

THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL BENEFITS OF GEOTHERMAL USE IN THE EASTERN UNITED STATES

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Geothermal waters in the Eastern United States have been used by many people for centuries. Today, the documented direct uses of geothermal waters are mostly related to spas and resorts, with some space heating. In this report, the Eastern United States refers to the states east of the Mississippi River.

A Brief Note on Past Studies and the Occurrence of Geothermal Resources in the Eastern U.S.

For most people, “geothermal” conjures images of geysers and volcanoes. Naturally, geothermal resources are commonly associated with volcanic features of the Western States. Exploitable geothermal resources occur in geologic environments other than in areas of recent volcanism, and with the current resurgence in interest in direct uses of geothermal energy, low-temperature electrical power generation, and in enhanced geothermal systems, the Eastern States are receiving considerable attention.

In 1967, a Geothermal Program was started at Virginia Tech University, and heat flow determinations in the southeastern United States were begun with funding by the National Science Foundation. In the late 1970s and early 1980s, the United States Department of Energy (DOE) funded a large number of research projects on the geothermal resources of the Eastern States. The results of these projects are described in reports by Renner and Vaught, (1979), Dunn Geoscience (1981), and Costain and Glover (1982), to name a few. These studies identified a few models of geothermal resource occurrence in the Eastern U.S.: (1) radiogenic granitic plutons beneath thick sediment covers, (2) warm spring systems, (3) abnormally warm aquifers, and (4) deep sedimentary basins with normal temperature gradients.

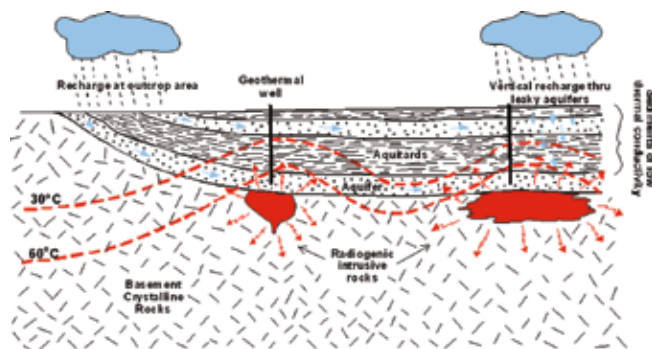


Fig. 1. Conceptual diagram of a radiogenic geothermal system (Lund, 2007).

More recently, the Chesapeake Bay area has been discovered to be a crater formed by a meteorite impact. The impact crater explains anomalous occurrences of

groundwater aquifers and flow patterns there, and may be related to some geothermal features in the area.

ECONOMIC BENEFITS

The spa/resort industry in some Eastern States enjoys significant economic benefits of geothermal energy, and some resorts owe their existence to warm springs. Documented direct uses of geothermal energy currently exist in the states of Arkansas, Florida, Georgia, North Carolina, and Virginia. A number of spas are located at natural springs in other states, but do not represent true direct uses of geothermal energy; these spas heat mineral waters using fossil fuels or other means. Some examples of spas using mineral water that is artificially heated are located in Florida, Illinois, Indiana, Massachusetts, New York (e.g., Saratoga Springs), Tennessee, and West Virginia (e.g., The Greenbrier).

ARKANSAS

Hot Springs, Arkansas was perhaps at one time the most popular commercial spa area in the United States. The geothermal resource consists of 47 springs, producing a total of about one million gallons per day of 143°F water. The National Park Service estimates that these hot springs have been used by humans for at least 10,000 years. In the early 1800s, European settlers developed the area with bathhouses to imitate spas in Europe, and the area became popular enough that it was made into a Federal Reservation in 1832. It became a National Park in 1921, and is the only national park in the U.S. created just to protect hot springs for spa use (Lund, 1993).

During the “Golden Age of Bathing” and the health spa craze of the late 19th and early 20th centuries, numerous extravagant bathhouses existed at the heart of Hot Springs National Park. Known as “Bathhouse Row,” the bathhouses were a popular destination for the wealthy from around the world seeking help from the hot spring waters for a variety of ailments. They hosted many famous (and infamous) people of the era, including Franklin Delano Roosevelt, Babe Ruth, and Al Capone. As with most of the bathhouse industry in the U.S., the popularity of Bathhouse Row saw a steady decline in usage throughout the 20th century, and now, the Buckstaff Bathhouse is the only original active facility in Bathhouse Row remaining from its heyday. The Buckstaff Bathhouse has been in continuous service since 1912, and currently employs about 40 people. The Fordyce Bathhouse has been restored by the National Park Service and is open for tours.

