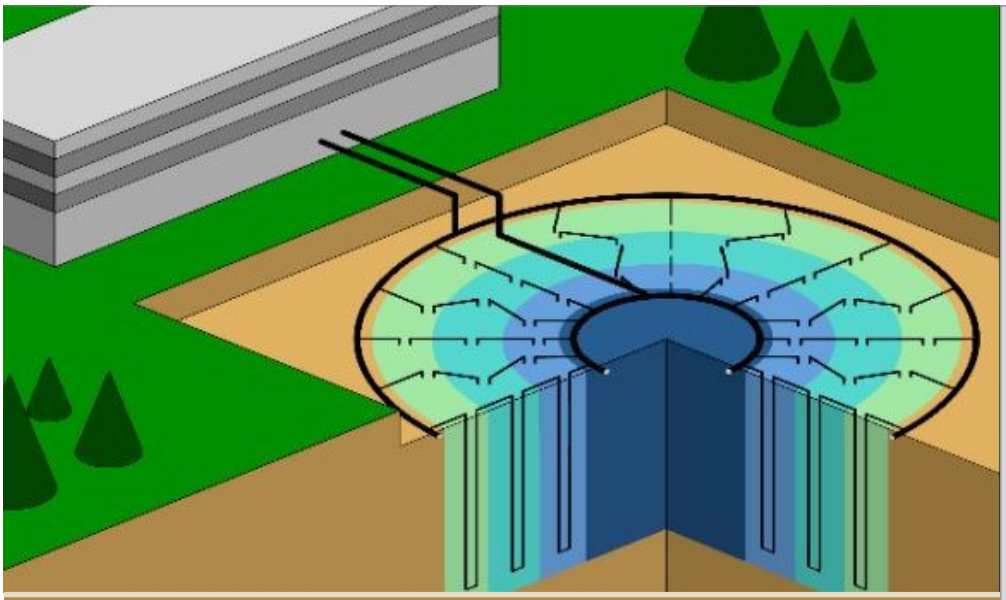
EW-201135 | MARCH 2017

Underground Thermal Energy Storage



Storing Waste Heat/Cold Underground Increases HVAC efficiency 15-48%

A borehole thermal energy storage system was installed to improve HVAC efficiency in Building 3700 at Marine Corps Logistics Base (MCLB) - Albany, GA.

► GEO-THERMAL BATTERY IMPROVES HVAC EFFICIENCY

A borehole thermal energy storage (BTES) system can store excess cold in winter and then retrieve it in the summer to satisfy building cooling needs. The system can also store excess heat in summer and release it in the winter to heat buildings.

► MORE EFFICIENT THAN TRADITIONAL GEO-THERMAL

In traditional geothermal applications the loops are designed to simply dissipate heat (or cold) into the subsurface. In a BTES system the well field is designed and operated so that heat (or cold) is stored and extracted seasonally. The analogy is that BTES uses the subsurface geology as a thermal battery, as opposed to a radiator.

► HEAT REJECTION TO "CHARGE" THERMAL BATTERY

In this cooling-dominated application, an **adiabatic dry cooler** was used in dry mode to reject heat to the atmosphere during cool weather (winter, or night), thereby charging the well field's core with chilled water for later use. Energy efficiency could be increased by running the cooler in wet mode with no need for chemical treatment.

Heating dominated applications would use a heat source like solar thermal collectors or waste heat from boilers to "charge" the well field with heat.

Technology Evaluated

BOREHOLE THERMAL ENERGY STORAGE

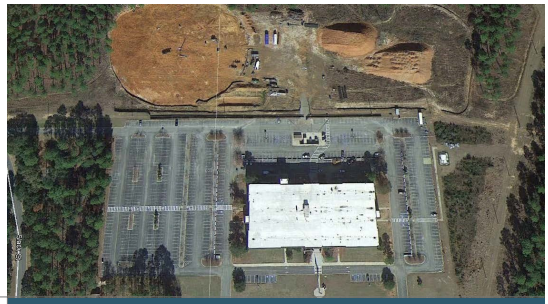
- Geothermal Heat Pumps (GHPs) coupled with Underground Thermal Energy Storage (UTES) capture the cold of winter or the heat of summer, storing it underground
- Later, during the opposite season, that stored energy is released and used by the HVAC system to increase system efficiency and reduce energy consumption
- Borehole Thermal Energy Storage (BTES) is a particular form of UTES that consists of a compact, radial loop well field that stores heat (or cold) in the geology, conveying it underground with water in a closed system that does not connect to, or have any contact with groundwater
- For this cooling-dominated application, flow and heat transfer through the vertical loops was designed to build cold in the core of the field during the heating season and extract it during the cooling season

