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SOUTH DAKOTA HYDROTHERMAL COMMERCIALIZATION BASELINE

PREPARED FOR

DEPARTMENT OF ENERGY - IDAHO OPERATIONS OFFICE

DEPARTMENT OF ENERGY - RESOURCE APPLICATIONS,
GEOTHERMAL RESOURCE OFFICE

BY

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

Observed well and spring temperatures in South Dakota suggest mainly that the Madison group consists of low- or moderate-temperature reservoirs that are best suited for direct applications. The Madison aquifer underlies most of the western portion of the state. Several demonstration projects for utilization of resources for direct applications are in progress, but leasing activity has been modest.

This handbook (draft) provides a synopsis of various aspects of the geothermal program in South Dakota. 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 South Dakota 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 (SOUTH DAKOTA)

A. Government Contracts

Governor - William Janklow (R).

Legislature

Senate Agriculture and Natural Resources Committee: Senator James B. Dunn (R), Chairman.

Senate President Pro Tem: Sen. Mary A. McClure (R).

House Agriculture Natural Resources Committee: Rep. G. F. Mortimer (R), Chairman.

House Speaker: Rep. George S. Mickelson (R).

State Geothermal Team

Operations Research: Steve Gomez, Office of Energy Policy.

Resource Assessment: Duncan McGregor, State Geologist.

State Agencies

Office of Energy Policy: Steve Gomez, Director.

Department of School and Public Lands: Jack J. Gerkin, Commissioner.

Department of Water and Natural Resources: Warren "Bob" Newfield, Secretary.

Water Rights Division: John Hatch, Chief Engineer.

Earth Resources Group: Larry Kyte.

South Dakota Geological Survey:
Duncan J. McGregor, State Geologist,
Fred Steece, Asst. State Geologist.

Department of Agriculture, Division of Conservation: Myron Lindquist, Program Chief.

Department of Revenue: Steven J. Zellmer, Secretary.

State Planning Bureau: James "Ric" Richardson, Commissioner.

B. Statistical Data

Demographic

Population (1970): 666,257

Area: 77,047 sq. mi.

Population Density: 8.6 persons/sq. mi.

Geothermal Resources

Confirmed Reservoirs > 150°C: None

Prospects > 150°C: None

Confirmed Reservoirs (20°C < T < 150°C): One Major

Prospects (20°C < T < 150°C): One Major

Identified Warm Springs & Wells (T > 40°C): ∿ 350

Geothermal Leases

Federal: None

State: None

Private: Not Available

Test Wells: ∿ 5

Operational Hydrothermal Systems

Spas: One

Space Heating: ∿ 10

Others: One

Major Active Developments

Direct Use: Philip schools, Pierre hospital and businesses, Diamond Ring Ranch

Electric: None

Government Assisted Activities

PONs: Philip schools, Pierre hospital and businesses, Diamond Ring Ranch

PRDA: One complete; one in progress.

Loan Guarantees: None

Energy

Supply (1975): 190 x 10^{12} Btu; 9% exported; 84% imported

Use (1975): 170 x 10^{12} Btu

Potential Conversion to Geothermal (1975): 9.5 x 10^{12} Btu

3. HYDROTHERMAL RESOURCES

A. Geologic Setting[1]

South Dakota is located entirely within the Great Plains province. In terms of geothermal geology, South Dakota has two main features of interest: the Madison group aquifer and the Black Hills. The Madison group occurs at depth throughout western South Dakota (see Figure 3.1). This group is composed of Mississippian carbonate rocks that contain a regionally interconnected network of fracture- and solution-opening porosity. Virtually every properly completed well into the Madison encounters waterflow, which is artesian where surface elevations are 700 meters or less. Recharge to the Madison comes predominantly from the Black Hills area, where winter snowmelt and summer rains enter the highly porous rocks at their outcrop around the Black Hills uplift. This meteoric water flows through the Madison system to depths of more than a thousand meters. The water is heated mostly from the normal geothermal gradient, but an area of hotter water occurs in the southeast where there may be a separate heat source. Wells into the Madison produce water varying in temperature up to 80°C. Water quality is generally good, but deteriorates in northwestern South Dakota on the edges of the Williston Basin, where evaporite beds occur in the upper part of the Madison. Hydrothermal waters are also found in part of the Dakota formation in south-central South Dakota.

At the present time artesian Madison hydrothermal waters are being used for space heating at Midland and Philip, South Dakota.

B. High Temperature Resources (>150°C)[2] (see Figure 3.2)

Confirmed Reservoirs: None.

Prospects: None.

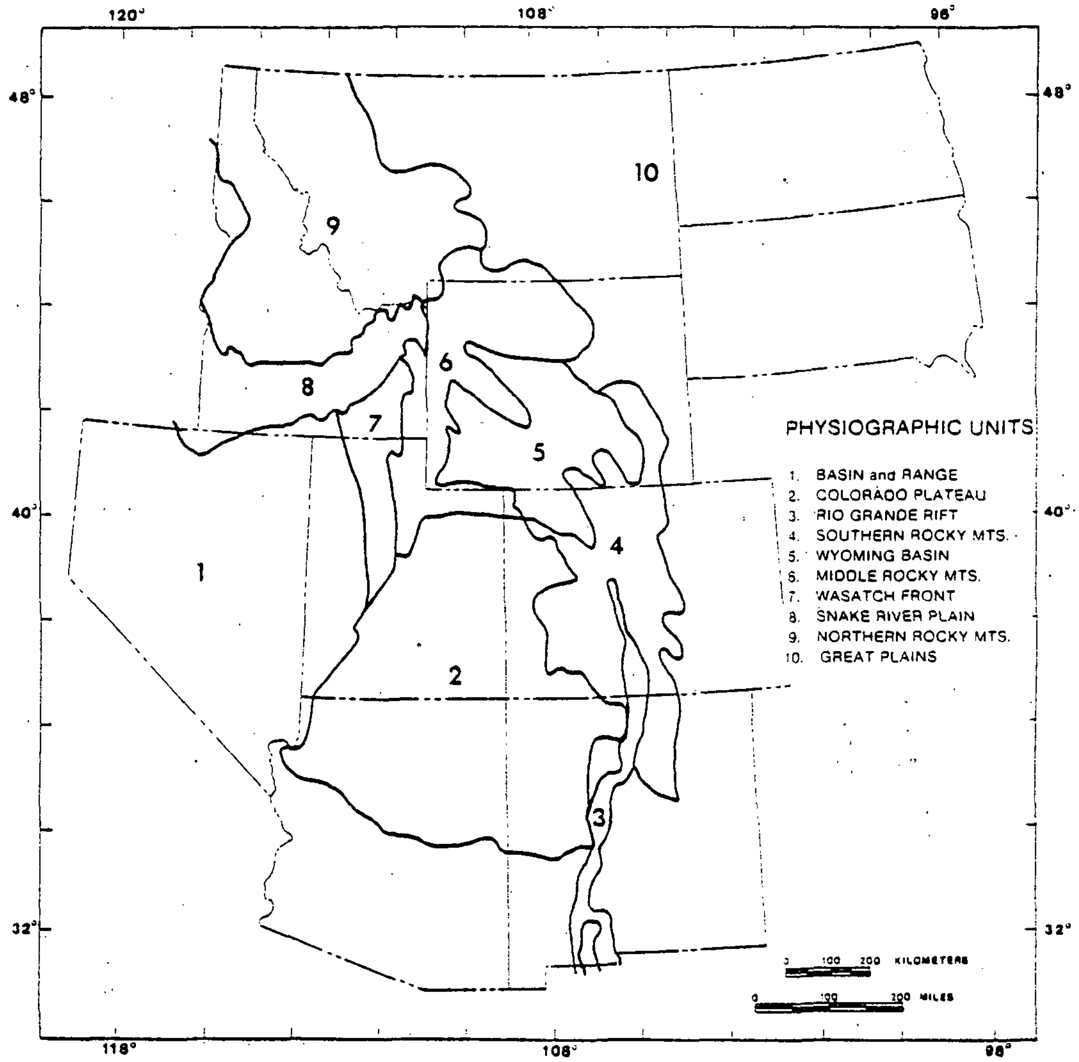

Figure 3.1 Physiographic provinces[1]

C. Low- and Moderate-Temperature Resources (<150°C)[2] (see Figure 3.2)

Confirmed Reservoirs: Madison Aquifer in western South Dakota.

Prospects: None other than the Madison group.

D. Comments

The Madison aquifer appears to be capable of producing heated waters wherever it is encountered, and must be considered a confirmed reservoir of great size. Other zones of porosity, both above and below the Madison group, have been located during petroleum-well drilling. It is possible that some production might ultimately come from them, although the Madison is the only known aquifer with a regionally interconnected recharge system capable of sustained artesian flow.

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 South Dakota[2,4].

