DOE/RA/50075--T/2

GEOHERMAL ENERGY IN NEVADA

Development and
Utilization

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

**LETTER FROM ROBERT LIST,
GOVERNOR, STATE OF NEVADA**

The people and industries of Nevada are struggling with vastly increased energy costs. Furthermore, the problems associated with these ever increasing energy costs have been compounded by uncertainties regarding the future availability of imported energy resources. It is time therefore, to look at other less expensive, locally available energy resources such as geothermal energy.

The utilization of geothermal energy in Nevada has great potential. Not only is the resource widespread throughout the state, but its temperature is sufficient to support the needs of many types of uses such as residential space heating, aquaculture, greenhouse horticulture and various manufacturing and industrial processes. In several areas, it is hot enough to generate electricity. The development of these resources offers an opportunity to stabilize energy prices, reduce our reliance on imports and promote economic diversification.

This brochure was prepared to help the public or private planner make decisions about geothermal energy development. It will help you to understand what geothermal energy is, where it is located in Nevada, what it can be used for and the types of assistance available for its development. We hope that the information in this brochure will help you make more informed decisions about the development of geothermal resources in our state.

Geothermal energy has been described as the "Sleeping Giant". Though we have allowed the giant to slumber for many years, the time has come to begin using this resource to benefit the citizens and industries of Nevada.

**This brochure was prepared by
Geothermal Development Associates of Reno, Nevada under a grant from the Nevada Department of Energy.**

GEOHERMAL ENERGY AND NEVADA

Geothermal energy, derived from the internal heat of the earth, has been successfully used since at least the 19th century as a reliable and inexpensive energy source for space and water heating, process steam and direct process heat. The current cost of energy from conventional sources has served to escalate the public's awareness of the need for alternative energy resources, and to focus attention on the suitability of geothermal energy for an ever increasing variety of public and private needs. It is the purpose of this brochure to provide both public and private energy users with information about the potential for further development of geothermal energy in Nevada; information that will be helpful in assessing current and future energy options and in making wise decisions about these options.

In the State of Nevada over ten million acres have been classified as having the potential for geothermal development. Such development can occur wherever geothermal energy occurs in concentrations close to the surface of the earth in an extractable form such as hot water. This energy can be transformed into either electrical power or can be utilized directly. Although electrical generation is an important aspect of geothermal development, an economical, direct-use system can supply energy for a wide variety of applications.

A simple direct-use system may consist of a single production well from which water is pumped to a heat exchanger where the heat is withdrawn and used. Often a second well is utilized to return the spent water to the geothermal reservoir. This direct-use system is very efficient and is particularly adaptable to the numerous geothermal sites in Nevada which have low and moderate temperature water. These sites are well suited to the many kinds of direct-use applications needed by industrial, commercial, and residential energy users.

Geothermal is a viable energy source for industrial applications related to greenhousing, aquaculture, food processing, distillation, refrigeration, crop drying, slaughter operations, kiln drying, and pulp and paper drying to name a few. Potential commercial users include laundries, hotels, hospitals, schools, shopping malls, retailers, and office buildings. Space heating and cooling, as well as water heating, are the major commercial and residential uses of geothermal energy.

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

There are several significant advantages for developers and users of geothermal energy. Conventional fuels are not used. Hence, total energy costs are much lower. The guaranteed availability of geothermal energy is more certain. Operations and maintenance costs of geothermal systems can be far less than systems using conventional fuels. Environmentally, geothermal energy development has fewer negative impacts than conventional fuel development. And, geothermal energy can be utilized with currently available technology. For all these reasons, geothermal energy must be given serious consideration as an important alternative to increasingly costly and scarce conventional fuels.

This brochure was written to help the public and private energy users and developers become familiar with the economic and social advantages of this natural energy resource. It is divided into four sections; each one considers a major aspect of geothermal development. The first section discusses the nature of geothermal resources in Nevada; the next deals with resource applications; the third section outlines the social and economic advantages of utilizing geothermal energy; and the final section discusses Federal and State programs established to foster the development of geothermal energy.

In addition, the names, addresses, and phone numbers of various organizations actively involved in research, regulation, and the development of geothermal energy have been included. This will enable potential geothermal users and developers to obtain specific information concerning how to proceed with development. In addition to the references given here, the Nevada Department of Energy is happy to provide information on geothermal energy to any interested persons and to answer questions concerning geothermal commercialization and use. Individuals may simply contact the Nevada Department of Energy in Carson City.

NEVADA'S GEOHERMAL RESOURCES

Geothermal energy is derived from naturally occurring concentrations of hot water and steam found beneath the surface of the earth. The presence of these geothermal resources may be indicated by hot springs, fumaroles, or by warm waters encountered in wells and mine workings. In Nevada, more than 300 geothermal occurrences have been identified (Figure 1).

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MGW

RET2AM

Known and potential geothermal resource areas in Nevada.

Nevada lies within a geologic region known as the Basin and Range Province. It is characterized by a thinning of the earth's crust, faulting, and a history of volcanic activity. These features have been recognized as some of the key elements of a potential geothermal province. This is because youthful faults, some extending downward thousands of feet into the earth, frequently act as conduits for thermal waters to rise into near-surface rock strata. Geothermal reservoirs are found along these faults as well as along adjacent porous zones where there is free circulation of the hot water from depth.

