FEDERAL UTILITY PARTNERSHIP WORKING GROUP SEMINAR

November 3-4, 2015
Houston, TX

Underground Thermal Energy Storage (UTES)

Via Borehole and Aquifer Thermal Energy Storage (BTES/ATES) Systems

Hosted by:

FEMP Federal Energy Management Program

CenterPoint Energy

Presented By:
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Presentation Outline

- "Direct-Use" (American) Geothermal Heat Pump (GHP) architecture vs. Geothermal designed for true Thermal Energy Storage (mostly European applications)
- Underground Seasonal (or Diurnal) Thermal Energy Storage (UTES or USTES)
- Aquifer Thermal Energy Storage (ATES) Systems
- Borehole Thermal Energy Storage (BTES) Systems
- Bonus Material (time permitting):
  - In-Situ Layered Thermal Conductivity Testing (LTCT) or DTRT
  - FO Distributed Temperature Sensing (DTS)

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Primary Differences of “Direct Use” Geothermal vs. “UTES” Geothermal

- Direct Use: Typical American ***closed loop*** piped in a grid with parallel flow or is a “one-way” ***open loop*** that can’t capture waste heat/”waste cold”
- Geo still used at Heat Sink & Heat Source but optimized to deliberately store cold or hot.
- Closed loop UTES (BTES) boreholes generally piped as 3-6 boreholes in series for deliberate thermal stratification or zones (bull's-eye)
- UTES (ATES or BTES) has the capability to reverse the flow to “charge” or “discharge” its stored thermal resource

Germany’s VDI-4640 Underground Thermal Energy Storage Guidelines

Table 2. Different requirements which the subsurface zone and the system layout must meet in the case of energy storage on the one hand and direct thermal use (e.g. for heat pump operation) on the other

	Energy storage	Direct utilization of heat/cold
Heat exchange at ground surface	minimize	maximize
Ratio of boundary surface area to volume	minimize	maximize
Geometry (for BTES , see Fig. 1)	compact, closed	expanded, open
Presence of groundwater flow	unfavourable	favourable

Underground Seasonal Thermal Energy Storage (USTES) via Boreholes or Aquifers

ESTCP
Environmental Security Technology Certification Program

- **Cooling Dominated Buildings**: Capturing the "cold" of winter and/or "waste cooling" and storing it in underground formations or aquifers and "harvesting" it in summer to cool the building
- **Heating Dominated Buildings:** Capturing the "hot" of summer and/or waste heat and storing it in underground formations or aquifers and "harvesting" it in winter to heat the building
- **Balanced Buildings:** Do Both!!!

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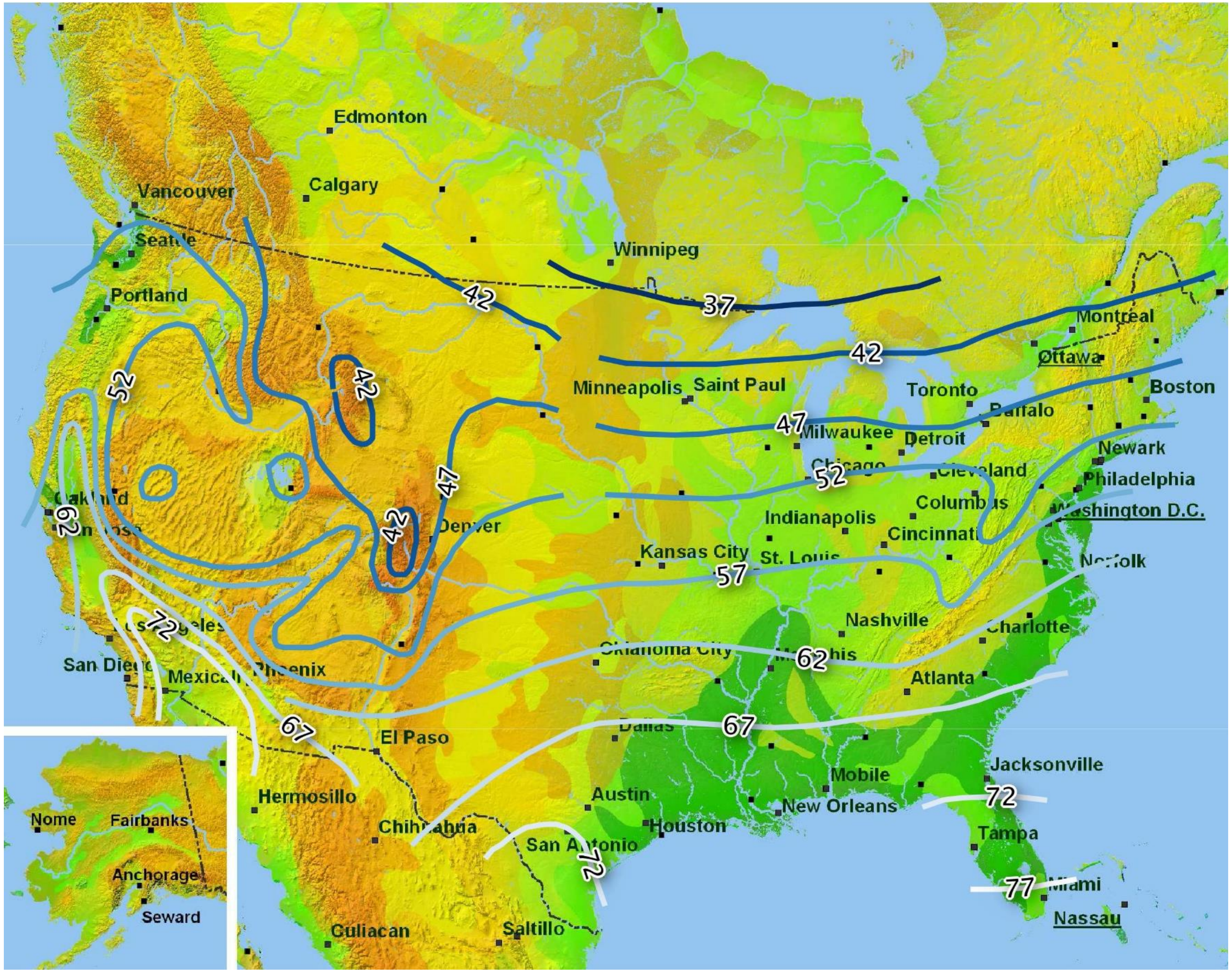