TABLE 3.1

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

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
BENNETT				
English No. 1 Kocer (OT)[a]	T37N, R36W	48		
BUTTE				
Amerada No. 1 State (OT)	T14N, R4E	65		
Banks No. 1-23 Fed. Richards (OT)	T10N, R7E	40		
Beer No. 1 Govt. (OT)	T11N, R8E	53		
Beer No. 1 Northworthy Reges (OT)	T10N, R7E	53		
Beer No. 1 State (OT)	T12N, R9E	55		
Beer No. 1 Stirling Govt (OT)	T8N, R8E	51		
Christie-Stewart No. 1 Eickler (OT)	T11N, R7E	43		
Delzer (W)[b]	T12N, R3E	57	4000 (est.)	2710
Harmon Olson (OT)	T9N, R3E	52	4100	1890
Harrison No. 1 Fed. Wheatley (OT)	T14N, R5E	40		
Harrison No. 1-17 Fed. Wheatley (OT)	T13N, R5E	41		
Harrison No. 1 U.S. Smelting (OT)	T14N, R4E	48		
Ken Bean (W)	T9N, R3E	42	4000	896
Koch No. 1 Aztec-State (OT)	T13N, R7E	43		
Koch No. 1 Olson (OT)	T14N, R6E	42		

[a] (OT) = Oil Well
[b] (W) = Water Well

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Mobil No. 1 Mickelson (OT)	T9N, R9E	68		
Mobil No. 15 Sipilia (OT)	T9N, R8E	64		
Pure No. 1 Govt (OT)	T14N, R2E	61		
Seylor No. 1 Anderson (OT)	T8N, R5E	59		
Sojourner No. 1 Widdoss (OT)	T12N, R2E	57		
Water Well (W)	T11N, R7E	46		
Water Well (W)	T9N, R5E	46		
CORSON				
Cayman No. 1 State "A" (OT)	T21N, R24E	44		
Cayman No. 1 State "C-2" (OT)	T22N, R23E	43		
Consolidated No. 1 Tribal (OT)	T20N, R18E	65		
Kilroy-Schwindler No. 1 Scholl (OT)	T18N, R21E	57		
Shell No. 22-12 Everidge (OT)	T18N, R19E	65		
Shell No. 11-23 Govt. (OT)	T19N, R18E	56		
Shell No. 1 Winter (OT)	T22N, R19E	66		
Wilhite No. 1 State (OT)	T22N, R21E	59		
Youngblood No. 1 Drascovich (OT)	T23N, R22E	72		
Youngblood No. 1 Macheel (OT)	T21N, R19E	54		
Youngblood No. 1 Winter (OT)	T22N, R19E	62		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
CUSTER				
Benedum No. 1 Govt. (OT)	T3S, R10E	42		
Benedum No. 1 Kaiser (OT)	T4S, R10E	53		
Gary No. 1 O'Neill (OT)	T3S, R11E	41		
Gary No. 1 Wilsey (OT)	T3S, R10E	41		
Palensky Streeter (W)	T6S, R6E	42		198
Samedan No. 1 Norris Grain (OT)	T3S, R11E	42		
Shell No. 1 Englebrecht (OT)	T6S, R8E	43		
Shell No. 1 Evans (OT)	T2S, R9E	49		
Shell No. 1 Flier (OT)	T2S, R11E	48		
Sterling No. 1 Flier (OT)	T2S, R11E	40		
Sterling No. 1 Ireland (OT)	T2S, R11E	41		
DEWEY				
Bueno No. 1 State (OT)	T12N, R22E	66		
Eagle Butte City (W)	T12N, R24E	53	400	2094
Gulf No. 1 Jewett (OT)	T13N, R27E	49		
Herndon No. 1 Merkel (OT)	T17N, R27E	52		
Herndon No. 1 O'Leary (OT)	T15N, R23E	49		
Herndon No. 1 State (OT)	T13N, R24E	42		
Inv. No. 2F Brings Your Horse (OT)	T13N, R22E	56		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Inv. No. 1 Brooks (OT)	T12N, R22E	54		
Inv. No. 1 M. Cook (OT)	T12N, R22E	49		
Inv. No. 1 Cowan (OT)	T13N, R22E	69		
Inv. No. 1 Holloway (OT)	T12N, R22E	49		
Inv. No. 2 Holloway (OT)	T12N, R22E	49		
Inv. No. 3 Holloway (OT)	T12N, R22E	49		
Inv. No. 6 Holloway (OT)	T12N, R22E	48		
Inv. No. 7 Holloway (OT)	T12N, R22E	54		
Inv. No. 1 Little Skunk (OT)	T13N, R22E	59		
Inv. No. 3 Little Skunk (OT)	T13N, R22E	54		
Inv. No. 2 McClellan (OT)	T12N, R22E	57		
Inv. No. 1 A Redbird (OT)	T13N, R22E	62		
Inv. No. 1 Wallace Cook (OT)	T13N, R22E	59		
Inv. No. 2 Wallace Cook (OT)	T13N, R22E	49		
Inv. No. 1 Williams State (OT)	T12N, R22E	49		
Kerr McGee No. 1 Cook (OT)	T13N, R22E	59		
Pendak No. 1 Cowan (OT)	T13N, R22E	58		
Youngblood No. 1 Galvin (OT)	T16N, R22E	53		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
FALL RIVER				
Ackman Schulein No. 9-13 Fed. (OT)	T12S, R1E	49		
Ackman Schulein No. 29-14 Fed. (OT)	T10S, R4E	43		
Amarillo No. 1-16 State (OT)	T9S, R2E	41		
Amerada No. 1 Voorhess (OT)	T10S, R8E	54		
B. H. Ord. Depot (W)	T10S, R2E	59		1331
B. H. Ord. Depot (W)	T10S, R2E	45	3000	1070
Conroy No. 1 Ideen Fed. (OT)	T9S, R2E	44		
Conroy No. 1 Peterson (OT)	T7S, R1E	41		
Conroy No. 1 USA Superior (OT)	T9S, R2E	44		
Cont. En. Corp. No. 1 Govt. (OT)	T10S, R9E	43		
Cramer No. 1 Wilkinson (OT)	T10S, R6E	66		
Echo-Rainbow No. 1-31 Ind. Crk. (OT)	T11S, R2E	42		
Edgemont B-N RR (W)	T9S, R2E	52		880
Edgemont City No. 2 (W)	T9S, R2E	59		1109
Edgemont City No. 4 (W)	T9S, R2E	54	1100 (est.)	1140
Gary No. 17-11 Cleveland Quarries (OT)	T8S, R3E	51		
Gary No. 1 Kimblom (OT)	T12S, R8E	44		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Gary No. 1 Lounsberry (OT)	T11S, R6E	42		
Gary No. 1 Pettigrew (OT)	T11S, R7E	44		
Gary No. 1 Rasmussen (OT)	T8S, R8E	41		
Gary No. 1 State (OT)	T10S, R5E	47		
Gary No. 16-1 State (OT)	T90S, R8E	48		
Haywood No. 1 Govt. (OT)	T8S, R1E	53		
Interior No. 1 Putnam (OT)	T10S, R8E	51		
Mines Development (W)	T9S, R2E	54	380 (est.)	836
Mule Creek No. 1 Clark (OT)	T8S, R9E	42		
North Central No. 1-32 Fed. (OT)	T8S, R8E	48		
North Central No. 1 Roll (OT)	T9S, R7E	44		
North Central No. 1 State (OT)	T9S, R7E	50		
Ohio No. 1 Hendrick (OT)	T9S, R7E	51		4706
Pac West No. 1 Govt. Christiana (OT)	T11S, R1E	49		
Pan Am No. 1 Govt.-Donough (OT)	T12S, R1E	47		
Pan Am No. 1 Socony Mobil (OT)	T11S, R1E	49		
Petro-Lewis No. 14-14 Childers (OT)	T8S, R2E	40		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Petro-Lewis No. 3-7 Trotter-Fed. (OT)	T9S, R2E	44		
Raymond No. 1 Mitchell (OT)	T11S, R1E	43		
Shell No. 1 Sides (OT)	T8S, R9E	51		
Shell No. 1 Thompson (OT)	T12S, R1E	47		
Sinclair No. 1 State (OT)	T11S, R6E	53		
Sun No. 1 Wollway Govt. (OT)	T9S, R1E	42		
Tenneco No. 1 USA Ideen (OT)	T10S, R4E	40		
Water Well	T9S, R2E	50		
Water Well	T9S, R2E	53		
Water Well	T9S, R2E	52		
Water Well	T10S, R2E	59		
Webb No. 35-15 State (OT)	T11S, R5E	42		
HAAKON				
Bar-N Ranch (W)	T5N, R24E	63	1000 (est.)	
Carter No. 1 Danielson (OT)	T3N, R22E	50		
Exeter No. 29-13 Bierwagon (OT)	T6N, R21E	47		
Exeter No. 26-4 Hamilton (OT)	T8N, R23E	43		
Exeter No. 29-12 Hudson (OT)	T7N, R23E	46		
Exeter No. 1 LeFee (OT)	T6N, R20E	47		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Exeter No. 10-7 Newmiester (OT)	T5N, R20E	49		
Exeter No. 6-13 Norris Grain (OT)	T4N, R21E	64		
Exeter No. 30-4 Norris Grain (OT)	T7N, R21E	46		
Exeter No. 16-1 State (OT)	T5N, R22E	42		
Exeter No. 16-9 State (OT)	T6N, R19E	52		
Exeter No. 36-10 State (OT)	T8N, R22E	46		
Gulf No. 1 Fenwick (OT)	T4N, R24E	61		
Gulf No. 1 Harry (OT)	T3N, R23E	59		
Inv. No. 1 Lee (OT)	T3N, R24E	46		
Jetters Water Well (W)	T7N, R21E	51		3702
Jones Water Well (W)	T1N, R25E	58		
Kerr McGee No. 1 Chute (OT)	T3N, R19E	57		
Kroech Water Well (W)	T1N, R20E	49		
Midland City (W)	T1N, R25E	71	210	1462
Parson, Bart (W)	T7N, R20E	50		5916
Philip City (W)	T1N, R20E	70	1500	1172
Plum Creek No. 1 Berry (OT)	T6N, R21E	52		
Stroppel (W)	T1N, R25E	41		2686
Texaco No. 1 State "B" (OT)	T6N, R21E	66		

