

GEOHERMAL POWER

There are immense quantities of heat trapped beneath the earth's surface. Geothermal plants pipe steaming water up to the earth's surface, where they use it to turn turbines that generate electricity. In contrast to geothermal heating, which can be deployed in a distributed fashion to heat individual homes and buildings, geothermal power requires utility-scale power plants that can accommodate large turbines and generation systems. There are two types of geothermal energy production: hydrothermal power (which uses natural sources of hot underground water) and enhanced geothermal power (EGS, in which water is pumped down into hot underground rock to create a hot underground reservoir that can be used to power a geothermal power plant).¹

In the U.S., geothermal power represents 2,587 MW in installed capacity,² but the U.S. has tapped less than 0.7% of geothermal electricity resources to-date³ Hydrothermal potential is exclusively located in the western states, Alaska, and Hawaii, which together account for 38 GW in potential capacity.⁴ EGS potential is found in all states except Alaska and Hawaii, but it is most concentrated in the Rocky Mountain states. However, much of this potential occurs on protected lands and may not be available for exploitation. Identified EGS sites represent 4,000 GW in potential capacity.⁵

Geothermal power produces a small amount of GHG emissions during operation. The steam brought up from beneath the Earth's surface can contain carbon dioxide, hydrogen sulfide, methane, ammonia, and radon. In open-loop systems, these molecules are released and they can contribute to global warming as well as acid rain. In closed loop systems, gases removed from the well usually injected back into the ground after releasing their heat,⁶ and the only emissions are in the form of water vapor. On average, geothermal plants emit only 37 kg CO₂/MWh of electricity generated, while for reference, coal plants produce over 1,000 CO₂/MWh.⁷

¹ DOE. "What is an Enhanced Geothermal System (EGS)?"

https://www1.eere.energy.gov/geothermal/pdfs/egs_basics.pdf

² IRENA. 2021. *Renewable capacity statistics 2021*. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Apr/IRENA_RE_Capacity_Statistics_2021.pdf

³ University of Michigan Center for Sustainable Systems. "Geothermal energy factsheet." <https://css.umich.edu/factsheets/geothermal-energy-factsheet>

⁴ NREL. 2012. *U.S. renewable energy technical potentials: A GIS-based analysis*. <https://www.nrel.gov/docs/fy12osti/51946.pdf>

⁵ NREL. 2012. *U.S. renewable energy technical potentials: A GIS-based analysis*. <https://www.nrel.gov/docs/fy12osti/51946.pdf>

⁶ USFWS. "Energy technologies and impacts: geothermal energy." <https://www.fws.gov/ecological-services/energy-development/geothermal.html>

⁷ NREL. 2021. "Life cycle greenhouse gas emissions from electricity generation: Update." <https://www.nrel.gov/docs/fy21osti/80580.pdf>

Subsurface fluids brought to the surface by geothermal power can also contain traces of toxic chemicals like sulfur, chlorides, silica compounds, vanadium, arsenic, mercury, nickel and other toxic heavy metals. If released into the environment, these materials can create localized fish and wildlife kills, but if they are properly handled and disposed of, risk can be minimized. Geothermal resource development is often highly centralized, so reducing their environmental impacts to an acceptable level is achievable.

Geothermal power plants require large amounts of water for cooling or other purposes. This need could raise conflicts with fish spawning and rearing in areas where water is in short supply.⁸ Additionally, geothermal construction has in some cases caused subsidence and affected land stability, and in the case of plants that re-inject fluids back into the Earth, geothermal power can cause mini-earthquakes.⁹

In contrast to technologies like solar and onshore wind, which have seen incredible growth rates in the last ten years, the installed capacity of geothermal power has remained stable.¹⁰ Although the energy source is free, the upfront costs of tapping wells for geothermal is expensive and there is a high risk of failure.¹¹ Investment in geothermal power can be supported through utility standards and mandates (e.g., interconnection standards, renewable portfolio standards), direct cash incentives (e.g., grants and feed-in tariffs), regulatory provisions (e.g., delineated resource ownership, expanded transmission infrastructure, single agency permitting, and standardized leasing and permitting practices), tax incentives, financing, outreach and training, and lead-by example policies.^{12, 13}

- Fishery friendliness: Localized impacts to freshwater ecosystems can occur if toxic chemicals that are naturally found in sub-surface fluids are released into the environment during production of geothermal power; this can be avoided through proper handling and disposal. Geothermal power plants tend to use large amounts of cooling water, which can impact aquatic resources through competition for available water resources in areas where water is scarce, and through thermal pollution.
- Co-benefits: None.
- Environmental externalities: Geothermal systems can have impacts on air and water quality. Open-loop systems can release contaminants that contribute to global warming and acid rain; this can be avoided through preference for closed-loop systems. Geothermal power production has in some cases caused land subsidence and mini-earthquakes.

