THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL BENEFITS OF GEOTHERMAL USE IN THE DAKOTAS

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North Dakota and South Dakota (the Dakotas) are not normally thought of as geothermal states, but direct uses of geothermal energy have existed for centuries. Today, the documented direct uses of geothermal waters are limited to South Dakota and are related to space and district heating, spas and resorts, and aquaculture. There are also many undocumented individual uses by ranchers, particularly in the winter months for space heating, stock watering, and snow melting. In addition to geothermal direct uses, numerous applications of geothermal heat pumps exist in the Dakotas. Further, the University of North Dakota is currently conducting research on the feasibility of electrical power generation from co-produced fluids (petroleum and hot water) from the deep petroleum wells in the Williston Basin – a deep sedimentary basin extending through western North and South Dakota, eastern Montana, and southern Saskatchewan known for its rich deposits of petroleum.

ECONOMIC BENEFITS

South Dakota has a rich history of use of geothermal waters for medicinal and curative purposes (balneology). Fall River County, in the southwestern corner of the State, is the only place where extensive development of balneology has taken place. Historically, Sioux and Cheyenne Indians frequented the warm and healing waters they called "wiwilakahta," or "hot springs." Tribes considered the soothing springs so important that they waged war over them in the 1840s, and locals now tell of a fierce battle that raged on the east summit above the springs and river (now called Battle Mountain), with the Sioux emerging victorious. When European settler Fred Evans arrived in 1879, he considered the 87˚F water a potential moneymaker, envisioning a warm water resort like those back East. Other homesteaders settling the area claimed it eased rheumatism, stomach troubles and other ailments. In 1890, Evans built a dome over several large springs and created Evans Plunge (Figure 1), the world's largest natural warm-water indoor swimming pool, which still exists today in what is now the city of Hot Springs, SD. According to South Dakota Magazine, Evans' venture may have been the unofficial start of the Black Hills' tourism industry, and today, families visiting the Southern Hills usually stop at Evans Plunge for a soak in hot tubs or a ride down one of three water slides into the big pool. From the inflow of 5,000 gallons of water per minute from the springs arising out of the pebble bottom, there is a complete change of water 16 times daily, thus insuring clean, fresh, living water at all times. The 50-ft. by 200-ft. pool ranges in depth from 4 ft. to 6 ft. with two shallow enclosures for children.

Except for Evans Plunge, there is very little balneological geothermal use in southwestern South Dakota today. A combination of lack of interest and belief in the therapeutic use of mineral waters, and corrosion and scaling of pipelines led to the demise of the industry in the 1950's (Lund, 1997). Eight other large springs exist in the area, some of which have had bath houses and sanatoriums in the first half of the 20th century. There are over 80 capped wells and springs in the area, but there appears to be a slow revival of some of these past uses, especially the spa therapy (Lund, 1997).

Figure 1. Post card image of Evans Plunge (right), Mammoth Plunge (center), and Courthouse (left.) circa 1908. Evans Plunge still exists today, but Mammoth Plunge, a large bathhouse, was torn down in the 1960s. (http://usgwarchives.org/sd/fall_riv / postcards/bevhs.jpg).

Other uses of geothermal waters in the Dakota States for balneological purposes occurs at the Stroppel Hotel, located in Midland, SD about 60 miles west of Pierre, SD. The small hotel uses warm water from a well drilled in 1939 to a depth of 1,784 ft., which produces 33 gallons per minute of water at 116˚F. The hotel caters to spa guests with three 8-ft. by 8-ft. separately enclosed bath tubs, each filled with 4 ft. of hot mineral water continually flowing through them. The hotel is also heated by the geothermal water.

The greatest use of direct geothermal energy today in the Dakotas is, by far, space and district heating. South Dakota currently has two municipal geothermal district heating systems and one "mini-district" heating system, in addition to many standalone buildings heated directly with geothermal energy.

