DOE/R8/01066--T2

DE85 011308

FINAL TECHNICAL REPORT

DISCLAIMER

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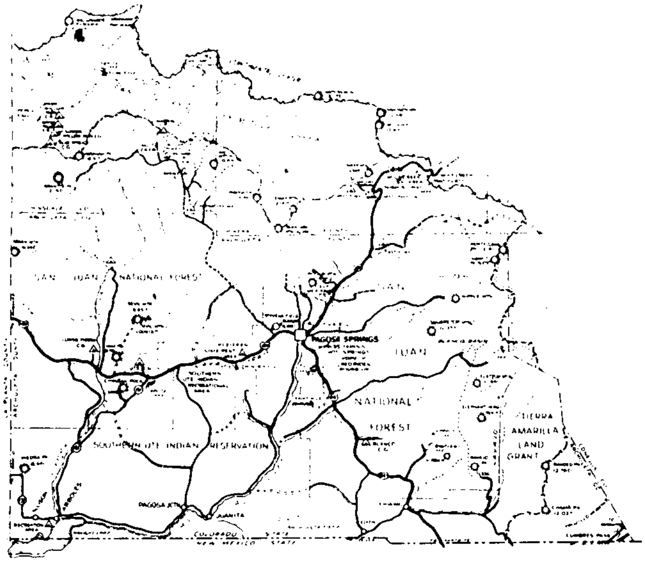


The World' rgest, Hottest Mineral Spring

Town of Pagosa Springs

Box 265-486 San Juan St.
Pagosa Springs, Colorado 81147

October 19, 1984

Heart of the Finest Big Game Hunting and Fishing Country.
Home of the Red Ryder Roudup, July 3-4
On U.S. 160 — The Navajo Trail.

Mr. Robert E. Ivey, Contracting Officer
Denver Support Office, Dept. of Energy
PO Box 26247, Belmar Branch
Lakewood, Colo. 80226

Dear Mr. Ivey:

In answer to your letter of October 16, 1984, re: Appropriate Technology
Grant Number DE-FG48-81R801066

NARRATIVE STATEMENT ✓

1. Technical Description of Project - Part 1. Pagosa Springs Geothermal Project - South 8th Street Lateral

Initially this project was to be installed in the alley between 8th and 9th Street and extend South to serve residential and Archuleta Housing project buildings.

The project was changed to run down 8th street due to residential density and consideration of buildings which would be more suitable for retrofit. This location will still allow for connections to the Archuleta Housing Project located between 8th and 9th street.

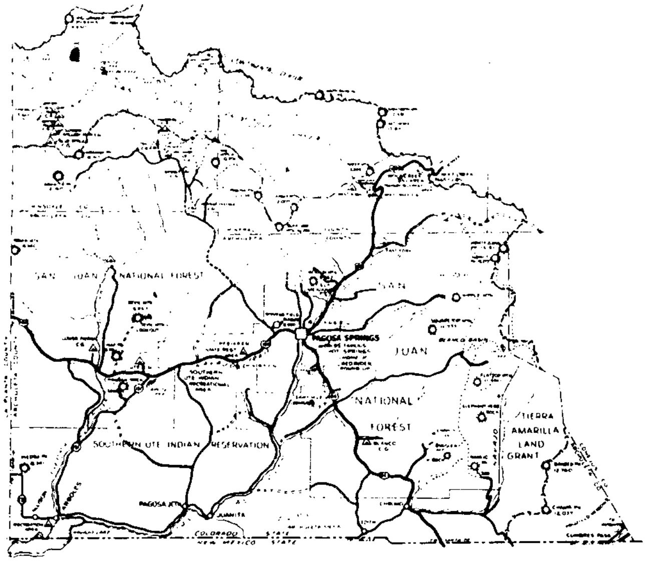
The 8th street laterial design called for 900 feet of line. Fifty-five feet was provided from the original project and 845 feet each of 6" insulated supply and 6" uninsulated return were purchased and installed with a cross-over connecting the two at the south end.

Originally there were five residences to be targeted for retrofit with a representation of change over ranging from natural gas to wood and/or coal.

Agreements for change over were not reached with the property owners in time. for compliance with the grant deadline resulting in no monies requested or used.

