GEOTHERMAL SYSTEMS IN UTAH

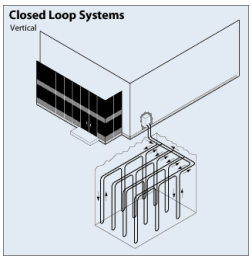
The following is a description of the three types of geothermal systems in operation, or under development, in Utah include, from low temperatures to high temperatures. These three types are: 1) Heating-Cooling Exchange; 2) Direct Use Geothermal; and 3) Geothermal Power Production.

HEATING-COOLING EXCHANGE

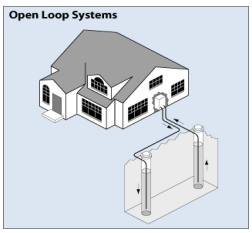
(aka ground source heat pump, geothermal heat pump)

These systems use the natural heat energy in the shallow ground and groundwater, and they do not require warm, moderate or high temperatures to operate. Two types of heating-cooling exchange systems are utilized in Utah including:

- **Closed-loop heat pump systems** utilize the earth's natural temperature to heat or cool buildings without removing groundwater from aquifers. These systems consist of one or more borings containing a closed-loop of HDPE tubing, and the tubing is completely sealed with grout inside the boring from bottom to top. Boring depths range near the surface to 400 feet. A non-toxic working fluid (e.g., propylene glycol) is then circulated through the tubing, then through a heat exchanger above ground to produce heating or cooling. These systems are considered non-production wells and regulated by the State Engineer's office under R655-4 UAC.



- **Open-loop heat pump systems** utilize the heat energy in pumped groundwater to heat and cool buildings. These systems typically consist of a production well and an injection well. Groundwater is pumped from the production well, circulated through a heat exchanger, then injected back into the same aquifer via an injection well. Groundwater used is naturally cold groundwater. Since these systems remove groundwater to the surface for a beneficial use, a water right is required. Because groundwater removed must be injected back into the same aquifer from which it came, the water right can be considered non-consumptive use. These systems are permitted and regulated by the State Engineer's office.



DIRECT USE GEOTHERMAL

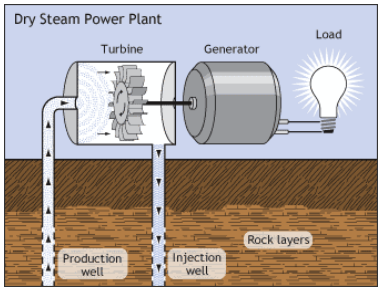
Direct use applications use low- to moderate -temperature (<120° C / <248° F) groundwater from wells or springs for direct applications such as heating greenhouses, buildings, recreation facilities (spas, bathing, swimming, diving), etc.

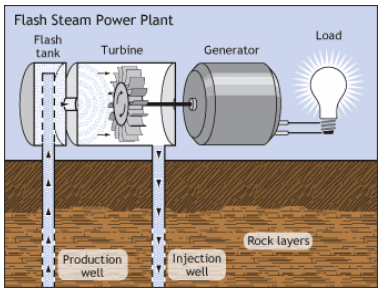
Low- to moderate-temperature groundwater is removed via a well and directly utilized for heating these applications. Direct use geothermal is considered a beneficial use and a water right is required as per Utah Water Rights law (Section 73 UCA). Direct use systems are permitted and regulated by the State Engineer's office.

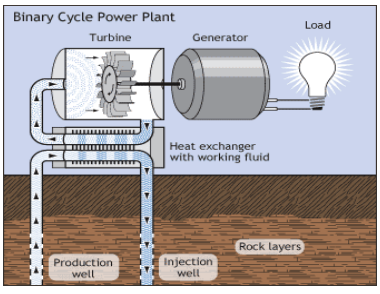
GEOTHERMAL POWER PRODUCTION

Geothermal systems containing high-temperature geothermal resources and fluids can be utilized for the production of electricity. High-temperature geothermal resources (>120° C or 248° F) used for power production are governed under the Utah Geothermal Resource Conservation Act (Section 73-22 UCA), Utah Water Rights law (Section 73 UCA) and administrative rules for Wells Used for the Discovery and Production of Geothermal Energy in the State of Utah (R655-1 UAC), and the State Engineer's office has regulatory authority. Three geothermal power production types being used or developed in Utah include:

- **Traditional Geothermal (aka Hydrothermal) Systems:** Wells are drilled into hot fractured rock which contain groundwater. Electricity is generated by a turbine-generator plant fed from the wells by direct dry steam, steam flashed at the

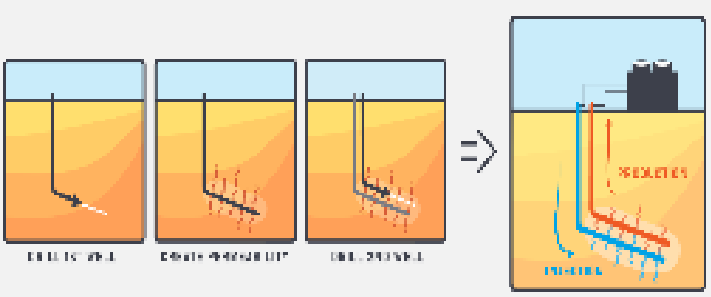






surface, or hot groundwater flashing a working fluid in a binary cycle system. Spent geothermal fluids are then injected back into the geothermal reservoir from which they came. Power production from hot groundwater (steam or brine) is considered a beneficial use, and a water right is required for this type of system.

- **Enhanced/Engineered Geothermal Systems (EGS):** EGS is a man-made geothermal reservoir, created where there is hot rock but insufficient or little natural permeability or fluid saturation. Two or more wells are directionally drilled adjacent to one another. The rock between the wells are then hydraulically fractured to create permeability between them. Water is then injected into a well and through the hot fractured rock, where it picks up heat energy and then brought back to the surface via an adjacent production well. This now hot water can then generate electricity through a binary cycle turbine generator plant at the surface. Once through the plant, the spent water is recirculated back into the injection well and the process repeats.



- **Advanced Geothermal Systems (AGS):** AGS wells are deep, large, artificial closed-loop circuits in which a working fluid is circulated and heated by subsurface rocks/sediments through conductive heat transfer. In essence, these systems are deep closed-loop heat exchangers. Two or more wells are directionally drilled into deep hot rocks or sediments with the intent of maximizing the surface area between the wells and the hot rock/sediments. Using advanced drilling technologies, wells are connected at depth to make a closed circuit. The wells are completely cased and sealed so no groundwater or geothermal fluids can enter the closed-loop system. A working fluid is then circulated through the closed loop to gather heat energy. Once brought back to the surface, this working fluid is then used to generate electricity through a modular binary cycle turbine generator plant. The spent working fluid is then reinjected and continues to recirculate through the system.