Nevada's geothermal areas are distributed more or less evenly throughout the state at depths ranging from a few feet to over a mile below the ground surface. A greater number of higher temperature reservoirs (above 200° F) are, however, located in the north where deep drilling has encountered

Flowing 205° F water from 700 - foot deep production well at the 162 - unit Warren Estates subdivision in the Moana area of Reno, Washoe County (photo by Geothermal Development Associates).

temperatures in excess of 400° F in several localities.

There is a wide variation in the chemical composition of water in Nevada's hydrothermal systems. Normally, salinities are very low — from 200 to 1,500 parts per million (ppm); although 7,500 ppm has been recorded in one of the hotter systems. In fact, the average salinity of recorded thermal waters is below the 1,000 ppm set by the State of Nevada for potable water. This means that corrosion and scaling problems will be minimal for most types of applications.

A great deal of information about Nevada's geothermal sites is currently available. This is summarized in 11 Area Development Plans prepared by the Nevada Department of Energy. However, many of the known thermal sites are still undeveloped and therefore, evaluation of the energy content of those specific geothermal resources must await drilling. Resource assessment of potential development sites should be conducted in order to define and evaluate the hydrothermal system, expected costs, and degree of risk. Geological, geophysical, and/or temperature gradient hole surveys provide the technical data necessary to properly locate exploratory and development wells for purposes of locating the reservoir and accurately defining its size, depth, temperature and water quality.

The State of Nevada may have greater potential for the development and utilization of geothermal resources than any other state in the Nation, given its many geothermal occurrences with a wide range of water temperatures and relatively good water quality. What is required now is a clear sighted recognition of this potential, and public and private commitment to the development of geothermal energy resources in Nevada.

APPLICATIONS OF GEOTHERMAL ENERGY

Geothermal energy can be used successfully in many applications whose energy needs are currently met with fossil fuels. Residential, commercial, agricultural, and even many industrial loads can be met with suitable geothermal resources. The suitability of a geothermal resource for a particular application depends upon many factors, not the least of which is temperature. Other considerations include the depth and volume of the resource, its

Artesian flow from a 220°F geothermal well at Wabuska Hot Springs, Lyon County. This well will be used to supply heat for a large commercial greenhousing and aquaculture project (photo by Geothermal Development Associates).

water quality, and the cost of developing the resource.

Uses for geothermal energy fall into two broad categories: electrical power generation and direct-use of the hot water. Power generation on a commercial scale requires both a high temperature resource and a large scale reservoir. Direct uses of the geothermal energy are more varied and can economically use both lower temperature and less extensive resources.

Electrical Power Generation

The current energy situation has led to serious economic problems for many American industries and for utility companies as well. Although electric utilities in Nevada have been able to meet the energy needs of industrial users, the cost of this energy is increasing dramatically every year. Additionally, the stability of future supplies of conventional fuels used to generate electricity is uncertain. It is not surprising therefore, that numerous utilities are turning to geothermal energy to provide their customers with the electrical energy that will be needed for the future. In addition, a growing number of industries are taking a serious look at the feasibility of using geothermal energy to provide electrical power for their manufacturing processes.

Historically, electrical generation has been restricted to areas where high temperature (350° F) geothermal water is present. Geothermal engineering is now, however, advancing to the point where methods for using moderate temperature (250° F) resources are being tested. Currently in Nevada, there are at least seven known resources with temperatures high enough to be useful for commercial power generation. Although no geothermal electrical power plant has yet been built in Nevada, a group of utilities including Sierra Pacific Power Company are actively seeking to construct a small (10 megawatt) geothermal power plant in northern Nevada by 1982.

Direct Use

Direct utilization of geothermal energy for residential, commercial, agricultural, and industrial applications has already proven to be feasible. Development of geothermal resources for direct-use can take one of two forms: retrofitting existing facilities or new development.

Both the development of new facilities and the retrofitting of existing facilities are possible within several miles of a geothermal reservoir, assuming the temperature, depth, volume, and quality of the resource are all suited for the intended use. However, if some of these characteristics are not ideal for

the proposed use, certain adaptations may be possible. Where reservoir characteristics are not adequate to meet the total energy needs of the developer, it may be possible to utilize the resource to supplement an existing conventional system, thus allowing the user to at least decrease dependence on conventional fuels. If there is no adequate geothermal resource on the facility's site, hot water can be transported several miles without significant heat loss. Where the water quality of a reservoir would seem to prohibit its use, it may be possible to control chemical problems such as scaling and corrosion by using the geothermal fluid to heat a secondary working fluid, then circulating the secondary fluid through the heat distribution system.

Retrofit is particularly adaptable to space heating if geothermal waters are above 180° F. Careful design of the heating system can allow successful utilization of temperatures down to 120° F. Ground-water heat pumps allow utilization of resources with temperatures as low as 90° F. Geothermal heating systems can be adapted to forced air systems, base-board units, radiant panels, and even steam radiation units. The economic feasibility of such adaptations will depend upon the characteristics of each specific heating system and each geothermal resource.

New developments are not subject to the same problems as retrofits because development locations can be selected on the basis of their ability to meet the energy requirements of each intended application. Proper utilization of a resource will guarantee its optimal performance by preventing it from being taxed beyond its production capabilities. This is not difficult to achieve in Nevada, since the State's varied geothermal reservoirs are suited to a variety of uses.

Whether one decides to retrofit existing facilities or to locate new facilities at a geothermal site, the advantages of direct utilization of geothermal energy over conventional fuels are significant. A number of these advantages are cited in Geothermal Resources Council Special Report No. 7 (1979):

1. The conversion efficiency is high (80 to 90 percent).
2. Numerous and readily available low and moderate temperature resources can be utilized.

