Supplement

Geothermal Cooling for Gas-Powered Data Centers in Pennsylvania

A single ChatGPT query consumes nearly ten times the electricity of a standard Google search. In early February 2025, Goldman Sachs projected that artificial intelligence (AI) would drive a staggering 160 percent increase in demand for data center power by 2030.[1] A significant proportion of that demand is used to keep data center infrastructure cool. In fact, cooling a data center can account for up to 40 percent of its total energy consumption and 50 percent of its CO_2 emissions.

Today, Big Tech companies are racing to find locations that can support the power needed for their expanding digital infrastructure. These companies would be well-served to look to Pennsylvania and geothermal energy. That is because the Commonwealth, renowned for its abundant natural gas reservoirs and production, enjoys a near-perfect nexus of energy resources and infrastructure for building new gigawatt-scale data centers powered by natural gas and cooled with geothermal.

Pennsylvania's suitability for geothermal cooling is less commonly understood but extremely valuable for data center developers. By coupling Pennsylvania's abundant natural gas resources with its subsurface cooling resources, less energy is needed to run a data center. This means companies can run less-expensive operations, or build larger data centers with little increase in power usage. And there are substantial geothermal resources in Pennsylvania's subsurface that can be used for cooling.

Using methods Project InnerSpace developed for the IEA's recent Future of Geothermal Energy Report,[2] we found that there are about 700 gigawatts of thermal resources within 13,000 feet of the surface in Pennsylvania that can be used for cooling. A 200 megawatt data center uses about 80 megawatts for cooling, so Pennsylvania has the technical potential to cool hundreds or thousands of data centers. While not all of this resource is recoverable right now, with today's technology, there is enough subsurface potential to cool

