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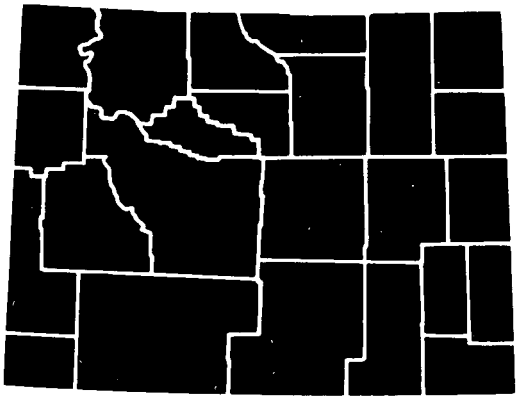

Hydrothermal Commercialization Baseline

for State of Wyoming

Personal Copy of

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No. CC-_____

DISCLAIMER

WYOMING HYDROTHERMAL COMMERCIALIZATION

BASELINE

PREPARED FOR

DEPARTMENT OF ENERGY - IDAHO OPERATIONS OFFICE

DEPARTMENT OF ENERGY - RESOURCE APPLICATIONS,
GEOTHERMAL RESOURCE OFFICE

BY

EG&G IDAHO, INC.
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JUNE 1979

CONTENTS

CONTENTS (contd)

FIGURES

TABLES

ACKNOWLEDGEMENTS

A number of people from EG&G Idaho and the Earth Science Laboratory of the University of Utah Research Institute have contributed to this document. Input has also been provided by Western Energy Planners Ltd., Stafco Inc., and G. A. Freund (consultant). R. W. James, Program Coordinator, Rocky Mountain Institute of Energy and Environment, contributed on behalf of the state geothermal team.

1. INTRODUCTION

Wyoming does have numerous hot springs; but there has been little development effort in geothermal energy, since the state's primary interests are in coal, gas and oil. The hot springs of Thermopolis are among the largest in the world. Recent data from the central portion of the state indicate the potential for electric power generation from geothermal energy. Oil and gas wells (about 70,000) have been drilled in the state and some have geothermal waters that can be utilized for direct applications. The Madison Aquifer extends into the northeastern quadrant of the state and offers considerable potential for geothermal energy. Leasing activity is very limited. Geothermal legislation is basically non-existent, but the State Engineer has the responsibility for protecting the thermal springs.

This handbook provides a synopsis of various aspects of the geothermal program in Wyoming. The section on Basic State Data (Section 2) lists government personnel (both legislative and executive branches) who are most directly involved with geothermal development. Some basic demographic data are also included. The various hydrothermal resources and the pertinent geology are summarized in Section 3. Activities (ranging from leases to operational systems) that lead to commercialization are described in Section 4. Plans for various developments are summarized in Section 5, while government assistance to Wyoming projects is listed in Section 6. The section on energy use patterns (Section 7) summarizes existing energy use and identifies counties and industries likely to be impacted most by geothermal energy. The section on leasing and permitting policies (Section 8) deals with legal and institutional considerations and includes a time table of institutional procedures for a typical resource to show the interrelationships among various organizations involved in development and regulation of the resource.

2. BASIC STATE DATA (WYOMING)

A. Government Contacts

Governor - Ed Herschler (D).

Legislature

Senate Mines, Minerals, and Industrial Development Committee: Diemer True (R), Chairman.

Senate Agriculture, Public Lands, and Water Resources Committee: Earl Christensen (R), Chairman.

Senate President: L. Donald Northrup (R).

House Mines, Minerals, and Industrial Development Committee: Dean Prosser Jr. (R), Chairman.

House Agriculture, Public Lands, and Water Resources Committee: J. Leonard Graham (R), Chairman.

House Speaker: Nels J. Smith (R).

NCSL Committee on Natural Resources: Senator Donald R. Cundall (R) and Representative C. R. "Bob" O'Neil (R).

State Geothermal Team

Operations Research: Dr. E. Gerald Meyer, Principal Investigator, Vice President of Research, University of Wyoming; Richard W. James, Program Coordinator; James Caplan and Carol Aspenwall, Rocky Mountain Institute of Energy and Environment (RMIEE); Pam Abel, Director, Energy Conservation Office, State of Wyoming.

Resource Assessment: Dr. Edward Decker and Henry Hessler, Department of Geology, University of Wyoming.

State Agencies

Department of Economic Planning and Development: John Niland, Executive Director.

State Land Office: Albert E. King, Commissioner.

State Engineer: George L. Christopulos.

Travel Commission: Randall A. Wagner, Director.

Recreation Commission: Jan L. Wilson, Acting Director.

Public Service Commission: Alex J. Eliopulos, Chief Counsel and Administrative Secretary.

Department of Environmental Quality: Robert E. Sundin, Director.

Gas and Oil Commission: Donald B. Basko, State Oil and Gas Supervisor.

Industrial Siting Administration: Dr. Blaine E. Dinger, Director.

Wyoming Geological Survey: Dr. Daniel N. Miller, Jr., State Geologist and Executive Director.

B. Statistical Data

Demographic

Population (1975 estimate): 374,000

Area: 97,914 sq. mi.

Population Density: 3.8 persons/sq. mi.

Geothermal Resources

Confirmed Reservoirs > 150°C: None

Prospects > 150°C: Two

Confirmed Reservoirs (20°C < T < 150°C): 6

Prospects (20°C < T < 150°C): 4

Identified Warm Springs and Wells > 40°C: 25

Geothermal Leases

Federal: 7,448 acres

State: 1,150 acres

Private: None

Test Wells - One identified

Operational Hydrothermal Systems

Spas: ∿ 15

Space Heating: 2

Others: < 5

Major Active Developments

Direct Use: Oil recovery in Salt Creek oil field

Electric: None

Government Assisted Activities

PON: None

PRDA: None

Loan Guaranties: None

Energy

Supply (1975): 3,156 x 10^{12} Btu; 88% exported

Use (1975): 320 x 10^{12} Btu

Potential Conversion to Geothermal (1975): 17 x 10^{12} Btu

3. HYDROTHERMAL RESOURCES

A. Geologic Setting[1]

Parts of four geologic provinces are recognized within Wyoming (see Figure 3.1):

(1) the Middle Rocky Mountains in northern and western Wyoming;
(2) the Great Plains in northern and eastern Wyoming;
(3) the southern Rocky Mountains in southeast Wyoming; and
(4) the Wyoming Basin in the southcentral portion of the state.

Yellowstone National Park contains the world's largest concentration of hydrothermal features. Outside the bounds of the national park, there are several thermal features; the state's known hydrothermal resources are mostly low temperature. A heat-flow anomaly is associated with recent volcanic activity within Yellowstone National Park, but appears to terminate abruptly outside the park to the east.

Exploration for uranium, oil, and gas has revealed slightly abnormal thermal gradients over much of the state, and a widespread potential for low-temperature utilization exists. The Madison aquifer is present over much of eastern Wyoming and is known to contain moderate-temperature fluids in places. Systematic information, however, has not been compiled, and so the potentially large Madison resource is not shown on the resource map (see Figure 3.2).