3. Technology for production is readily available.
4. Development time is comparatively brief.
5. Lower-temperature resource development is less expensive since it requires only conventional equipment.
6. Waters can be transported at least 2 to 8 miles and occasionally as far as 20 to 40 miles.

All of these factors favor geothermal energy development. They indicate that it would be wise for decision makers to consider geothermal energy resources when making development decisions.

Residential Applications

Space conditioning is certainly the greatest existing and potential application in the residential sector. Many homes in the southwest Truckee Meadows are heated with geothermal energy extracted from wells ranging in depth from 100 to 1,000 feet. In the Pinion Hills area of Carson City there are several homes using geothermal energy from wells that are less than 200 feet deep. Some remote ranches, fortunate enough to be located near a geothermal resource, use the waters for space heating. Domestic hot water, pool, and spa heating using geothermal energy are common in these areas. Cooling, by means of an absorption refrigeration cycle, is technically possible but not yet common.

The simplest geothermal heating system for residential applications consists of a single well and a downhole heat exchanger. Heat is transferred from the well to the home by means of fresh water that is circulated through the downhole heat exchanger and the heating system equipment in the house. In some areas it may be necessary to pump the well regularly so that the well does not become too cool for satisfactory operation of the heating system. Applications requiring large amounts of heat generally cannot use the downhole heat exchanger, and must pump the well in order to use the hot geothermal water directly. In these applications, a second well may be required to dispose of the used water.

The potential for expanded use of geothermal energy for space heating is great in Nevada. Many communities are located directly over or near resources that could supply a considerable portion of the space heating load. These communities

include Reno, Sparks, Carson City, Elko, Caliente, Gabbs, Hawthorne, Carlin, and Gerlach. As exploration locates new, hidden resources, others will be added to this list. The development of district heating systems in these communities could bring about tremendous economic benefits.

A district heating system is one in which a single geothermal well or well field is shared by multiple users in a community. It involves four components: one or more supply wells, a distribution network, individual consumer installations, and one or more injection wells. The cost of developing geothermal resources for district space heating is less than or approximately the same as the cost of using conventional fuels. Given the continuing increase in conventional fuel prices, the outlook for the development of geothermal district space heating appears promising.

Most of the district heating systems in the United States such as those at Boise, Idaho, and Klamath Falls, Oregon, are municipal systems. In Nevada, the City of Reno has proposed several studies to determine the feasibility of establishing municipal geothermal district heating systems in appropriate parts of the city. The Nevada Department of Energy is currently sponsoring site-specific development studies for Hawthorne, Gabbs, and Carlin that will evaluate the feasibility of developing district space heating in those communities. Several groups of homeowners in the Reno area are considering cooperative geothermal district heating systems to avoid the cost of drilling individual wells.

Geothermal district space heating also presents an opportunity for private enterprise. Land developers may want to provide district space heating for new housing developments, apartment buildings or shopping complexes. Utilities, such as Sierra Pacific Power Company, have already begun to investigate the long-term commercial possibilities of direct-use geothermal district heating for present and future customers. As the cost of conventional fuels continues to increase and the stability of supplies remains questionable, geothermal district space heating will become a more and more commercially valuable enterprise.

Commercial Applications

Space heating and water heating are also common commercial applications of geothermal energy. The recently expanded Peppermill Inn and Casino

in Reno, the Hot Springs Motel in Caliente, the Aqua Caliente Trailer Park in Caliente, the Mark Twain Hotel and Virginia Lake Townhouses in Reno, Steamboat Springs Spa at Steamboat, and Carson Hot Springs Spa in Carson City are all currently using this energy resource. Others in various stages of planning or construction include the Elko Heat Company in Elko and the Moana Municipal Pool in Reno. In addition, Shepard of the Mountain Church and St. Luke's Church in Reno use geothermal energy for space heating, and two other churches on Lakeside Drive in Reno are considering the use of geothermal heating systems. The Double Diamond Development Corporation is planning to utilize geothermal for space heating at the River Inn in Reno, and is investigating the possibility of geothermal district space heating for certain sectors of a planned community to be located on the Double Diamond Ranch in the Truckee Meadows.

Onions on the production line at the Geothermal Food Processors vegetable dehydration plant near Fernley, Churchill County. Geothermal water of 270°F from a nearby well provides the process heat (photo by Geothermal Development Associates).

Industrial Applications

Geothermal energy can be utilized for a wide variety of industrial applications. The production of fuel grade ethanol is a major industrial application. Geothermal energy can easily be used in the cooking, distillation, and drying processes associated with the production of ethanol. A recent study has located at least ten geothermal sites in Nevada with potential for the commercial production of ethanol. The first geothermal ethanol plant in Nevada was built by TAD's Enterprises, Inc. and began operating in November 1980, at Wabuska Hot Springs. The plant will produce 400,000 gallons of 199 proof ethanol annually, using corn as the feedstock. Similar plants are being considered near Winnemucca, Crescent Valley, and Brady's Hot Springs. If the potential for geothermal ethanol production is realized, ethanol production could become a major industry in Nevada.

Many other industrial applications are possible, particularly those involving product preheating, washing, cooking, blanching, peeling, evaporating, sterilizing, distilling, separating, drying, and refrigeration. These processes encompass industries such as: meat packing, bottle washing, poultry dressing, canning, textile finishing, metal and plastics fabrication, food processing, pulp, paper and textile drying, beet pulp drying, distilled liquor, grain drying, and cement drying to name a few.