⁸ USFWS. "Energy technologies and impacts: geothermal energy." <https://www.fws.gov/ecological-services/energy-development/geothermal.html>

⁹ Project Drawdown: "Geothermal power." <https://drawdown.org/solutions/geothermal-power>

¹⁰ IRENA. "Geothermal energy." <https://www.irena.org/geothermal>

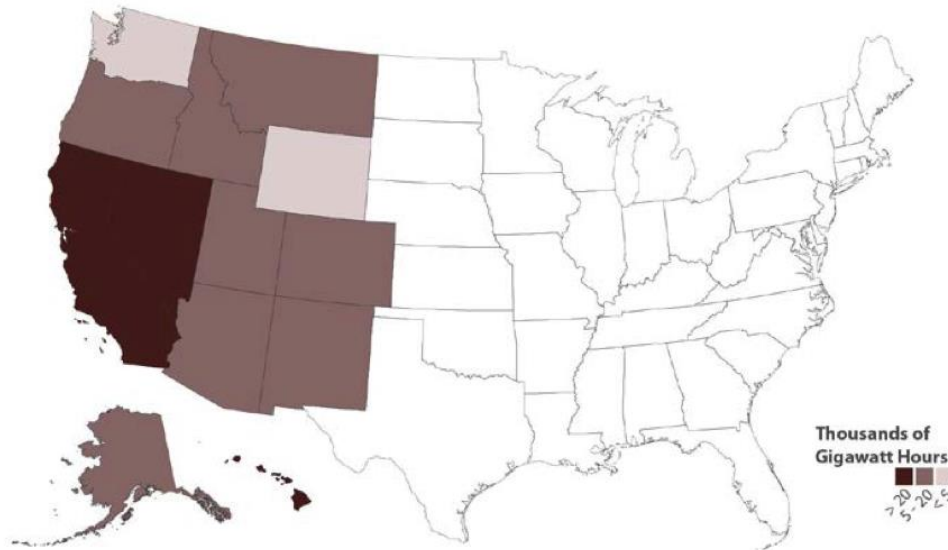
¹¹ Project Drawdown: "Geothermal power." <https://drawdown.org/solutions/geothermal-power>

¹² NREL. *Policy makers' guidebook for geothermal electricity generation*. <https://www.nrel.gov/docs/fy11osti/49476.pdf>

¹³ Project Drawdown: "Geothermal power." <https://drawdown.org/solutions/geothermal-power>

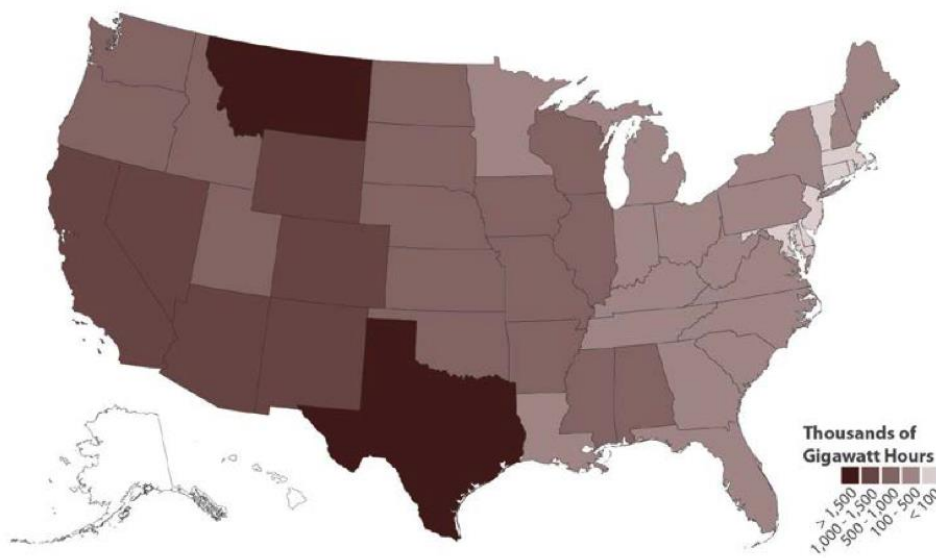
- Policy catalysts: Geothermal power can be supported through tax incentives, power purchase agreements, public investment in research and resource mapping, standard offer contracts including feed-in tariffs, carbon pricing, and renewable/clean energy portfolio standards.
- More information:
 - [Drawdown: Geothermal power](#)
 - [U.S. Energy Information Administration: Geothermal explained](#)
 - [IRENA: Geothermal power](#)
 - [NREL: Geothermal energy basics](#)
 - [Wikipedia: Geothermal power](#)
 - [Roberts, David \(October 21, 2020\). "Geothermal is poised for a big breakout." Vox.](#)

Figure 1. Total estimated technical potential for hydrothermal power in the U.S. Source: NREL 2012.¹⁴



¹⁴ NREL. 2012. *U.S. renewable energy technical potentials: A GIS-based analysis*. <https://www.nrel.gov/docs/fy12osti/51946.pdf>

Figure 2. Total estimated technical potential for EGS in the U.S. Source: NREL 2012. ¹⁵



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¹⁵ NREL. 2012. *U.S. renewable energy technical potentials: A GIS-based analysis*.
<https://www.nrel.gov/docs/fy12osti/51946.pdf>