The pipe line was, from all available information, installed satisfactorily and from actual experience has proven to be a solid and reliable line. This line is now serviceable and available for provision of geothermal heat to the area of south 8th street.

The Town of Pagosa Springs is currently in the process of finalizing the production permits for Geothermal Wells PS-3 and PS-5. Once this is accomplished, expansion of services to residential customers will become a reality and allow for servicing of houses located along the entire geothermal system.



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We hope this information is satisfactory. If more information is needed please feel free to call. A map is enclosed showing the line extension of this project.

Sincerely,

Jacquelyn M. Schick
Town Clerk

Enclosure

APPROPRIATE TECHNOLOGY

Through its Appropriate Technology Small Grants Program, the U.S. Department of Energy funded a number of energy conservation projects in Colorado. This booklet is one of a series reviewing those Colorado grants.

Appropriate Technology or AT means finding the right solution to a given problem--one no more costly, time consuming or complicated than it needs to be. It involves using local people, skills and resources to solve local problems.

Some AT ideas are new. Others are old, rediscovered ways of doing things or novel uses of familiar methods and materials. As it relates to energy, AT means finding ways to reduce our energy needs and new ways to get the energy we need.

Heat from the earth

Geothermal energy: a Colorado resource

Colorado Office of Energy Conservation

Department of Regulatory Agencies
June 1984

Introduction

Geothermal energy, the heat of the earth, has a variety of uses, depending on its form. And that form can vary from the very high geothermal temperatures that produce enough hot steam to generate electricity to the normal temperature gradient of the earth. Even at the low end, we can use geothermal energy to heat and cool our buildings with earth temperatures that rarely vary much more than 5 degrees F (at 20 to 30 feet deep) from the average annual year-round air temperature.

Between these two extremes are areas with temperatures that are anomalous or unusually high but not high enough for power generation. These areas, especially when found in a medium of water, are particularly valuable. This hydrothermal or hot water energy can be piped to a building and be used to heat water or to provide space or process heat.

This booklet discusses some ideas and methods for using Colorado geothermal energy as shown in several projects funded by the U.S. Department of Energy in its Appropriate Technology Small Grants program. The booklet is not intended to be a comprehensive guide to the development of geothermal energy but to provide an overview of what can often be a very complex and involved development process. For those who wish to pursue the subject further, we have provided a resources section listing other publications, experts and governmental agencies that can be helpful.

Colorado potential

The hydrothermal or hot water energy resources of Colorado can provide large quantities of heat for Colorado homes, businesses and industries. The technology is simple and well-developed. The processes for development, including permitting, are in place but can be complicated and--as the case studies illustrate--controversial. The energy form is generally acknowledged to be clean and renewable. Beyond that, Colorado's settlement patterns and economy offer some excellent opportunities for using geothermal energy. And, depending on the particular resource and how it's used, the savings in money and conventional energy can be impressive.

Around the state 58 geothermal sites have been identified by the presence of hot springs or wells (see Appendix A). The full extent of the geothermal energy is much greater than what can be seen on the surface, though. Many good geothermal areas have no surface signs such as wells or geysers. Not all the springs or wells with elevated temperatures that may lend themselves to geothermal application have been found or reported and many good geothermal areas have no surface signs such as wells or geysers.

The known geothermal sites in Colorado are spread widely along the mountains from north to south. Of the 63 Colorado counties, 23 have some known geothermal sites. Seventeen of the sites are within five miles of an incorporated community and thus well-located for development and use. Most of these communities are located in the heart of the recreation, tourism and mining districts of the state. And most are either economically depressed or suffering from the impacts of rapid growth. In either case, they offer good development opportunities.

The temperatures of Colorado springs or wells vary from a low of 57 degrees F to 181 degrees F. (The subterranean temperatures are usually higher because the hot water mixes with cold on its way to the surface; at one site, the underground temperature of the water is estimated to be at least 347 degrees F.) Water at the higher temperatures can be used to drive small, well head electrical generators. At the lower end, groundwater heat pumps could allow the extraction of useful heat. To date in Colorado, 34 known sites have temperatures high enough to allow direct use without heat pump enhancement and more will probably fall within this range when subsurface temperatures are better known.