Shallow Earth Groundwater /Geological Isotherms

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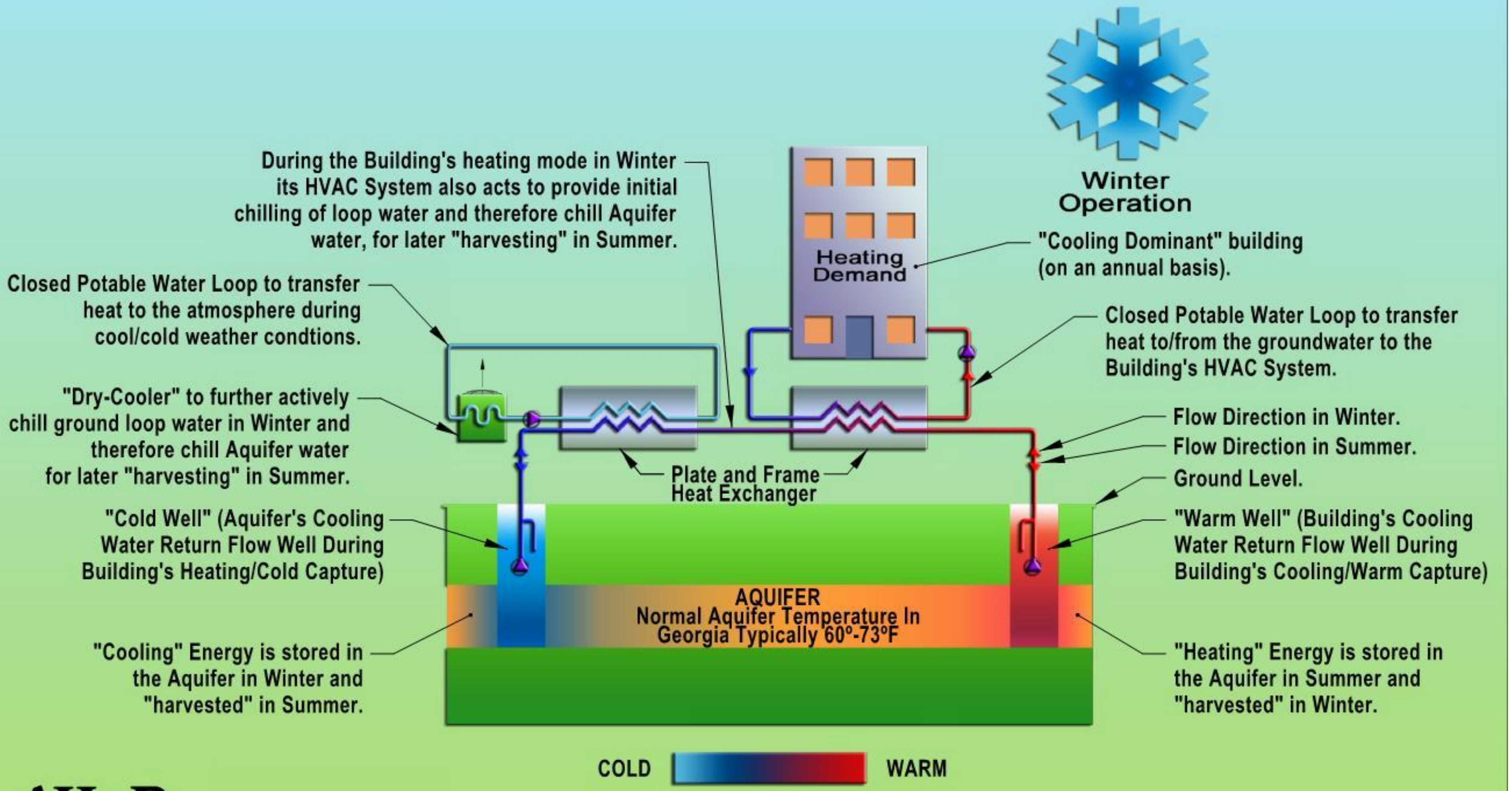
Aquifer Thermal Energy Storage (ATES)

