



Accelerating Geothermal Research

Geothermal research at the National Renewable Energy Laboratory (NREL) is advancing geothermal technologies to increase renewable power production. Continuous and not dependent on weather, the geothermal resource has the potential to jump to more than 500 gigawatts in electricity production, which is equivalent to roughly half of the current U.S. capacity. Enhanced geothermal systems have a broad regional distribution in the United States, allowing the potential for development in many locations across the country.

Supporting a Cleaner Environment

NREL is a strategic partner of the U.S. Department of Energy (DOE) Geothermal Technologies Office (GTO). NREL teams are leading the research and deployment efforts through various projects. Summaries of a few key activities follow.

Geothermal-Solar Hybrids: The objective is to examine the viability of using solar thermal heat combined with geothermal energy to improve plant efficiency and reduce cost. This project, performed by NREL and the Idaho National Laboratory, evaluates the potential and feasibility of using solar heat to mitigate the risks and consequences of an underperforming geothermal resource. NREL is studying the adverse impacts of seasonally higher summer ambient temperatures on plant output, and thus, how to improve the economics of geothermal energy and contribute to goals of reducing the levelized cost of energy (LCOE) of new geothermal systems.

Low-Temperature and Coproduced Resource Demonstration: This project demonstrates the coproduction of geothermal energy during operations in oil and gas production. The demonstration validates a novel application of geothermal energy in a large untapped resource. In addition, the study collects a large dataset of operating performance that optimizes future commercial systems.

Low-Enthalpy Geothermal Desalination: While thermal desalination of saline water is energy-intensive, rejected



The largest geothermal field in the world is The Geysers, near San Francisco. NREL has worked with Calpine Corporation, the owner and operator of most of The Geysers geothermal power plants, to apply R&D 100 Award-winning technology to plants to improve performance. Photo from Pacific Gas & Electric, NREL 00060

NREL's core capabilities that support office goals include:

- **Analysis** that informs GTO decisions in the development of near- and long-term geothermal technologies through strategic and techno-economic analysis. Identification of opportunities to mitigate market barriers provides an important boost to the prospects for near-term geothermal systems.
- **Power Systems Engineering** contributes to improved energy conversion components developed in R&D activities leading to reductions in the levelized cost of energy (LCOE) of geothermal energy. These skills are also applied to field demonstrations of geothermal technology ensuring that engineering improvements are captured for use by the private sector.
- **Systems Engineering and Integration** ensures issues that occur at system interfaces (e.g., the interaction of reservoir lifetime performance with the above-ground energy conversion system) are properly recognized, evaluated, and optimized for overall system performance and cost.
- **Decision Science** aids geothermal technology stakeholders with access and understanding of information relevant for identifying and efficiently developing geothermal resources. Examples include support for the National Geothermal Data System and the Geothermal Prospector.

geothermal brine provides large quantities of low-grade heat for the various processes, like desalination.

Results of the project provide DOE with insight into the potential impacts and technology challenges related to geothermal desalination. The project expands a desalination decision support software tool developed by project partner Colorado School of Mines. The data and tools developed in the project allow stakeholders to identify the most efficient and suitable desalination processes for site-specific applications.

Exploration Analysis and Open EI: The exploration phase of geothermal projects is very uncertain; thus, its successful completion remains one of the greatest challenges for increased deployment. Previous work by NREL related to exploration analyses involved development of an exploration knowledge exchange framework on OpenEI—an NREL-sponsored energy information exchange (en.openei.org).

Sedimentary Geothermal Potential: Commercial development of low-permeability sedimentary geothermal systems would greatly expand the size of the geothermal resource potential. NREL's Sedimentary Geothermal Feasibility Study uses technoeconomic modeling to focus on a sedimentary basin with relatively low permeability, and studies reservoir enhancement techniques, including hydraulic fracturing, hydraulic



One of Calpine's 15 geothermal power plants at The Geysers, the Big Geyser plant has an installed capacity of 97 megawatts. Big Geyser has been in operation since 1980 and is a dry steam-type geothermal power plant. Photo from Calpine Corporation, NREL 17270



An NREL senior geothermal analyst examines a heat sensor order before the wire attached to the sensor descends 500 feet under the new IKEA store construction site in Centennial, Colorado. The new store relies on geothermal heat pumps to supply much of its heating, cooling, and hot water needs. Photo by Pat Corkery, NREL 17907

stimulation, and long-reach horizontal completions to increase reservoir productivity to commercial levels.

Drilling and Completion Systems: NREL identifies oil and gas drilling and completion practices (methods and technologies) that can be transferred to geothermal drilling and completion, to

provide the geothermal industry with more effective, lower cost and lower risk methods. The project, a joint effort with the Colorado School of Mines, identifies pathways for technology transfer and advises GTO about opportunities to accelerate technology transfer and testing of petroleum best practices for geothermal.

Regulatory and Permitting Information Desktop (RAPID) Toolkit: Reducing the permitting time, or reducing the number of required permits, can significantly lessen total project costs and investor risk, encouraging clean energy developments for the benefit of all stakeholders. Building on the success of the Geothermal Regulatory Roadmap at improving outcomes for federal permitting and review of infrastructure projects, NREL is partnering with others to create a new suite of tools to facilitate efficient permitting of new geothermal, solar, and transmission projects—the RAPID Toolkit (en.openei.org/wiki/RAPID).

Geothermal Prospector: Access to a wide range of data is critical to the development and adoption of geothermal technology. Everything from geologic maps, temperature measurements, land cover, land ownership, the potential to support other energy technologies, and population areas are needed to understand technology limitations and opportunities. NREL's Geothermal Prospector (maps.nrel.gov/) aims to provide easy access to publicly available data generated through DOE and other institutions.

A hot spring near Steamboat Springs, Colorado, is a visually obvious geothermal resource. Especially in many proven and potential geothermal resource sites in the western United States, geothermal energy is right under our feet. Photo from Sierra Pacific, NREL 07215



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