TABLE 3.1 (contd)

COUNTY, NAME AND TYPE	LOCATION	TEMP (°C)	FLOW	TOTAL DISSOLVED SOLIDS (ppm)
Towne, Allen	T7N, R22E	43		5000
Water Well (W)	T1N, R20E	43		
Water Well (W)	T1N, R23E	49		
Water Well (W)	T6N, R21E	40		
Water Well (W)	T1N, R22E	47		
Water Well (W)	T6N, R18E	48		
Water Well (W)	T6N, R22E	45		
Water Well (W)	T7N, R22E	44		
Water Well (W)	T7N, R24E	41		
Water Well (W)	T3N, R20E	48		
Water Well (W)	T5N, R21E	54		
HARDING				
Amerada No. 1 Govt.-Ellis (OT)	T17N, R1E	43		
Amerada No. 1 Short Pine Hill (OT)	T16N, R2E	53		
Amerada No. 2 Short Pine Hill (OT)	T16N, R2E	48		
Amerada No. 1 State (OT)	T16N, R1E	45		
Amerada No. 1 USA Holland (OT)	T15N, R2E	41		
Carter No. 1 Hendriks (OT)	T20N, R3E	80		
Depco No. 23-22 Fed. (OT)	T20N, R5E	87		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Depco No. 42-27 Fed. (OT)	T22N, R5E	84		
Depco No. 41-5 Janvrin (OT)	T22N, R5E	87		
Harrison Murfin No. 1-11 State 15-3 (OT)	T15N, R3E	45		
Harrison No. 1 Blair (OT)	T19N, R4E	56		
Harrison No. 2 Blair (OT)	T19N, R4E	49		
Harrison No. 1 Brengle (OT)	T19N, R6E	49		
Harrison No. 2 Clanton (OT)	T16N, R5E	43		
Harrison No. 1 Fox (OT)	T16N, R4E	46		
Harrison No. 1 Hollister (OT)	T15N, R5E	48		
Harrison No. 1 Johnson & Sons (OT)	T15N, R5E	46		
Harrison No. 1 Ludlow Grezing (OT)	T19N, R6E	57		
Harrison No. 1 Matchett (OT)	T15N, R2E	42		
Harrison No. 1 Matson (OT)	T16N, R5E	43		
Harrison No. 1 M. Counts (OT)	T15N, R11E	44		
Harrison No. 1 Norris Grain (OT)	T20N, R6E	50		
Harrison No. 1 L. B. Smith (OT)	T20N, R5E	59		
Harrison No. 1 State (OT)	T15N, R5E	44		
Harrison No. 1-10 State 16-2 (OT)	T16N, R2E	48		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Harrison No. 1-36 State 15-4 (OT)	T15N, R4E	45		
Harrison No. 16-1 State McBride (OT)	T15N, R2E	41		
Harrison No. 16-1 State 20-6 (OT)	T20N, R6E	54		
Harrison No. 1 Van Horn (OT)	T15N, R4E	43		
Hunt No. 1 Peterson (OT)	T20N, R3E	51		
Hunt No. 1 State (OT)	T18N, R1E	68		
Hunt No. 1 Travers (OT)	T21N, R4E	53		
Hunt No. 1 USA (OT)	T20N, R4E	49		
Hunt No. 1 USA Chilicoat (OT)	T21N, R3E	48		
Jone No. 1 State (OT)	T18N, R1E	76		
Ladd No. 1 Laflin (OT)	T17N, R7E	81		
Miami No. 1 Painter (OT)	T21N, R2E	81		
Mid-America No. 1 Gardner (OT)	T20N, R3E	82		
Mid-America No. 1-17 State (OT)	T21N, R4E	76		
Miller-Shelley No. 1 Catron (OT)	T18N, R1E	46		
Mobil No. F-21-9-G (OT)	T22N, R1E	54		
Mule Creek No. State 1116 (OT)	T22N, R3E	77		
Murfin-Biggs No. 1-23 State (OT)	T18N, R1E	47		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Murfin-Harrison No. 1 Truman (OT)	T16N, R4E	44		
Murfin No. 1 Davis (OT)	T16N, R1E	41		
Murfin No. 1 Johnson Lund (OT)	T15N, R2E	47		
Murfin No. 1 State (OT)	T18N, R1E	49		
Natol No. 1 Arithson (OT)	T23N, R4E	95		
Occidental No. Govt. Norrey (OT)	T22N, R5E	97		
Ohio No. 1 Evenson (OT)	T21N, R1E	41		
Pennzoil No. 12-17 Little Graves (OT)	T21N, R4E	91		
Pennzoil No. 14-11 Tilus (OT)	T20N, R4E	82		
Pennzoil No. 32-10 Tilus (OT)	T20N, R4E	78		
Placid No. 23-16 Orwick (OT)	T15N, R6E	43		
Placid No. 28-3 Schuck (OT)	T16N, R6E	42		
Placid No. 15-13 State (OT)	T17N, R5E	43		
Placid No. 17-16 State (OT)	T17N, R6E	43		
Placid No. 27-4 State (OT)	T18N, R5E	43		
Placid No. 30-13 Van Horn (OT)	T17N, R5E	44		
Quad-West No. 33-26 Buckley (OT)	T23N, R3E	99		
Richfield No. 1-A State (OT)	T17N, R4E	46		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Schlaikjer No. 1 Painter (OT)	T21N, R2E	51		
Shell No. 1 Clarkson-Hansen (OT)	T21N, R3E	50		
Shell No. 32-27 Govt. (OT)	T20N, R5E	54		
Shell No. 14-4 Johnson (OT)	T21N, R8E	59		
Shell No. 1 State "A" (OT)	T21N, R4E	56		
Shell No. 32-16 State (OT)	T21N, R4E	79		
Shell No. 41-23 State (OT)	T18N, R8E	91		
Sinclair No. 1 White (OT)	T15N, R7E	76		
S. Min. No. 1-8 Orwick (OT)	T15N, R4E	43		
Sun No. 1 Govt. Gregg (OT)	T22N, R5E	83		
Texaco No. 1 State (OT)	T18N, R4E	49		
Texaco No. 1 White (OT)	T15N, R7E	53		
Union No. 1 State 217 (OT)	T15N, R6E	44		
Union No. 1 USA 664 (OT)	T15N, R2E	43		
Wheatley No. 1 Junek (OT)	T15N, R5E	47		
HUGHES				
Pierre Airport (W)	T111N, R75W	43	750 (est.)	2318
JACKSON				
Addison Water Well (W)	T1S, R24E	60		
Belvidere Water Well (W)	T2S, R24E	44		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Campbell No. 1 Dale (OT)	T1S, R22E	43		
Cities Svc. No. 1-A Phipps (OT)	T2S, R23E	59		
Cities Svc. No. 1 Renning (OT)	T2S, R23E	51		
Cities Svc. No. 1-A Vilhaur (OT)	T2S, R25E	58		
Sorrelle No. 1 State (OT)	T1S, R22E	63		
Water Well (W)	T2S, R22E	54		
Water Well (W)	T3S, R22E	43		
Water Well (W)	T1S, R22E	52		
Young Water Well (W)	T1S, R22E	51		
JONES				
Booth Water Well (W)	T3S, R31E	44		
C & NW R. R. (W)	T2N, R26E	48		2848
Gulf No. 1 Dahlke (OT)	T3S, R30E	50		
Gulf No. 1 Hight (OT)	T3S, R29E	53		
Gulf No. 1 Hulse (OT)	T2S, R31E	43		
Gulf No. 1 Sandy (OT)	T2S, R27E	58		
Gulf No. 1 State (OT)	T4S, R28E	60		
Herman Well (W)	T1N, R29E	52		
Murdo City Well (W)	T1S, R28E	60	200	1572

