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FACILITIES OPERATIONS

University of Connecticut

Carbon Neutral Task Force
Meeting #7

March 2023

Agenda

- Geothermal Discussion

Geothermal Discussion

Geothermal Power

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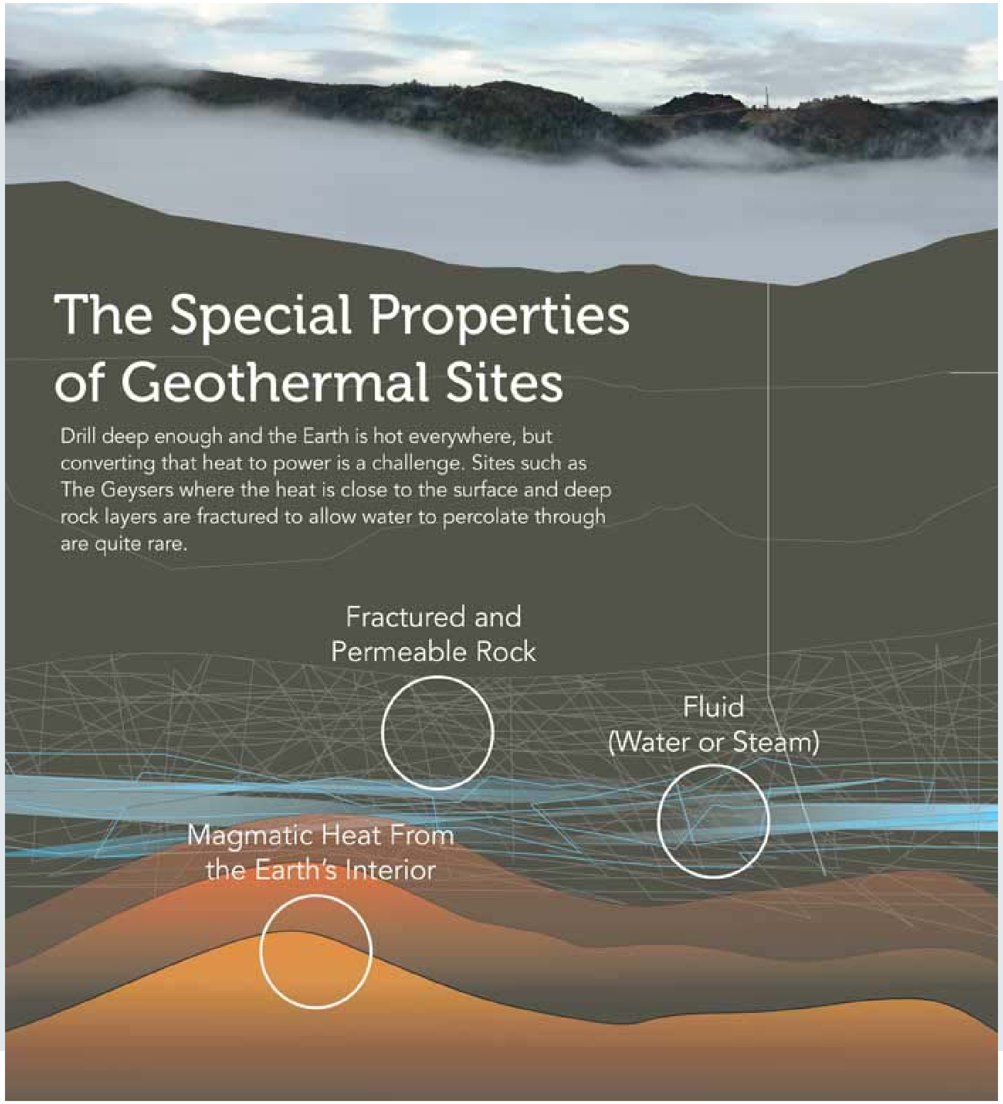
- Generation of electrical power is possible, but at production scale currently requires unusual geological conditions that trap steam deposits close to the surface:
    - Fractured or permeable rock that is saturated with fluid and both in contact with magma and close enough to the surface to be tapped with wells.
    - A thin confining layer (low permeability rock, clay) that traps the heated fluid.
    - Deep rock wells are drilled to create controlled/artificial geysers that generate electricity using traditional turbine technology.