Capturing the "Cold of Winter" and utilizing it for summer cooling



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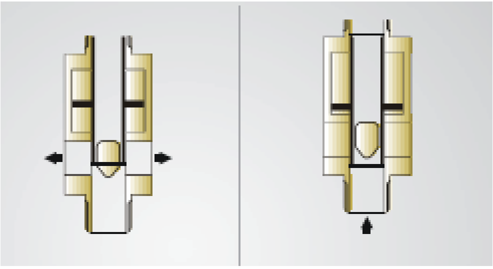
Section/Detail of ATES Extraction and Injection Well

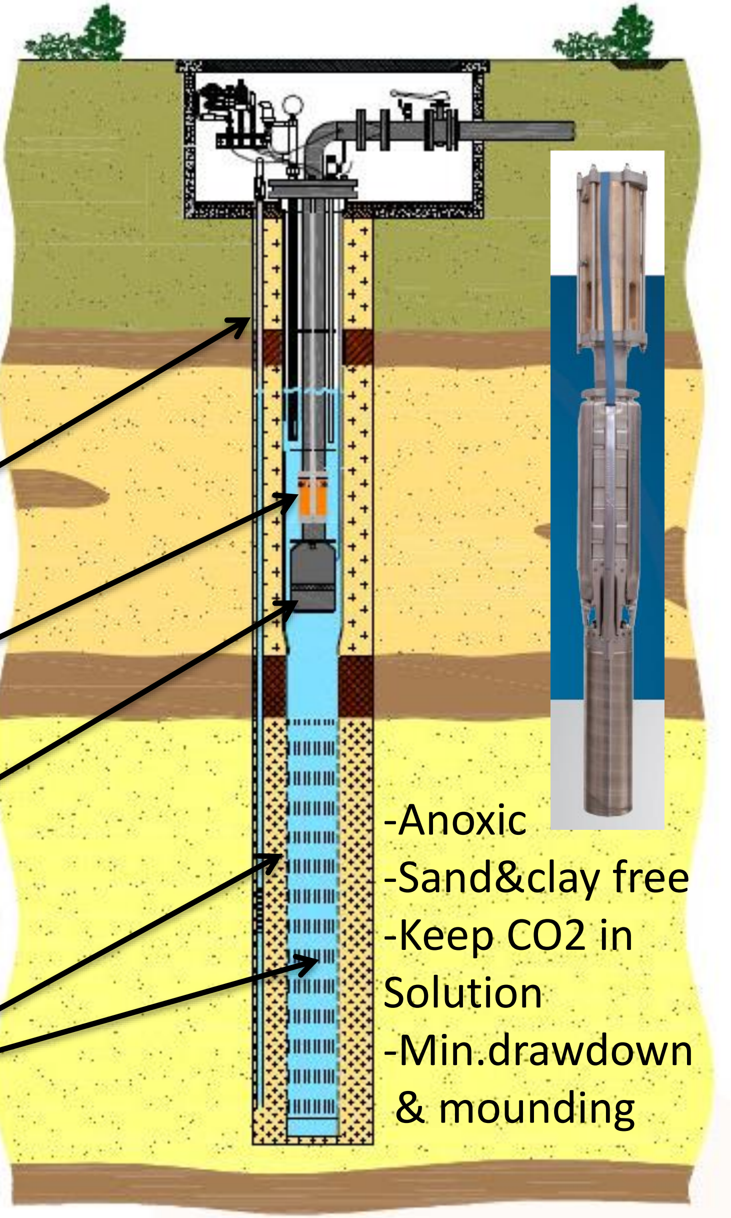
Monitoring Well Piping



Injection Valve

Submersible Pump

Intake Filter Screen with “Gravel” Pack



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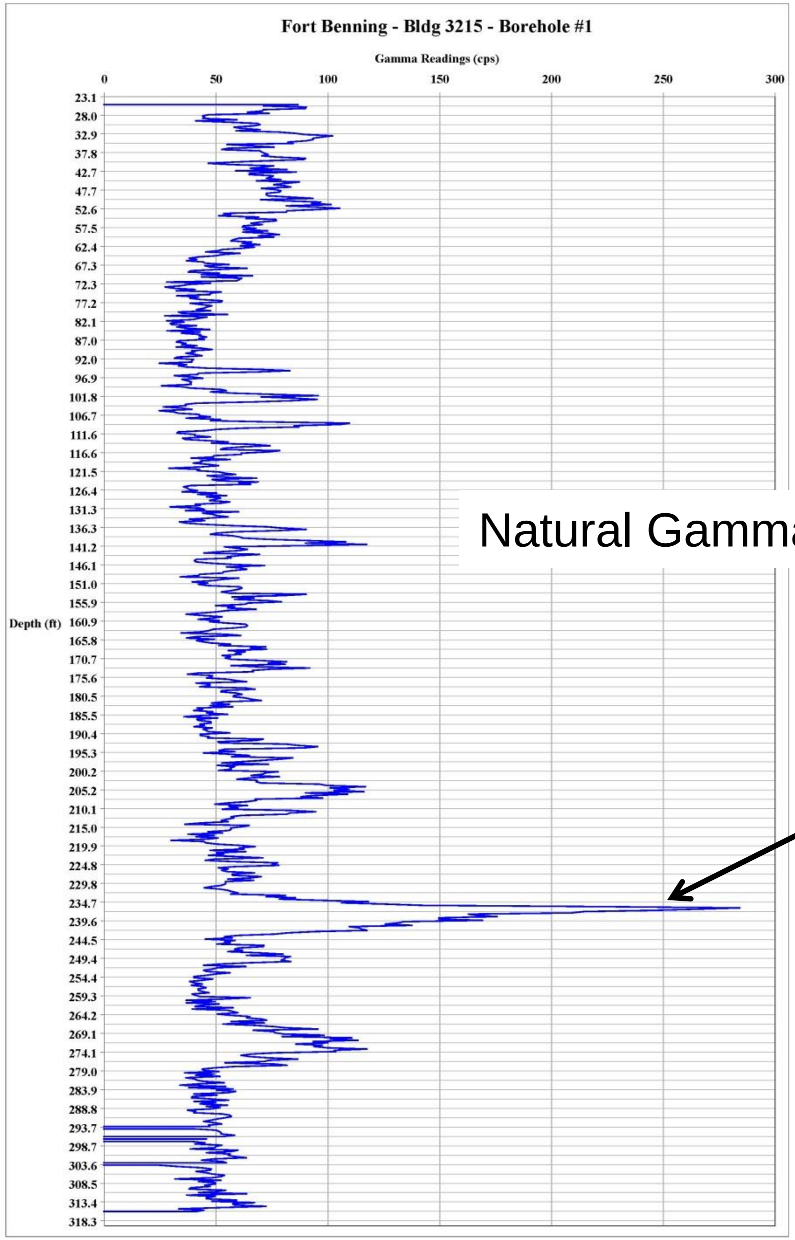
Geophysical Logging