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Olson Water Well (W)	T2N, R29E	44		
Shell No. 1 Herman (OT)	T1N, R29E	46		
Shell No. 2 Herman (OT)	T1N, R29E	41		
Shell No. 1 Olson (OT)	T2N, R26E	41		
Tenneco No. 1 Herman (OT)	T1N, R29E	42		
Water Well (W)	T2N, R27E	46		
Water Well (W)	T3S, R28E	60		
LAWRENCE				
Homestake Mine (W)	T5N, R3E	50		
Weller No. 1 Weisman (OT)	T7N, R4E	46		
LYMAN				
Gulf No. 1 G. K. Hutchinson (OT)	T103N, R77W	57		
Gulf No. 1 G. K. Hutchinson (OT)	T103N, R77W	58		
Water Well (W)	T103N, R78W	43		
Water Well (W)	T105N, R77W	41		
Water Well (W)	T105N, R77W	43		
MEADE				
Amerada No. 1 Corwin (OT)	T6N, R13E	44		
Beer No. 1 Morrell (OT)	T10N, R10N	53		
Herndon No. 1 Oakland (OT)	T10N, R17E	57		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Herndon No. 1 Price (OT)	T9N, R13E	76		
Herndon No. 1 Shinost (OT)	T8N, R13E	65		
Jones-Pellow No. 1 Jensen (OT)	T9N, R11E	43		
Jones-Pellow No. 1 Kolby (OT)	T9N, R13E	46		
Lion-Libertin No. 1 Govt. (OT)	T4N, R11E	58		
Mid-Am. No. M8993 Fed. "O" (OT)	T7N, R10E	43		
Morton No. 1 Olson (OT)	T3N, R9E	43		
Morton No. 1 Snyder (OT)	T5N, R9E	41		
Phillips No. 1 Ferguson (OT)	T7N, R13E	62		
Phillips No. 1 Richardson (OT)	T8N, R17E	46		
Water Well (W)	T6N, R17E	51		
Water Well (W)	T7N, R17E	43		
Water Well (W)	T7N, R17E	52		
MELLETTE				
Anderson (Nelson) (W)	T42N, R25W	61 & 64		1270
Bachman (W)	T42N, R26W	60		1270
Edwards (W)	T43N, R26W	46		
Gulf No. 1 Olson (OT)	T43N, R29W	61		
Iwan Water Well (OT)	T45N, R32W	63		
Koskan Water Well (W)	T42N, R26W	65		1180
Olson Water Well (W)	T43N, R29W	58		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Till Water Well (W)	T43N, R26W	54		
Water Well (W)	T42N, R25W	44		
Water Well (W)	T43N, R26W	45		
Water Well (W)	T43N, R27W	50		
PENNINGTON				
Anderson Water Well (W)	T5N, R13E	41		
Ellsworth AFB (W)	T2N, R9E	54	1500 (est.)	1210
Ellsworth AFB (W)	T2N, R8E	49		461
Gary No. 1 Boydston (OT)	T1N, R11E	40		
Gary No. 1 Hopkins (OT)	T1S, R11E	43		
McIllravy Water Well (W)	T5N, R17E	44		
Peno Water System (W)	T2N, R17E	49		
Shell No. 1 Stromer (OT)	T1N, R12E	57		
Shell No. 1 Wisehart (OT)	T1N, R10E	50		
True No. 1 Govt. Knox (OT)	T5N, R17E	53		
Water Well (W)	T5N, R17E	49		
Wheless No. 5 Federal (OT)	T4S, R17E	49		
Wheless No. 35-14 Federal (OT)	T3S, R16E	50		
Wheless No. 16-5 State (OT)	T4S, R16E	42		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
PERKINS				
Evans-Querbes No. 1 Capp (OT)	T13N, R16E	65		
Hunt-Brooks No. 1 Fed. (OT)	T22N, R11E	85		
Inv. No. 1 Miller (OT)	T14N, R16E	64		
Mule Creek No. 41-33 State (OT)	T13N, R10E	53		
Shell No. 12-7 Bastian (OT)	T15N, R16E	71		
Shell No. 1 Homme (OT)	T20N, R12E	107		
Shell No. 1 Veal (OT)	T17N, R15E	85		
S. Minerals No. 1-11 Blomberg (OT)	T14N, R12E	49		
S. Minerals No. 1-13 Fed. (OT)	T13N, R11E	61		
S. Minerals No. 1-23 Marks (OT)	T13N, R13E	49		
Texaco No. 1 Crawford (OT)	T14N, R11E	56		
Texaco No. 1 Diamond (OT)	T13N, R12E	49		
Youngblood No. 1 Anderson (OT)	T21N, R14E	96		
SHANNON				
Webb Res. No. 30-16 Linehan (OT)	T37N, R45W	48		
STANLEY				
Benedum No. 1 Shaffner (OT)	T6N, R27E	49		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Carter No. 1 Loucks (OT)	T9N, R27E	48		
Cities Svc. No. 1 "A" Barrick (OT)	T7N, R28E	50		
Cities Svc. No. 1 Wagner (OT)	T5N, R29E	46		
C & NW Railroad (W)	T3N, R29E	42		
Gulf No. 1 Stanley-Fed. (OT)	T8N, R26E	46		
Shamrock No. 1 Barrick (OT)	T8N, R27E	54		
Shell No. 1 Abbott (OT)	T4N, R27E	47		
Shell No. 1 McCrone (OT)	T3N, R25E	56		
Tenneco No. 1 Hall (OT)	T3N, R27E	40		
Tenneco No. 1 Rankin (OT)	T4N, R28E	44		
TODD				
Water Well (W)	T38N, R30W	68		
TRIPP				
Gen. Crude No. 1 Assman (OT)	T98N, R78W	53		
Gen. Crude No. 1 Rural Credit (OT)	T95N, R77W	44		
Gen. Crude No. 1 Shippey (OT)	T96N, R75W	54		
Gen. Crude No. 1 Vogt (OT)	T99N, R79W	51		
Gulf No. 1 Keyapaha State (OT)	T96N, R79W	53		
Gulf No. 1 Swedlund (OT)	T102N, R78W	41		
Jorgensen Water Well (W)	T101N, R75W	52		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Kucera No. 1 Bartels (OT)	T100N, R77W	47		
Schlaikjer Water Well (W)	T100N, R79W	54		
Water Well (W)	T102N, R77W	43		
Water Well (W)	T102N, R74W	47		
Water Well (W)	T101N, R75W	53		
Water Well (W)	T101N, R74W	43		
Water Well (W)	T101N, R74W	44		
Water Well (W)	T101N, R74W	41		
Water Well (W)	T102N, R74W	43		
Water Well (W)	T102N, R74W	41		
Water Well (W)	T102N, R74W	43		
Water Well (W)	T102N, R75W	41		
Water Well (W)	T102N, R78W	44		
ZIEBACH				
Amerada No. 1 Briscoe (OT)	T16N, R18E	56		
Amerada No. 1 Trent (OT)	T16N, R18E	62		
Cities Service No. 1 "A" Jensen (OT)	T12N, R22E	56		
Dupree City (W)	T13N, R21E	59		2521
Herndon No. 1 Butler (OT)	T12N, R19E	58		
Herndon No. 1 Young (OT)	T16N, R20E	60		

TABLE 3.1 (contd)

COUNTY, NAME, AND TYPE	LOCATION	TEMP (°C)	FLOW (L/min)	TOTAL DISSOLVED SOLIDS (ppm)
Inv. No. 1 Eulborg (OT)	T13N, R21E	56		
Kerr McGee No. 1 Brammer (OT)	T13N, R20E	67		
Norris No. 1 Cheyenne (OT)	T15N, R21E	58		
Shell No. 14-18 Dries (OT)	T17N, R18E	57		
Ward Dayton No. 1 Olson (OT)	T12N, R20E	62		
Boarding School	T12N, R24E	42		7600
Cherry Creek School	T8N, R22E	41		4600
Red Scaffold School	T9N, R19E	48		5000

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] R. A. Schoon and D. J. McGregor, Geothermal Potentials in South Dakota, Report of Investigation 110, South Dakota Geological Survey, 1974.

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

[4] J. P. Gries, Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota, Final Report IDO/1625-2, South Dakota School of Mines and Technology, September 1977.

4. COMMERCIALIZATION ACTIVITIES

A. Highlights

- The first deep geothermal water well was drilled to 2983 ft in Edgemont, South Dakota in 1910-13, producing 515 gallons per minute (1960 L/min) at 54°C (130°F) and 94 psi.

- The Stroppel Hotel in Midland has used geothermal waters for hot mineral baths since the 1930s.

- Many ranchers in South Dakota have utilized hot well water for stock tanks, heating barns, chicken houses, etc., for years.

- There are numerous hot wells and springs in South Dakota with temperatures in excess of the 7°C annual mean temperature. Several major aquifers (in the Madison group), underlying about 40,000 sq. mi., yield hot water at temperatures above 100°F (38°C). Many oil and gas wells have recorded temperatures in the 100°C range.

- Four DOE PONs were awarded in 1977 to the Douglas High School in Box Elder, Haakon School in Philip, St. Mary's Hospital in Pierre, and to the Diamond Ring Ranch in Haakon County.

- A study was conducted in 1976-77 by the South Dakota School of Mines and Technology on "Geothermal Application on the Madison Aquifer System in South Dakota". This study examined the geology, water quality, water treatment, and corrosion and scaling aspects of the Madison. In addition, engineering and economic analyses were performed for a Midland district heating system, Cherry Creek and Red Scaffold district heating systems on the Cheyenne River Sioux Reservation, and for other uses including irrigation, stock watering, heating of livestock buildings, greenhouses, etc.

- The State Energy Policy Office is presently conducting a feasibility study of the use of 34°C water from the Capitol Lake well for space heating and fuel preheating for several of the buildings of the state capitol complex. Findings of the study will be presented to the 1980 state legislature in the request for project funds.

- Thermal gradients have been determined for a number of deep wells in South Dakota. The worldwide average geothermal gradient from such determinations is 1.6-1.7°F/100 ft; in South Dakota several areas with gradients three or four times this average have been tentatively identified.

B. Leases

No leasing activity has taken place in South Dakota on federal or state lands. Tables 4.1 - 4.5 and Figure 4.1 are provided as a frame work for summarizing any future leases on these lands. Table 4.1 provides latest totals of federal and state acreages leased to private organizations for geothermal development.

For federal lands in South Dakota, Figure 4.1 is a synopsis of various leasing summaries produced by Automatic Data Processing (ADP) of USGS's Conservation Division. 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) for 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 South Dakota. 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 South Dakota and the size of their holdings. No state leases have been applied for or issued in South Dakota. The state controls the surface rights for 900,000 acres and the subsurface mineral rights for 5.2 million acres of land[1].