The Philip, SD district heating project was based on a Program Opportunity Notice (PON) solicitation and the resulting grant of cost shared funds, and the project was completed in 1982 at a cost of $1.21 million (Lund, 1997). The geothermal well is 4,200 ft. deep, producing 340 gallons per minute of 157˚F water to heat Haakon School. The geothermal water is then cascaded to heat downtown businesses. Currently, the district system heats five school buildings (total floor area of about 44,000 sq. ft.) of the Haakon School District and eight downtown buildings. With ARRA funds, the Hans P. Peterson Memorial Hospital has been connected to the district heating system, and will become a customer in 2012. The district system includes a special design to remove Radium-226 from the spent fluid using barium chloride before the water is disposed of in the Bad River.

Philip, SD also has a "mini-district" geothermal heating system, sourced from a geothermal well located about 2.5 miles north of town, just west of Lake Waggoner. The well is owned by the City of Philip, and was drilled in the 1970s to a depth of 5,280 feet, and can produce 700 gallons per minute of water at 157˚F. The district customers have changed over the years, with the system at first supplying heat to the Haakon County highway equipment maintenance shop, a water treatment plant, and a greenhouse operation. Today, the well still provides heat to the Haakon County highway equipment maintenance shop, and the greenhouses, which are now used for an aquaculture operation to raise Tilapia for commercial markets. The water treatment plant is no longer in existence, as Philip obtains drinking water from another source. However, the well now provides heat to the adjacent golf course club house and a small private business. The well is artesian, and spent water is used as irrigation water on the golf course. This well also serves as a community heating well for ranchers who come and load up hot water for various ranching needs, including hot water washing, ice thawing, and snow melting (VanLint, 2012).

The Midland, SD district heating system uses a municipal well drilled in 1969 to a depth of 3,300 ft. that supplies 152˚F water at over 180 gallons per minute (Lund, 1997). The well supplies hot water to heat approximately 40,000 sq. ft. of floor space, including two school buildings, a church, campground buildings and pool, car wash, four downtown buildings, and about 12 residential buildings that were added to the district system around 2002 (Nemec, 2012). Some of the water from the supply well is treated and supplied to the town for domestic water use, while used geothermal water is discharged into a creek and the Bad River. In addition, there is a hot water valve at the well where ranchers can obtain hot water for their stock watering tanks in the winter, and highway maintenance personnel and ranchers clean their equipment in the summer.

The Dakotas also have a history of large single-building uses of space heating. St. Mary's Hospital in Pierre, SD received a PON grant to drill a geothermal well (Lund, 1997), and completed a 2,200-ft. deep well in 1980. The well produced 375 gallons per minute of water at 106˚F that was used to heat portions of the hospital up until recently in 2004, when a hospital expansion resulted in the geothermal well to be taken out of service.

Another large use of geothermal space heating is at Scotchman Industries (Figure 2), which is an 80,000 sq. ft. manufacturing facility in Philip, SD. Scotchman Industries is a leading producer of metal fabricating equipment, accessories, and custom tools, which began in the early 1960's by making and selling farm-related products, such as pickup stock racks, corral panels, gates and chutes. The facility has been heated with geothermal energy since the 1970s from a 2,400-ft. deep well producing water at 110˚F (Kroetch, 2012).

Figure 2. Aerial photo of Scotchman Industries, Philip, SD (http://www.scotchman.com/about/).

The numerous geothermal-related businesses across the Dakotas employ many people directly and indirectly. Geothermal heating systems are generally low-maintenance, and therefore employ only a few folks that are qualified to work on them. In fact, folks in Midland, SD remark that the district geothermal heating system practically runs itself. However, space heating of buildings and other applications using geothermal energy for heat results in significant energy cost savings to people, which, in turn, results in money that can be kept in the local economy. Relative to 2011-2012 natural gas prices, an estimated $1.3 million is saved annually by South Dakotans using geothermal energy, representing dollars that can stay in the local economy. The use of geothermal energy that directly employs the most people in the Dakotas is related to space heating. Some businesses would not exist where they are in South Dakota without the geothermal resource. Mineral spas and resorts (i.e. Evans Plunge) create many direct and indirect jobs in the tourism industry. Using a standard multiplier of 2.5, geothermal businesses create an estimated 100 direct, indirect, and induced jobs in the Dakota States.