Drying applications are essential for many industries, from coal and grains to pharmaceutical products, as well as for vegetable and fruit dehydration. Geothermal Food Processors, Inc. built the first food dehydration plant in Nevada near Fernley. The plant currently produces dehydrated onions and other vegetable products. ABC Concrete Products, Inc. of Reno is planning a concrete block plant at Steamboat Springs. Geothermal energy will be used there for steam curing and drying of concrete blocks.

A very important industrial application of geothermal energy is agriculture. In 1972, Agri-Technology Corp. began building greenhouses for vegetable production near the site of the Wabuska Hot Springs. Unfortunately, financial difficulties arose which defeated this project. At present, Alexander Dawson, Inc. is planning approximately four acres of greenhouseing, also to be located at Wabuska. In addition to greenhouseing, the Dawson company is building ponds for fresh water shrimp and fish

farming. Agriculture applications such as these, are particularly viable because they require lower resource temperatures.

Greenhousing may be the principle agricultural application of geothermal resources, but there are others as well. Animal husbandry (environmentally controlled livestock raising), aquaculture (raising prawns and fish), soil warming for increased production, mushroom growing, and biogas generation are examples of other agricultural applications which require no new technology and offer a full spectrum of possibilities to industrial developers.

Double-column still and anhydrous tower for ethanol production at Wabuska Hot Springs, Lyon County. This plant, built by TAD's Enterprises, is the first ethanol plant in the country to use geothermal energy for cooking, distilling, and drying (photo by Geothermal Development Associates).

Cascading

To obtain maximum benefit from a particular resource, a cascade of applications may be necessary. That is, applications which require successively lower temperatures are connected in a series so that maximum economic energy extraction is accomplished. A typical cascading system could begin with a high temperature (400° F) resource serving a power plant. The spent fluid from the power plant, perhaps at 250° F, could then be used in a crop dehydration plant which might return the fluid at 200° F. The fluid might then be used in a space heating application such as greenhousing, and finally in an aquaculture application such as prawn farming. Other cascades are of course possible, and they need not begin at a high temperature such as suggested in this example. Figure 2 illustrates a typical cascaded system of applications.

Sunset behind a geothermally heated greenhouse under construction near Elko, Elko County (photo by Geothermal Development Associates).

Potential Applications by County

All seventeen counties in Nevada have geothermal resources. Some of them are already developed, but none are being utilized to the maximum extent

possible. Most of these resources have the potential to support further development. The Nevada Department of Energy (NDOE) has drafted several Area Development Plans for major resources in all counties of the state, ranking them according to their suitability to particular applications. Table 1 summarizes the ratings given to each resource by county. These tables are not inclusive nor are they meant to be the final assessment of these resources or of their potential applications. They are a preliminary analysis of the types of development that would seem to have the best opportunity to succeed, given current knowledge about each reservoir and current technology. The ratings, low, medium and high (L, M, H) are based on the (NDOE) area development plan analyses. For a more detailed explanation of how these ratings were developed, contact NDOE in Carson City.

NEVADA'S GEOTHERMAL ADVANTAGE

The continuing increase in the price of imported oil and natural gas, and decontrol of domestic oil prices have contributed to making geothermal resources an economically attractive energy supply. Since early 1979, the U.S. has experienced an 80 percent increase in fuel oil prices, a 28 percent increase in natural gas prices, and a 30 percent increase in the cost of electricity. The cost of developing and using geothermal energy is not however, tied to the rapidly inflating costs of conventional fuels.

Public and private sector interest in the development and utilization of geothermal energy for industrial, commercial and residential energy needs will be influenced by the availability of geothermal resources to help reduce dependence on fossil fuels, and to provide a relatively clean energy source. Thus, geothermal energy can help alleviate concern over the natural and social environment, as well as mitigate and even eliminate the direct financial impact of the energy situation on individuals and businesses.

The presence of substantial geothermal reservoirs may also result in broadening the general economic base of the county, city or town in which they are located. Due to the unique ability of geothermal to provide business with a stable and cost efficient energy supply, many more businesses could be attracted to the State. This influx of capital would increase county and state revenues, provide jobs, and promote greater economic diversification throughout the state.

Simple cascade of applications

(Figure 2)

Nevada is fortunate to contain substantial geothermal resources that are suited to a variety of applications. The multiple advantages of geothermal energy should serve to stimulate energy users and developers to either retrofit existing facilities or to develop new facilities to use this resource. With this in mind, it is helpful to look at the most important advantages of geothermal energy.

Resource Characteristics

Geothermal resources in Nevada are relatively clean compared to conventional energy sources. This means that the negative impacts of their development on the natural and social environment are limited. The most intense effects will be localized at the drilling site during the developmental stages. Continuing impacts, both aesthetic and environmental, are again confined almost exclusively to the geothermal site. This also means that Nevada's geothermal resources involve few safety hazards and provide few potential land-use conflicts.

Marketability

The market for geothermal energy is rapidly expanding in Nevada. This is due largely to the growth in population, increased energy prices and energy scarcity. Nevada still must import up to 95 percent of the energy used in the State. Low grade thermal applications such as space heating could easily replace natural gas, propane and electricity, since the temperature requirements for these uses correspond to the temperature range of many of the State's geothermal resources.

The primary commercial and residential market for direct use of geothermal is space heating and cooling, low to moderate temperature industrial processing and greenhousing. Commercial markets exist for geothermal space heating in laundries, hotels, schools, shopping malls, retail outlets and office buildings. Industries use process heat to produce food, lumber, wood, paper, and chemical products. All these processes require substantial amounts of energy, which drives up production costs and so increases product cost. These costs may be substantially reduced if current facilities are converted from conventional fuels to geothermal energy, or if new facilities are located near geothermal reservoirs so as to take advantage of geothermal energy.