Natural Gamma Radiation: CPS

Confining Clay Layer

Adiabatic Dry Cooler for BTES/ATES

Adiabatic Dry-Cooler with: Evaporative Cooling Pads @ Coil Inlets. 18 Compartmentalized ECM Fans. (360 to 1 turndown), Modbus Interface

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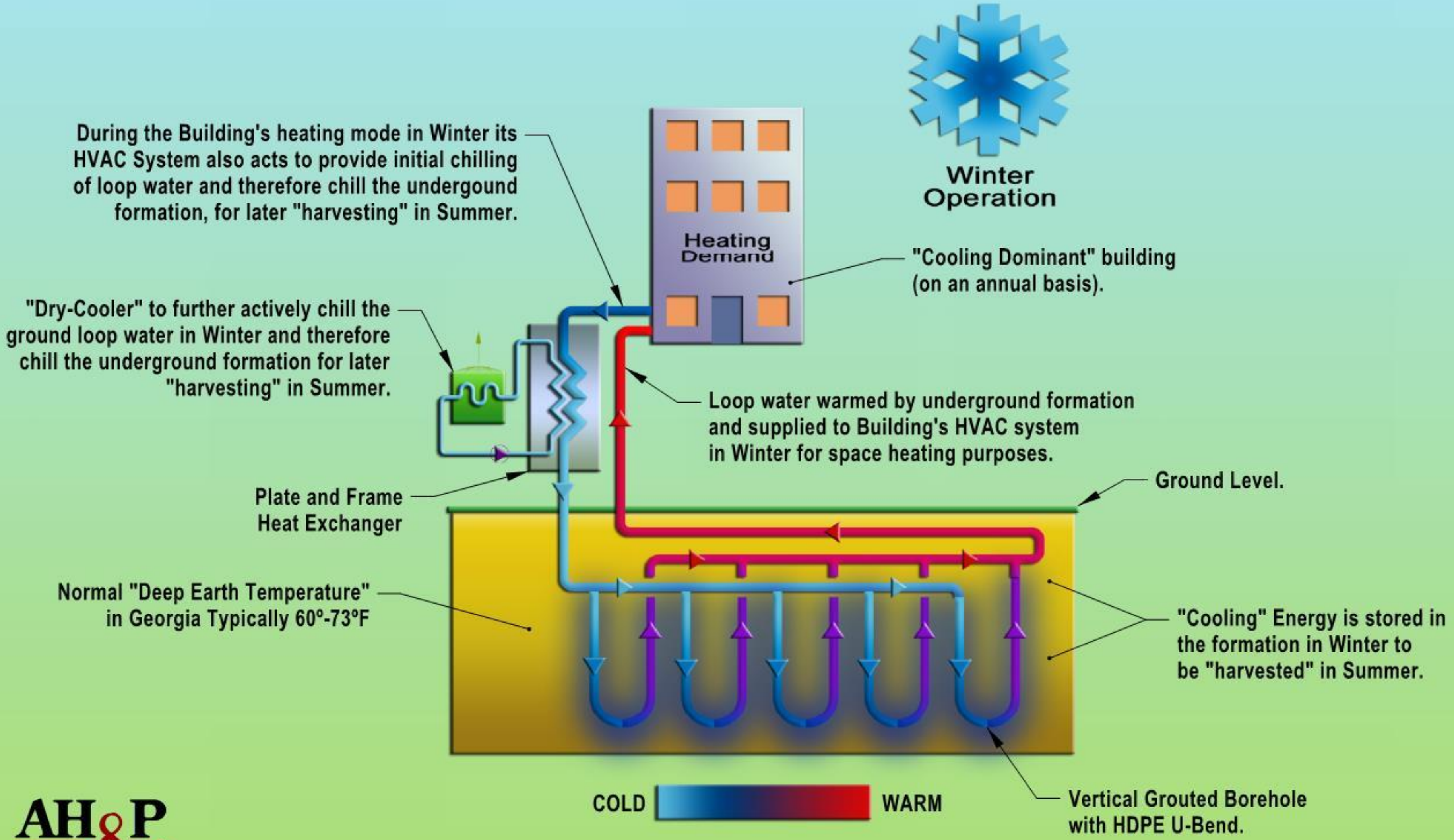
Borehole Thermal Energy Storage (BTES)