Colorado has a number of existing geothermal developments, most of them some years old, that have been developed privately. They include space heating in Pagosa Springs and Ouray, catfish and algae growing and hog-pen heating in the San Luis Valley, commercial greenhouses at Mt. Princeton in the Arkansas Valley and spas at Glenwood Springs, Idaho Springs and other places around the state.

The federal government funded a number of projects in the 1970s, ranging from industrial use in the Arkansas Valley to district heating schemes in Pagosa Springs. Some private development is underway today as well.

The Colorado geothermal AT grants

The U.S. Department of Energy provided funds for a number of Colorado geothermal projects in 1979 through 1981. The four projects examined here offer a good look at both the diversity of potential geothermal uses and the difficulties that can confront the geothermal developer.

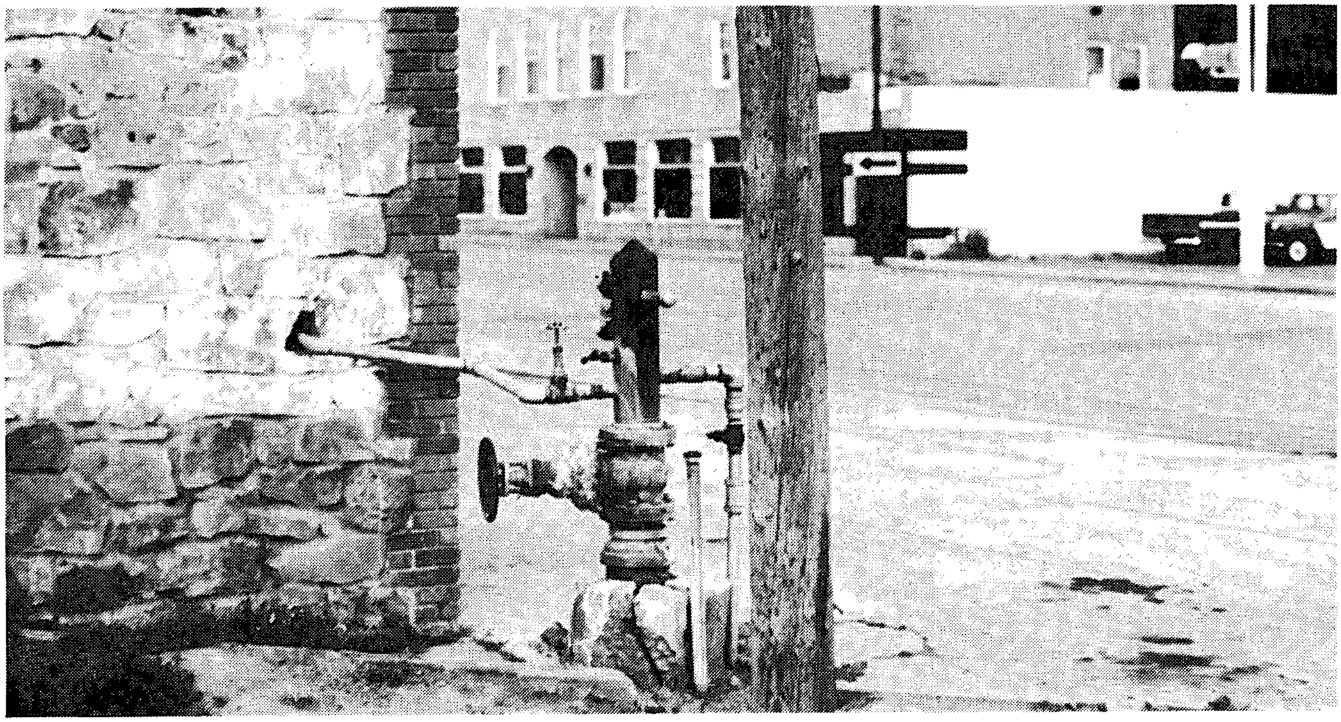
The Pagosa Springs municipal geothermal project

Pagosa Springs is one of several Colorado towns that seem well-suited for geothermal district heating. The town was originally sited to take advantage of the hot springs. It has had a hot springs spa and has heated several buildings from private geothermal wells since the early part of the century.