There are also excellent opportunities for geothermal development in the area of electrical power

production. Electric utilities can utilize geothermal power plants to supplement their existing electrical generating facilities to manage peaking problems as well as contribute to the base load. Under recently enacted federal legislation, the Public Utility Regulatory Policy Act (PURPA), individuals and companies may produce small amounts of electrical energy (up to 80 megawatts) to use on site or market to electric utilities by interconnection with the utility grid. These small power producers are entitled to reimbursement for this electrical energy from the utility at a rate set by the Nevada Public Service Commission, that is equal to or higher than that utility's avoided cost. Information regarding PURPA and how it is implemented in Nevada can be obtained from Nevada Public Service Commission.

Because it is not tied to the rising cost of conventional fuels, geothermal power production may turn out to be an extremely good investment. In addition, it is safe, clean, and non-polluting, factors which will all contribute to its popularity.

Cost Effectiveness

Increased development and utilization of Nevada's geothermal resources will depend upon a clear demonstration of the economic success of such investments. At least two major economic factors must be considered before attempting either retrofit or new development. One, the cost of geothermal exploration, development, production and maintenance versus conventional fuel costs; and two, the payback period and internal rate of return on the investment. Commercial development of geothermal resources is capital intensive. Therefore, the potential user should compare the substantial capital investment a geothermal system requires, and the operating costs of the system, with the cost of conventional fuel systems. To do so the Geothermal Resources Council, Special Report No. 7 (1979), recommends that the potential geothermal developer do the following:

1. Establish the heat load and current cost of conventional fuel.
2. Determine inflation rates for energy, operation and maintenance costs.
3. Establish the cost of geothermal equipment and installation.

4. Establish the annual operation and maintenance costs of conventional and geothermal systems.

5. Consider the effects of tax credits, depreciation and depletion allowance.

With this information in hand, the developer should be able to make a wise decision about the geothermal system versus the conventional system.

The savings generated by the investment in a geothermal system must be evaluated just like revenues from ordinary investment, and this will vary considerably with the type of system and its intended application. The "stream of savings" must be spread over a realistic payback period and evaluated in terms of their present worth. The appropriate discount rate for these savings is generally the rate being paid on other conservative investments at the time. However, it is important to note that there are other considerations, not directly economic, which will factor significantly into this question regarding the economic value of geothermal development. These considerations include:

1. Predicted future prices of conventional fuels.
2. Availability and stability of the supply of conventional fuels.
3. Superior energy quality.
4. Convenience.
5. System life-cycle costs.
6. Availability of technology required to utilize the resource for a specific application.

Each of these questions must be carefully considered in order to determine whether or not the development of geothermal power is a wise investment.

FEDERAL AND STATE INCENTIVES

Both the Federal Government and the Nevada State Legislature are committed to providing incentives to encourage the development of geothermal resources. Such assistance takes the form of tax credits, loans, and subsidies. Relevant Federal

and State programs and incentives are outlined below.

At the time of printing, all of the Federal loans and grants outlined are available. However, individuals planning to apply for any of them should first contact NDOE to determine their current status, as some may be discontinued.

Federal Taxes and Incentives

Residential Tax Credits. The Energy Security Act of 1980 defines geothermal as a "renewable energy source" and so allows taxpayers a 40 percent deduction for geothermal expenditures up to \$10,000 for principle residences. Unused credit can be carried over each year up to 1987 for investments made as of 1980. Individual tax credits can be pooled when individuals get together to drill a single geothermal well to supply several homes with space and/or hot water heating or cooling.

Business Energy Investment Credits. Businesses investing in "geothermal property" (except public utilities) may take a 15 percent energy tax credit in addition to the normal investment tax credit for investments made between January 1, 1980, and December 31, 1985.

Intangible Drilling Cost (IDC's) Deductions. IDC's are costs incurred in developing a geothermal resource (wages, fuel, supplies, etc.) that have no salvage value but are incident and necessary to drilling and preparing wells. These costs may be deducted as expenses in the year incurred or capitalized and deducted over a period of time as depreciation (physical property) or depletion (non-physical property).

Depletion Allowances. The 1978 Energy Tax Act grants depletion on income from geothermal resources at the rate of 22 percent through 1980. The rate then decreases 2 percent yearly until 1983 when it will remain at 15 percent.

Conversion. Converting from oil and gas is encouraged by the 1978 Energy Tax Act. Accelerated depreciation to allow early retirement of oil and gas using equipment is allowed.

Small Power Production. The Federal Energy Regulatory Commission (FERC) is authorized to exempt small power producers (80 megawatts or less) and cogenerators from the Federal Power

Act and the Federal Public Utility Holding Company Act. FERC can also order electric utilities to provide transmission and interconnection services for small geothermal power plants. In addition, new Federal regulations (PURPA) require public utilities to purchase electricity from small scale energy producers at a price equal to what it would have cost the utility to produce and/or purchase the energy itself.

Federal Programs

Geothermal Energy Technical Assistance Program. A maximum of 100 man hours of technical assistance is offered to the general public, industry, DOE contractors, federal, state and local agencies by this USDOE program. The Oregon Institute of Technology (OIT), Geo-Heat Utilization Center provides assistance in the areas of: engineering evaluation, preconceptual design, and materials technology. Contact the NDOE for referral.