B. High-Temperature Resources (>150°C)[1-3] (see Figure 3.2).

Confirmed Reservoirs: None

Prospects: None

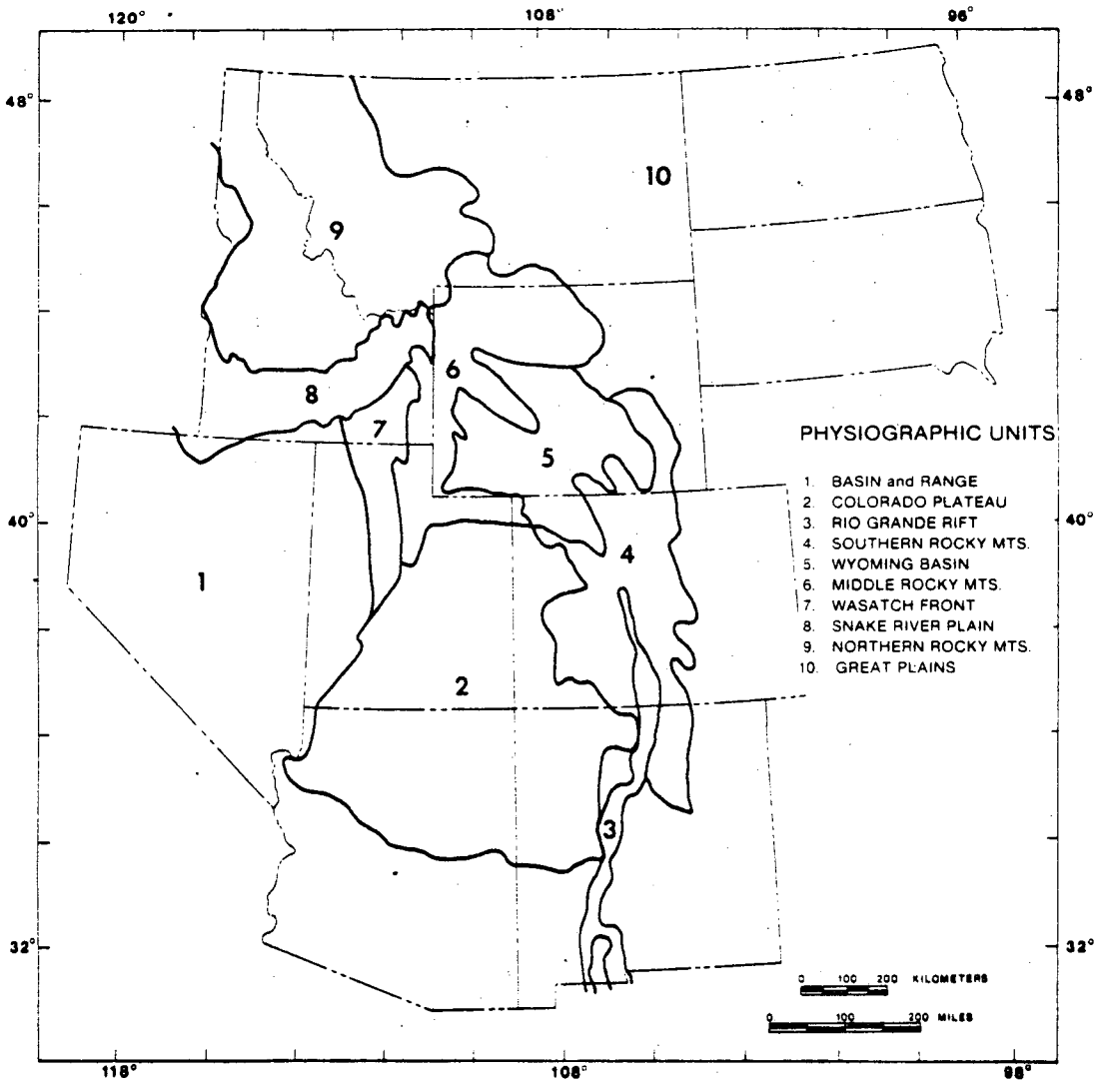
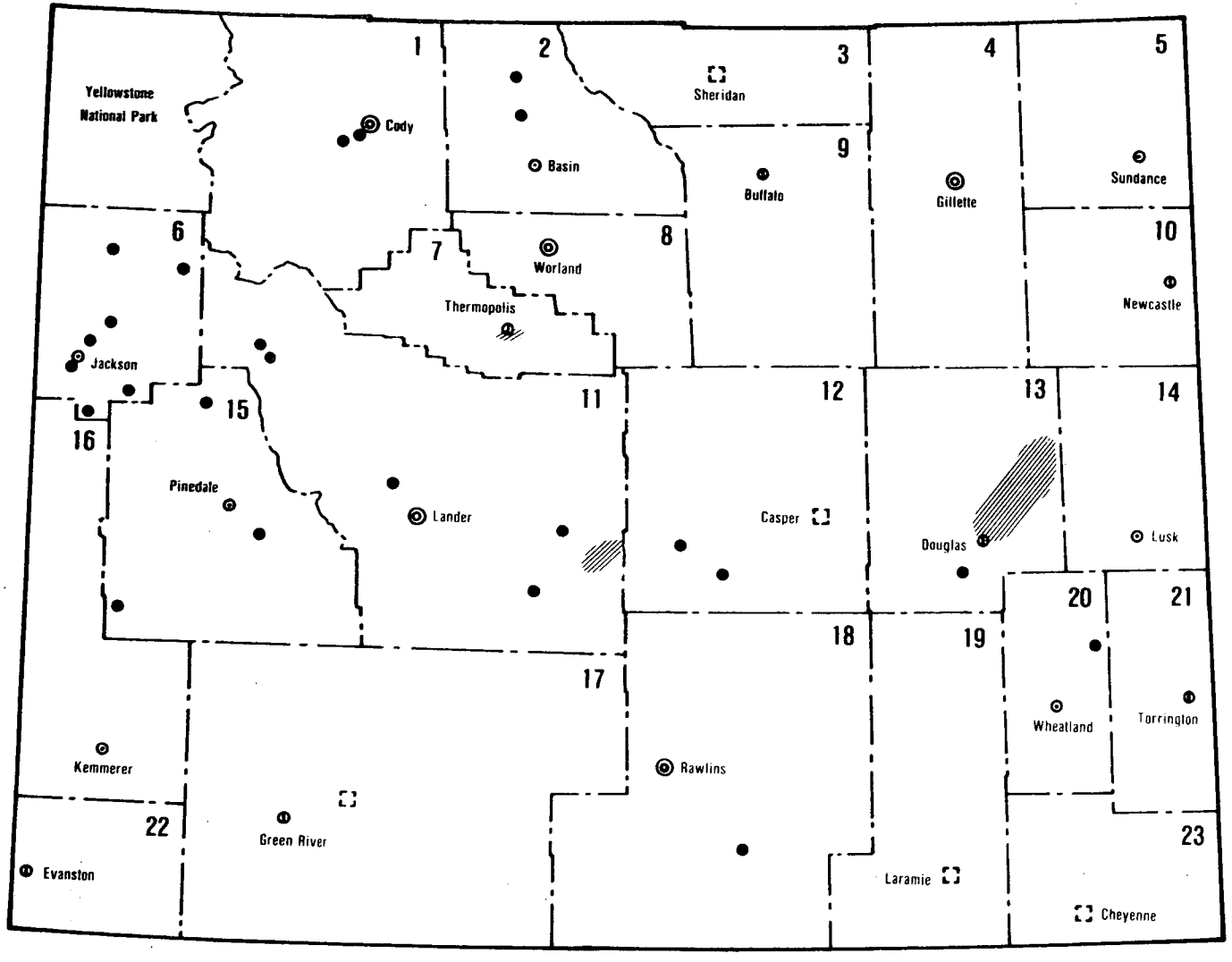


Fig. 3.1 Physiographic provinces[1]

Number	County
1	Park
2	Big Horn
3	Sheridan
4	Campbell
5	Crook
6	Teton
7	Hot Springs
8	Washakie
9	Johnson
10	Weston
11	Fremont
12	Natrona
13	Converse
14	Niobrara
15	Sublette
16	Lincoln
17	Sweetwater
18	Carbon
19	Albany
20	Platte
21	Goshen
22	Uinta
23	Laramie



WYOMING

0 10 20 30 40
Scale in Miles

Cities and Towns with Approximate Populations

- ○ Under 500
- ⊙ 500 to 2,500
- ◐ 2,500 to 5,000
- ◎ 5,000 to 10,000
- ⊡ Over 10,000

Areas of Low- and Moderate-Temperature Potential

●●● Hot Springs

Fig. 3.2 Wyoming counties and geothermal springs and resource areas[1-3].

C. Low- and Moderate-Temperature Resources (<150°C)[1-4]

Confirmed Reservoirs: Auburn Hot Springs, Countryman Well (near Lander), Huckleberry Hot Springs, Saratoga, Thermopolis, Cody.