TABLE 4.1

TOTAL ACREAGES OF GEOTHERMAL LEASES - SOUTH DAKOTA

(as of May 1979)

Federal Leases:	
Total Acreages of Competitive Leases in KGRAs:	None
Total Acreages of Noncompetitive Leases:	None
State Leases:	
Total Acreages of State Leases:	None
TOTAL OF ALL ACREAGES LEASED	None

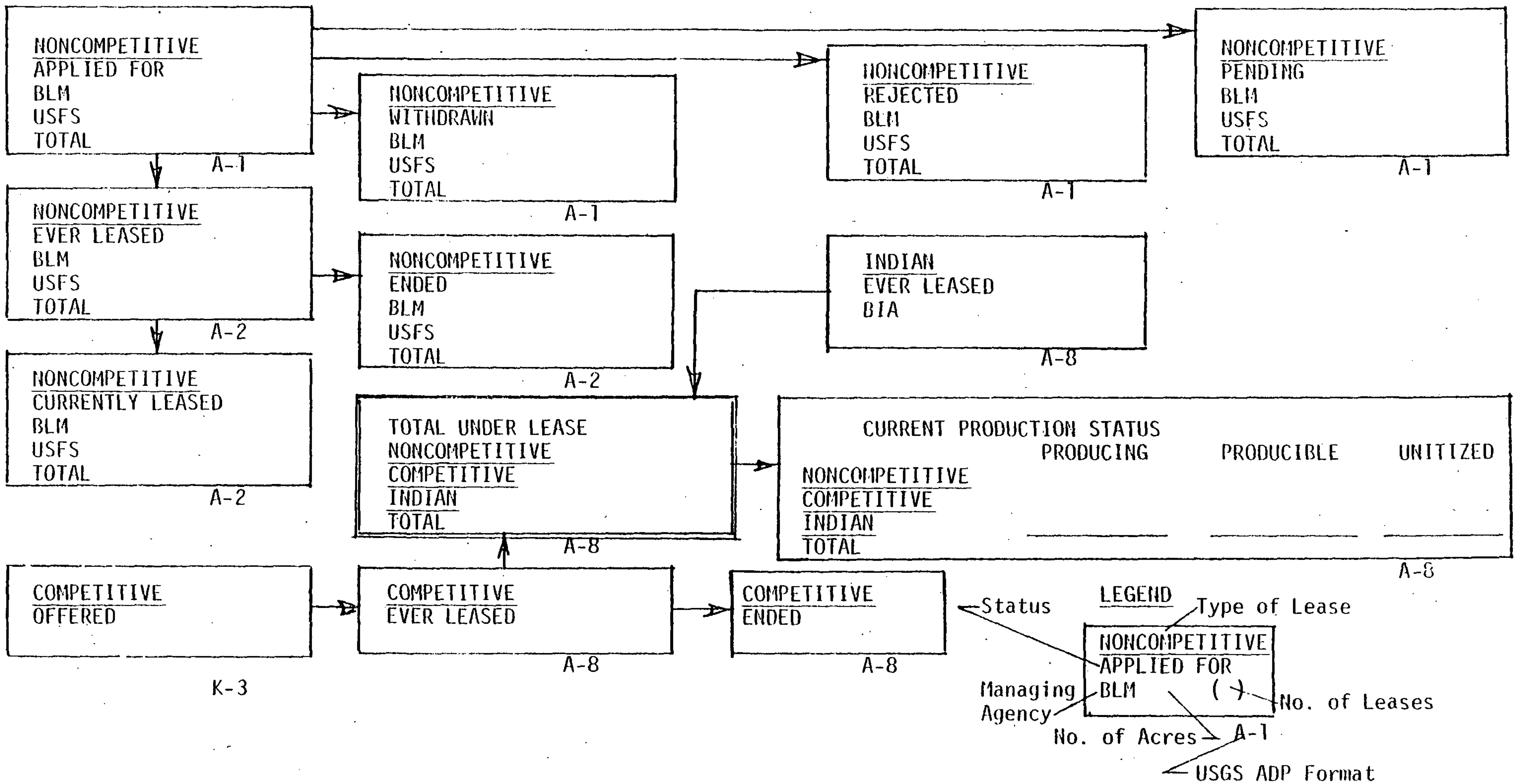

Figure 4.1 Summary of federal leasing activity - South Dakota

(Source - USGS ADP File)[1]

NO ACTIVITY

TABLE 4.2

FEDERAL ACTIVE NONCOMPETITIVE GEOTHERMAL LEASES - SOUTH DAKOTA

(as of May 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION
None		

TABLE 4.3[2]

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

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

TABLE 4.4

FEDERAL ACTIVE COMPETITIVE GEOTHERMAL LEASES - SOUTH DAKOTA

(as of May 1979)

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

TABLE 4.5

STATE LEASES - SOUTH DAKOTA

(as of May 1979)

COUNTY & LESSEE	SIZE, ACRES & (NO. OF LEASES)	LOCATION
None		

C. Test Wells

Test wells in South Dakota are listed in Table 4.6[2,3]

TABLE 4.6

TEST WELLS - SOUTH DAKOTA

COUNTY & LOCATION	COMMENTS
FALL RIVER	
Edgemont	First deep waterwell drilled in South Dakota in 1910-13; 515 gpm (1960 L/min), 54°C (130°F) and 94 psi; five existing wells into Madison or Minnelusa basin. Superintendent of Schools investigating applications.
HAAKON	
Diamond Ring Ranch	PON demonstration well;
Philip	PON demonstration well for Haakon School;
HUGHES	
Pierre	PON demonstration well for St. Mary's Hospital;
	South Dakota Water Rights Commission has issued geothermal well permits to Pierre Flower Shop and Greenhouses, Inc.; no drilling yet.
PENNINGTON	
Box Elder	PON demonstration well for Douglas High School;

D. Other Exploratory Activity

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

TABLE 4.7

OTHER EXPLORATORY ACTIVITY - SOUTH DAKOTA

COUNTY & LOCATION	COMMENTS
VARIOUS	
Madison Aquifer	Well temperatures and thermal gradients for deep-water and oil-test wells in South Dakota have been determined by Schoon and McGregor (Reference 2). The well temperature data in the reference are regarded as correct, but some of the temperature gradient data are questionable. Electric log analyses of approximately 150 wells to determine porosity (Reference 4). Potentiometric surface determinations made by several investigations (References 4 - 6). Except for an initial steep gradient away from outcrop area in west central South Dakota (west of Rapid City) potentiometric surface is nearly flat. Very little information is available on transmissivities, storage coefficients, or specific capacities of Madison wells in South Dakota (Reference 4). Well yields range from 80 to 1000 gpm (Reference 4).

E. Operational Systems

Table 4.8 provides a summary of operational systems using geothermal energy in South Dakota[1,2,4,7,8].

F. References

[1] John Gerken and Jerry Ortbah, South Dakota Department of School and Public Lands, Personal Communication, May 1979.

[2] R. A. Schoon and D. J. McGregor, Geothermal Potentials in South Dakota, Report of Investigation 110, South Dakota Geological Survey, 1974.

[3] John Hatch, Water Rights Commission, Personal Communication, May 1979.

[4] J. P. Gries, Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota, Final Report IDO/1625-2, South Dakota School of Mines and Technology, September 1977.

[5] L. F. Konikow, Preliminary Digital Model of Groundwater Flow in the Madison Group, Powder River Basin and Adjacent Areas, Wyoming, Montana, South Dakota, North Dakota, and Nebraska, U.S. Geological Survey, Water Resources Investigation 63-75, 64 pp., 1976.

[6] V. Latkobich, The Piezometric Surface of the Pre-Charles Mississippian Limestone, South Dakota, Bachelor's Thesis, South Dakota School of Mines and Technology, 1960.

[7] Dan Carda, South Dakota School of Mines and Technology, Personal Communication, May 1979.

[8] Fred Steece, Assistant State Geologist, Personal Communication, May 1979.

TABLE 4.8

OPERATIONAL SYSTEMS - SOUTH DAKOTA

COUNTY & USE	LOCATION	COMMENTS
CHARLES MIX		
Space Heating	Platte	Heating barns using plastic pipe; resource 32°C (90°F).
HAAKON		
Space Heating	City of Midland	Municipal well for space heating of public school buildings since 1968. 200 gpm; attributed to the Madison Aquifer 71°C (160°F).
	Several ranchers in the area of Midland	Artesian wells for heating of homes, buildings, garages, and cattle shelters.
	Little Scotchman Industries, Philip	Space heating attributed to Dakota water approximately 50°C (122°F).
Swimming Pools and Baths	Stroppel Hotel, Midland	Mineral baths attributed to Dakota water approximately 48°C (118°F).
Potable Water	City of Philip	Municipal water plant (after cooling); 70°C (158°F) resource.

5. DEVELOPMENT PLANS

A. Description

A contract is being negotiated with the Energy Policy Office of South Dakota so the state can participate in the Department of Energy's (DOE) Operations Research Geothermal Planning Project. One major objective of this DOE/State geothermal planning process has been to generate specific plans for prospective development and commercialization of geothermal energy through the year 2020.

The present planning process for other states in the Rocky Mountain/Basin and Range Region consists of three categories of plans for prospective and actual geothermal developments. The three 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 in 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 South Dakota 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 1979. (This table is to be defined during the second half of 1979).

B. <u>References</u>

None

TABLE 5.1

DEVELOPMENT PLANS - SOUTH DAKOTA

TIME PHASED PROJECT PLANS	SITE SPECIFIC DEVELOPMENT PLANS	AREA DEVELOPMENT PLANS

To be defined during second half of 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: Four proposals from South Dakota (under PON No. EG-77-N-03-1553, issued in September 1977) were accepted by DOE for funding:

(1) Geothermal Heating of Douglas High School in Box Elder (being discontinued),
(2) Direct Utilization of Geothermal Energy for Philip schools,

(3) Geothermal Application for St. Mary's Hospital and Capitol Lake Plaza in Pierre, and
(4) Direct Utilization of Geothermal Energy at Diamond Ring Ranch in Haakon County.

