North Dakota Geothermal Power

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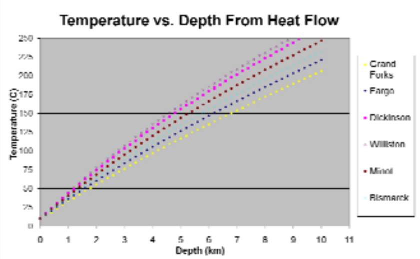
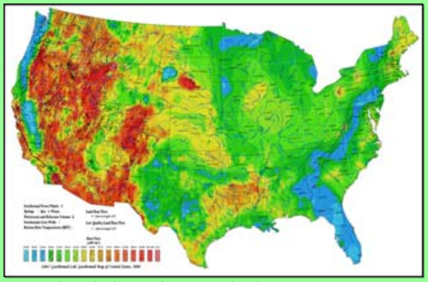
Abstract

Currently, active oil and gas wells produce approximately 10 Mbbls of water monthly from the Madison Group and Red River Formation in North Dakota. These formations are deep enough to have temperatures sufficient to produce nearly 1.5 MW of electrical power using only coproduced fluids. Comparison of pumping volumes for coproduced fluids with volumes from water flood sites in these formations suggests that pumping the wells for water raises electrical power production potential by 2 orders of magnitude. Today, technological advances in the development of scalable organic Rankine cycle (ORC) power plants makes the low-to-intermediate temperature (90 °C to 150 °C; 194 °F to 302 °F) geothermal waters that lie within sedimentary basins an attractive electrical power source. Until recently, ORC systems were available only on an at large scale, i.e., 10's of MW, and had efficiencies of about 10 percent. Currently there are at least five manufacturers making scalable ORC systems in the 50 kW to 1 MW range, and at least one system has an efficiency of about 17 percent and is expected to attain an efficiency in the low 20's as it is scaled up to produce power in the MW range. Values needed for these systems are temperatures of 92+ ºC and flow rates of 140-1000 gpm. The minimum temperature differential between the evaporator and condenser temperature for generating power economically is 120°F (65°C). The amount of power is dependent on both the temperature differential and the volumes of water (hot and cold). The mean annual temperature in North Dakota, which is essentially the ground temperature 2 m below the surface, remains around 50°F (10°C). Therefore, water produced at temperatures as low as 170°F (83°C) could produce electricity economically in all of the Williston Basin. To estimate the practicality of developing the resource, we used heat flow, bottom-hole temperatures, and measured temperature gradients to calculate the energy contained within specific formations having temperatures in the range of 100 ºC to 150 ºC. We found that at a 2% recovery factor, approximately 4500 MW can be recovered from heat stored at depths of 3-4 km. North Dakota currently produces approximately 3100 MW from non-renewable sources such as coal and petroleum. We conclude that the geothermal resource in the Williston Basin could completely replace fossil fuels as an electrical power supply for North Dakota.





SMU Geothermal Lab, Heat Flow, a Transfer of Temperature <http://smu.edu/geothermal/heatflow/heatflow.htm>

Calculating Temperature from Heat Flow Values

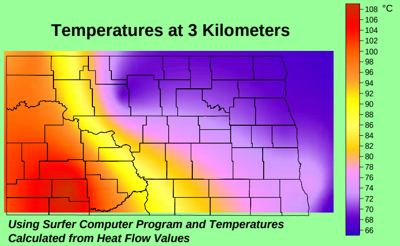
Taking heat flow values for Grand Forks, Fargo, Bismarck, Minot, Williston, and Dickinson of 45, 50, 54, 68, 59, and 65 respectively, allows us to calculate temperatures to a depth of 10 km using the following equation:

$T=Q*\Delta d/K+T_0$.

where:
T=temperature
Δd=change in depth interval
K=thermal conductivity

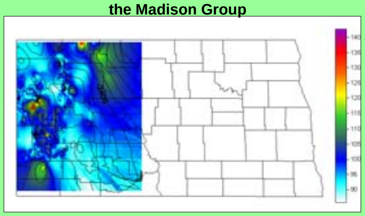
Heat flow values are much higher in the western part of the state where the cities of Williston, Dickinson and Minot are located. These cities are located in the Williston Basin and have numerous oil wells located around them that could produce power for these cities and also for small rural communities.