Prospects: City of Glenrock; Madison and Minnelusa Formation (Campbell, Crook, Niobrara, Sheridan and Weston Counties), North of Douglas and the Gas Hills.

D. Comments

The geochemistry of the Huckleberry Hot Springs and the Auburn Hot Springs south of Yellowstone indicates moderate reservoir temperatures, but capacity may be limited. High reservoir temperatures (suitable for electric power generation) may be available at depths beyond present drilling capabilities and economic potential.

Thermopolis is a well-known, high-volume warm spring that has a long history of recreational usage. The thermal waters are presently being considered for expanded direct-heat applications.

Numerous intermediate and deep wells drilled into the Madison aquifer have encountered abnormal gradients and low- to moderate-temperature fluids. Areas of particular interest include Casper and Sheridan. Some limited use is now being made of the near-boiling water for "water-flood" secondary oil-recovery operations.

E. Hydrothermal Springs and Wells

A listing of hydrothermal springs and wells with measured temperatures in excess of 40°C is given in Table 3.1 for Wyoming[4].

TABLE 3.1

HYDROTHERMAL SPRINGS AND WELLS - WYOMING
(Source: USGS File GEOTHERM)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
CARBON				
Saratoga Hot Springs (S)[a]	T17N, R84W	48	454	1920
FREMONT				
Fort Washakie Hot Springs (S)	T1S, R1W	44	568	832
Fort Washakie Hot Springs (S)	T1S, R1W	47		801
Fort Washakie Hot Springs (S)	T1S, R1W	45		1006
HOT SPRINGS				
Bathtub Spring (S)	T43N, R95W	53	7.6	2330
Big Spring (S)	T43N, R94W	56	11008	2190
Maytag Well (W)[b]	T43N, R95W	54	2040	
McCarthy Well (W)	T43N, R94W	54	2207	2380
Sacajawea Well (W)	T43N, R95W	52	4618	2390
Van Norman Well (W)	T43N, R95W	51		
White Sulphur Spring (W)	T43N, R94W	53	780	2350
LINCOLN				
Auburn Hot Springs (S)	T33N, R119W	62	140	5250
Auburn Hot Springs (S)	T33N, R119W	62		
Johnson Springs (S)	T33N, R119W	46	7.6	
NATRONA				
Alcova Hot Springs (S)	T30N, R83W	54	379	1260
Alcova Hot Springs (S)	T30N, R83W	59		1381

[a] (S) = Surface
[b] (W) = Well

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
TETON				
Granite Falls Hot Springs (S)	T39N, R113W	45	454	
Granite Hot Spring (S)	T39N, R113W	41	1136	670
Huckleberry (S)	T48N, R113W	71		
Huckleberry Hot Springs (S)	T48N, R115W	45	1136	688
Huckleberry Hot Springs (S)	T48N, R115W	61		613
Huckleberry Hot Springs (S)	T48N, R115W	61		837
Huckleberry Hot Springs (S)	T48N, R115W	71		
Jackson Lake Hot Springs (S)	T45N, R115W	72		
North Buffalo Fork Springs (S)	T45N, R113W	45	757	

[a] (S) = Surface
[b] (W) = Well

F. References

[1] Regional Hydrothermal Commercialization Plan, Department of Energy-Division of Geothermal Energy and Idaho Operations Office, EG&G Idaho Inc. and the University of Utah Research Institute Earth Science Laboratory.

[2] Dr. P. M. Wright, University of Utah Research Institute Earth Science Laboratory, Personal Communication, April 1979.

[3] L. J. P. Muffler (ed.), Assessment of Geothermal Resources of the United States - 1978, U.S. Geological Survey Circular 790, 1979.

[4] R. W. James, Geothermal Operations Report for 1978, Oregon Institute of Technology, Draft Report, March 1979.

[5] U.S. Geological Survey File GEOTHERM as of March 1979.

4. COMMERCIALIZATION ACTIVITIES

A. Highlights

Hot Springs State Park in Thermopolis, the most famous thermal area in Wyoming outside Yellowstone, was bought by the Federal government from the Indians in 1896 and ceded to Wyoming the next year. Private springs in the area have significant space heating potential without disturbing state owned facilities.

Yellowstone National Park provides probably the greatest manifestations of geothermal energy in the U.S. Because of its National Park status, no geothermal development is anticipated within its borders.

Large volumes of geothermally heated water at moderate temperatures are being used in secondary and tertiary oil recovery operations in the Salt Creek oil field in northeastern Wyoming. These waters are issuing forth from the Madison Formation which underlies that part of the state as well as much of the Dakotas.

B. Leases

Almost no leasing activity has been done in Wyoming either on federal or state lands. Tables 4.1 - 4.5 and Figure 4.1 summarize the current status of leasing activity in the state. Table 4.1 provides latest totals of Federal and State acreages leased to private organizations for geothermal development.

For federal lands in Wyoming, Figure 4.1 is a synopsis of various leasing summaries produced by Automatic Data Processing (ADP) of the Conservation Division[1] of the USGS. It traces the three types of federal leases (noncompetitive, competitive, and Indian Land) from inception to production. For noncompetitive leases it summarizes: (1) applications, (2) withdrawals, (3) rejections, (4) pending actions, (5) total leases, (6) terminations, (7) active leases, (8) production status, and (9) unitization. For competitive leases, the figure summarizes the lease offerings and the same items (5) through (9) of the noncompetitive leases. For Indian land leases, it shows the same items (5) through (9). Some entries appear in more than one ADP format and minor discrepancies exist for these entries, possibly because the summaries are run on different dates. These discrepancies should be correctible in updates of the baseline document. Table 4.2 is a county-by-county listing of the holders of active noncompetitive federal leases, the size and location of holdings.

Table 4.3 summarizes by KGRA the bidding history of Federal competitive geothermal lease sales in Wyoming. It lists the KGRA, the county, number of sale dates, number of tracts and acreage offered, number of offerings culminating in leases, acreage leased, and average cost per acre in successful bids.

Table 4.4 is a county-by-county listing of the holders of active competitive federal leases, the size and location of their holdings, the effective date, and cost per acre of the lease.

Table 4.5 lists the holders of active state leases in Wyoming and the size of their holdings[2].

TABLE 4.1

TOTAL ACREAGES OF GEOTHERMAL LEASES - WYOMING

(as of April 1979)

Federal Leases:	
Total Acreages of Competitive Leases in KGRAs:	None
Total Acreages of Noncompetitive Leases:	7,448
(Four leases)	
State Leases:	
Total Acreages of State Leases:	1,150
(One lease)	
TOTAL OF ALL ACREAGES LEASED	8,598