In 1979, the town received a DOE grant to build a geothermal district heating system for its central business district. Then, to expand that system to heat a number of homes of low-income residents, the town sought and received another AT grant from the DOE in 1981. The $44,834 grant was planned to bring geothermal heat to five homes using different types of heating delivery systems. With the two grants, the town hoped to be able to provide about 50 percent of its heating needs with geothermal energy. The town designed a pricing structure it hoped would cover the cost of operating and maintaining the system, pay back the cost of retrofitting for geothermal use within three years, and still limit the monthly cost to no more than 75 percent of the cost of heating with natural gas.

The business district system was built. But the owners of water rights senior to the town's filed suit against the town, charging that wells drilled for the system had damaged their rights. The system went unused for the first heating season after its completion but has been operating for the past year.

Although the distribution line to bring the geothermal heat to the five homes has been built, it is not being used because the homes have not been fitted to use it. The retrofit costs for each heating system conversion included in the grant were understated and the estimated cost of $2,000 each to convert them is apparently prohibitive for the owners. In addition, community conflict has become a barrier. There is some dispute as to which homes will be equipped to use the new energy source and some continuing fear that the new wells drilled for the municipal project will diminish the flow from privately-developed wells. Project officers report that the water rights issue is close to being solved. They also report that the town is examining the heating systems in the expanded distribution area to see which can most economically be retrofitted to use the geothermal energy for heat.



SOME GEOTHERMAL USES can be very simple, such as this one in Pagosa Springs, which pipes hot water directly into a building. Others may require elaborate pumping or heat exchange systems.

If Pagosa Springs can overcome the community and legal conflicts and actually deliver the geothermal heat to the homes, low-income families can reduce their heating bills by around 25 percent and the project can stand as a model for other Colorado communities interested in municipal geothermal projects. The painful lessons are just as valuable. Chief among them is that the technology for the effective use of geothermal energy is proven and simple and, generally speaking, the simplest of the problems; it is the social, political and legal questions that can pose the greatest barriers to geothermal development. And that is particularly the case when they are either overlooked or ignored until they become major issues. The concerns of everyone who is involved in--or likely to be affected by--a geothermal project must be considered early in the process if the project is to succeed.

The Ouray geothermal feasibility study

The City of Ouray is another Colorado community with a historic spa and the potential to make excellent use of geothermal energy. The city received a $10,000 AT grant to study the economic feasibility of developing its extensive geothermal resources but with no specific use in mind. The study's goal was to "explore new ways for the city to use its geothermal energy for economic development and diversification."

Like people and towns everywhere, Ouray was faced with high bills for electricity and propane fuel. It was also burdened by a high unemployment rate because some local mines had closed. The only other industry is seasonal tourism. City leaders believed that the development of geothermal energy could help their economy as well as reduce energy costs for residents, many of whom are elderly. The study was to examine both potential energy uses and good sites for drilling geothermal wells. It would develop a preliminary engineering design and determine whether geothermal energy could, in fact, cut energy costs for the town and its residents.

(In addition to the appropriate technology grant from the DOE, Ouray received a grant from the Region 10 Economic Development Commission and the Colorado Commission on Higher Education to look at legal and market aspects.)

The study showed that Ouray's geothermal resources probably have a subsurface temperature of between 156 and 255 degrees and that they could probably sustain a discharge rate of 10 times the present rate with no damage to existing springs. That answered a key question: would new geothermal wells diminish the flow of hot water from springs feeding the municipal swimming pool, the city's largest single revenue source?

THE CITY OF OURAY has abundant geothermal resources in and around the community. One is used to heat the municipal swimming pool, shown here. One of the first concerns the city had when it began to investigate expanded use of geothermal resources for heating was the impact of additional well drilling on the spring that heats the pool. Studies showed Ouray could greatly increase geothermal use without harming this one.

The study evaluated four geothermal distribution plans:

1. Space and hot water heating for public buildings;
2. Heat for public buildings, as above, plus space and hot water heating for a bathhouse at the city pool and for a proposed year-round recreation center near the pool;
3. Space and hot water heating for the Main Street commercial district, public buildings, bathhouse and recreation center; and
4. A city-wide district heating system to serve most of the buildings in town by the year 2000.

The study showed the more ambitious plans would provide the best rate of return for the city, that geothermal energy could be competitive with propane and fuel oil in its first year of operation and that the larger systems would be the most economical.