National Energy Conservation Policy Act Grants. Grants subject to cost-sharing requirements are offered for projects promising to identify conservation measures that will reduce consumption and associated costs of conventional energy resources in schools and hospitals. Funding is also available for hospitals and schools wishing to implement selected conservation measures.

Synfuels Act. The Energy Security Act of 1980 embodies numerous provisions that should serve as incentives to geothermal development. These provisions include: feasibility studies, forgivable loans for drilling, non-electric construction loans, and 90 percent loan guarantees for municipalities or cooperatives.

Other Federal Grants. The Department of Housing and Urban Development (HUD) offers three grants that may be applied to geothermal development. These grants are:

- Urban Development Action Grants (UDAG) to aid severely distressed cities and urban counties to revitalize local economics and reclaim deteriorated neighborhoods.
- Community Development Block Grants to fund community development activities.

- Comprehensive Planning Assistance Grants to help State and Local governments finance comprehensive planning activities.

U.S. Small Business Administration (SBA) Loans. SBA loans are available to start, continue or expand businesses developing, manufacturing, selling, installing, or servicing geothermal energy resources. Loans up to \$350,000 are made directly; 90 percent of a loan obtained from private lender up to \$500,000 is guaranteed by SBA.

Other Loans. Numerous other loans are available to qualified applicants from the following agencies:

- Farm Credit System (FCS)
- The Farmers Home Administration (FmHA); Department of Agriculture
- The Economic Development Administration (EDA)

State Incentives

Taxation. The state of Nevada provides a number of tax exemptions, credits, and allowances to encourage residential, commercial and industrial development of geothermal energy. They are:

1. Owners of residential buildings heated or cooled by geothermal energy are granted property tax allowances equal to the differences between the tax on the property at assessed value with the geothermal system and the tax without the system.
2. Exemption of non-producing geothermal leases from property taxes.
3. Property tax credits of up to \$2,000.00 for the construction of residential geothermal facilities for heating and cooling. This tax credit is applicable only to the added assessed value due to the installation.

Geothermal Resource Insurance

Geothermal Resource Insurance is now available from the Insurance Company of North America, through their managing agent, Corroon & Black of Pennsylvania, Inc. This program is designed to insure the presence of a sufficient quantity of the resource over an agreed period of time, on both direct use and indirect use projects.

ADDITIONAL INFORMATION

For additional information on geothermal assessment, Nevada's resources, leasing, water rights, geothermal financing, taxes, environmental and utility regulation, call or write one of the agencies listed below:

General Information, Technical Assistance, Nature of Nevada's Resources

Nevada Department of Energy
400 West King Street
Carson City, Nevada 89710

Contact: Maggie Pugsley, Urban Planner
(702) 885-5157

Geothermal Resources Council
P.O. Box 98
Davis, California 95616

Contact: Dave Anderson
(916) 758-2360

Resource Assessment

Nevada Bureau of Mines and Geology
University of Nevada — Reno
Reno, Nevada 89557

Contact: Larry Garside, Geologist
(702) 784-6691

Division of Earth Sciences
University of Nevada — Las Vegas
255 Bell Street
Reno, Nevada 89503

Contact: Dennis Trexler
(702) 784-6151

Land Ownership — Access — Leasing

U.S. Bureau of Land Management
Room 3008, Federal Building
300 Booth Street
Reno, Nevada 89509

Contact: Norman Melvin, Geothermal
Coordinator
(702) 784-5748

Division of State Lands
201 South Fall Street
Carson City, Nevada 89710

Contact: Jack Shaw, Administrator and
Land Registrar
(702) 885-4363

Water Rights and Water Allocation

Nevada Department of Conservation and
Natural Resources —
Division of Water Resources
201 South Fall Street
Carson City, Nevada 89710

Contact: Peter G. Morros, State Engineer
(702) 885-4380

Operational and Environmental Permits

U.S. Geological Survey
District Geothermal Office
4600 Kietzke Lane
Reno, Nevada 89502

Contact: Bernie Moroz, District Geologist
(702) 784-5676

Division of Environmental Protection
201 South Fall Street
Carson City, Nevada 89710