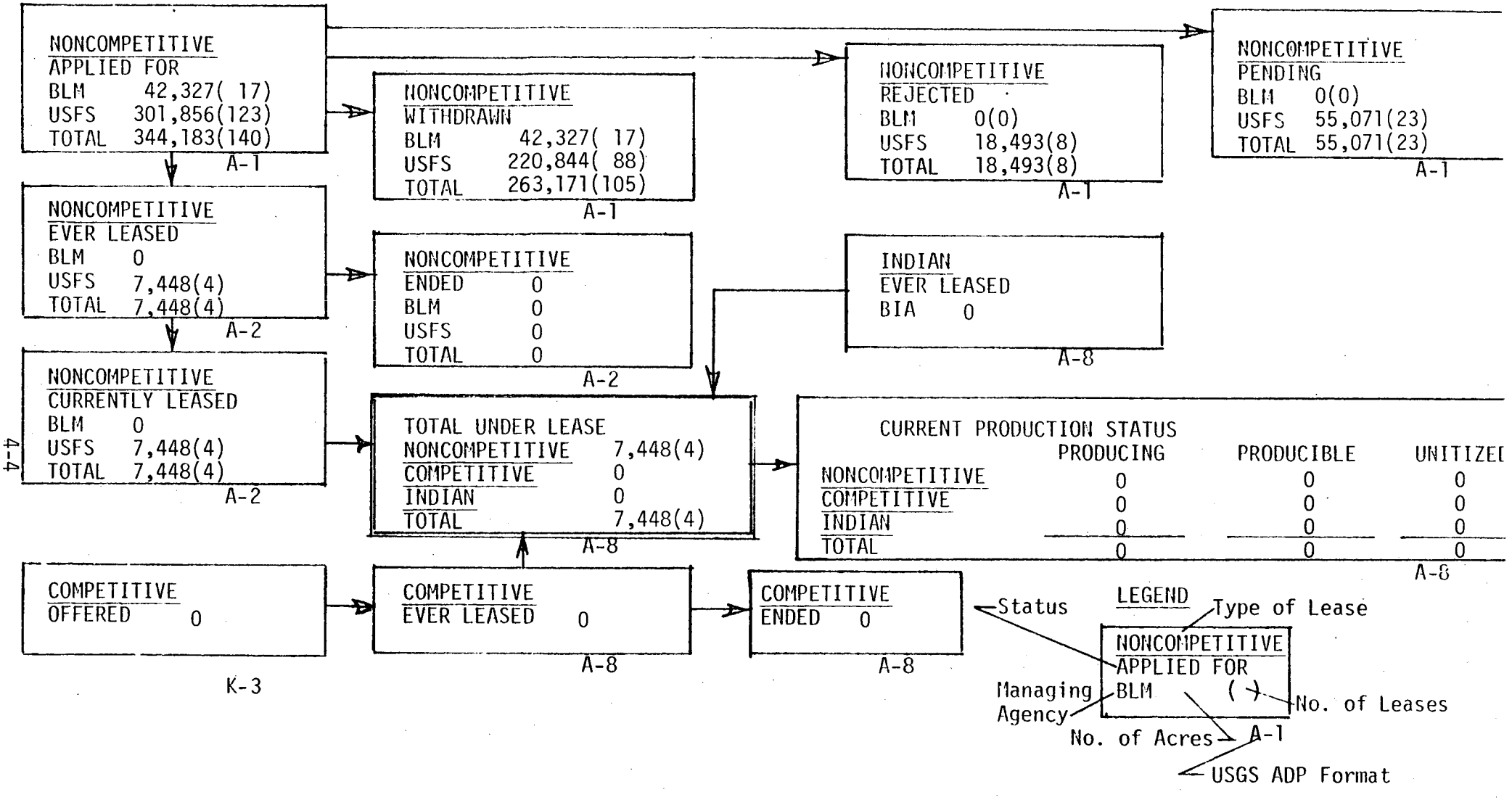


Figure 4.1 . Summary of Federal Leasing Activity - Wyoming

(Source - USGS ADP File)[1]

TABLE 4.2

FEDERAL ACTIVE NONCOMPETITIVE GEOTHERMAL LEASES - WYOMING

(as of 3/14/79)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION
LINCOLN		
Thermex Co.	2804.47(2)	T34N, R119W
U. S. Geothermal Corp.	4463.50(2)	T33N, R119W

TABLE 4.3[2]

SUMMARY OF BIDDING HISTORY FOR COMPETITIVE GEOTHERMAL LEASE SALES ON FEDERAL LANDS - WYOMING
(Source USGS ADP File - Format K-4)

COUNTY	KGRA	OFFERED (INC. REOFFERS) SALES	TRACTS	ACREAGE	LEASES ISSUED NUMBER	ACREAGE	AVG. $/ ACRE
NONE							

TABLE 4.4

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES - WYOMING

(as of 4/13/79)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	KGRA/LOCATION	DATE ISSUED & (COST/ACRE)
NONE			

TABLE 4.5

STATE GEOTHERMAL LEASES - WYOMING

(as of March 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION	DATE ISSUED & (COST/ACRE)
LINCOLN			
Intercontinental Energy Corp.	1149.6(1)	T33N, R119W	1975 (N.A.)

C. Test Wells

Test wells in Wyoming are listed in Table 4.6[2].

TABLE 4.6

TEST WELLS - WYOMING

COUNTY & LOCATION	COMMENTS
CROOK	
T57N, R65W	One hole drilled to test water quality.

D. Other Exploratory Activity

Other exploratory activity in Wyoming for geothermal resources is given in Table 4.7.

TABLE 4.7

OTHER EXPLORATORY ACTIVITY - WYOMING

COUNTY & LOCATION	COMMENTS
NONE	

E. Operational Systems

Table 4.8 provides a summary of operational systems using geothermal energy in Wyoming[2,3].

F. References

[1] USGS Conservation Division, Office of Geothermal Supervisor, Automatic Data Processing File.

[2] R. W. James, RMIEE, Personal Communication, May 1979.

[3] R. M. Breckenridge, and B. S. Hinckley, Thermal Springs of Wyoming, Bulletin 60, The Geological Survey of Wyoming, Laramie, 1978.

TABLE 4.8

OPERATIONAL SYSTEMS - WYOMING

COUNTY & USE	LOCATION	COMMENTS
CARBON		
Spas	Saratoga Hot Springs; T17N, R84W; on west bank of Platte River near south end of Saratoga.	Two city pools; one commercial pool; three small private pool-baths; 30-54°C (avg. 48°C) at flow rates of 120 gpm for city pools, 3-5 gpm for all others.
CONVERSE		
Spas	Jackalope Plunge; 7 mi. south of Douglas on Esterbrook Road.	Commercial pool; 30°C.
FREMONT		
Spas	Fort Washakie Hot Springs; T1S, R1W; 3.5 mi. southwest of Ethete.	Commercial pool and bathhouse; 44°C, 150 gpm.
	Little Warm Spring; T41N, R107W.	One private pool; 25°C, 560 gpm.
Greenhouse	Countryman Ranch, near Lander.	40°C, 500 gpm.
HOT SPRINGS		
Spas	Big Spring; T43N, R94W.	Several bath houses; 56°C, 2908 gpm.
	Hot Springs State Park; NE of Thermopolis.	State bathhouse (free); several commercial pools; 55°C.
	Sacajewea Well; T43N, R95W.	Large pool; 52°C, 1220 gpm, 900 ft. depth.
Space heating	Maytag Well; T43N, R95W.	Domestic; 54°C, 539 gpm, 900 ft.
	McCarthy Well; T43N, R94W.	One home; 54°C, 583 gpm, 500 ft.
	VanNorman Well; T43N, R95W	One home, 51°C, approx. 500 ft.

TABLE 4.8 (contd)

COUNTY & USE	LOCATION	COMMENTS
LINCOLN		
Spas	Auburn Hot Springs; T33N, R119W.	Bathhouse; 62°C, 37 gpm
PARK		
Spas	Bronze Boot Spa; 2 mi. west of Cody.	Commercial pool; 32°C.
	DeMaris Hot Springs; T52N, R102W.	Pool; 27-36°C, 1700 gpm.
SUBLETTE		
Spas	Steele Hot Springs; T32N, R107W.	Pool; 35.5°C at 20 gpm and 39°C at 5 gpm.
TETON		
Spas	Astoria Springs; T39N, R116W, 17 mi. south of Jackson on U.S. 26.	Commercial pool and bathhouses; 37°C, 100 gpm.
	Granite Hot Springs; T39N, R113W; 26 mi. south of Jackson on U.S. 189, 12 mi. up Granite Creek.	Commercial pool and laundry; 41°C, 300 gpm.
	Huckleberry Hot Springs; T48N, R115W, 1.5 mi. west of U.S. 287, just north of Flagg Ranch.	Commercial pool and laundry; 61°C, 300 gpm.
	Kelly Warm Spring; T42N, R115W, 1 mi. north of Kelly on Gros Ventre Rd.	Natural pool, 27°C, 16 cfs.
Agriculture	Teton Valley Warm Springs; T42N, R115W.	Natural pool and extensive irrigation, 18°C, 8000 gpm.
Fish Farming	Jackson Hole Fish Hatching.	