Since the study was completed, the city has rejected a proposal for private development and decided to keep the project in municipal ownership. The city of Ouray is now looking for money to drill wells, a necessary next step in measuring the geothermal resource accurately enough to provide the basis for more detailed development plans.

Lessons

The Ouray project suggests that, given certain conditions, the development of a geothermal district heating system is economically feasible. It also emphasizes the importance of detailed information before a developer--public or private--launches a project of that magnitude. The resource, market and economic assumptions are particularly important. Ouray has also weighed the value of municipal development versus private geothermal development under contract to the city and its experience may help other communities similarly situated.

Space heating at Timberline Academy

The Timberline Academy is a private, non-profit high school located north of Durango. The school sought to cut high heating bills in an old 8,000 square-foot building by putting to work a low temperature (92 degrees F) geothermal spring that ran past the building, the main facility on the campus.

With the DOE grant of $23,888, the school intended to circulate the warm spring water directly through an existing baseboard heating system in the building. This supplemental heat was expected to save the school around $2,900 worth of propane fuel per month and at the same time demonstrate the use of a low-temperature spring-fed geothermal resource for space heating and give the students some training in alternative energy use.

None of the original plans materialized. First, the school learned during the course of the project that the heating demand of the old building was far greater than the warm springs could effectively meet. The school changed its plans, deciding to heat three smaller buildings, using the spring water, which is highly mineralized, to heat some other fluid through a heat exchanger. That portion of the project was built but before the modified system could be put into operation, the Colorado Department of Highways diverted the spring flow while doing road work in the area. The relocated stream flows too far from the buildings to be efficiently used as planned. So far, the stream flow has not been restored and the highway department says it lacks the money to do the work now.

The heat exchanger and its controls and pumps, as well as thermostats in the three small buildings, are in place. But until the stream is returned to original channel, the school cannot put the geothermal resource to work. The history of the Timberline Academy project again

THE GEOTHERMAL HEAT of the Routt Hot Springs near Steamboat Springs keeps part of this hillside free of snow. Many Colorado geothermal areas have been located by such surface signs as very warm ground temperatures, hot springs and even a few small geysers--none in the Old Faithful class, though. Other Colorado geothermal resources have no visible surface signs.

Assessing geothermal feasibility

The case studies also show that, while the uses for geothermal energy are many and varied, feasibility is very much dependent upon the specific site and the specific use. Developers should identify all the elements that are critical to a successful project and predict as accurately as possible whether any of those features is likely to change--and, in changing, turn a promising project into an utterably unworkable one.

Some of the considerations geothermal specialists stress are these:

--The heating requirements the geothermal energy is designed to meet must be great enough to justify the costs involved, particularly if wells must be drilled. Often, this requirement can be met by pulling together a number of small uses--a group of homes, for example. But this can also make the problems multiply.

makes the point that the technology for using geothermal energy is fairly straightforward. But planning problems and miscalculations on one end and institutional barriers on the other can turn a simple project into a very complicated one.

Solar/geothermal agricultural project

Morgan Community College in Ft. Morgan used a $9,600 appropriate technology grant to build and demonstrate a solar and geothermal system aimed at reducing high farm energy costs, often cited as the single biggest problem facing agricultural families today.

The Morgan Community College system uses stable 50 degrees F ground temperatures in summer to cool air for a swine farrowing and nursery building and in winter to pre-heat the outside air used to ventilate the building. Young swine need constant temperatures of between 65 and 80 degrees; the college's simple system can help achieve that at an energy savings of around $800 per year.

The south-facing roof of the building carries seven liquid solar panels with a collection area of 224 square feet. The solar-heated hot water passes through a heat exchanger to provide space heat and to preheat water for the domestic hot water tank. A 600-gallon storage tank provides evening heat.

The geothermal system, which cost only about $500 to install, consists of 168 linear feet of plastic pipe, joined in a pattern like two capital E's, one on top of the other, buried 6 1/2 feet deep on the north side of the swine building. Building air circulates through this pattern of pipes, driven by a thermostatically controlled fan system along an underground duct. Air emerging from the plastic piping system buried in 50-degree earth will be cooler in the summer and warmer in winter than outside air. An air handling system allows outside and room air to be mixed in any proportion, to maintain adequate ventilation and achieve the right temperature. A backup propane furnace provides additional heat when the solar/geothermal system cannot maintain the temperature. This system is an inexpensive, efficient way to heat and cool buildings. It relies on normal ground temperatures, not on an "anomalous" geothermal resource or high subsurface temperatures. While many geothermal applications demand projects large enough to pay for drilling wells and for extensive piping and pumping systems, this one is inexpensive enough to be used almost anywhere, even for small, individual buildings.