Capturing the "Cold of Winter" and utilizing it for summer cooling



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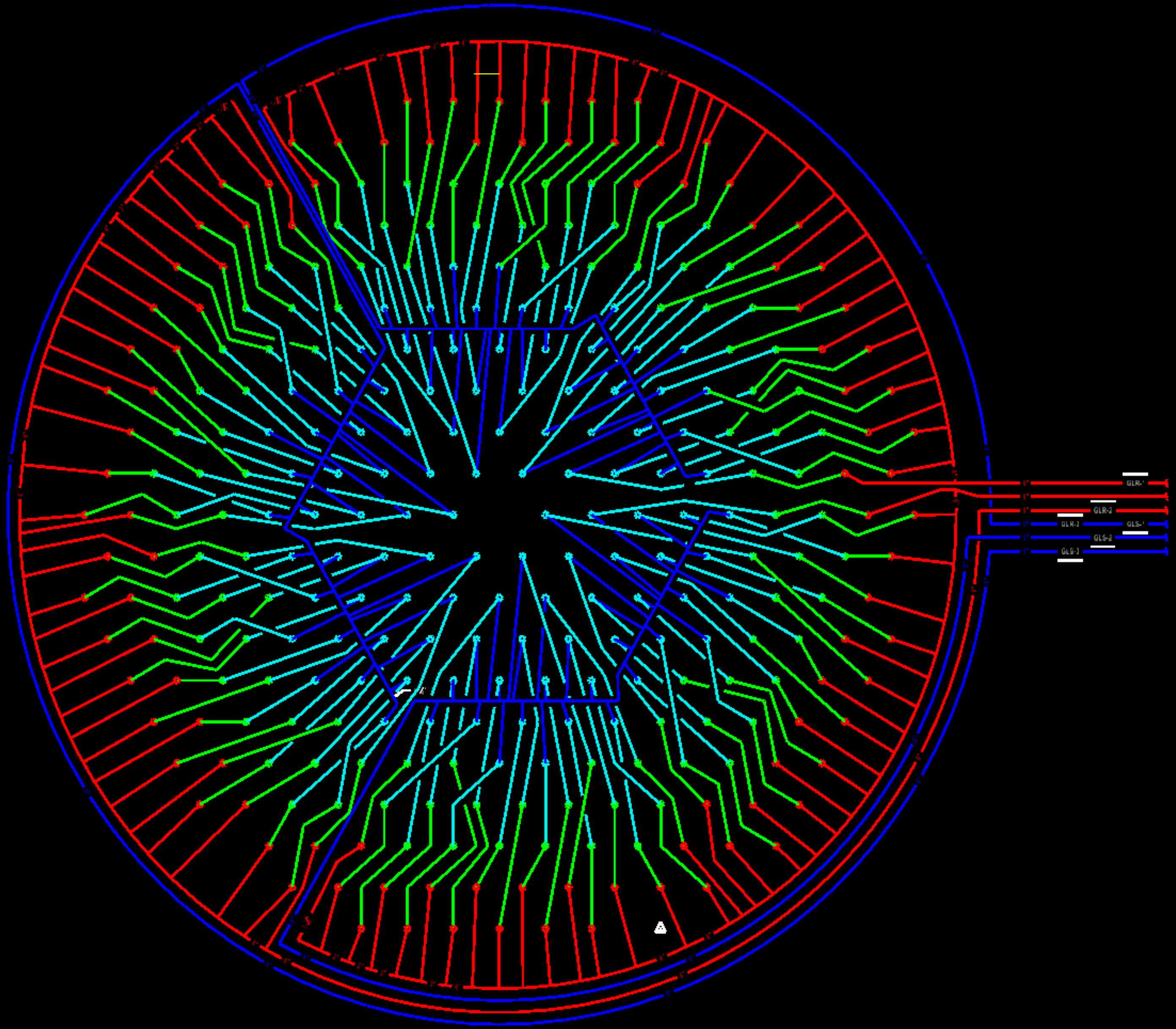
New Satellite Imagery of MCLB BTES System Under Construction

13 Dec 2014 Google Earth Image-Published Jan 2015



GEOTHERMAL BOREHOLE THERMAL ENERGY STORAGE (BTES) BOREFIELD LAYOUT

SCALE: 1/16"=1'-0"

BTES Construction Progress

Outer Circular Headers

Radial Sub-Headers

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Reversing Valves for BTES System Charging & Discharging