ENVIRONMENTAL BENEFITS

In addition to energy savings, geothermal energy usage prevents the emissions of greenhouse gases (GHG) and air pollutants, helping to keep a healthy living environment. If these businesses and residences used fossil fuels to generate the heat that geothermal water provides, they would emit at least 27,679 tonnes of carbon dioxide equivalent each year (Table 1) — the equivalent of removing 5,411 passenger vehicles from the road, saving 64,371 barrels of oil, and saving 5,890 acres of pine forest.

SOCIAL BENEFITS

Social benefits are difficult to measure quantitatively. One key social benefit from geothermal energy use in South Dakota, however, is improved quality of life through recreation and spa therapy. District energy systems are known to promote and foster community pride. Geothermal sources provide many unique recreational opportunities enjoyed by tens of thousands of people each year, attracting tourists to the state. Given the rich history of the geothermal spa industry, social benefits have been evident for many past generations. According to South Dakota Magazine, Evans Plunge in the 1890s may have been the unofficial start of the Black Hills' tourism industry.

THE FUTURE

The Dakotas have significant geothermal potential for future uses, from new and expanding applications of direct use heating, to resurgence in mineral spa therapy, to development of low-to-moderate temperature resources for electrical power generation. In addition, geothermal heat pump installations continue to grow, with over 1,100 installations now in North Dakota alone (Manz, 2012). Mitchell, SD is home to Hydron Module, a geothermal heat pump manufacturer now operating in an 80,000 sq. ft. facility, making quality products since 1989.

The Geo-Heat Center lists over 50 communities in the Dakotas that are within 5 miles of a geothermal resource with a temperature of 122˚F or greater, making them possible candidates for district heating or other geothermal use. South Dakota has a rich history related to the use of mineral waters for medicinal purposes, a practice which is making a comeback.

Researchers at the University of North Dakota continue to explore electrical power generation from co-produced fluids from the Williston Basin in North Dakota. The Williston Basin has been extensively drilled for petroleum production, with over 19,000 wells in North Dakota alone. Wells in the western part of the State record bottom hole temperatures favorable for electrical power production and/or direct use applications.

ACKNOWLEDGEMENTS

This material is based upon work supported by the Department of Energy under Award Number DE-EE0002741.

REFERENCES

Kroetch, J., 2012. Personal communication, J. Kroetch, Scotchman Industries, Philip, SD

Lund, J. W., 1997. "South Dakota Geothermal Resources", *Geo-Heat Center Quarterly Bulletin*, Vol. 18, No. 4, pp. 6-11, Klamath Falls, OR.

Lund, J.W., Freeston, D.H., and Boyd, T.L., 2010. *Direct Utilization of Geothermal Energy.*

Manz, L., 2012. "Geothermal Update", *Geo News*.

Nemec, J., 2012. Personal communication, J. Nemec, former Mayor of Midland, SD.

VanLint, M., 2012. Personal communication, M. VanLint, City Finance Officer, Philip, SD.

Table 1. Energy Production and Carbon Emissions Offsets by Geothermal Energy Utilization in the Dakotas.

Site	Location	Application	Temp.	Annual Energy Use		Annual Emission Offsets (metric tonnes)**		
			(˚F)	(10^9 Btu/yr)	(10^6 kWh)	NO_x	SO_x	CO_2
Aquaculture Operation	Phillip, SD	Aquaculture	157	42	12.3	19.1	20.2	11,396
Midland District Heat	Midland, SD	District Heating	152	1.7	0.5	0.8	0.8	451
Philip District Heating (2 sites)	Philip, SD	District Heating	155	18.6	5.4	8.4	8.9	5,033
Evans Plunge	Hot Springs, SD	Resort/Pool	87	36.2	10.6	16.5	17.4	9,822
Scotchman Industries	Phillip, SD	Space Heating	110	3.6	1.1	1.6	1.7	977
Totals				**102**	**30**	**46**	**49**	**27,679**

