*Energy at a Glance*

# Understanding Geothermal Power

By Linnea Lueken

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## Introduction

Although geothermal power has a range of applications, this paper primarily focuses on utility-scale use for geothermal power plants, and does not address smaller scale geothermal heat pumps like those used to heat and cool buildings.

Geothermal energy comes from deep earth heat that remains from the formation of the planet, as well as ongoing radioactive decay inside the earth's mantle.[2] The high temperatures form magma, which heats surrounding rock in the crust. This natural heat of the earth is most easily available for use when it comes closer to the surface as hot springs, geysers, lava pits, underground hot water or steam reservoirs, and some high temperature dry rock reservoirs.[3] These kinds of conditions are most often found in tectonic plate boundary regions, like the Western United States, as seen in Figure 1 below, or in geologic "hot spots" of geothermal activity like Hawaii.[4]

## How It Works

To produce power from a fluid-filled geothermal reservoir, a few conditions must exist: porosity, which allows a fluid to be collected in the rock; permeability, which allows the fluids to migrate throughout the rock; and the right temperature contained in the rock formation and associated fluids.

To begin with, a well is drilled to access the high temperature water or steam in a geothermal reservoir, then the fluid is piped to the surface, where it is used to turn a turbine and generate electricity. Geothermal energy can also be used to directly heat greenhouses, bodies of water, buildings, sidewalks, and other structures.[5]

### Quick Bullets

- Geothermal energy is generated by drilling wells into high-temperature water or "hot rock" reservoirs and using the hot water or steam to turn a turbine.
- Geothermal energy has the smallest land surface footprint of any renewable energy source, aside from nuclear power.1
- Electricity generation by geothermal energy does not produce significant carbon dioxide emissions.
- Potential environmental threats from heavy metal contamination must be considered and mitigated.

Sometimes, if a hydrothermal reservoir does not have the right permeability conditions, fluid injection can open cracks in the rock to improve permeability, in a process that is very similar to hydraulic fracturing used in tight shale for natural gas production.[6]

## Environment

Electricity generated by geothermal energy does not produce significant carbon dioxide emissions. However, drilling and circulating deep well water does emit some carbon dioxide and methane. It is also common to see hydrogen sulfide emissions, which can be dangerous to human and environmental health unless removed with scrubbers.[7]

Without reinjection of produced geothermal fluids back into the reservoir, there may be an