5. DEVELOPMENT PLANS

A. Description

The state of Wyoming through the Oregon Institute of Technology and the Rocky Mountain Institute for Energy and the Environment at the University of Wyoming has participated since spring 1978 in the Department of Energy (DOE) Operations Research Geothermal Planning Project[1].

The present planning process for Wyoming and other states of the Rocky Mountain Basin and Range Region consists of three categories of plans for prospective and actual geothermal developments. The three plans are called Area Development Plans (ADP), Site Specific Development Plans (SSDP), and Time Phased Project Plans (TPPP).

Area Development Plans are plans for prospective development of geothermal resources and utilization of the geothermal energy for a multicounty substate area. The plan encompasses several geothermal resource sites and all potential residential, commercial, industrial and agricultural uses of geothermal energy. The resource sites for an ADP include confirmed (proven) reservoirs and reservoir prospects (potential and inferred resources). In most cases no private sector action has been taken toward development or commercialization. The time table for an ADP is a best estimate of when increments of geothermal energy will come on line from the several geothermal prospects and applications in the plan area.

Site Specific Development Plans are plans for development of specific geothermal single or integrated applications of the geothermal energy. The plans are restricted to confirmed (proven) reservoirs and potential reservoirs. Applications may be for any electric and/or direct thermal use of geothermal

energy which is compatible with the quality of the confirmed (proven) or potential resource. In most cases, either some level of development or commercialization activity is already underway or is deserving of consideration by the community of geothermal energy developers and users. The time schedule of events in a SSDP represents a possible sequence of technological and institutional achievements under an atmosphere generally favorable for geothermal development of the specific site and application.

Time Phased Project Plans are plans for geothermal developments that are now at a commercialization level of activity or are in advanced stages of planning by the public and private sectors. The plans are confined to site-specific confirmed reservoirs or high potential geothermal prospects and to specific energy consumptive applications, either electric or direct thermal. The TPPP portrays or reproduces as closely as possible the actual planning and construction array of events and the associated time schedule of the commercial developer and user of the geothermal energy. The TPPP reveals actions by both the private and government sectors that must be accomplished on time in order to achieve successful geothermal energy production and utilization of a specific site for a committed application.

Table 5.1 identifies for Wyoming the geothermal resource sites and applications for which development plans have been prepared or which are candidates (designated by asterisk) for the preparation of development plans by the State Planning Teams in 1980[1].

B. Reference

[1] R. W. James, Geothermal Operations Report for 1978. Oregon Institute of Technology, Draft Report, March 1979.

TABLE 5.1

DEVELOPMENT PLANS - WYOMING

TIME PHASED PROJECT PLANS	SITE SPECIFIC DEVELOPMENT PLANS	AREA DEVELOPMENT PLANS
None	Little Sheep Mountain Springs (barley malting plant)	Bighorn Basin Area (Park, Hot Springs, Washington, Big Horn Counties)**
	Thermopolis (district heating)*	Fremont County**
	Countryman Well (greenhouse)*	Midwest Area (Natrone, Converse Counties)*
	Saratoga (district heating)	Cheyenne Area (Platte, Goshen, Laramie Counties)*
	Midwest/Salt Creek (greenhouse complex)	Laramie Area (Albany, Carbon Counties)**
	Glenrock (oil processing)*	Bridger Area (Teton, Sublette, Lincoln Counties)*
	Auburn Hot Springs (aquaculture)	Sweetwater Area (Sweetwater, Uintah Counties)*
	U.S. Fish and Wildlife Service (hatchery)*	Sheridan Area (Sheridan, Johnson, Campbell Counties)*
	Cody (Gasohol plant)*	Black Hills Area (Crook, Weston, Niabrara Counties)*

* Candidates for preparation of development plans in 1979.

** Limited-content development plans were prepared in 1978 and will be refined in 1979.

6. GOVERNMENT ASSISTED ACTIVITIES

A. Geothermal Direct Use PON Program

Background: In September 1977 and April 1978, the Department of Energy, Division of Geothermal Energy, in conjunction with the San Francisco Operations Office, issued a document which indicated DOE's desire to receive and consider for partial support proposals for direct heat utilization or combined electric/direct heat utilization field experiments demonstrating single or multiple usages of geothermal energy. These documents were issued under the title, "Program Opportunity Notice - Direct Utilization of Geothermal Energy Resources - Field Experiments." The Program Opportunity Notice (PON) is the name of this offering document, but it has become common practice to call any program which results from these notices a PON.

These solicitations are part of DOE's national geothermal energy program plan, which has as its goal the near-term commercialization by the private sector of hydrothermal resources for direct use purposes. Encouragement is being given to the private sector by DOE's cost sharing of a significant portion of the front-end financial risk in a limited number of field experiments.

DOE's primary interest under these PONs is to encourage field experiments in space/water heating and cooling for residential and commercial buildings, agricultural and aquacultural uses, and industrial processing application.

Current Status: No activity so far in Wyoming.

B. Program Research and Development Announcement

Background: This program, commonly referred to as the PRDA program, is to provide funding for engineering and economic studies for direct applications of geothermal energy. The last announcement had a closing date of January 16, 1979 for applications. The cost of the studies is up to $125,000 each, and covers a study period of 6 to 12 months.

Current Status: No activity so far in Wyoming.

C. Demonstration Projects and Experiments

No projects so far in Wyoming.

D. Geothermal Loan Guaranty Program (GLGP)

Background: Congress authorized $300,000,000 for loan guaranties. Each loan can be up to 75% of the total development cost. Nationally, DOE has received eleven applications to date, totalling $150,000,000 in loan guaranties. Of those eleven, three have been approved (two electric and one direct application); two turned down; one withdrawn; one is obtaining more information, and four are in the review process.

Current Status: In Wyoming, there has been no activity on this program.

E. National Conference of State Legislatures (NCSL)

Background: After a preliminary study on geothermal energy in 1976, the National Conference of State Legislatures (NCSL) launched the Geothermal Policy Project in January 1978. The objective of the project is to stimulate and assist the review of state policies that affect the development of geothermal resources. Successful completion of the project is to facilitate state statutory and regulatory environments that are consistent with efficient development of geothermal resources.

Current Status: The project selected six states in which to concentrate its efforts in 1978. Wyoming is not one of these states; however, the state planning team has used the NCSL project as a resource for prospective Wyoming legislation in 1980 or 1981.

F. State Coupled Program

Background: The objectives of the State Coupled Program are: (a) to assist the U.S. Geological Survey in its ongoing geothermal resource assessment effort, and (b) to stimulate confirmation of low- and intermediate-temperature reservoirs at sites with an apparent but unquantified potential for direct heat application development. Major energy companies have generally shown little interest in lower grade resources because of a national and industrial focus on electrical power generation.

The State Coupled Program consists of cooperative effort among: (a) DOE, (b) an agency or institution in each state, (c) the U.S. Geological Survey, (d) the National Atmospheric and Oceanic Administration (NOAA), and (e) the Earth Science Laboratory of the University of Utah Research Institute. DOE provides overall program management and direction. The State Agency manages and performs the project within the state. The U.S. Geological Survey interfaces with the program through the local Water Resources Division Offices, through the U.S. Geological Survey Geothermal Program Office, and by providing the use of computer file GEOTHERM. NOAA will publish the state map. The Earth Science Laboratory provides management assistance to DOE.

In order to accomplish this work contracts are written between DOE and each participating state. A separate contract for overall management assistance and program coordination is negotiated between DOE and the University of Utah/University of Utah Research Institute.

Each state project consists of: (a) Phase I, geothermal data compilation, with emphasis on low- and intermediate-temperature systems, culminating in publication of state maps and reports on the location and possible viability of geothermal resources, and (b) Phase II, investigation of specific geothermal sites, with drilling to demonstrate reservoir characteristics.

Current Status: The resource data base is being compiled for thermal springs and wells with many new sites having been identified in the last year. Three areas were selected for depiction on Map 1 of USGS Circular 790. Ongoing projects include: (a) field verifications of thermal sites, (b) measurements of thermal gradients and heat flow in available water, petroleum and mineral drill holes and (c) chemical analyses of water from new sites. Publication of the Phase I user-oriented map is anticipated during 1979.