The Hot Springs Arkansas National Park Service Visitor Center building serves as the collection point for the various thermal springs, and users of the thermal waters must purchase the water from the National Park Service as

enacted by law. From the Visitor Center, geothermal water is pumped to customers in the park, including the Buckstaff Bathhouse for spa use, and for direct-use heating of the Visitor Center itself and the Administrative Building. The Hot Springs National Park in Arkansas employs about 50 people permanently, and about 100 during the summer season. Geothermal spring water from the national park Visitor Center is also pumped to spas at the Arlington Resort Hotel, The Springs Hotel and Spa (formerly the Downtowner Hotel and Spa), Quapaw Baths and Spa, and the Austin Hotel, all in downtown Hot Springs, Arkansas.



Fig. 2. Bathhouse Row in Hot Springs, Arkansas

FLORIDA

Warm Mineral Springs, located in North Port, is the only warm water mineral spring in the State of Florida, and is claimed to be the largest warm water mineral spring in the world. The surface area of the spring is approximately 1.4-acres, and is nearly 250 feet deep in the center. The hourglass shaped sinkhole is the result of a subsurface cave-in that occurred some 20,000 years ago. The spring's main water source originates from over 3,000 feet deep, which is believed to be in hydraulic connection to the Floridian Aquifer. The spring produces 9 million gallons of 87°F mineral rich water per day, which is used directly for swimming, soaking, and therapy.

GEORGIA

Warm Springs, Georgia is the most famous of Georgia's seven known warm springs. It has the largest flow of up to 914 gpm with an average temperature of 88°F. The springs issue from at least 12 separate locations along a 500-ft long belt in the edge of a quartzite hillside.

A number of resorts were built in the area, including the Meriwether Inn, known mainly for the treatment of polio from the early 1920s to the 1960s. The Inn was promoted by President Franklin Delano Roosevelt, who had polio and established the "Little White House" on the premises in 1932. The Georgia Warm Springs Foundation, who managed the springs, dedicated itself to the conquest of polio. It provided treatment in various pools supplied by warm springs. With the advent of polio vaccines in the 1950s and 60s, use of the facility declined.

Today, the Roosevelt Warm Springs Institute for Rehabilitation provides medical rehabilitation and therapy for a broad range of disabilities. The Institute also uses the water for bathing.



Fig. 3. Photograph of Meriwether Inn, Warm Springs, GA, 1894. The Inn closed in the 1920s.

NORTH CAROLINA

The Natural Hot Mineral Springs, located in the Great Smokey Mountains, is the only one known in North Carolina. Prior to 1778 when European settlers discovered the area, it is believed that the Cherokee Indians used these springs for centuries for their magical curative powers. Thermal waters issue from the springs at about 110°F at a flow rate of several hundreds of gallons per minute.

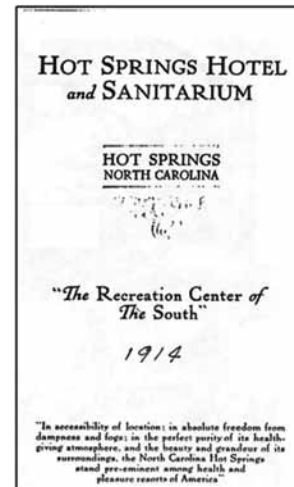


Fig. 4. Brochure for the Hot Springs and Sanitarium, circa 1914.

Two hundred acres of land including the springs were deeded in 1788, and a tavern was established, making the area a popular stopping point for travelers during the American Revolution. This tavern also became legend and was an infamous site for robberies and many murders.

Today, the Hot Springs Resort and Spa offers modern spa services and mineral baths using the geothermal water. The water cools to about 103°F by the time it reaches the facility. The facility also offers a campground with camp sites ranging from primitive, to full RV hookups, to cabins that include indoor/outdoor soaking tubs. The Appalachian

Trail runs between the camp sites and the pools. The facility employs about 45 people.

The Mountain Magnolia Inn also uses the geothermal resource at Hot Springs, NC for spa therapy. The Mountain Magnolia Inn is the former residence of Colonel James Henry Rumbough who owned the 350-room Mountain Park Hotel in Hot Springs, which was the site of North Carolina's first golf course (the Wanna Luna) as well as a popular vacation resort. Built in 1886, the Mountain Park Hotel boasted 16 marble pools surrounded by landscaped lawns with croquet and tennis courts and was known as one of the most lavish resorts in the Southeast. The hotel and grounds were leased to the U.S. Government in 1917 to be used as a World War I internment camp. That hotel burned in 1920, and two more were built, neither as large nor as lavish. Both later burned as well.



Fig. 5. Post Card for the Mountain Park Hotel in Hot Springs, NC circa early 1900s.