Geysers Geothermal Complex -California

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- Placed in operation in the 1960s, located in California. Harvested steam from naturally occurring deposits, and injected steam condensate form power production back into the reservoir.
- By 1989, steam extraction had depleted the steam deposits, lowering steam pressure and energy production.
- The reservoir was renewed by the transport and injection of treated wastewater effluent from communities including Santa Rosa, CA.
- This reservoir renewal has allowed the Geysers geothermal complex to grow, now with 13 power plants with a generating capacity of 725 megawatts that provide 9% of California’s renewable power.

Broader Application for Geothermal Energy

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Ground Source Heat Exchange

- Ground source heat exchange utilizes relatively stable subsurface temperatures (~55 degrees in CT) as a thermal source and sink to provide year-round heating, cooling, and hot/chilled water.
- Ground source heat exchange may use a shallow horizontal well field (for systems designed for stable soil temperatures) or a vertical well field (systems designed to utilize the geothermal gradient – changing temperature with depth).
- The most common use of ground source heat exchange is as the method of heat exchange for a traditional heat pump.
- Institutional users are also beginning to use ground source heat exchange for “district energy”.

Ground Source Heat Exchange (contd)

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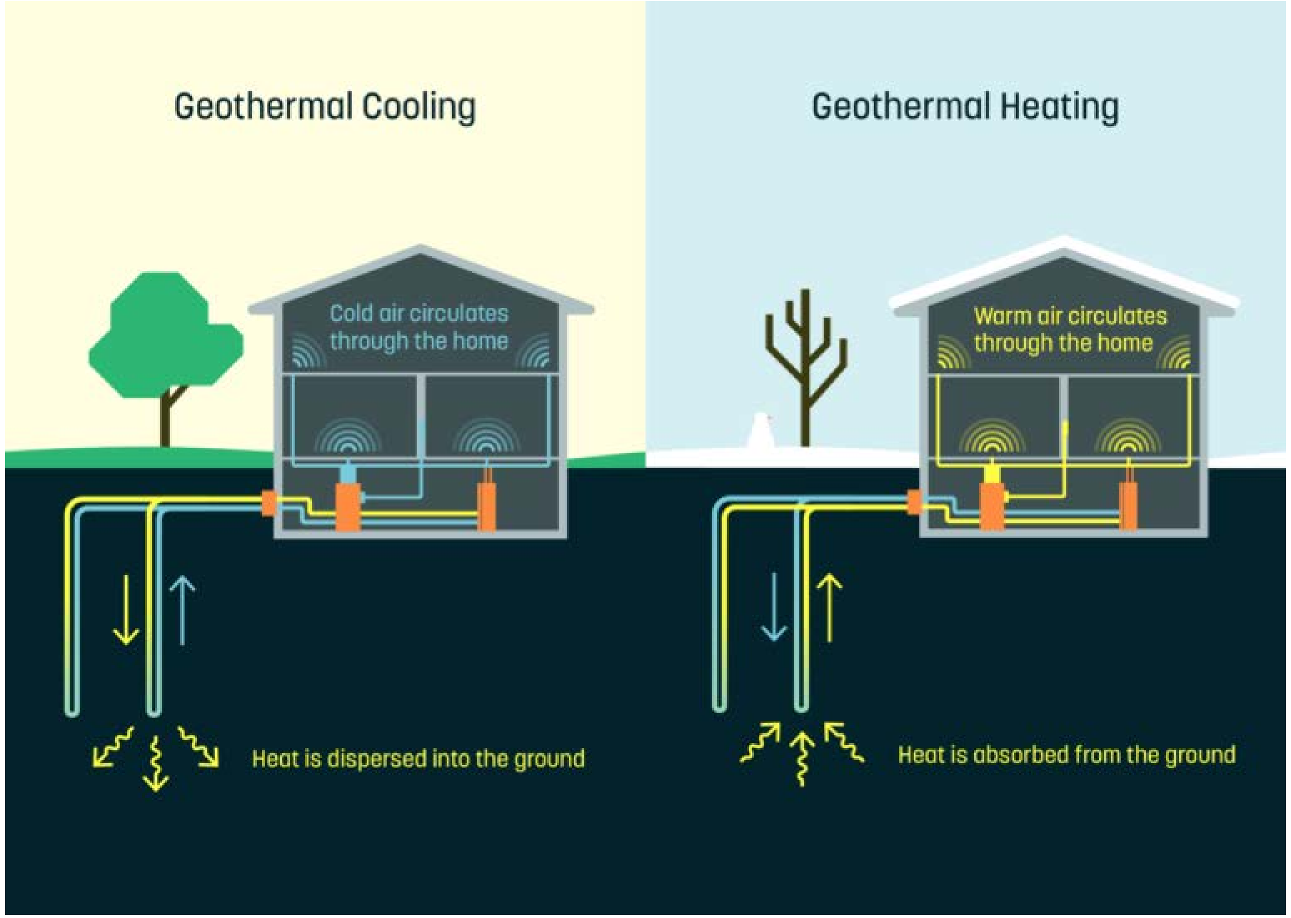
- Geothermal heat pumps may circulate water through closed horizontal or vertical piping installed in drilled wells or an open excavation, may directly use groundwater from drilled wells in the heat pump, or may exchange heat in a body of water such as a pond or lake.