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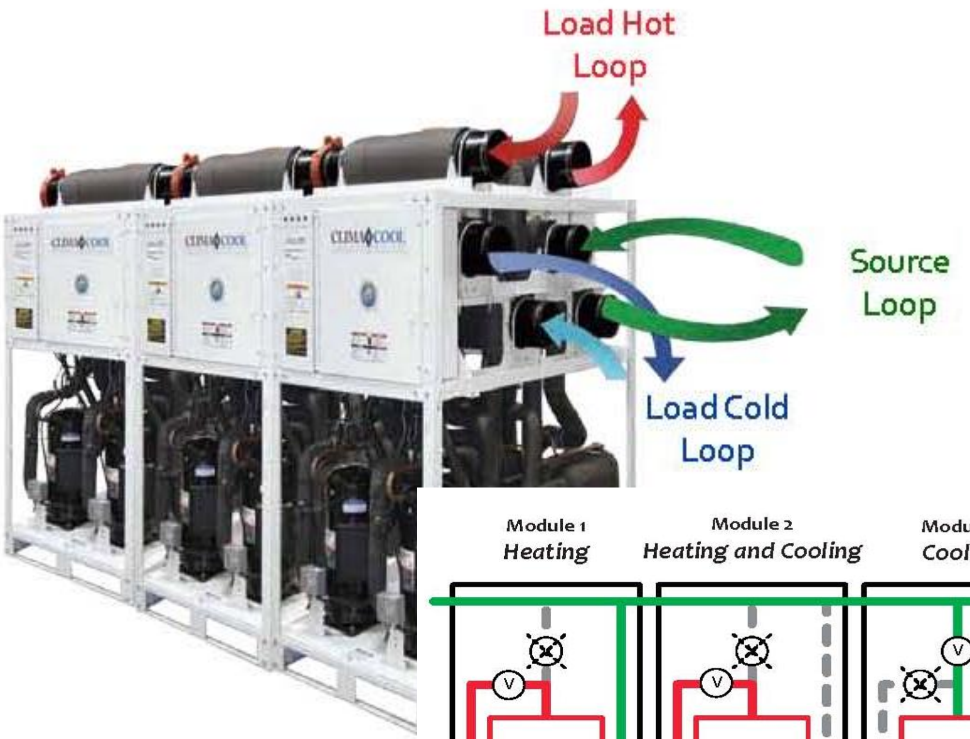
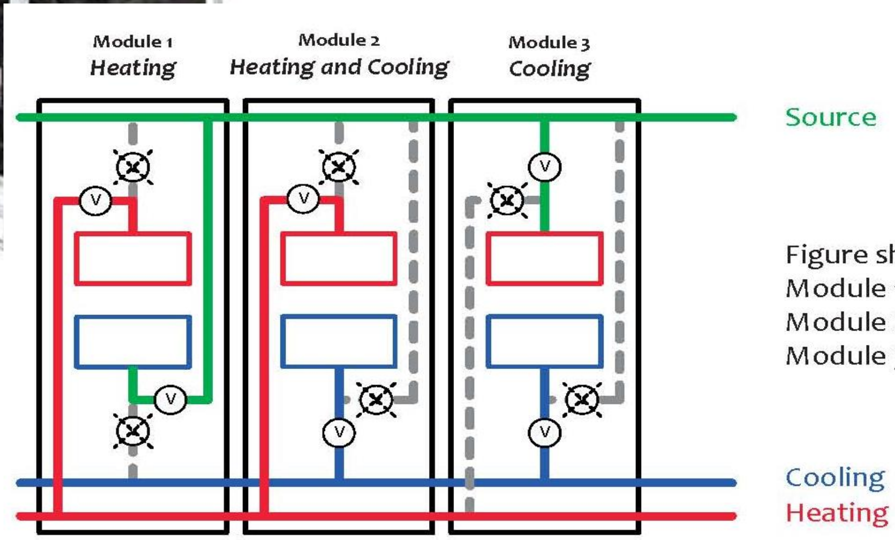
Modular Heat Recovery Chiller





*Simplified single line water circuit shown; V=motorized isolation and control valve

Figure shows a bank of three modules:
Module 1 in Heating
Module 2 in Heating and Cooling
Module 3 in Cooling

Why use ATES (or BTES) vs. normal Open and Closed Loop GEO??