Site specific activities under Phase II of the state coupled program include investigations of the Thermopolis, Cody, Saratoga, Auburn and Alcova sites. Preliminary indications suggest that some of these areas may be larger and hotter than previously thought.

In Wyoming, close ties exist between resource assessment work and the DOE-funded operations research work. Both projects are being handled at the University of Wyoming. This approach gives a high degree of coordination and perhaps a greater reliability to resource application estimates.

G. Industry Coupled Program

Background: The purpose of DOE's Industry Coupled Program is to foster a viable geothermal electrical power generation industry in the United States. Development by industry has been seriously lagging due to a number of problems. Front end costs are high in geothermal development due to leasing costs, regulatory costs, and the high cost of exploration, particularly for drilling. In addition, geothermal electrical power generation is a high-risk venture given the uncertainties of reservoir longevity. As a result of these factors, industry has made only a limited commitment to the development of high-temperature resources.

The Industry Coupled Program addresses some of the above problems through: (a) cost sharing with industry for exploration, reservoir assessment and reservoir confirmation, (b) release to the public of geoscience data which will improve our understanding of the geothermal resource. Improved understanding will decrease reservoir uncertainty and lower exploration and assessment costs.

The Program is a cooperative effort between DOE and an industrial organization engaged in geothermal exploration. Industry responds with proposals to DOE procurement initiatives. Succcessful proposers then negotiate contracts with DOE. The contracts specify: (a) an exploration and/or reservoir confirmation program which industry will manage and perform, (b) a data package which industry agrees to make public, and (c) a certain percentage of total costs (generally in the range of 20% to 50%) which DOE will contribute toward funding the work.

The Earth Science Laboratory of the University of Utah Research Institute provides assistance to DOE on the Industry Coupled Program by: (a) assisting in management of the Program, (b) releasing geoscience data generated by the program to public open file, and (c) interpreting and supplementing the above data for the purpose of developing and publishing reservoir case studies.

Current Status: There has been no Industry Coupled Program so far in Wyoming.

H. Technical Assistance

Background: Technical assistance is provided to potential geothermal users as an on-call service by EG&G Idaho's geothermal program Office and by the Earth Science Laboratory of UURI. The strategy of this program is to provide a catalytic agent in fostering geothermal energy use, particularly for direct applications. The amount of assistance given is limited so as to protect the interest of private engineering organizations and others working in the field. Generally, enough information is provided so that a potential user can make an evaluation of how or where to proceed. The technical assistance activity is extensive: 115 separate requests were handled for the 10-state Rocky Mountain Basin and Range Region during the first half of FY 1979.

Current Status: Wyoming grain farmers were provided assistance on a barley malting process for the Cody-Thermopolis area. The growers have decided to seek additional resource data. Some information transmittals to other interested parties have also been made. Very preliminary advice has been given to Saratoga on geothermal heating of a proposed recreational complex.

I. State Assisted Activities

None

J. References

None

7. ENERGY USE PATTERNS

A. Energy Use Summary - Wyoming[1, 2]

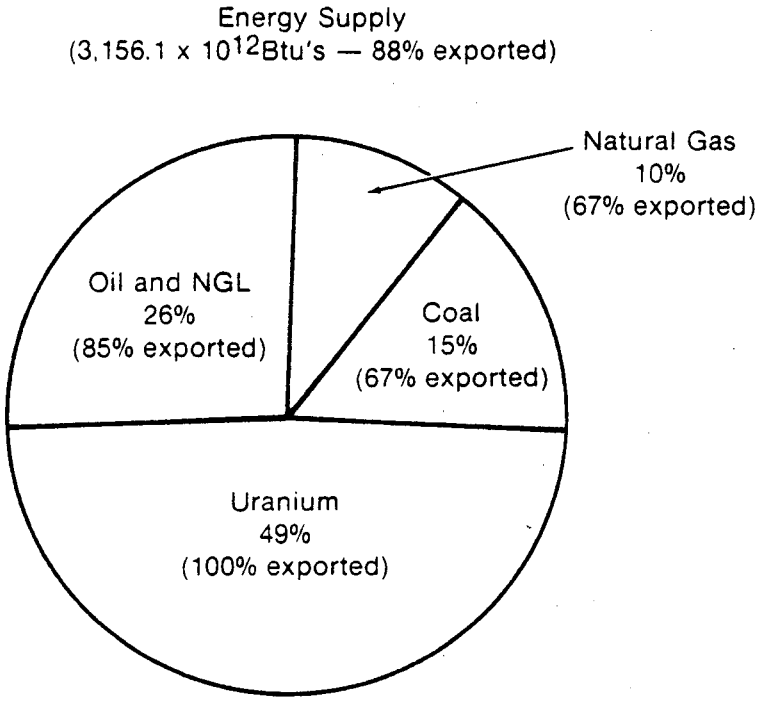
Wyoming is the leading exporter of energy in the western U.S. (see Figure 7.1). It exports larger quantities of all energy sources than it consumes. The industrial sector is the largest energy consumer, followed by the transportation, commercial, and residential sectors. All sectors use mostly oil and natural gas. Figure 7.2 shows how much energy is consumed by the state's communities.

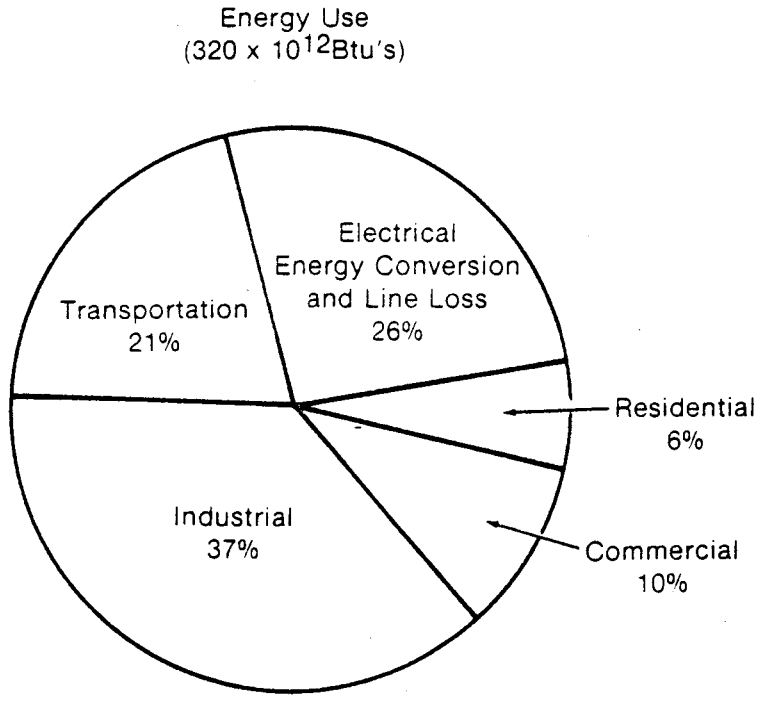
The petroleum and oil-products sector uses approximately 65% of the energy consumed by Wyoming industries. However, approximately 15% of the remaining use is by industries that can use low- to intermediate-heat energy sources.

The residential and commercial sectors use primarily oil and natural gas. It can be assumed that the space conditioning requirements for Wyoming are similar to those of its neighboring states, which range from about 70 to 80% of the energy used by these sectors.

Wyoming, as part of the northcentral census region, should experience an average 2.8% increase per year in energy consumption. This growth increase is expected from the industrial and residential sectors, which will cause an approximate doubling of the current energy consumption as shown in Figure 7.3.

