Geothermal Resources of South Dakota

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STRATABOUND GEOTHERMAL RESOURCES

A stratabound geothermal resource is the thermal energy that can be extracted from hot water contained in porous, permeable, sedimentary strata. Stratabound geothermal resources in the Great Plains occur in both conductive and advective thermal regimes in sedimentary basins where thick layers of low thermal conductivity shale overlie regionally continuous sandstone and carbonate aquifers. In conductive regimes, such as the Williston and Denver Basins, high geothermal gradients in the thick sections of low-thermal conductivity shales produce high temperatures in the underlying aquifers (Figure 1). In advective regimes, gravity-driven groundwater flow carries heat from deeper parts of a basin to the flanks. The deep aquifer system in south-central South Dakota is covered by thermally insulating shales, and the geothermal area is enhanced by advective groundwater flow which extends the geothermal area to the Missouri River (Figure 2).

The accessible geothermal resource base in South Dakota is approximately 12.52 exajoules ($10^9 \text{ J} = 1 \text{ exajoule}$, $10^6 \text{ J} = 1 \text{ Mj}$). The accessible resource base is that quantity of the total resource that may be economically produced using existing technology. The resource area includes most of the western half of the state and includes 8 aquifers (Table 1). Resource temperatures range from about 40°C in the Dakota Sandstone along the Missouri River in central South Dakota to a maximum of 105°C in the Deadwood Formation in northwest South Dakota.

Quantitative estimates of the resource were calculated in a sequence of steps for each of the aquifers. First, stratigraphic and hydrologic data (Rahn, 1981) were combined with heat flow data (Gosnold et al., 1990; Gosnold, 1991) and geothermal gradient data (Schoon and McGregor, 1974) to generate temperature contour maps of the aquifers. Quantitative values for the resource were calculated from

$$Q_r = \rho V(T-15^\circ) \quad [\text{Eq. 1}]$$

where Q_r is the accessible resource base, ρ is the volumetric specific heat of the aquifer, V is the volume of fluid that can be produced, and T is the average temperature of the aquifer (Sorey et al., 1982). Values for T were determined in this study, values for V were obtained from Rahn (1981).

A summary report of the resource assessment was published in Transactions of the Geothermal Resources Council (Gosnold et al., 1990), and a detailed report (Gosnold, 1991) is available from the Energy and Environmental Research Center, University of North Dakota, P.O. Box 8215, Grand Forks, ND 58202-8215.

References:

Downey, J.S., 1986, Geohydrology of bedrock aquifers in the Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming, U.S.G.S. Professional Paper, 402-E.

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Downey, J.S., 1986, Geohydrology of bedrock aquifers in the Great Plains in parts of Montana, North Dakota, South Dakota, and Wyoming, U.S.G.S. Professional Paper, 402-E.

Gosnold, W.D., Jr., Lefever, R.D., Chu, M., Craswell, J.J., and Brekke, J., 1990, Stratabound geothermal resources in the northern Great Plains: Geothermal Resources Council Transactions, v. 14, p. 675-682.

Gosnold William D., Jr., 1991, Stratabound geothermal resources in the northern Great Plains, Final Report: Vol. 1, Resource Assessment; Energy and Environmental Research Center, University of North Dakota, 49 p., 9 appendices.

Rahn, P.H., 1981, Ground water stored in the rocks of western South Dakota, in Rock, F.J., ed., Geology of the Black Hills, South Dakota and Wyoming: second edition America Geological Institute, p. 154-174.

Schoon, R.A., and McGregor, D.J., 1975, Geothermal potentials in South Dakota: South Dakota Geological Survey Report of Investigations 110, 76 p.

Sorey, M.L., Nathenson, M., and Smith, C., 1982, Methods for assessing low-temperature geothermal resources, in Reed, M.J., ed., Assessment of low-temperature geothermal resources of the United States - 1982: U.S. Geological Survey Circular 892, p. 17-30.

TABLE 1

Geothermal Resources Base for South Dakota*

Formation	Resource, Exajoules	Avg. Thickness, meters	Avg. Temp., °C	Max. Temp., °C
Dakota	0.42	36.5	18.5	73.4
Jurassic	1.22	81.9	42.5	71.5
Spearfish	0.66	43.8	57.7	82.3
Minnekahta	0.52	36.8	46.4	85.4
Minnelusa	2.02	134.1	47.3	86.5
Madison	2.93	153.7	51.0	90.3
Ord-Sav	2.90	140.2	53.7	97.2
Cambrian	1.85	110.0	56.1	104.8
TOTAL	12.52			

* Temperatures are given for formation tops. Average thickness values are calculated from top to top. All of the formations named are aquifers which may produce water. Higher temperatures are typical for the Williston Basin in northwestern South Dakota.

Interstate highway
U.S. highway
State highway
Other principal road

Population Key
Sturgis ..... More than 5000
Sturgis ..... Less than 5000

METRIC CONVERSION
1 liter = 0.264 gallons
1 meter = 3.281 feet
1 kilometer = 0.621 miles
1 milligram/liter = 1 part per million
1 milliwatt/meter = 0.024 Heat Flow Unit (HFU)
°Celsius = 5/9 (°Fahrenheit - 32)
°Fahrenheit = 9/5 (°Celsius + 32)

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Map prepared by the
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