VIRGINIA

Three major springs are located in the Warm Springs Valley of the Allegheny Mountains in western Virginia along U.S. route 220: the Warm, the Hot, and the Healing - all now owned by Virginia Hot Springs, Inc. The Homestead, a large and historic luxurious resort, is located at Hot Springs. The odorless mineral water used at The Homestead spa flows from several springs at temperatures ranging from 102°F to 106°F (Gersh-Young, 2003). It is piped to individual, one-person bathtubs in separate men's and women's bathhouses, where it is mixed to provide an ideal temperature of 104°F. Tubs are drained and refilled after each use so that no chemical treatment is necessary. Mineral water from the same springs is used in an indoor swimming pool maintained at 84°F, and an outdoor swimming pool maintained at 72°F.

Five miles away to the northeast, but still within the 15,000-acre Homestead property, are the Jefferson Pools at Warm Springs, which flow at 98°F. The rate of discharge is so great, 1000 gpm (Muffler, 1979) that the two large Warm Springs pools, in separate men's and women's buildings, maintain the temperature on a flow-through basis requiring no chemical treatment. The men's pool was designed by Thomas Jefferson and opened in 1761; the

women's pool was opened in 1836. The adjacent "drinking spring" and two covered pools have been preserved in their original condition.



Fig. 6. Photo of the Jefferson Pools (Source: thehomestead.com).

Healing Springs located approximately five miles southwest of Hot Springs is reported at 86°F with a flow rate of 15 gallons per minute (Muffler, 1979).

The facilities at The Homestead include 700 bedrooms, a conference center, restaurants, shops, and tennis courts. Skiing and ice skating are available in the winter. It is the only Virginian spa still in operation as a public resort.

NEW YORK

No known direct uses of geothermal energy currently exist in the State of New York, but it is worth mentioning the prior use of a deep well in Auburn, Cayuga County for direct heating of the East Middle School and Cayuga Community College. The Auburn Well was drilled in 1982 by the New York State Energy Research and Development Authority (NYSERDA), the original well owner, and DOE to explore for low-temperature geothermal resources for direct-use heating.

The Auburn area was chosen for the exploration well because of its anomalously high geothermal gradient and proximity to two educational facilities. The well was drilled to 5,250 feet into Precambrian basement rocks. The relatively high geothermal gradient was explained by a radiogenic heat source. The well produced warm water and natural gas. According to the Geo-Heat Center data base for New York, the well produced 600 gpm of 125°F water. Today, the well produces only natural gas, and the Cayuga Community College has converted to geothermal heat pumps.

The numerous geothermal-related businesses across the Eastern U.S. employ many people. Using a standard multiplier of 2.5, geothermal businesses create an estimated 450 direct, indirect, and induced jobs in the Eastern U.S.

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 used fossil fuels to generate the heat that geothermal water provides, not only would most be unable to afford to stay in business, but they would emit at least 7,333 tonnes of carbon dioxide each year — the equivalent of 17,300 barrels of oil. In addition, they would emit 12

tonnes of nitrogen oxides and 13 tonnes of sulfur dioxides each year into our air (Table 1).

SOCIAL BENEFITS

Social benefits are difficult to measure quantitatively. One key social benefit from geothermal energy use in the Eastern U.S., however, is improved quality of life through recreation and spa therapy. Geothermal provides many unique recreational opportunities enjoyed by tens of thousands of people each year, attracting tourists to the area. Given the rich history of the geothermal spa industry, social benefits have been evident for many past generations.

THE FUTURE

The Eastern States 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.

Cornell University has proposed to develop a potential geothermal energy resource for the production of campus power and heat in Ithaca, New York. West Virginia University has proposed a retrofit and expansion to a district heating system in a community redevelopment project at West Virginia University campus.

In West Virginia, researchers uncovered the largest geothermal hot spot in the eastern United States. According to a unique collaboration between Google and geologists,

West Virginia sits atop geothermal hot spots, some as warm as 392°F at depths as shallow as five kilometers (Fig.7). If this geothermal energy could be feasibly tapped, the state could become a significant producer of geothermal energy for the region.