Contact: Marvin Tebeau
(702) 885-4670

Utility Regulation

Public Service Commission
505 East King Street
Carson City, Nevada 89710

Contact: John Clark, Deputy Commissioner
(702) 885-4180

Financial Assistance and Incentives

Internal Revenue Service
300 Booth Street
Reno, Nevada 89509

**Contact : Gerald Swanson, District Director
(702) 784-5521**

**Nevada Department of Taxation
Division of Assessment Standards
1340 South Curry Street
Carson City, Nevada 89710**

**Contact: Charles Chinnock
(702) 885-4840**

Federal Geothermal Loan Guaranty Program

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

**Contact : Ken Bromberg
(415) 273-7151**

Program Research and Development Announcement

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

**Contact: Hilary Sullivan, Project Coordinator
(415) 273-7943**

Program Opportunity Notice

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

**Contact: Hilary Sullivan, Project Coordinator
(415) 273-7943**

Geothermal Energy Technical Assistance Program

**Geo-Heat Utilization Center
Oregon Institute of Technology
Klamath Falls, Oregon 97601**

**Contact: Gene Culver
(503) 882-6321**

National Energy Conservation Policy Act Grants

**Department of Energy
20 Massachusetts Avenue N.W.
Room 4117
Washington, D.C. 20045**

**Contact: Michael Willingham, Director,
Office of State — Specific Programs
(207) 376-4149**

Urban Development Action Grants

**Department of Housing and
Urban Development
2500 Wilshire Blvd.
Los Angeles, California 90057**

**Contact: John Tuite, Area Manager
(213) 688-5100**

HUD Assistance Programs

**U.S. Department of Housing and
Urban Development
One Embarcadero Center
Suite 1600
San Francisco, California 94111**

**Contact: Henry Dishroom, Area Manager
(415) 556-2238**

U.S. Small Business Administration

**Small Business Administration
3030 North Central Avenue
Phoenix, Arizona 85012**

(602) 261-3611

Geothermal Resource Insurance Program

**Corroon & Black of Pennsylvania, Inc.
1530 Chesnut Street
Philadelphia, Pennsylvania 19102**

**Contact: Gilbert M. White,
Senior Vice President
Norman K. Barrett, Vice President
(215) 568-5505**

TABLE 1: APPLICATIONS

County — Resource	Residential - Commercial Space Heating	District Heating	Green - housing	Aqua- culture	Animal Husbandry	Recreation	Industrial Process Heat	Electrical Power Generation
Carson City:								
— Carson Hot Springs	H	M	M	H	M	H	M	L
— Prison Hot Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Pinion Hills	H	H	M	M	M	M	M	L
Churchill:								
— Brady's Hot Springs	L	L	M	M	M	L	H	M
— Desert Peak	L	L	L	L	L	L	M	H
— Soda Lakes/Upsal Hogback	H	H	H	H	M	H	H	M
— Stillwater	M	M	H	H	M	M	H	M
— Lee Hot Springs	M	L	H	M	M	H	H	M
— Dixie Valley	L	L	L	L	L	L	M	H
Clark:								
— Moapa	M	M	M	H	M	H	M	L
— Las Vegas Valley	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Black Canyon	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.

(n.r. — not rated)

TABLE 1: APPLICATIONS

County — Resource	Residential - Commercial Space Heating	District Heating	Green - housing	Aqua- culture	Animal Husbandry	Recreation	Industrial Process Heat	Electrical Power Generation
Douglas:								
— Walley's Hot Springs	H	M	M	M	M	H	L	L
— Saratoga Hot Springs	M	L	M	H	M	M	M	L
— Hobo Hot Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Elko:								
— Hot Sulfur Springs	L	L	H	M	M	L	H	M
— Sulfur Hot Springs	L	L	H	H	M	L	H	H
— Elko Hot Springs	H	H	H	H	H	H	M	L
— San Jacinto Ranch	M	L	M	H	H	L	M	M
— Humboldt Wells	H	M	M	M	H	M	M	L
— Carlin Hot Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Thousand Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Esmeralda:								
— Fish Lake Valley	L	L	M	L	L	L	M	L
— Alkali Springs	M	L	M	H	H	M	L	L
— Silver Peak Hot Springs	L	L	M	H	M	L	L	L
— Pearl Hot Springs	L	L	L	M	L	L	L	L

Eureka:

— Beowawe Geysers	L	L	M	M	M	L	H	H
— Hot Springs Point	M	L	M	M	H	L	M	L
— Walthi Hot Springs	M	L	M	M	H	L	M	L
— Klobe Hot Springs	M	L	M	M	H	L	M	L
— Horseshoe Ranch	L	L	L	H	M	L	M	L
— Bruffey's Hot Springs	M	L	M	M	H	L	L	L
— Shipley Hot Springs	L	L	M	M	M	L	M	L
Humboldt:								
— Double Hot Springs	L	L	H	M	M	L	H	M
— Pinto Hot Springs	L	L	H	M	M	L	H	M
— Baltazor Hot Springs	L	L	H	M	M	L	H	M
— Tipton Hot Springs	L	L	M	M	M	L	H	H
— Golconda	M	L	H	H	H	L	H	M
— Howard Hot Spring	L	L	M	M	M	L	H	L
— Dyke Hot Spring	M	L	H	M	H	L	M	L
— Lordero Mercury Mine	L	L	M	H	M	L	M	L
— Bog Hot Springs	M	L	H	M	H	L	H	L
— Soldier Meadows Hot Springs	M	L	M	H	M	L	M	L

(n.r. — not rated)

TABLE 1: APPLICATIONS

County — Resource	Residential - Commercial Space Heating	District Heating	Green - housing	Aqua- culture	Animal Husbandry	Recreation	Industrial Process Heat	Electrical Power Generation
Lander:								
— Spencer Hot Springs	M	L	H	M	H	M	H	L
— Smith Creek Valley	L	L	H	M	M	L	M	M
— Buffalo Valley Hot Springs	M	L	M	M	H	L	M	L
— Hot Springs Ranch	L	L	M	H	M	L	M	L
Lincoln:								
— Caliente	H	M	M	M	H	M	M	L
— Panaca Warm Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Delmue's Spring	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Flatnose Ranch Spring	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Hiko Spring	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Crystal Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Ash Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Geyser Ranch Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Hammond Ranch	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Sand Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Bennett's Spring	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.