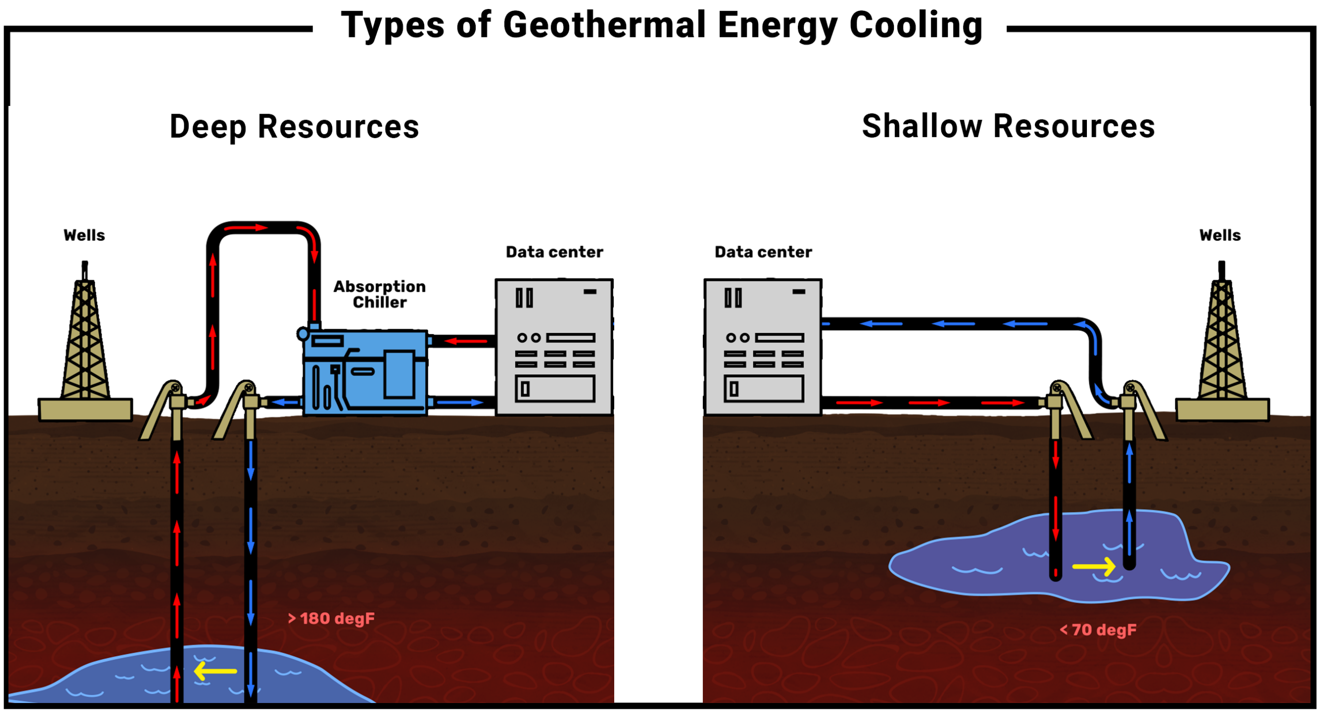

Figure 1: The geothermal resource acts as a closed circuit, where the fluid goes to the surface, delivers its energy, and is re-injected back into the subsurface to maintain the pressure and secure a long-lasting operation. Left: A deep resource requires an absorption chiller to transform the heat at 180° into cooling energy. Right: A shallow resource at less than 70° may be capable of directly providing the cooling energy to the data center.

a data center at a cost comparable to the drilling of an average onshore oil and gas well. Integrating geothermal cooling with natural gas-powered electricity reduces overall gas consumption and improves operations.

Depending on the available geothermal resources, there are two possible pathways for cooling a data center:

- A subsurface at less than 70°F allows for direct use of naturally cooled fluid to cool data centers. Examples include shallow aquifers and abandoned mines.
- A subsurface at greater than 180°F allows for the use of absorption chillers to transform hot fluids into super cold refrigerants.[3] For example, the Abu Dhabi National Oil Company (ADNOC) is using this method to provide 43°F refrigerant to cool Masdar City.

Of the 67 data centers already in Pennsylvania as of this writing—most of them close to Pittsburgh and Philadelphia—one already uses geothermal for cooling. The Iron Mountain Data Centers in Boyers, PA, uses a unique geothermal cooling system located 200 feet underground in a former limestone mine. The system uses an underground reservoir for cooling and its mechanics are not overly complex, which keeps maintenance costs low. The data center also has unlimited backup thermal storage capacity, unlike standard diesel backup generators, which can only provide energy for a limited number of hours. With this system, Iron Mountain saw a 34 percent reduction in total energy use.[4]

Integrating geothermal cooling systems with a gas-powered data center can offer several significant benefits:

1. Energy and System Efficiency

Geothermal cooling systems can significantly reduce the energy *consumption* of a data center. One study found that integrating geothermal cooling with a data center can reduce energy consumption by up to 30 or 40 percent.[5]

2. Operation and Maintenance Cost Savings

The energy efficiency gains from geothermal cooling can translate into significant cost savings for data centers. Recent studies from NREL suggest an annual cost savings of up to $1 million for a typical data center. Geothermal cooling systems can reduce energy costs by up to 30 percent compared to traditional HVAC systems.

3. Emissions Reduction

Geothermal cooling systems can help data centers reduce their carbon footprint by reducing reliance on fossil fuels. NREL found that integrating geothermal cooling can reduce CO_2 emissions by up to 50 percent.[6]

4. Water Consumption

Geothermal cooling can, when implemented as a closed-loop system, decrease the total water consumption of a data center compared to traditional cooling solutions.

5. Efficient System Design

If a data center is powered by natural gas, a geothermal cooling system can be designed to take advantage of the waste heat stream from a combined cycle gas turbine (CCGT) plant, increasing the overall efficiency of the cooling system. The same waste stream can be redirected for subsurface energy storage, thus augmenting the energy content of the cooling system. Such a design can create a significantly more energy-efficient plant.

The use of geothermal systems can also, depending on the system: offer additional benefits including a constant, secure energy supply, thereby reducing dependence on grid infrastructure; and serve as long-duration energy storage, retaining excess energy underground during periods of low demand and retrieving it when necessary.

For more information, see *Chapter 2. Where to Develop Geothermal*, and *Chapter 3: Geothermal Direct-Use Opportunities*.

CHAPTER REFERENCES

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