Problems with geothermal development

As the case studies of the appropriate technology grants suggest, there can be problems with geothermal development. They are not unique to Colorado but have to do with the nature of the resource and its likely use.

Often, the biggest problem is the sheer size necessary to make a project economically workable. The bigger the project, the greater the need for careful planning, analysis and coordination. If it reaches a community-wide scale, many diverse groups and interests can be involved. Water rights conflicts have taken their toll on some Colorado geothermal projects and are likely to continue to do so. Financing can also present problems especially if the project requires much well-drilling. Bankers tend to look at drilling as a risky venture and are often reluctant to provide financing. Developers may have to forget debt financing for early stages of the process and look for some alternative financing methods.

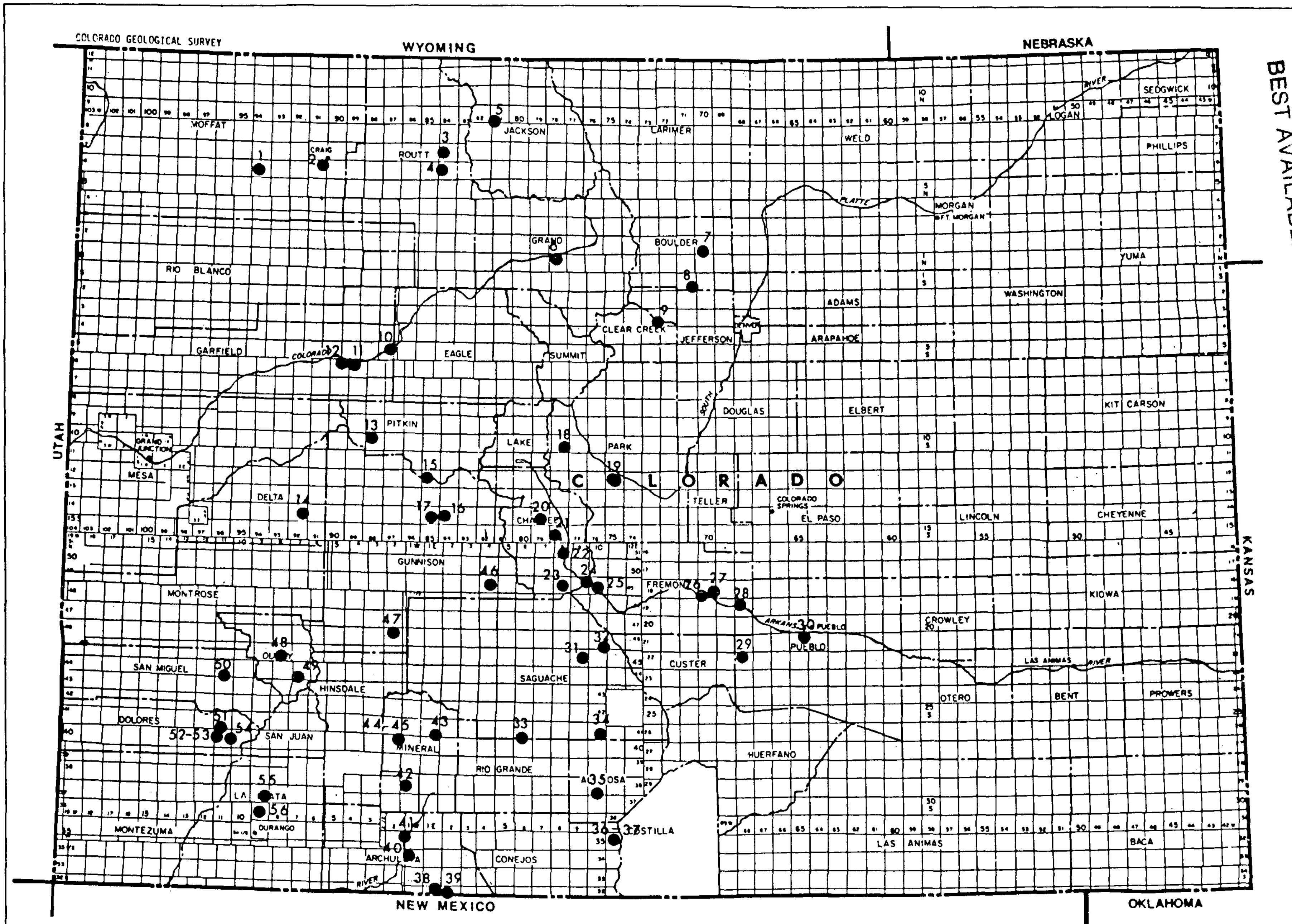
--The other factor in cost-effectiveness of geothermal use is the cost, today and over time, of the fuel that geothermal energy will replace. If conventional energy is available, is relatively inexpensive and likely to remain so, conversion to geothermal for a given use may be a bad bargain.