In the Box Elder project the objectives were to provide space heating for the Douglas High School building and to provide domestic water for the City of Box Elder. The Douglas school complex and the City of Box Elder are located approximately 14 miles northeast of Rapid City, South Dakota. A well was to be drilled for domestic water use and the school district was to utilize the geothermal water for heating a portion of the Douglas High School with a maximum of approximately 1.25×10^6 Btu/hr. The water (100 gpm) from the Madison aquifer (predicted 125°F at 4000 ft) was to be pumped directly from one production well through insulated pipe to reheat coils located in the existing ductwork. The geothermal coils were to be placed in series with the existing reheat coils and the control of the geothermal system was to be integrated into the conventional heating system thermostats. The system was to be fully instrumented to determine actual performance. The principal investigator was Mr. Jack Issler, Douglas School Facilities Engineer. Dunham Associates of Rapid City was responsible for implementing the project with assistance from the South Dakota School of Mines and Technology. The well originally drilled by the City of Box Elder was completed to the cooler and shallower Lakota Formation. The Douglas School Board has voted to discontinue the project.

In the Philip project, the objective is to provide space heating and domestic hot water to the Philip school buildings. The town of Philip and the Philip school complex are located approximately 80 miles east of Rapid City, South Dakota. Three buildings in this complex will be retrofitted to use geothermal energy for space heating. The scope of the project requires the drilling of a well (450 gpm capacity) into the Madison Aquifer (predicted 150°F at 4000 ft) and the conversion of the present steam and electrical heating systems to hot water systems with a capacity of approximately 4.3×10^6 Btu/hr. Instrumentation will be installed to monitor the system performance and to provide data for other potential users. As currently planned, water discharged from the heating system will be piped into a rural water distribution system. The principal investigator is Dr. Charles A. Maxon, Haakon School District Superintendent. Hengel, Berg and Associates of Rapid City is responsible for implementing the project with assistance from the South Dakota School of Mines and Technology. As of May 1979, the geothermal well has been completed and the preliminary design of the school heating system has been finished.

In the Pierre project, the objective is to demonstrate the economic feasibility of using a low-temperature geothermal resource for space heating. St. Mary's Hospital and Capitol Lake Plaza are currently heated by fossil-fuel systems. This project will demonstrate the feasibility of utilizing low-temperature water (approximately 117°F) from a 2,100-ft deep well for space heating. The characteristics of the Madison aquifer in this area are not well known. Therefore, the water quality and well production characteristics will be closely monitored after the well is completed. Based upon the water temperature and quality, heating and ventilating system modifications will be designed and the hospital retrofitted to utilize the geothermal fluid. The Capitol Lake Plaza heating system will also be modified to install hot water coils in the existing forced-air ducts. Expansion of the distribution system to other commercial businesses is considered feasible. The principal investigator is Mr. Jim Russell, St. Mary's Hospital Administrator. Kirkham, Michael and Associates of Omaha is responsible for implementing the project. As of May 1979, the well drilling has been completed and design of the heating system (approximate 8×10^{12} Btu/hr) has started.

In the Diamond Ring Ranch project, the objective is to demonstrate the feasibility of utilizing geothermal water to heat farms and ranches, dry grain, and provide warm stock water. Geothermal water from a 154°F (68°C) artesian well, flowing at 165 gpm from the Madison aquifer since 1959, will be used to heat three ranch homes, a shop, an insulated barn, and livestock shelters, and to dry grain. The system capacity will be approximately 3×10^6 Btu/hr. The construction will consist of laying PVC pipelines to connect the wellhead to the various structures requiring heat. After flowing through the central heat exchanger, the geothermal fluid will be used for warm stock water and will be discharged into an existing reservoir system now used for both geothermal well and runoff catchment. At the conclusion of the construction phase, the system will be monitored for two years to determine the actual system performance. The principal investigator is Dr. Stanley M. Howard of the South Dakota School of Mines and Technology. RE/SPEC Inc. of Rapid City is responsible for implementing the project. The final design phase of the project has been completed. Construction bids are being evaluated as of May 1979.

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 studies is up to $125,000 each, and covers a study period of six to twelve months.

Current Status: Under the PRDA program, a general study of the Madison formation underlying western South Dakota has been completed[1]. Pertinent geologic, hydrologic, and chemical data for the formation have been compiled. A temperature anomaly in west central South Dakota makes 130 to 160°F (55 to 70°C) water available at depths of less than 3500 ft. A central geothermal space heating system designed for Midland, South Dakota indicated that by 1980 geothermal heat will be competitive with existing energy sources. Preliminary tests indicated the superiority of 304 or 316 stainless steel for fabrication of equipment to use the warm, corrosive Madison water. Since South Dakota had no statutes governing geothermal resources, geothermal water would be classified as a top priority domestic use under existing water law. Suggestions were made for state legislation pertaining to the development of geothermal energy.

One additional PRDA project is now being completed in western South Dakota to study geothermal usage from the Madison aquifer. This PRDA study was conducted under the direction of Edgemont School District 23-1. The principal investigator is Mr. John Iszler.

The objective of this 9-month was to investigate the methods for utilizing the available geothermal water in Edgement, South Dakota, for heating the school complex. Available reservoir, water chemistry, and well data have been collected and extensive corrosion tests are still underway. Alternative heating systems were analyzed and the most economic system was selected for further study. The various buildings in the school complex have been modeled to determine energy requirements and sensitivity to selected parameters. The data have been used as a basis for the design of a control system to efficiently utilize the available geothermal energy. The final report is being prepared and will be published in July 1979.

C. Demonstration Projects and Experiments

None except PONs described under 6.A above.

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: No activity thus far in South Dakota.

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. South Dakota is not one of these states so there has been no activity on this project in the state.

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: There is no present activity in the State Coupled Program in South Dakota.

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; and (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 (UURI) 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 the 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 activity in the Industry Coupled Program in South Dakota.

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: There has been no activity in the Technical Assistance Program in South Dakota.

I. State Assisted Activities

None

J. Reference

[1] R. A. Schoon and D. J. McGregor, Geothermal Potentials in South Dakota, Report of Investigation 110, South Dakota Geological Survey, 1974.

7. ENERGY USE PATTERNS

A. Energy Use Summary - South Dakota[1,2]

Over the past twenty years, the state of South Dakota has had no population increase, so past and projected growth in energy consumption is essentially due to a per-capita increase in energy use. Because of the sparse population and great distances between the few urban centers, transportation (see Figure 7.1), is by far the largest user of energy -- considerably larger than the national average.

The next largest use of energy is for residential and commercial purposes. Except for North Dakota, South Dakota is one of the coldest states in the contiguous United States. Based on a district heating factor, its heating requirements are double the national average, and are exceeded by those of only two or three other states in the upper midwest. In the western part of the state, propane is the primary source of residential heating. Available information does not make clear, however, whether this use of propane applies to urban as well as to rural areas.

Figure 7.2 gives approximate energy-use figures for population centers in the state. The percentage of energy used for industrial purposes is the smallest of the states in the region; however, over three-fourths of this energy is used by industries requiring mostly low- to intermediate-temperature energy, as in the food and lumber industries.

Except for a few oil wells, and some coal fields that have been worked only intermittently over the last decade, the only sizable energy production in South Dakota is hydroelectric (see Figure 7.1). Much of this energy is exported to surrounding states.

As shown in Figure 7.3, South Dakota's energy demand is expected to nearly double by the year 2000 (mostly because of a per-capita increase in energy use).