Lyon:								
– Wabuska Hot Springs	M	M	H	H	M	M	H	L
– Hazen Area	L	M	H	M	M	M	H	L
– Hind's Hot Springs	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Mineral:								
– Wedell Springs	M	L	M	H	M	L	L	L
– Sodaville Springs	M	L	H	M	H	M	M	L
– Hawthorne Area	H	H	M	L	M	H	M	L
Nye:								
– Diana's Punchbowl	L	L	M	H	M	L	M	L
– Gabbs Area	H	M	M	L	H	M	M	L
– Duckwater	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
– Darrough's Hot Springs	M	L	H	M	M	L	H	L
– Little Fish Lake Valley	L	L	M	H	M	L	M	M
– Lockes Big Springs	L	L	M	M	M	L	L	L
– Blue Eagle	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
– Chimmney Hot Springs	M	L	M	H	M	L	M	L
– Coyote Hole	L	L	M	H	M	L	L	L

(n.r. = not rated)

TABLE 1: APPLICATIONS

County — Resource	Residential - Commercial Space Heating	District Heating	Green - housing	Aqua- culture	Animal Husbandry	Recreation	Industrial Process Heat	Electrical Power Generation
Nye — Continued:								
— Abel Hot Springs	L	L	M	H	M	L	L	L
— Hot Creek Canyon	M	L	M	M	H	L	M	L
— Nanny Goat Springs	M	L	M	H	H	L	M	L
— Tonopah Mining District	L	L	L	L	L	M	M	L
— Sarcobatus Flat	M	L	M	H	M	M	M	L
— Amargosa Desert	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Pahrump Valley	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Pershing:								
— Leach Hot Springs	M	L	H	M	H	L	H	M
— Kyle Hot Springs	L	L	H	M	M	L	H	M
— Trego Area	L	L	H	M	M	L	H	L
— Sou Hot Springs	M	L	H	H	H	L	L	L
— Hot Springs in Dixie Valley	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
— Colado Area	H	H	H	H	H	H	H	M
— Humboldt House	L	L	M	L	M	L	H	H

Storey:								
– Comstock Mining District	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Washoe:								
– Steamboat Hot Springs	H	H	H	H	H	H	H	H
– Moana Hot Springs	H	H	H	L	L	H	M	L
– The Needles Rocks	M	L	H	M	H	L	M	L
– Gerlach Hot Springs	M	M	M	M	M	M	H	H
– Ward's Hot Springs	M	L	H	M	H	L	H	L
– San Emidio Desert Hot Springs	L	L	H	M	M	L	H	M
White Pine:								
– Monte Neva Hot Springs	M	L	M	H	H	H	M	L
– Cherry Creek Hot Springs	M	L	M	H	H	H	M	L
– Williams Hot Springs	L	L	M	H	M	L	L	L
H = High (> 200)								
M = Moderate (125 – 199)								
L = Low (< 125)								
n.r. = not rated								

BIBLIOGRAPHY

- Anderson, D.N., and Lund, J.W. [Editors], 1979, Direct utilization of geothermal energy, A technical handbook: Geothermal Resources Council Sp. Rept. No. 7, Ch. 6 Financing direct-use projects.
- Bateman, R.L., and Scheibach, R.B., 1975, Evaluation of geothermal activity in the Truckee Meadows, Washoe County, Nevada: Nevada Bureau of Mines and Geology, Report No. 25.
- Brook, C.A., Mariner, R.H., Mabey, D.R., Swanson, J.R., Guffanti, M., and Muffler, L.J.P., 1979, Hydrothermal convection systems with reservoir temperatures $\geq 90^{\circ}\text{C}$, in Assessment of geothermal resources of the United States — 1978: U.S. Geological Survey Circular 790.
- Eastlake, W.B., 1980, Geothermal: Energy of the eighties: A primer on economic feasibility for direct-users, Transaction, v.4.
- Garside, L.J., 1974, Geothermal exploration and development in Nevada through 1973: Nevada Bureau of Mines and Geology, Report No. 21.
- Garside, L.J., and Schilling, J.H., 1979, Thermal waters of Nevada: Nevada Bureau of Mines & Geology, Bulletin 91.
- Geothermal Development Associates, 1979, Geothermal direct heat use market potential/penetration analysis for Nevada, Department of Energy region IX, in Geothermal direct heat use: Market potential/penetration analysis for federal region IX (Arizona, California, Hawaii, Nevada), Powell, W., and Tang, K. [Editors], May, 1980, prepared for U.S. Department of Energy through agreement with NASA by Jet Propulsion Laboratory.
- Kestin, J., 1980, Sourcebook on the production of electricity from geothermal energy: U.S. Department of Energy.
- Nevada Department of Energy, 1980, Energy in Nevada: Nevada Department of Energy, 2nd Edition.
- Sammel, E.A., 1979, Occurrence of low-temperature geothermal waters in the United States, in Assessment of geothermal resources of the United States — 1978: U.S. Geological Survey Circular 790.
- Trexler, D.T., Flynn, T., and Koenig, B.A., 1979, Assessment of low — to moderate — temperature geothermal resources of Nevada, final report and map, Geothermal resources of Nevada and their potential for direct utilization, scale 1:500,000: Under Contract to the U.S. Department of Energy, Contract ET-78-5-08-1556.
- Trexler, D.T., Flynn, T., Koenig, B.A., and Bruce, J., 1980, Assessment of geothermal resources of Caliente, Nevada: Nevada Bureau of Mines and Geology, work performed under U.S. Department of Energy, Contract DE-AC08-79NV10039.
- Trexler, D.T., Flynn, T., Koenig, B.A., and Bruce, J., 1980, Assessment of the geothermal resources of Carson-Eagle Valleys and Big Smoky Valley, Nevada: Nevada Bureau of Mines and Geology, first annual report, prepared for the U.S. Department of Energy, Division of Geothermal Energy, Contract DE-AC08-79NV10039.
- United States Geological Survey Computer file GEOTHERM. ____ (no date), Small business, solar energy and energy conservation loan program: U.S. Small Business Administration, Fact Sheet No. 29.