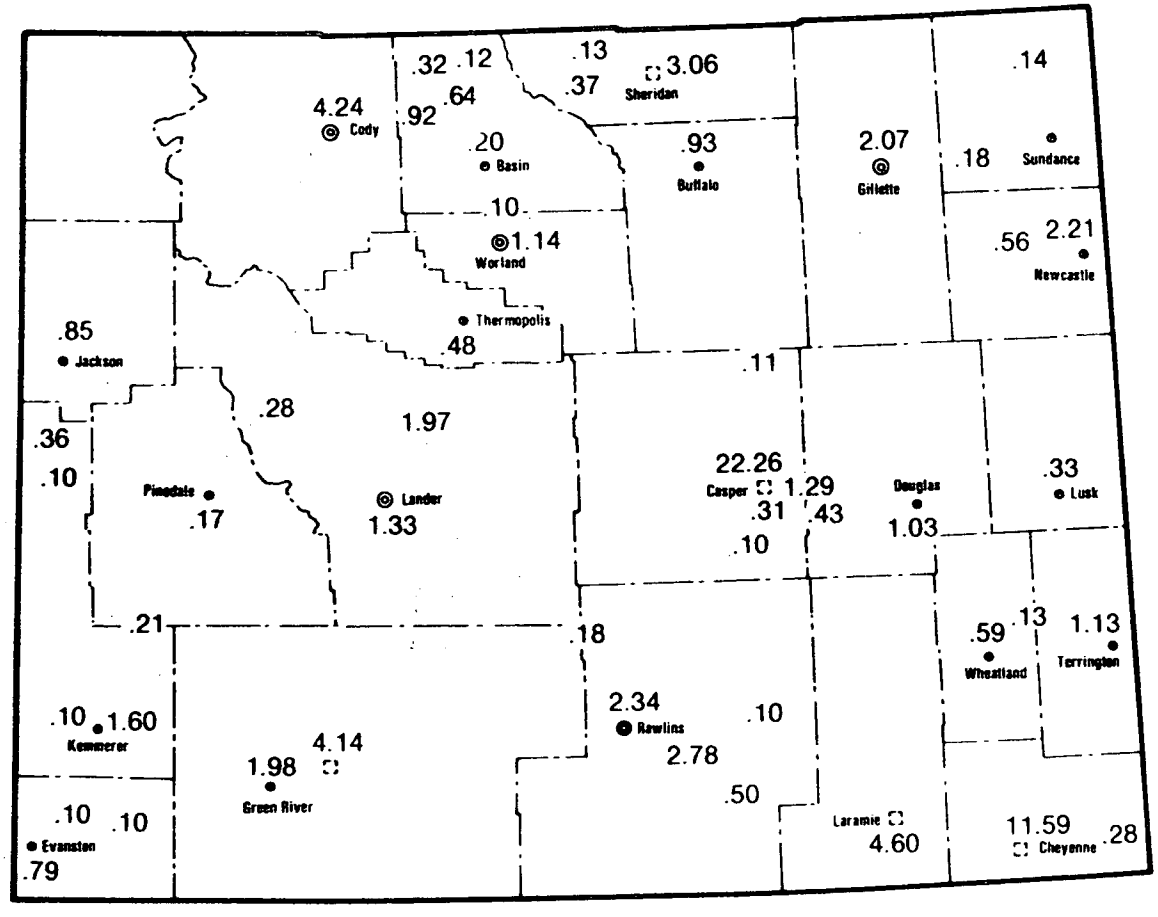
Wyoming 1975





Rev. April 1979

Fig. 7.1 Wyoming energy supply and use[1]



WYOMING

0 10 20 30 40
Scale in Miles

Cities and Towns with Approximate Populations

- Under 500
- 500 to 2,500
- 2,500 to 5,000
- 5,000 to 10,000
- Over 10,000

Values shown are x 10^{12} Btu's

Fig. 7.2 Wyoming energy usage map[1]

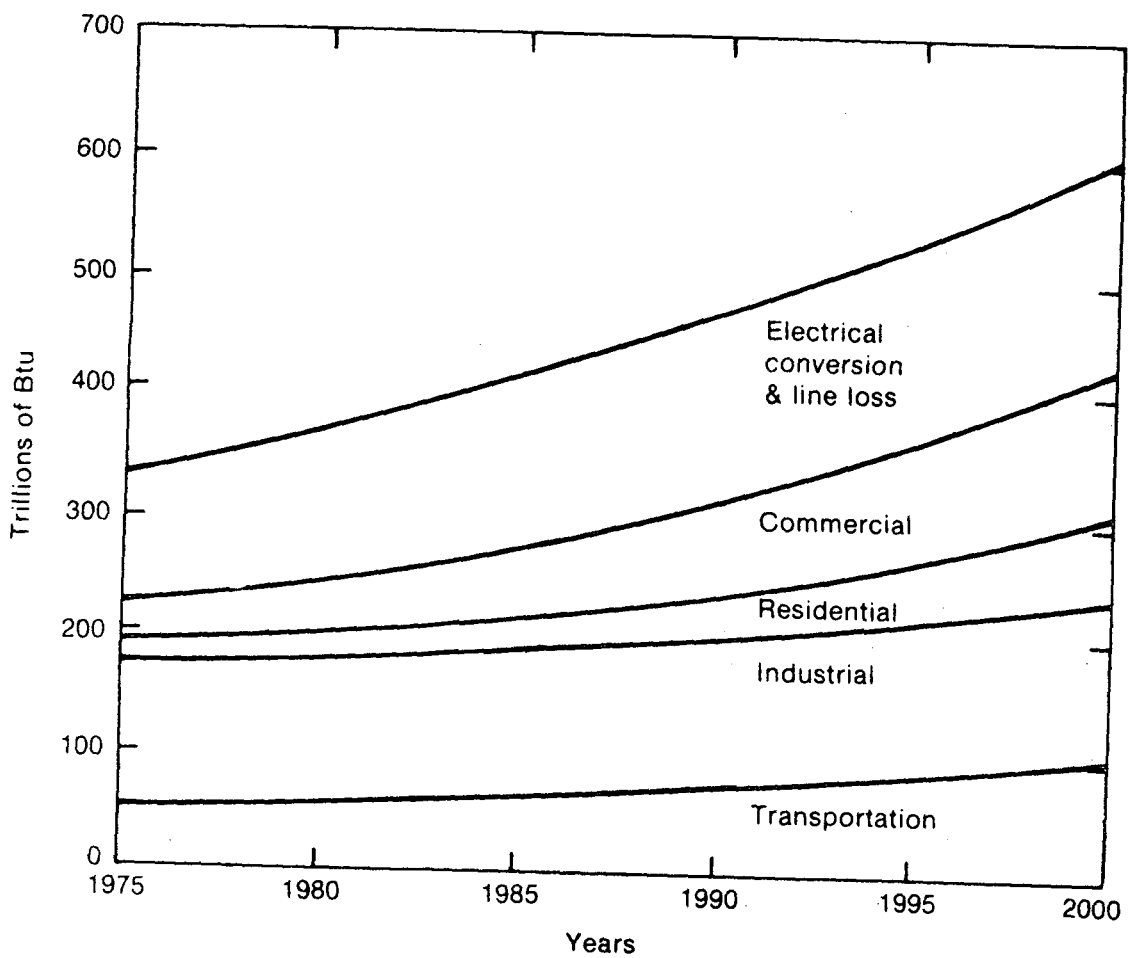


Fig. 7.3 Wyoming total energy use projection[1]

Counties overlying hydrothermal resources (Figure 3.2) have been assessed to determine how many manufacturers could use the available hydrothermal energy in their industrial processes. For these preliminary calculations, a single reservoir temperature has been assumed for each of these counties. Hydrothermal energy at this temperature is assumed to be recoverable without regards to economics. (As more detailed reservoir data becomes available, this assumed reservoir temperature may be refined or more than one temperature assumption may be used for different locations in the county. Such assumptions would then be used to recalculate potential hydrothermal energy usage.) A list of potential hydrothermal use industries is compiled from the manufacturer's directory for the state. The number of employees per manufacturer is taken to be the midpoint of the employee range listed for the manufacturer. Each Standard Industrial Classification (SIC) category is aggregated within the county. A Btu use value for each manufacturer was determined by employing energy intensity coefficients (Btu/employee). Industrial, as well as residential/commercial, data for each such county are given in Table 7.1. These data show the potential for conversion to hydrothermal energy based on 1975 usage in these counties.