South Dakota 1975

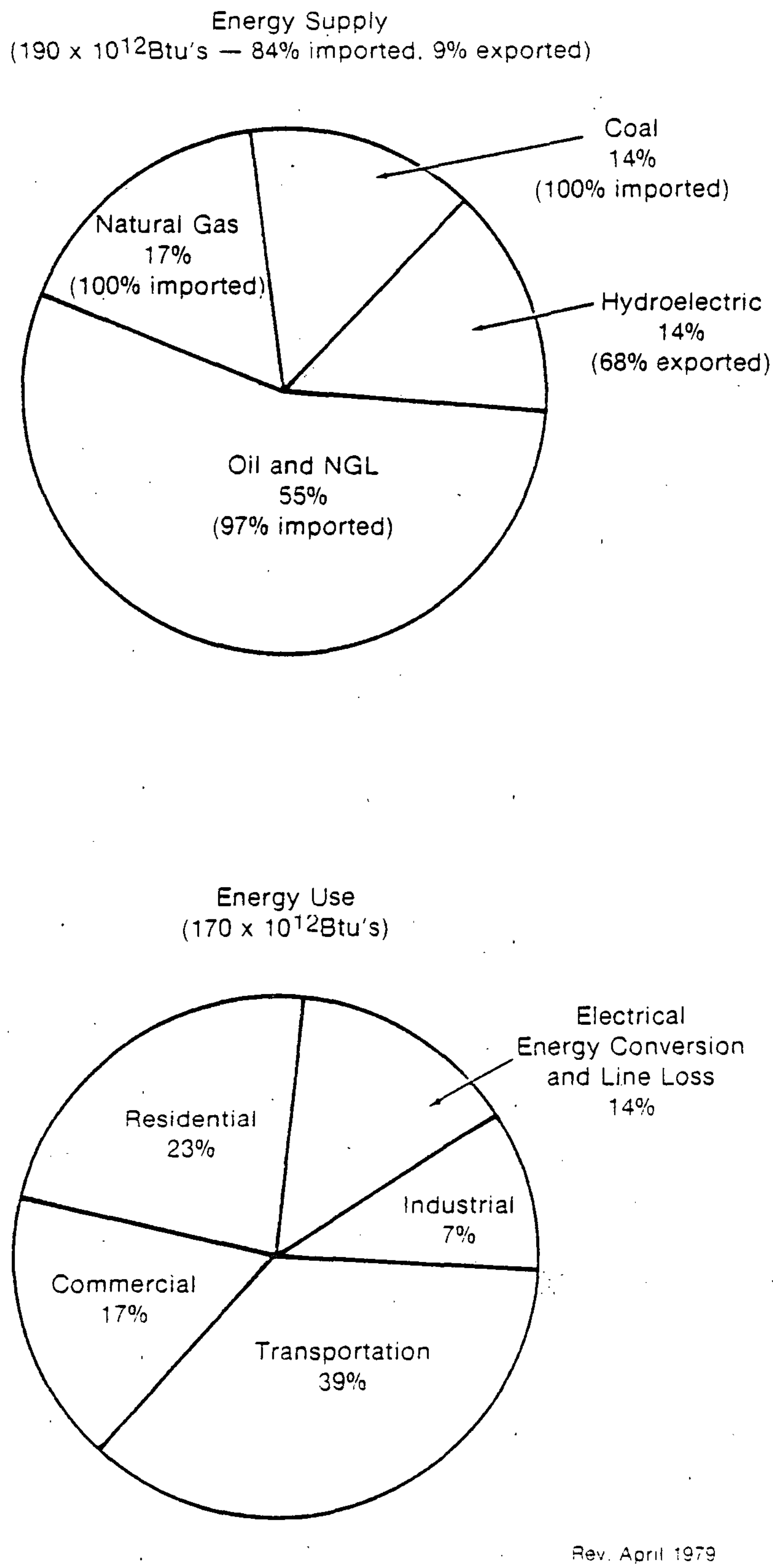

Fig. 7.1 South Dakota energy supply and use[1]

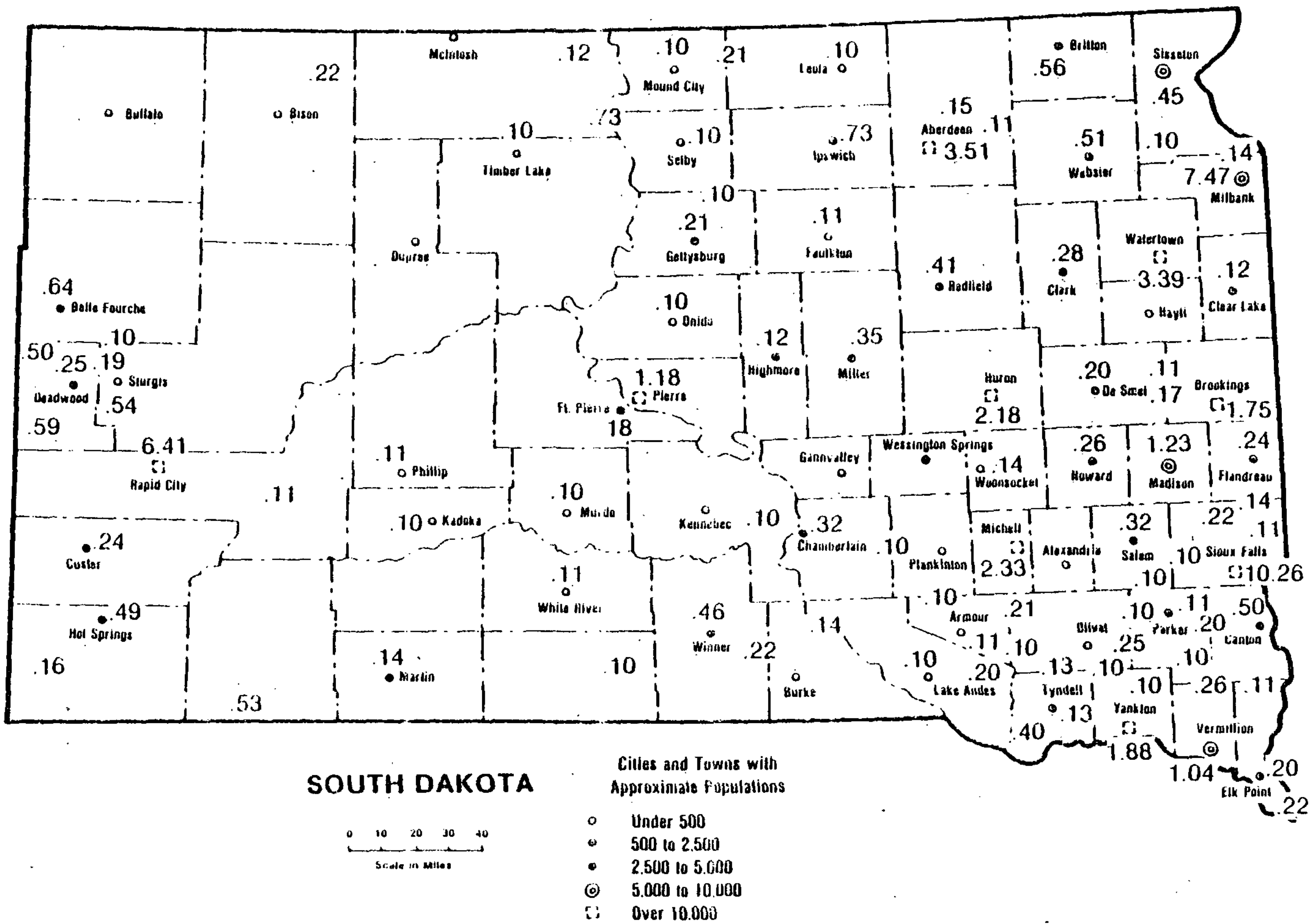

Fig. 7.2 South Dakota energy usage map[1]

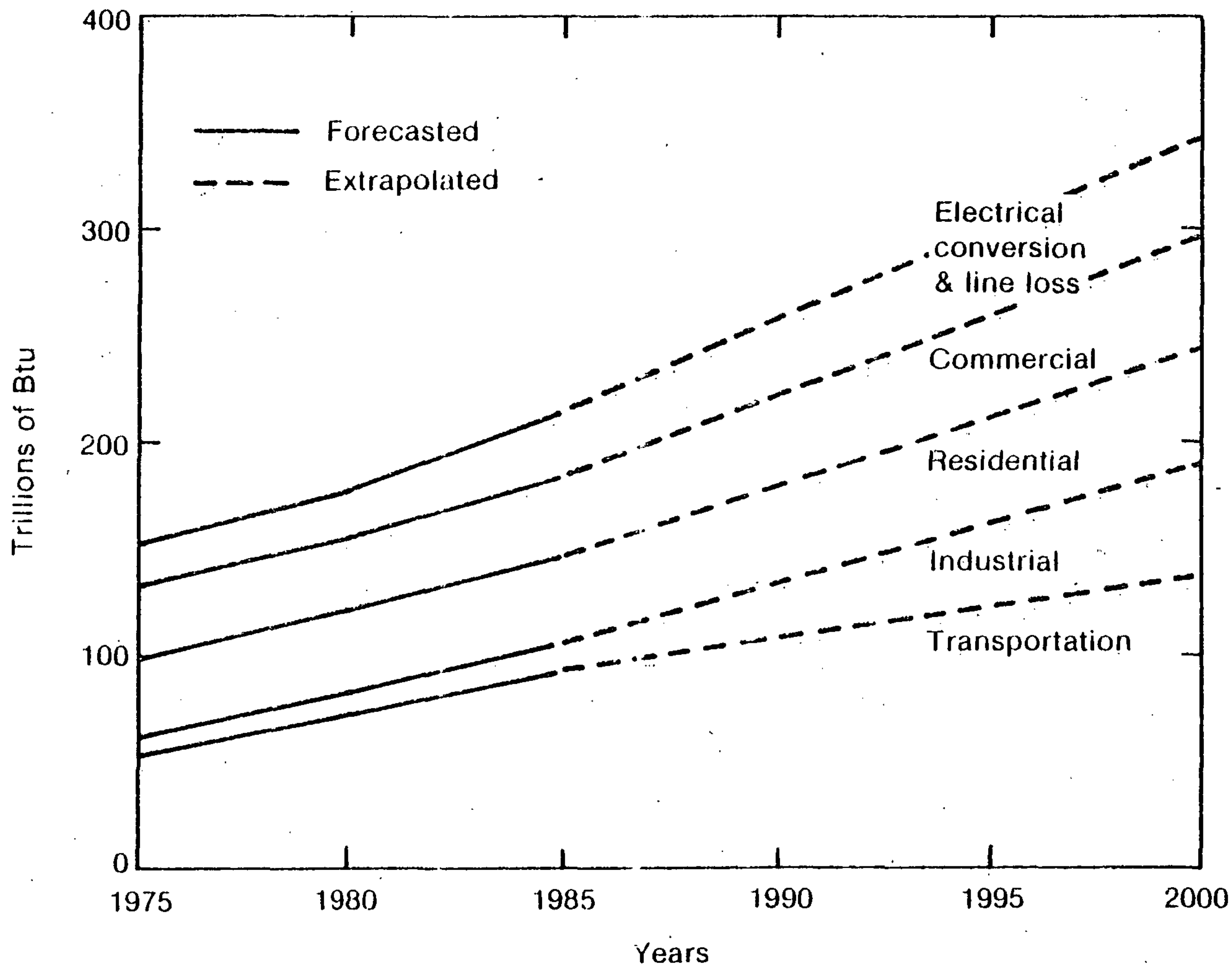

Fig. 7.3 South Dakota total energy use projection[1]

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 SOUTH DAKOTA ENERGY USE BY COUNTY