ACKNOWLEDGEMENTS

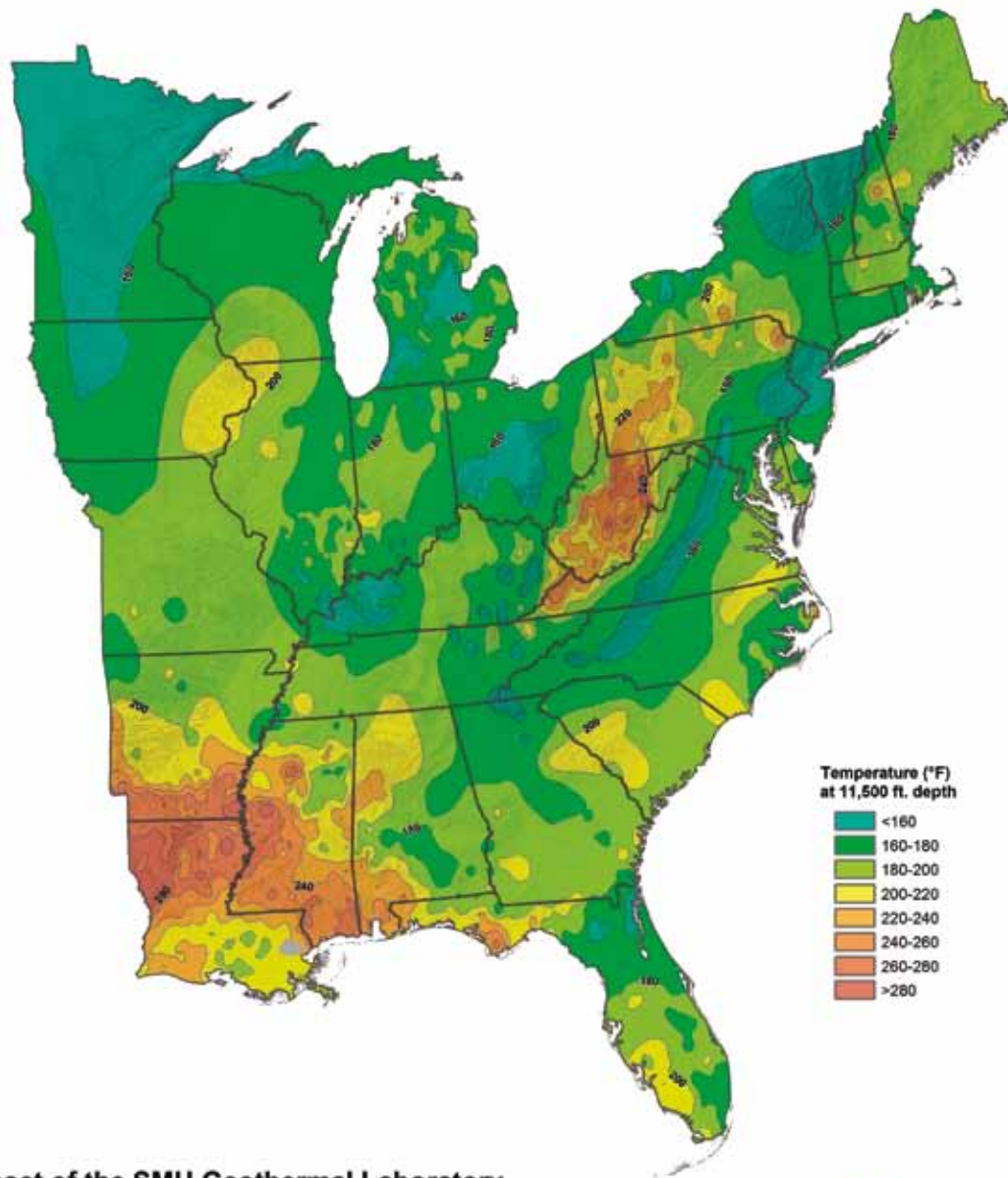
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Table 1. Energy Production and Carbon Emissions offsets by Geothermal Energy Utilization in the Eastern United States of America.

Site	Location	Application	Temp. (°F)	Annual Energy Use		Annual Emission offsets (metric tonnes)		
				(10 ⁹ Btu/yr)	(10 ⁶ kWh)	NOx	SOx	CO ₂
Hot Springs National Park	Hot Springs, AR	Space Heating	143	1.0	0.3	0	0	271
Bathhouses, spas, resort hotels	Hot Springs, AR	Resort/Pool	90 to 143	6.5	1.9	3	3	1,764
Roosevelt Warm Springs Institute for Rehabilitation	Warm Springs, GA	Resort/Pool	88	7.0	2.1	3	3	1,899
Homestead Resort	Hot Springs, VA	Resort/Pool	104	2.9	0.8	1.3	1.4	787
Hot Springs Resort	Hot Springs, NC	Resort/Pool	110	6.0	1.8	2.7	2.9	1,628
Mountain Magnolia Inn	Hot Springs, NC	Resort/Pool	110	1.6	0.5	0.7	0.8	441
Warm Mineral Springs	North Port, FL	Resort/Pool	87	2.0	0.6	0.9	1.0	543
TOTALS				27	8	12	13	7,333



**Subset of the SMU Geothermal Laboratory
3.5 km (11,500 ft) Temperature at Depth Map,
Blackwell et al., 2011**



Fig. 7. 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).

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