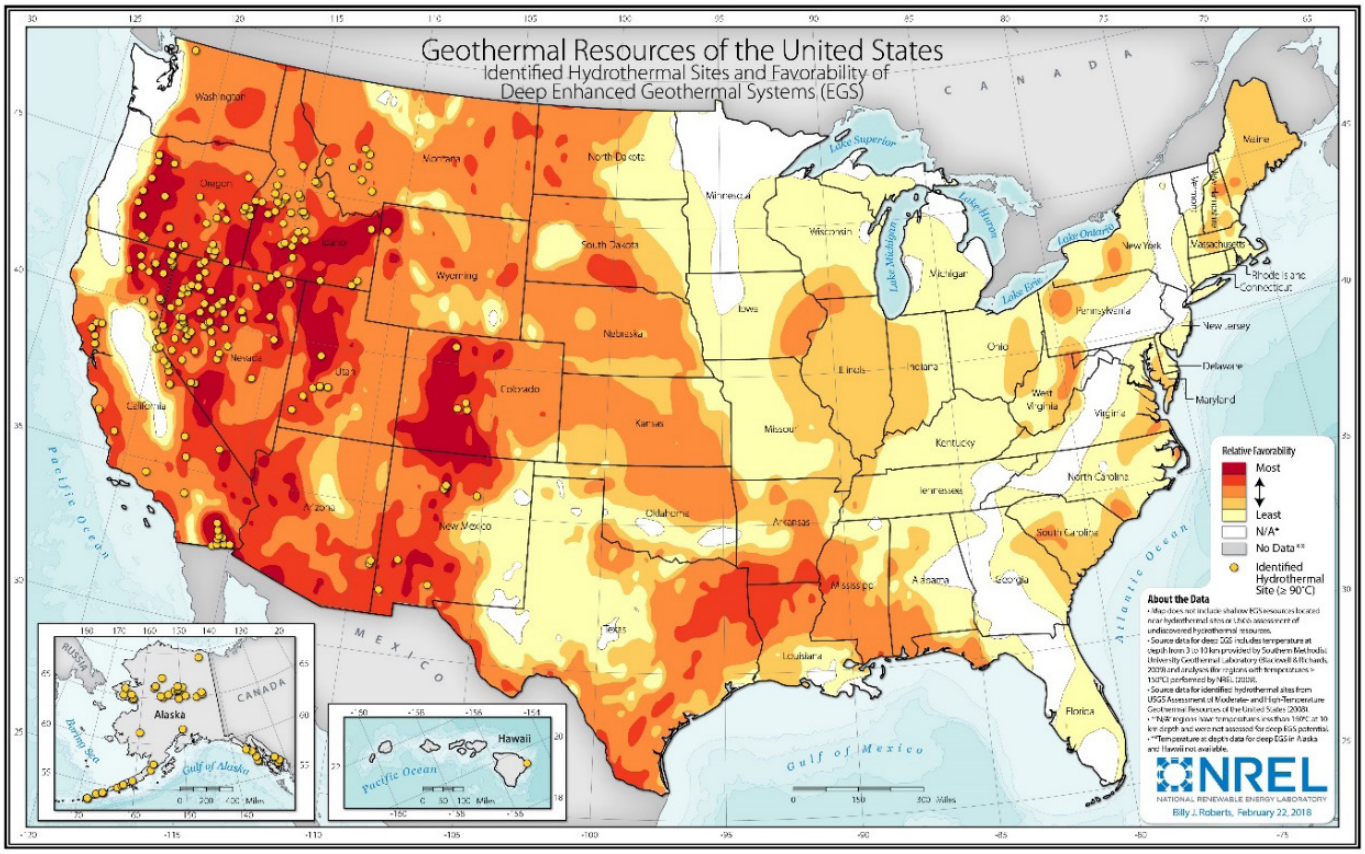


*Figure 1: Geothermal Resources map of the United States, from the National Renewable Energy Laboratory, created by Billy J. Roberts (February 22, 2018). https://www.nrel.gov/gis/geothermal.html*

environmental threat from the heavy metals and other toxic elements that can come up with the produced water. These span the periodic table from mere salt to arsenic, boron, and mercury, among others.[8] If these materials are not managed, they can contaminate the soil and water.

Geothermal power plants take up less land than other renewable power sources. Because geothermal power is collected mainly in geologically active areas, such as tectonic plate boundaries, there is some evidence that the withdrawal and reinjection of steam or water can cause small tremors.[9]

## Endnotes


1 Alexander Richter, “Geothermal energy is least land-use intense source of the renewable energy technologies,” Think GeoEnergy, January 22, 2021, https://www.thinkgeoenergy.com/geothermal-energy-is-least-land-use-intense-source-of-the-renewable-energy-technologies/

2 Encyclopedia Britannica, “Geothermal energy,” Retrieved January 19, 2023, from https://www.britannica.com/science/geothermal-energy

3 *Ibid*.

4 Robert Tilling *et al.,* “Plate tectonics and the Hawaiian Hot Spot,” Geology.com, Retrieved January 19, 2023, from https://geology.com/usgs/hawaiian-hot-spot/

5 U.S. Department of Energy, “Geothermal Technologies Program,” Retrieved January 19, 2023, from https://www.nrel.gov/docs/fy04osti/36316.pdf

6 U.S. Department of Energy, “Enhanced Geothermal Systems,” Office of Energy Efficiency and Renewable Energy, Retrieved January 19, 2023, from https://www.energy.gov/eere/geothermal/enhanced-geothermal-systems

7 Aras Karapekmez and Ibrahim Dincer, “Modelling of hydrogen production from hydrogen sulfide in geothermal power plants,” *International Journal of Hydrogen Energy*, Vol .43, Issue 23, pp. 10569–10579, June 2018, https://www.sciencedirect.com/science/article/abs/pii/S0360319918303987

8 J.E. Sabadell & R.C. Axtmann, “Heavy metal contamination from geothermal sources,” *Environmental Health Perspectives*, Vol. 12, December 1975, pp. 1-7, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1475015/

9 U.S. Geological Survey, “Why are there so many earthquakes in the Geysers area in Northern California?” Retrieved January 19, 2023, from https://www.usgs.gov/faqs/why-are-there-so-many-earthquakes-geysers-area-northern-california