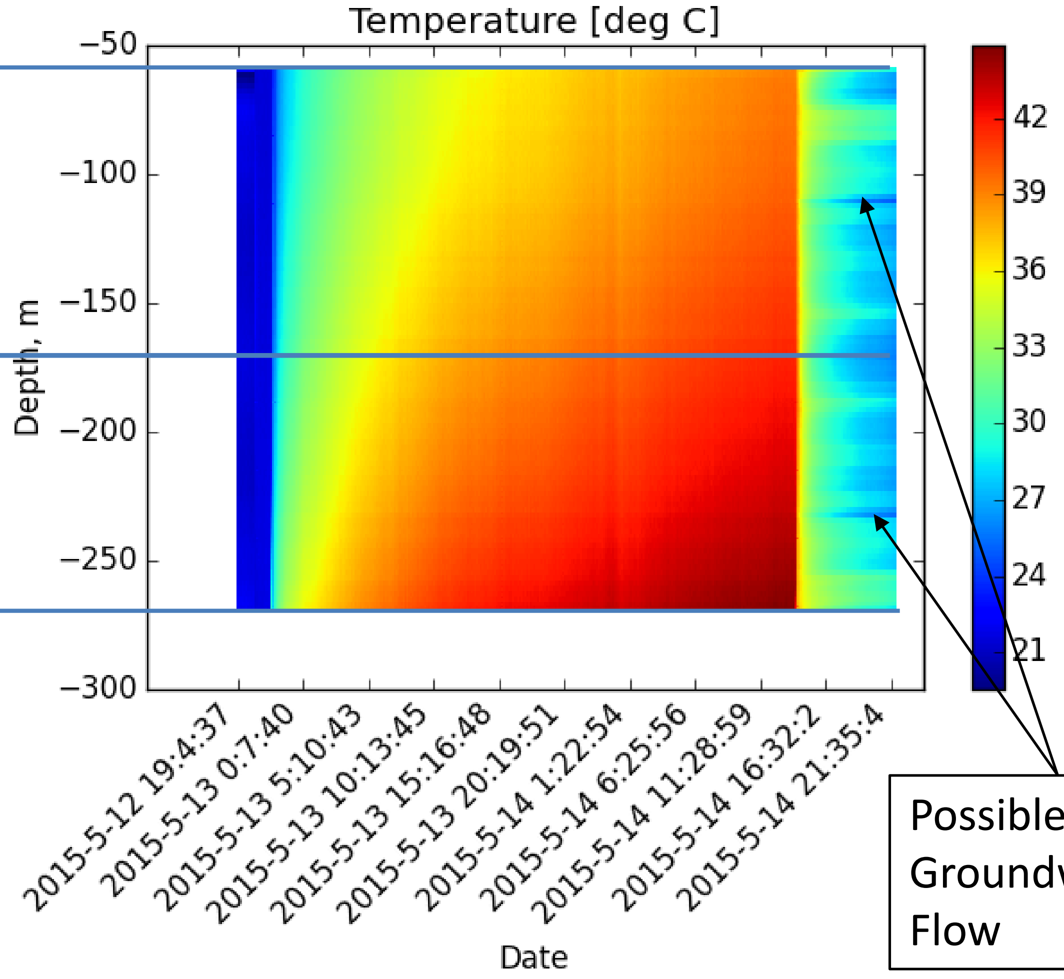
- Allows you to take same basic open or closed loop systems that have been used and increase their efficiency. Requires extensive modeling
- Via Cold Capture or Hot Capture allows Geo to move beyond energy efficiency to true renewable architecture. Can eliminate summer water usage.
- Proven technology used outside of the US for decades. Beyond superior source/sink, real storage
- Direct Chilled water storage systems in the right climate(<50F ground) reduce cooling kwh by 85%

Layered Thermal Conductivity Test (LTCT/DTRT) Downhole Temperatures

Outlet water from the Un-bend (surface)

Bottom of the U-Bend (Axis of Symmetry)

Inlet Water into the U-Bend (surface)



Possible Groundwater Flow

This contour diagram shows the fluid temperature along the whole heat exchanger over the time observed. Right side is after elements de-energized

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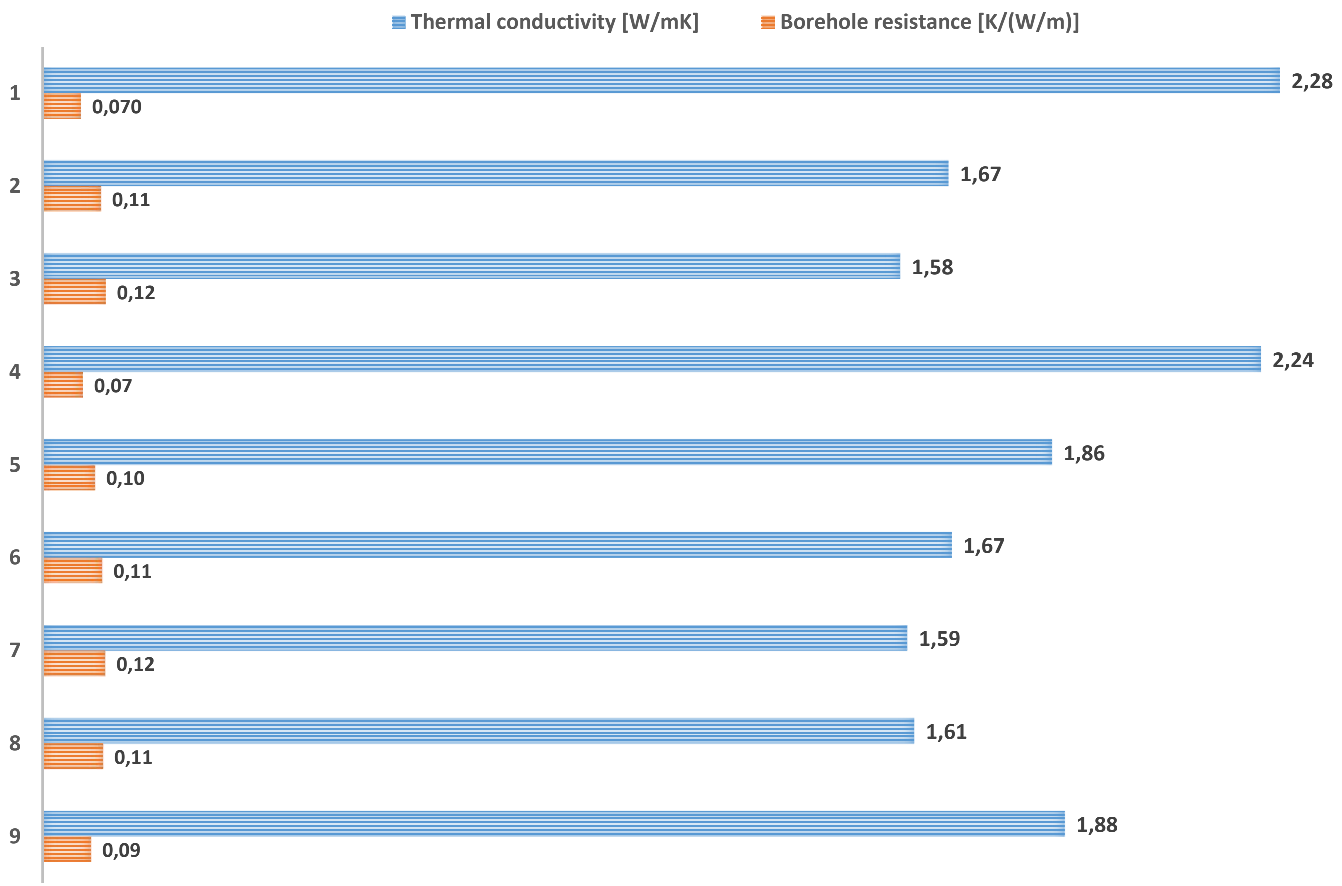
Layered Thermal Conductivity Test (LTCT) or Distributed Thermal Response Test (DTRT)