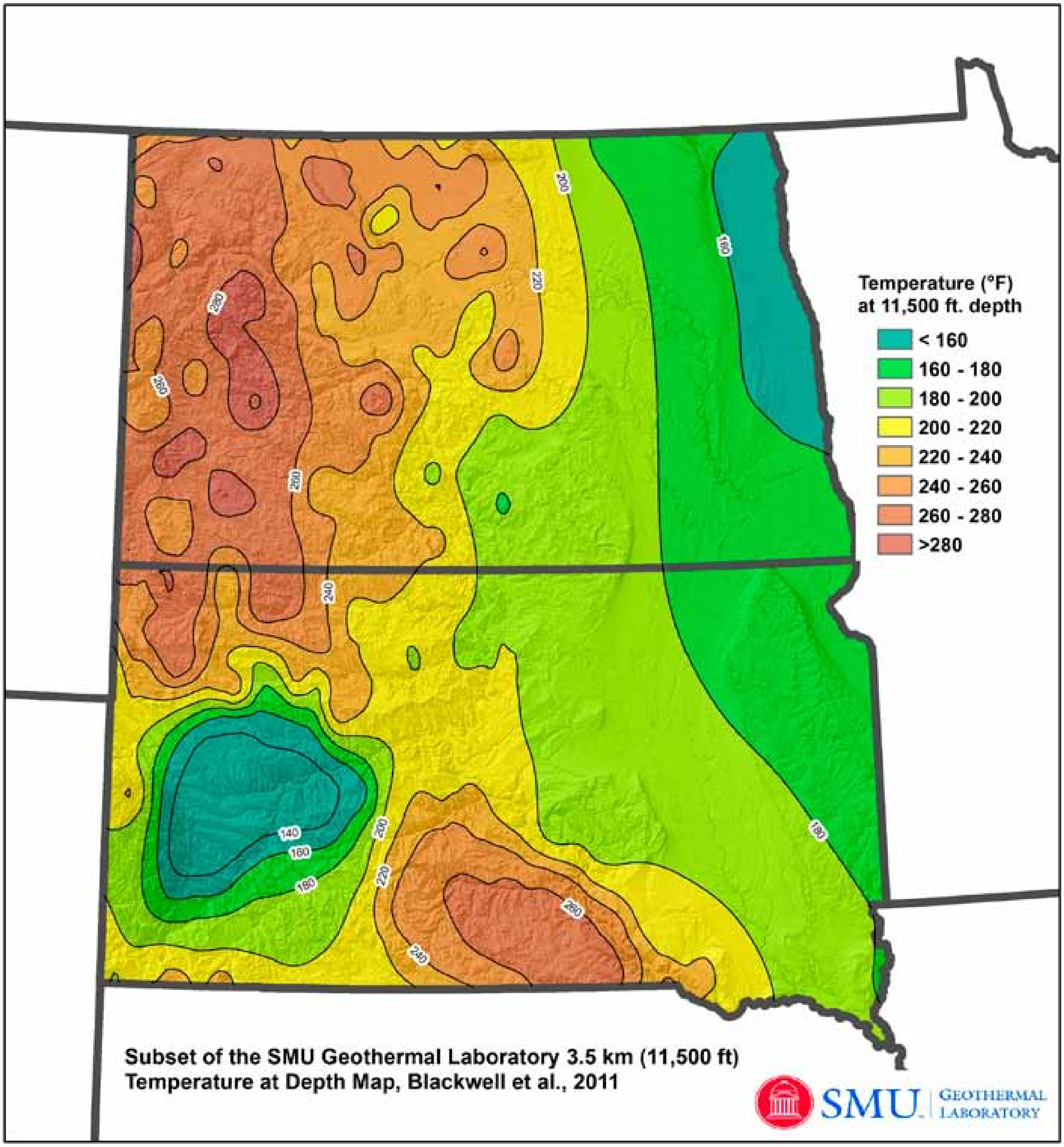

Figure 3. Temperature-at-Depth Maps for 3.5 to 9.5 km, Google.org/EGS (Blackwell, D.D., M. Richards, Z. Frone, J. Batir, A. Ruzo, R. Dingwall, and M. Williams, 2011).