--Geothermal development can often involve complicated legal issues, such as water rights and permitting processes (at virtually every level, from town or county to state and federal). Professional guidance can be very important in these steps. The help of competent professionals is not cheap but neither is ignoring or glossing over issues that can later delay or kill a project.

Steps for geothermal project development

The steps for geothermal project development in Colorado should include assessment, financing, leasing, permitting, drilling, and construction. The complexity of the proposed project will determine which of the activities are necessary.

1. Assessment. The required assessments include: geologic, to determine the potential of the resource relative to the proposed use; economic, to determine whether the resource can be economically developed for the particular use; and engineering, to determine how to build the system.
2. Financing. A geothermal developer must decide whether a geothermal development will be financed with equity funds or debt. For initial well drilling, venture capital may offer the best potential, especially for a large project. For later wells and construction after the source is defined, more conventional sources may be available.
3. Leasing. Land and minerals leasing may be necessary. Even if the developer owns the land, he will need minerals leases if the mineral rights are under different ownership from that of the land.
4. Permitting. The state requires permits for drilling wells, discharging the fluid, and for air pollution; local governments regulate rezoning or subdividing, construction, and sometimes other aspects; federal leases and permits will be required where federal ownership is involved. In addition, water rights must usually be acquired, either through purchase or adjudication.
5. Drilling. Well drilling, to determine the value of the resource, usually begins with some preliminary exploration such as geophysical work and shallow gradient wells to help identify the best drill sites and required depth. Next, one or more wells are drilled, preferably by a driller experienced with geothermal wells. Flow tests then will determine the temperature and volume of fluid available, the rate at which it may be safely extracted, and any effect on other wells or springs.



Location of thermal springs and wells in Colorado.
Numbers identify thermal areas.

Appendix A.