Table 7.2 lists the industry, the SIC number, and the percent of the process heat used in various temperature ranges from 40 to 275°C. By use of this temperature breakdown, industries can be considered as candidates for hydrothermal energy applications, even if their total energy requirements cannot be met by hydrothermal energy.

B. References

[1] Regional Hydrothermal Commercialization Plan, Department of Energy Division of Geothermal Energy and Idaho Operations Office, EG&G Idaho, Inc., and University of Utah Research Institute Earth Science Laboratory, July 14, 1978.

[2] Draft Regional Hydrothermal Market Penetration Analysis, Appendix B, EG&G Idaho, Inc., and Utah University Research Institute Earth Science Laboratory, October 31, 1978.

Table 7.1

1975
Energy Use by County

County	Assumed Reservoir Temperature (°C)	Industrial		Residential/Commercial	
		Standard Industrial Code (SIC)	Energy Use (Btu/yr x 10^{12})	Total Energy Used Btu/yr x 10^{12})	Energy Used for Space Conditioning and Water Heating (Btu/yr x 10^{12})
BIG HORN	90	2011 2026 2048 3271 3273	0.050 0.100 0.035 0.010 0.058		
		Subtotal	0.253	3.00	2.25
CARBON	90	2011 2048 3273	0.009 0.005 0.007		
		Subtotal	0.021	2.70	2.00
CONVERSE	90	2011 3271	0.006 0.035		
		Subtotal	0.041	1.30	0.99
FREMONT	90	2011 2026 2048 3273	0.007 0.015 0.010 0.008		
		Subtotal	0.040	3.00	2.25
HOT SPRINGS	70				

TABLE 7.1 (contd)

1975
Energy Use by County

County	Assumed Reservoir Temperature (°C)	Industrial		Residential/Commercial	
		Standard Industrial Code (SIC)	Energy Use (Btu/yr x 10^{12})	Total Energy Used Btu/yr x 10^{12})	Energy Used for Space Conditioning and Water Heating (Btu/yr x 10^{12})
LINCOLN	82	2011 2022 3275	0.003 0.040 0.045		
		Subtotal	0.088	1.97	1.48
NATRONA	90	2011 2013 2026 2086 3273	0.020 0.070 0.005 0.030 0.038		
		Subtotal	0.163	7.40	5.55
PARK	90	2011 2026 2086 3273	0.003 0.005 0.010 0.005		
		Subtotal	0.023	1.20	0.90
PLATTE	90	No Match		0.690	0.50
SUBLETTE	90				
SHERIDAN	90	2011	0.025	0.21	0.16

TABLE 7.1 (contd)

1975
Energy Use by County

County	Assumed Reservoir Temperature (°C)	Industrial		Residential/Commercial	
		Standard Industrial Code (SIC)	Energy Use (Btu/yr x 10^{12})	Total Energy Used Btu/yr x 10^{12})	Energy Used for Space Conditioning and Water Heating (Btu/yr x 10^{12})
TETON	90	2013 2086 2421 3273	0.010 0.010 0.010 0.018		
		Subtotal	0.038	0.68	0.50
STATE TOTAL			0.692		16.58

TABLE 7.2

INDUSTRIAL PROCESS HEAT REQUIREMENTS - WYOMING

INDUSTRY	SIC Number	40°C-60°C	60°C-80°C	80°C-100°C	100°C-120°C	120°C-140°C	140°C-160°C	160°C-180°C	180°C - 200°C	200°C	275°C
Meat packing	2011	NA	99%	100%							
Prepared meats	2013	NA	46.2%	61.5%	100%						
Natural cheese	2022	23%	100%								
Fluid milk	2026	NA	NA	100%							
Prepared feeds	2048										
pellet conditioning		NA	NA	100%							
alfalfa drying		NA	NA	NA	NA	NA	NA	NA	NA	100%	
Soft drinks	2086	60.9%	100%								
Sawmills and planing mills	2421	NA	NA	NA	NA	NA	100%				
Concrete block	3271										
low pressure		NA	100%								
autoclaving		NA	NA	NA	NA	NA	NA	NA	100%		
Ready mix	3273	100%									

8. LEASING AND PERMITTING POLICIES

A. General[1]

A number of Wyoming laws treat the leasing, exploration, and use of minerals. Likewise a number of statutes are in existence regarding the use of surface and ground water. The relatively recent interest in geothermal energy in Wyoming leaves the exploration and development of resources in an unclear position. Significant steps have been taken by the State Geologist and the State Land Office (Board of Land Commissioners and Farm Loan Board) to develop a geothermal exploration permit system as well as a leasing system for state lands.

An interested party must first apply for an Exploration Permit. This permit costs $15 for the application and $1/acre/year for the permit if granted. The permit allows the holder to explore for geothermal energy for three years, reporting the exploration activity and findings to the state. At the end of the three-year term the holder can request an extension, apply for a lease, or let the permit expire. The lease is for an initial 10-year period at a fee of $2/acre/year.

After geothermal resources are developed, the state requires royalties as follows:

(1) "Ten percent (10%) of the gross revenue as determined by the Board (of Land Commissioners), made or incurred with respect to transmission or other services or processes, received from the sale of steam, brines, from which no minerals have been extracted, and associated gases at the point of delivery to the purchaser thereof, ...".

(2) five percent (5%) of the gross revenue, exclusive of charges, approved by the Board, that were made or incurred with respect to transmission or other services or processes, received from the sale of mineral products or chemical compounds recovered from geothermal fluids or chemical compounds (Rules and Regulations, 1975).

The major issue yet to be resolved is the legal definition of geothermal energy as a natural resource. Is it groundwater, a mineral, or a unique entity? At this point in time the state is apparently looking at it as a unique entity. This approach has advantages but could require legislation to amend existing laws to include geothermal. A case in point is the Department of Environmental Quality (DEQ). There are four divisions within it: Air Quality, Land Quality, Water Quality, and Solid Waste Management. In effect it appears that a geothermal developer would need to obtain permits from Land Quality and perhaps Air Quality unless the DEQ can develop a special permitting system for geothermal use.

Various agencies may be drawn into the regulation of geothermal development. Currently, the lack of specific legislation and a designated agency to overview potential development activity may cause confusion in the regulatory process. It seems appropriate that the State Engineer, whose current responsibility covers all groundwater, would be the appropriate agency to integrate regulatory efforts. These efforts should be made in close coordination with the State Land Office.

The need for clarifying legislation will become more and more apparent as the resource potential is better understood throughout the state. Future legislation may direct regulatory responsibility elsewhere, since the current designation is unclear and potentially inadequate.

Work is continuing on the development of draft legislation on geothermal energy to be presented in the spring 1980 session. Comparisons have been made with statutes of surrounding states and contacts have been made with the National Conference of State Legislatures.

Other agencies that may be involved in geothermal development and/or legislation are: The Department of Economic Planning and Development, the Energy Conservation Office, State Engineer, State Department of Game and Fish, State Geological Survey, Industrial Siting Council, State Land Use Commission, State Land Office, Oil and Gas Commission, Public Service Commission, Recreation Commission, Department of Revenue and Taxation, and the University of Wyoming research centers.

B. Time Table of Institutional Procedures

A generic time table, showing minimum times for various institutional procedures related to any geothermal project in Wyoming, is shown in Table 8.1.

C. Reference

[1] R. W. James, Geothermal Operations Report for 1978. Oregon Institute of Technology, Draft Report, March 1979.

TABLE 8.1

TIME TABLE OF INSTITUTIONAL PROCEDURES FOR A GEOTHERMAL PROJECT - WYOMING

To be prepared by State Team in FY 1979.

9. BIBLIOGRAPHY (SELECTED REFERENCES)

This list of selected references is not yet a complete bibliography on geothermal energy in Wyoming. This objective will be sought in future updates of this baseline document.

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