Geothermal pumped well power projects

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Geothermal pumped-well power projects are a growing niche within the larger geothermal industry, contributing approximately 1000 MWe of installed generating capacity to the global energy mix.

These projects utilize the moderate temperature range of geothermal fluids between 100-190°C. Below this temperature, geothermal fluids are generally used for direct heating and above this the fluids are produced as steam and water with the steam providing the motive force in power generation. Pumped-well power projects maintain the geothermal fluid in single liquid phase throughout the production, power cycle and re-injection processes.

Pumped-well geothermal projects utilize "binary" power plant technology which consists of Organic Rankine Cycle (ORC) heat exchangers. The geothermal fluid is pumped from the wells through the ORC units and re-injected back into the subsurface reservoir. The working fluids used in the heat exchangers are re-cycled and do not come in contact with the geothermal fluids. Binary units are also sometimes used to produce power from the separated water of high temperature geothermal resources.
This article is the first of a series of three installments that will cover a range of topics including a global overview of operating pumped-well projects and subsurface characteristics (this article), pump hydraulics and energy conversion (second in the series), and economics and emerging technologies.

Global Overview of operating projects

Pumped-well geothermal power projects are primarily located in the Western U.S., but growth of these type of projects has occurred in recent years to include Europe, Turkey, and Honduras.

In this overview of operating pumped-well projects, installed capacities are given in Megawatts electric (MWe), sometimes referred to as nameplate capacity. Pumped-well projects consume 20-25% of their gross electrical generation for own use (mostly for the pumps). Net generation delivered to the power grid is also determined by on-line availability, which varies from 70-90% for most of these types of projects. Generation data is stated in Gigawatt hours (GWh), net delivered to the grid (if available).

Nevada and the Western US

Largest concentration of geothermal pumped-well power projects in the world, spread over some 15 fields.

Largest pumped-well project in the world is McGuiness Hills, with installed capacity estimated between 150-170 MWe (gross).

The Steamboat geothermal complex is second in size with 80-150 MWe installed capacity.

Most of the Nevada projects produce fluids in the range of 120-180°C, however Nevada also contains the lowest reported resource temperature (~100°C at Wabuska) of any pumped-well geothermal power project worldwide.

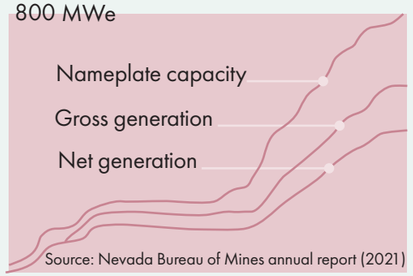
The prolific **Basin and Range geothermal province** in Nevada is attributed to the high heat flow and extensional tectonic setting of the region.

Most of the geothermal activity in the region occurs along faults and cannot be attributed to any recent shallow magma sources. Extensional faulting is required to generate productive geothermal systems, with the fault zones enabling both the upflow of hot fluids and the high permeability characteristics of these systems.

Much of the geothermal production in Nevada comes from **Miocene age volcanic or sedimentary rocks**, although production ranges from Pliocene alluvium to Mesozoic crystalline basement. In general, the geothermal production zones are between 500-1500 meters in depth.

~720 MWe
installed capacity

Growth of Nevada geothermal sector



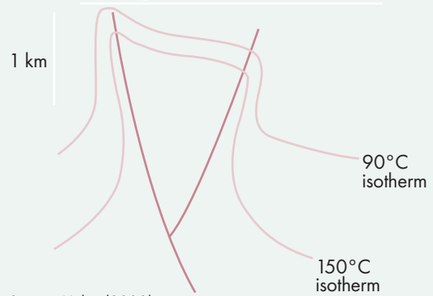
Honduras

One operating geothermal field, the Platanares pumped-well project

Commissioned in 2017 at 35 MWe (gross) capacity.

~35 MWe
capacity

Subsurface temperature anomalies in Basin and Range



Source: Hulen (2008)

Germany

Around 8 power projects in the Bavaria region (**Molasse Basin**) between 3 to 5.5 MWe (gross) installed capacity each. The **Malm limestone** is the primary target of these projects, often containing fracture or dolomitized zones that enhance permeability.

2 projects in the **Rhine Graben** region. The primary target is the **Triassic Buntsandstein**, which consists of interbedded sandstones and claystones with permeability controlled by faulting.

Limited number of geothermal power projects in Europe; exceptions are Velika Ciglena in Croatia (reported as 17 MWe) and Tura in Hungary (reported as 3 MWe).

Geothermal wells for power production in the Molasse Basin and Rhine Graben are generally drilled to depths between 3,500-4,500 meters, significantly deeper than projects elsewhere.

~47 MWe
installed capacity (2021)

Turkey ~300 MWe

installed capacity

Probably one operating project that uses pumped wells (15 MWe Buharkent project).

High CO_2 has precluded the use of pumping

California ~160 MWe

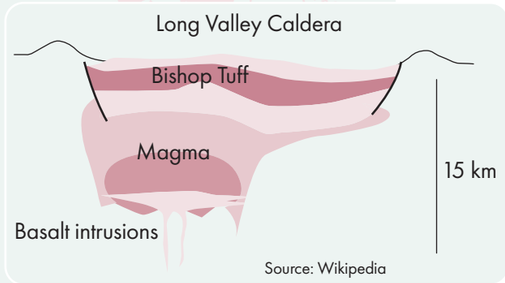
installed capacity

Ormesa complex in Southern California was the largest pumped-well geothermal project in the world (80 MWe). In recent years the Ormesa fields have been reduced to 36-48 MWe capacity due to cooling in the reservoir as a result of both reinjection of the produced fluids and incursion of cooler water from surrounding aquifers.

The other major pumped-well projects in California are Heber and Mammoth. The pumped-well portion of Heber (known as SIGC) had an original design criteria of 34 MWe, and subsequent updates on the Heber project indicate that it has performed as originally designed over a period of 30 years.

The Ormesa and Heber pumped-well geothermal fields both occur in the **Salton Trough**, a prominent continental rift basin that straddles Southern California and Northern Mexico. The main geothermal reservoir in the Salton Trough are **Pliocene age high poro-perm** sandstones. These sandstones are capable of supporting the high flow rates typical of pumped geothermal wells. Though faulting is known in these areas, porosities of 20-30% and permeability-thickness of 10-60 Darcy-meters (D-m) are characteristic of the sandstone matrix in these fields.

The Mammoth pumped-well project is located in the Eastern Sierra mountain region of California and consists of approximately 65 MWe (gross) installed capacity, including a recent 30 MWe expansion reported in 2022. The project consists of pumped wells completed in recent volcanic formations of the **Bishop Tuff and overlying lavas**. These formations are **very recent** (< 1 million years) and are associated with resurgent dome activity within the Long Valley Caldera.



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