ADVANTAGES COMPARED TO TRADITIONAL GEOTHERMAL HVAC

- **More efficient** because heat and cold that would normally be wasted, are instead captured for later use when they can benefit the building, improving system efficiency
- **Cheaper to install** than traditional geothermal because it requires fewer boreholes to deliver the same tonnage, which reduces the installed cost
- **Smaller footprint** than traditional geothermal systems because fewer boreholes can be configured in a smaller well field that consumes less real estate

BEST SUITED FOR

- Use in all 50 states, all climate zones
- Minimum peak HVAC demand of 50 tons
- Horizontal groundwater movement less than 4.3 inches (11 cm) per day or 130 feet (39m) per year to ensure the well field can effectively store thermal energy



Demonstration Site: MCLB, Albany, GA

The BTES system was demonstrated at Marine Corps Logistics Base (MCLB) - Albany, located in southwest Georgia. Building 3700 is a three-story, 168,000 square foot administration building with a maximum cooling load of 425 tons. It was constructed in 1974 of brick with a flat roof and single pane windows.

The existing HVAC system was found to be suitable for conversion to BTES since it utilized a system of chilled water air handlers and hot water re-heat, variable air volume terminal units. This system was converted to BTES by removing the existing water cooled chillers and cooling tower and installing 6 heat recovery modular chillers and 2 adiabatic dry coolers connected to a BTES system.

The BTES system consisted of 306 wells drilled 210 feet deep, set in a radial pattern so the outer layers insulated the core to preserve cooling capacity. Two adiabatic dry coolers were used in this cooling-dominated application to reject heat any time the ambient air was cool enough (winter or night), thereby storing chilled water in the well field's core for later use.

COMPARISON OF INSTALLATION COSTS

	Traditional Geo-Thermal	BTES
Site Work	$312,260	$329,487
Geothermal Drilling	$2,645,031	$1,332,514
Dry Coolers	$0	$300,000
TOTAL	$2,957,291	$1,962,001
Cost per Ton	**$6,958**	**$4,616**

Additional Resources

- **EW-201135 FINAL REPORTS AND TECHNOLOGY TRANSFER TOOLS**
  https://serdp-estcp.org/Program-Areas/Energy-and-Water/Energy/Conservation-and-Efficiency/EW-201135
- **CONTACT THE DEMONSTRATION SITE**
  Department of Public Works, Marine Corps Logistics Base Albany, BTES Office, 229-639-5693 (or 5979)
- **TECHNOLOGY USED AT DEMONSTRATION SITE**
  Andrews, Hammock, and Powell Consulting Engineers, www.ahpengr.com

Demonstration Results

ENERGY SAVINGS

48% better than air-source HVAC

15% better than traditional geothermal HVAC

WATER SAVINGS

100% compared to cooling tower

4,200,000 gallons per year

INSTALLATION COST

34% less than traditional geothermal HVAC

RESILIENCE

- Impervious to storms since the infrastructure is completely underground
- 3 tornadoes struck MCLB Albany in the year following the demonstration project, but there was no impact to the BTES system

CUSTOMER REACTION

- Following the demonstration, Marines at MCLB Albany installed 3 more BTES systems serving 10 additional facilities

COST EFFECTIVENESS

- 11 year simple payback versus conventional air-source HVAC using the following utility rates for Albany, GA

Electricity	$0.095 per kWhr
Natural gas	$0.65/therm
Potable water	$9.97/kgal

CONSIDERATIONS

- BTES systems require land near the building(s) they will support in order to accommodate a well field
  - Well depth: 200 to 400 feet
  - Well field diameter: slightly less than well depth
  - Well spacing: ~20 ft to allow space for drilling rig while keeping well field compact