily rise to or above the surface of the ground.

ARTESIAN WELL A well that penetrates an aquifier containing water with sufficient pressure to rise above the local ground level.

AUGER A drilling tool designed so that during the drilling operation, the cuttings are carried continuously to the top of the hole by helical grooves on a rotating drill pipe.

BIPOLE-DIPOLE MAPPING Electrical method of geophysical exploration. Current flow is established in the earth by using a pair of source electrodes; the electric field is determined by observing the voltage drop between two pairs of electrodes oriented approximately at right angles.

BLOWOUT PREVENTER A device used to prevent the escape of oil, water, or gas when a pressurized pocket is penetrated by a drill.

BOILING POINT The temperature at which the vapor pressure of a liquid is equal to the pressure of the atmosphere on the liquid.

BOREHOLE A hole drilled into the earth, often to a great depth, as a prospective oil well or for exploratory purposes.

BRITISH THERMAL UNIT (BTU) A unit of energy defined as the amount of energy required to heat one pound of water one degree Fahrenheit.

CONTOUR MAP A map showing the configuration of the surface by means of lines connecting the points that have the same elevation.

CONVECTION A process of mass movements of portions of any fluid (liquid or gas) in a gravitational field as a consequence of different temperatures in the medium and hence different densities. The process thus moves both the medium and the heat and the term is used to signify either or both.

DENSITY LOG A well log that records the formation density. The logging tool consists of a gamma-ray source and a detector shielded so that it records backscattered gamma rays from the formation.

DRILLING MUD A suspension, generally aqueous, used in rotary drilling. It is pumped downward through drill pipe to seal off porous zones and to counter-balance the pressure of oil, gas, and water.

DRILL PIPE Pipe to which the bit is attached and which is rotated by a drill. Drilling fluid circulates through the pipe.

EFFICIENCY The efficiency of an energy conversion is the ratio between useful work or energy output to total work or energy output.

EFFLUENT 1. Something that flows out, as an outflowing branch of a main stream or lake. 2. Waste material discharged into the environment, especially when serving as a pollutant.

ENERGY The ability to do work, expressed in watts, KW, BTU/hr, cal/sec.

FAULT A fracture or fracture zone along which there has been displacement of the sides relative to one another, parallel to the fracture.

FOSSIL FUEL A deposit of organic material containing stored solar energy that can be used as fuel. The most important are coal, natural gas, petroleum.

GEOLOGIC MAP A map showing surface distribution of rock varieties, age relationships, and structural features.

GEOTHERMAL ENERGY The internal energy of the earth, available to man as heat from heated rocks or water.

GEOTHERMAL GRADIENT The rate of increase of temperature in the earth with depth.

HEAT EXCHANGER A device used to transfer thermal energy from a fluid flowing on one side of a barrier to a fluid flowing on the other side. Often this is done by running a coil of pipe through a tank.

HEAT PUMP A device that transfers heat from a cooler reservoir to one a higher temperature (or vice versa). A heat pump works on the same principal as a refrigerator.

KILOWATT (KW) One thousand watts. Electric energy measurement.

KILOWATT HOUR (KWH) The power expended by 1 kw in 1 hour.Equals 3,412 BTU.

LIFE CYCLE COSTS Total cost of an item including initial purchase price as well as costs of operation, and maintenance over its lifetime.

MEGAWATT (MW) One million watts, or 1,000 kilowatts.

PERMEABILITY The permeability of a rock is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter.

REINJECTION The process of pumping waste water back into a well or aquifier.

RESERVOIR A natural underground container of liquids, such as oil, water, or gases.

RESISTIVITY The resistance to electrical current of a three-dimensional unbound medium, as opposed to resistance that refers to electrical impedance of confined conductors.

SPACE HEATING The process of supplying the required heat for the physical comfort of human beings in houses, offices, or enclosed industrial plants.

SUBSIDENCE 1. A sinking of a large part of the earth's crust. 2. Movement in which there is no free side and surface material is displaced vertically downward with little or no horizontal component.

TECTONIC MAP A map on which are shown areas or lines of major structural features produced by uplift, downwarp, or faulting, together with the major lineation within such features.

WATT Unit of electric energy equal to 3.4 BTU/hour.

WORK The product of the force acting upon a body and the distance through which the point of application of force moves.

APPENDIX TWO

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REFERENCES

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