Temperatures at 3 Kilometers

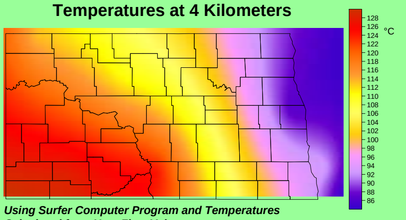


Using Surfer Computer Program and Temperatures Calculated from Heat Flow Values

BHT and Structure Contour Map of the Madison Group

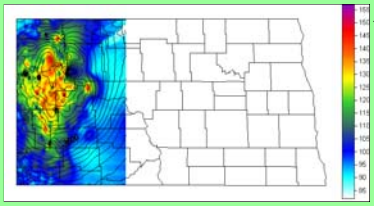


Temperatures at 4 Kilometers



Using Surfer Computer Program and Temperatures Calculated from Heat Flow Values

BHT and Structure Contour Map of the Red River Formation

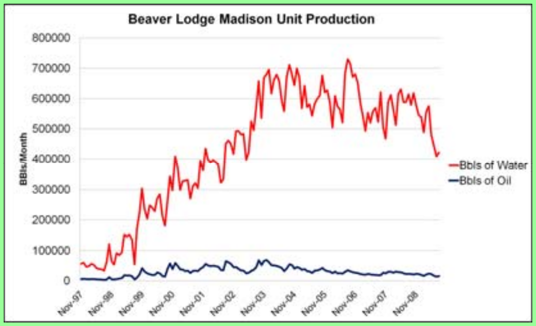


Lithology and Temperature

The Red River Formation is predominately a gray to brownish gray argillaceous fossiliferous limestone in the center of the basin and is dolomitic near the margins with some anhydrite interbedding. It is Late Ordovician in age and is widespread throughout the Williston Basin with a maximum thickness of 213 meters (700 ft.). The Madison Group is comprised of three formations, the Lodgepole, Mission Canyon and Charles, all in ascending order. They are Mississippian in age and have a max thickness of 753 meters (2470 ft.). The Mission Canyon and Lodgepole Formations are the larger oil producers and have similar lithologies. The lithology is mainly dark organic, thin bedded argillaceous limestone. Both of these formations, as seen in the figures above, have temperatures sustainable for ORC technology. The Madison Group has temperatures of 95-135°C and the Red River Formation's temperatures are 90-150°C. The temperature maps are used to calculate resources if a fraction of the heat could be used for other areas outside of the Madison Group or Red River Formations for future consideration.

Top Ten Water Producing Wells in North Dakota

Pool	BBLS Oil	BBLS Water	Days Produced	Gallons/Minute
MADISON	2387	95508	31	89.85967742
MADISON	4242	80232	31	75.48709677
MADISON	1094	80026	28	75.29327957
LODGEPOLE	2700	76018	31	71.52231183
LODGEPOLE	2700	76018	31	71.52231183
MADISON	1451	67967	31	63.94744624
MADISON	383	61627	31	57.98239247
SOUTH RED RIVER B	7438	56825	31	53.46438172
SOUTH RED RIVER B	3420	54019	31	50.82432796
MADISON	850	53575	31	50.40658602



Water Production

The chart lists the top ten water producing wells throughout the Williston Basin in North Dakota. These ten wells produce large quantities of water with high flow rates. Producing these wells for mainly water production could increase the potential for electrical production. Altogether there are 129 wells that produce 20,000+ bbls of water monthly which is equivalent to 19+ gallons per minute. Water flood sites for these formations have produced up to 880 gallons per minute. The graph to the left is the monthly production of the Beaver Lodge Unit producing from the Madison Group. The Beaver Lodge Field currently produces 400,000+ bbls monthly with temperatures approximately around 90-105°C. If wells could centralize the location of the water production, and if temperatures would still be sufficient after piping, large scale ORC power plants could produce power on the MW scale. This field is located in the upper western half of North Dakota, near Tioga. A MW scale plant could essentially power most of the community.

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