- Closed piping is mostly commonly used as it allows for controlled conditions, is suitable for most sites, and minimizes environmental impact.

- Geothermal heat pumps may be used in any climate, but the systems must be properly sized to meet seasonal peak loads, or supplemental heating/cooling (such as electric baseboard heaters) may be used to reduce peak loads.

- Geothermal exchange heat pumps are significantly more efficient to operate than traditional air exchange heat pumps. Both require electricity to operate.



Scaling Up

District Geothermal Heat Exchange for Institutions

- District geothermal systems are used to heat and cool buildings via a network of distribution pipes and heat pumps, and utilize one or more plants.
- Most geothermal district energy systems in the U.S. were installed during the "energy crisis" of the 1970s and early 1980s, but the technology is seeing renewed interest among institutions committed to emissions reductions.
- Typically, low temperature hot water produced by heat exchangers tied to geothermal well fields is used to heat buildings, partially or totally replacing existing steam infrastructure.

Considerations for District Energy

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- Systems are sized to the energy demand profile of buildings. Under or over sized systems, outset of operational tolerances, will not perform well (may fail/strain to meet demand, result in moisture issues, etc.). Several years of energy use data at full/typical occupancy after construction or energy efficiency improvements are ideal.
- Peak shaving via heating and/or cooling by existing/conventional methods may be necessary for peak demand days.
- Current, future, and potential availability of land for geothermal well fields, as well as other identified uses of this land should be considered to avoid conflicts and assess available capacity for well installation.
- Subsurface condition including, but not limited to: the groundwater table elevation, groundwater chemistry, other uses of and outlets for this groundwater (surface water bodies, extraction for potable use, etc.), and the hydraulic conductivity (capacity to transmit water) of bedrock and overburden deposits. Subsurface explorations have a degree of uncertainty due to limitations of available methods, horizontal heterogeneity, etc.

Project Overview - Carleton College District Geothermal

- District geothermal systems are used to heat and cool buildings via a network of distribution pipes and heat pumps, and utilize one or more plants.
- Most geothermal district energy systems in the U.S. were installed during the "energy crisis" of the 1970s and early 1980s, but the technology is seeing renewed interest among institutions committed to emissions reductions.
- Typically, low temperature hot water produced by heat exchangers tied to geothermal well fields is used to heat buildings, partially or totally replacing existing steam infrastructure.

Project Details – Well Fields

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- The project includes 3 geothermal borehole fields – 1 horizontal and 2 vertical and 320,000 linear feet (approximately 6 miles) of piping.
- The horizontal bore field consists of 95 horizontal bores, which were installed under a playing field that was restored to use after installation. The depth of the bores varies from 15 to 30 feet.
- The vertical bore fields are located at surface features called the "Bald Spot" and "Mini Bald Spot", and contain 210 boreholes between them. The wells are 520 feet deep.

Project Details – East Energy Station

- While Carleton has a large campus relative to student population, much of their land is restricted in use.

- The geothermal energy project required new equipment and distribution infrastructure that could not be located in the steam plant.

- The solution – put the distribution piping and equipment under the basement of the new science center, Evelyn Anderson Hall. This subterranean facility is known as the "East Energy Center".

Other campus projects of interest

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- Smith College – Field House test boring (1000 foot test and research geothermal borehole), and steam to geothermal conversion. Institutional commitment – carbon neutrality by 2030.
- Princeton University low-temperature hot water for campus expansion (Tiger CUB) . Institutional commitment – carbon neutrality by 2046.

Open Discussion