Name	County	Name	County
1. Juniper Hot Springs	Moffat	29. Don K. Ranch Artesian Well	Fremont
2. Craig Warm Water Well	Moffat	30. Clark Artesian Well (Clark Springs Warm Water Well)	Pueblo
3. Routt Hot Springs	Routt	31. Mineral Hot Springs	Saguache
4. Steamboat Springs	Routt	32. Valley View Hot Spring	Saguache
5. Brand's Ranch Artesian Well	Jackson	33. Shaw's Warm Springs	Saguache
6. Hot Sulphur Springs	Grand		
7. Haystack Butte Warm Water Well	Boulder	34. Sand Dunes Swimming Pool (Hot Water Well)	Alamosa
8. El Dorado Warm Springs	Boulder	35. Splashland Hot Water Well	Alamosa
9. Idaho Hot Springs	Clear Crk.	36. Dexter Warm Spring	Conejos
10. Dotsero Warm Springs	Eagle	37. McIntyre Warm Spring	Conejos
11. Glenwood Hot Springs	Garfield	38. Stinking Springs	Archuleta
12. South Canyon Hot Springs	Garfield		
13. Penny Hot Springs (Avalanche Hot Springs)	Pitkin	39. Dutch Crowley Artesian Well	Archuleta
14. Colonel Chinn Hot Water Well	Delta	40. Eoff Artesian Well	Archuleta
15. Conundrum Hot Springs	Pitkin	41. Pagosa Springs	Archuleta
16. Cement Creek Warm Springs	Gunnison	42. Rainbow Hot Spring	Mineral
17. Ranger Warm Springs	Gunnison	43. Wagon Wheel Gap Hot Springs	Mineral
		44. Antelope Warm Spring	Mineral
18. Rhodes Warm Springs	Park	45. Birdsie Warm Spring	Mineral
19. Hartsel Hot Springs	Park	46. Upper Waunita Hot Springs	Gunnison
20. Cottonwood and Jump-steady Hot Springs	Chaffee	47. Cebolla Hot Springs	Gunnison
21. Chalk Creek Area (wells/spring)	Chaffee	48. Orvis Hot Spring	Ouray
22. Browns Canyon Thermal Area	Chaffee	49. Ouray Hot Springs	Ouray
		50. Lemon Hot Spring	San Miguel
23. Poncha Hot Springs	Chaffee	51. Dunton Hot Spring	Dolores
24. Wellsville Warm Springs	Chaffee	52. Geyser Warm Spring	Dolores
25. Swissvale Warm Springs	Chaffee	53. Paradise Warm Springs	Dolores
26. Canon City Hot Springs	Fremont	54. Rico Warm Springs	Dolores
27. Fremont Natarorium	Fremont	55. Pinkerton Hot Springs	La Plata
28. Florence Artesian Well	Fremont	56. Tripp and Trimble Warm Springs	La Plata

For Further Information

Colo. State Board of Land Commissioners
Room 620, 1313 Sherman St.
Denver, Colo. 80203
(303) 839-3451
Issues geothermal leases on state-owned property, surface or sub-surface.

Colo. Oil and Gas Conservation Commission
Room 721, 1313 Sherman St.
Denver, Colo. 80203
(303) 839-3531
Regulates geothermal well drilling in Colorado.

Colo. Division of Water Resources
Room 818, 1313 Sherman St.
Denver, Colo. 80203
(303) 839-3587
Administers water rights within Colorado.

Colo. Geological Survey
Room 715, 1313 Sherman St.
Denver, Colo. 80203
(303) 839-2611
Conducts research concerning geothermal resources and development. Makes available site-specific Colorado reports, including:

An Appraisal of Colorado's Geothermal Resources, by J.K. Barrett and R.H. Pearl, 1979.

Bibliography of Geothermal Reports in Colorado, by R.H. Pearl, T.G. Zacharakis, F.N. Repplier and K.P. McCarthy, 1981.

Colorado's Hydrothermal Resource Base--An Assessment, by R.H. Pearl, 1979.

Colo. Department of Health
Water Quality Control Division
4210 East 11th Ave.
Denver, Colo. 80220
(303) 320-6231
Issues permits for the discharge of pollutants into surface or sub-surface waters.

Bureau of Land Management
U.S. Department of the Interior
Room 700, Colorado State Bank Bldg.
1600 Broadway
Denver, CO 80202
(303) 837-4481
Issues leases for land or mineral rights under federal jurisdiction.

U.S. Geological Survey
U.S. Department of the Interior
345 Middlefield Road
Manlo Park, Calif. 94025
(415) 323-8111
Issues permits for exploration and development activities.

U.S. Forest Service
U.S. Department of Agriculture
Box 25127 - 11177 West 8th Ave.
Lakewood, Colo. 80227
(303) 234-3711

Colo. Office of Energy Conservation
112 E. 14th Ave.
Denver, CO 80203
(303) 866-2507
Literature is available concerning energy conservation and renewable resources, including:

Using the Earth to Heat and Cool Homes, U.S. Dept. Energy, DOE/CE/15095-6, 1983.

Conservation and Renewable Energy Inquiry and Referral Service
Box 8900
Silver Spring, MD 20907
(800) 523-2929 U.S.
(800) 462-4983 Pennsylvania
(800) 233-3071 Alaska and Hawaii
Renewable energy technologies and energy conservation information.

Geo-Heat Center
Oregon Institute of Technology
Klamath Falls, Oregon 97601
(503) 882-6321

U.S. Department of Energy
Division of Geothermal Energy, 3122-C
20 Massachusetts Ave., N.W.
Washington, D.C. 20545
(202) 252-5340