County	Assumed Reservoir Temperature (°C)	INDUSTRIAL: Standard Industrial Code (SIC)	INDUSTRIAL: Energy Use (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL: Total Energy Used (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL: Energy Used For Space Conditioning And Water Heating (Btu/yr x 10^{12})
BUTTE	90	2048 3271	0.010 0.025		
		Subtotal	0.035	0.51	0.45
CAMPELL	90	3271	0.025	0.06	0.05
CARSON	90	No Match		0.09	0.08
DEWEY	90			0.065	0.055
EDMUNDS	90			0.12	0.10
FALL RIVER	90	2011 2048	0.003 0.010		
		Subtotal	0.013	0.60	0.54
HAAKON	90			0.10	0.09
HARDING	90				
JACKSON	90				
JONES	90				
LAWRENCE	90			0.56	0.50

TABLE 7.1 (CONT'D)

1975 SOUTH DAKOTA ENERGY USE BY COUNTY

County	Assumed Reservoir Temperature (°C)	INDUSTRIAL: Standard Industrial Code (SIC)	INDUSTRIAL: Energy Use (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL: Total Energy Used (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL: Energy Used For Space Conditioning And Water Heating (Btu/yr x 10^{12})
MCPHERSON	90	2022	0.005		
		2048	0.040		
		Subtotal	0.045	0.24	0.22
MEADE	90	2022	0.010		
		3271	0.025		
		Subtotal	0.035	0.47	0.42
HUGHES	90	2086	0.010		
		3271	0.150		
		Subtotal	0.160	1.00	0.90
MELLETTE	90	No Match		0.06	0.05
PERKINS	90			0.20	0.18
PENNINGTON	90	2011	0.096		
		2026	0.105		
		2046	0.115		
		2086	0.050		
		3271	0.155		
		Subtotal	0.521	4.56	4.10
POTTER	90			0.20	0.18
STANLEY	90	2011	0.007	0.15	0.11

TABLE 7.1 (CONT'D)

1975 SOUTH DAKOTA ENERGY USE BY COUNTY

County	Assumed Reservoir Temperature (°C)	INDUSTRIAL Standard Industrial Code (SIC)	INDUSTRIAL Energy Use (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL Total Energy Used (Btu/yr x 10^{12})	RESIDENTIAL/COMMERCIAL Energy Used For Space Conditioning And Water Heating (Btu/yr x 10^{12})
SULLEY	90				
WALWORTH	90	2021	0.005		
		2022	0.005		
		2026	0.010		
		3271	0.025		
		Subtotal	0.045	0.64	0.60
STATE TOTAL			0.886		8.62

TABLE 7.2

INDUSTRIAL PROCESS HEAT REQUIREMENTS - SOUTH DAKOTA

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%							
Creamery butter	2021										
Natural cheese	2022	23%	100%								
Fluid milk	2026	NA	NA	100%							
Wet corn milling	2046	21.5%			36.4%	46.6%		84.1%		100%	
Prepared feeds	2048										
pellet cond.		NA	NA	100%							
alfalfa drying		NA	NA	NA	NA	NA	NA	NA	NA	100%	
Soft drinks	2086	60.9%	100%								
Concrete block	3271										
low pressure		NA	100%								
autoclaving		NA	NA	NA	NA	NA	NA	NA	100%		

8. LEASING AND PERMITTING POLICIES

A. General[1-4]

While there has been moderate geothermal development in South Dakota, it has produced little state legislation aimed at defining geothermal resources and establishing the government policies for the development of geothermal energy. Presently, there are no policies or procedures for geothermal leasing or permitting in the state. The state has not determined if geothermal belongs to the surface land owner or the mineral right owner.

State Regulations: The state of South Dakota presently does not have set guidelines for the development of geothermal energy. There is no clarity as to which state agency has the authority to regulate geothermal. The partial reason for this is the lack of definition by the legislature as to whether geothermal is a water resource, mineral resource, or unique resource.

The Water Rights Commission and the Department of Water and Natural Resources have assumed responsibility for the regulation of geothermal energy as it is presently being developed. According to SDCL 46-2-5, the Water Rights Commission's main responsibility is to regulate rights in surface and subsurface water. This implies that geothermal is being considered as a water resource that generally belongs to the land surface owner. While there is no reference to geothermal in the enabling statutes of the Water Rights Commission, the state statutes do state that beneficial use must be made of the water.

The Water Rights Commission issues permits for drilling of wells deeper than 1,000 ft. Those wells which are less than 1,000 ft do not require permits, but the owner must own water rights. Water rights permits are required for all beneficial use of water except vested rights in reasonable domestic use. To date, beneficial use has included rural water supplies, irrigation, and municipal water supplies. A holder of the permit must put water to beneficial use within three years or lose his preferential use of the water right. In the case of the three geothermal well permits issued to date, the Commission has prescribed that the water be applied to beneficial secondary use within five years. The Commission may recognize the reinjection of the geothermal water as an alternative to beneficial use. The Commission has indicated that it does not intend to issue any more geothermal well permits for at least a year or more, until it has determined whether or not the withdrawal of water could interfere with domestic and agricultural wells.

Surface Leasing: If geothermal energy is to be developed on state land, the developer must lease the surface land from the state. The Department of School and Public Lands has full right (SDCL 5-5) to conduct all leasing of lands in mineral interests owned by the state or held in trust by the state, including schools, indemnity, and endowment land, rural credit lands, lands owned by the state and administered by the Game, Fish and Parks Commission, the Board of Regents, the Board of Charities and Corrections, or any other mineral interests of any kind in the state for any of its departments or institutions. The state presently owns approximately 900,000 acres of surface land and 5.2 million acres of mineral rights.

The Department of Schools and Public Lands issues five-year leases on lands and minerals. Most leases are for grazing and agricultural use, but the Department has issued one 37-acre mineral lease. The lessee has the option to renew his lease for an additional five years if he wishes to do so. The Department does have the option for multiple leases on the same land if the new uses do not conflict with existing uses. The lessee is not permitted to sublease land to other parties. There is no minimum or maximum size to the number of acres that can be leased.

The Department of School and Public Lands issues prospecting permits for the exploration of minerals other than oil and gas on state-owned lands, but has no established procedure for geothermal prospecting. The mineral permits are for a one-year period, with two one-year extensions allowable. The prospector then has the option to apply for a preference right lease. The royalty rate is negotiable; but if the state and prospector are unable to agree on a royalty rate, all findings are made public and a competitive procedure is initiated.

Fluid Discharge Permits: According to Chapter 26-5-1 of the State Agency Rules and Regulations, the Water Rights Commission is responsible for issuing permits to discharge fluids into rivers and streams. In the case of geothermal development, the Commission discourages the discharging of geothermal water without a secondary beneficial use. The Commission may issue permits to reinject geothermal water into aquifers.

Other Permits and Regulations: The developer of geothermal energy must follow several standards in exploratory drilling and well development. The Water Rights Commission requires guidelines to be followed concerning minimum well construction standards (Chapter 52-01-04), minimum specifications for flowing artesian wells (Chapter 52-01-02), and regulation of ground water use (Chapter 52-01-05).

The State Conservation Commission regulates mining land reclamation (SDCL 45-6A) which would probably affect geothermal exploration and development to some extent. The Commission requires plans to be submitted for reclaiming land and permits allowing for exploratory drilling, operation of mines, and possibly geothermal operations if the exploration is for an "unknown" source.

Geothermal System Development: South Dakota requires that any new facility or facility expansion designed to produce more than 100 MW of electricity go through permitting procedures with the State Public Utilities Commission. The South Dakota Energy Facility Permit Act of 1977, Chapter 390, outlines the procedures provided for siting of energy conversion and transmission facilities. Applications for permits must be filed with the Commission not less than 6 months prior to the construction of the facility. The Commission schedules a public hearing and designates a local review committee aimed at reviewing the social, environmental and economic effects of the project on the areas around the plant.

Local Permits: Counties and muncipalities regulate many activities. Most local governments in South Dakota have the option to regulate geothermal development. Control of geothermal would probably be carried out through subdivision regulations.

B. Time Table of Institutional Procedures

The detailed steps and specific times associated with state institutional processes for geothermal development will be compiled and evaluated by the State Geothermal Planning Team during the second half of 1979 (see Table 8.1).

C. References

[1] Jack J. Gerken, Department of School and Public Land, Personal Communication, May 1979.

[2] John Hatch, Department of Water and Natural Resources, Personal Communication, May 1979.

[3] Bill Harris, Division of Conservation, Personal Communication, May 1979.

[4] State of South Dakota Legislative Council, Personal Communication, May 1979.

TABLE 8.1

TIME TABLE OF INSTITUTIONAL PROCEDURES FOR A GEOTHERMAL PROJECT - SOUTH DAKOTA

To be prepared by State Team in 1979.

9. BIBLIOGRAPHY (SELECTED REFERENCES)

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

J. P. Gries, Geothermal Applications on the Madison (Pahasapa) Aquifer System in South Dakota, Final Report IOD/1625-2, South Dakota School of Mines and Technology, September 1977.

L. Howells, Geothermal Resources, In Mineral and Water Resources of South Dakota, U.S. Geological Survey, Committee Print, Committee on Interior and Insular Affairs, U.S. Senate, July 1975.

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R. A. Schoon, Geology and Hydrology of the Dakota Formation in South Dakota, Report of Investigation 104, South Dakota Geological Survey, 1971.

R. A. Schoon and D. J. McGregor, Geothermal Potentials in South Dakota, Report of Investigation 110, South Dakota Geological Survey, 1974.