- Marines Corps Logistics Base, Albany GA (MCLB)
- 110 m u-bend borehole heat exchanger
- A 72 hours LTCT was conducted between May 12 and 14, 2015



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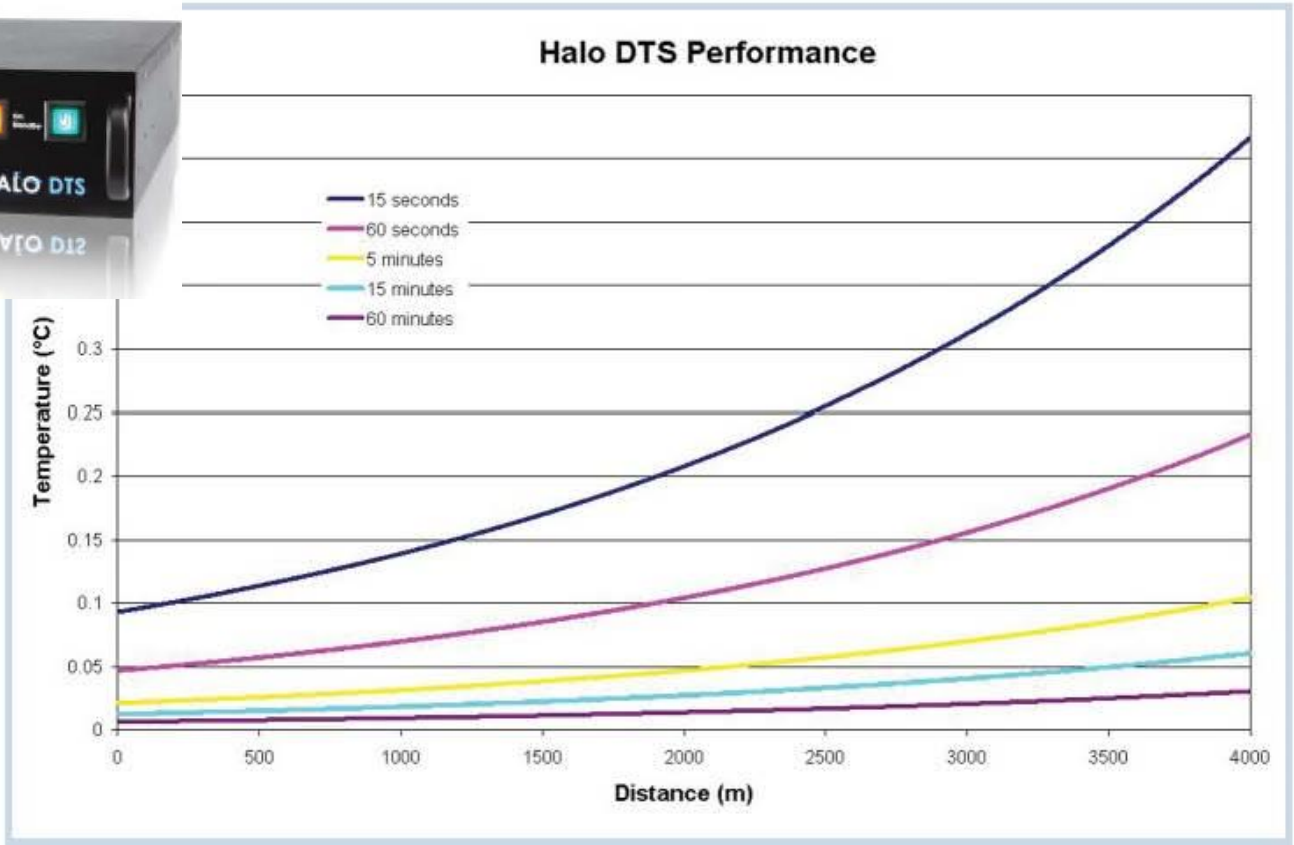
Distributed Temperature Sensing (DTS)



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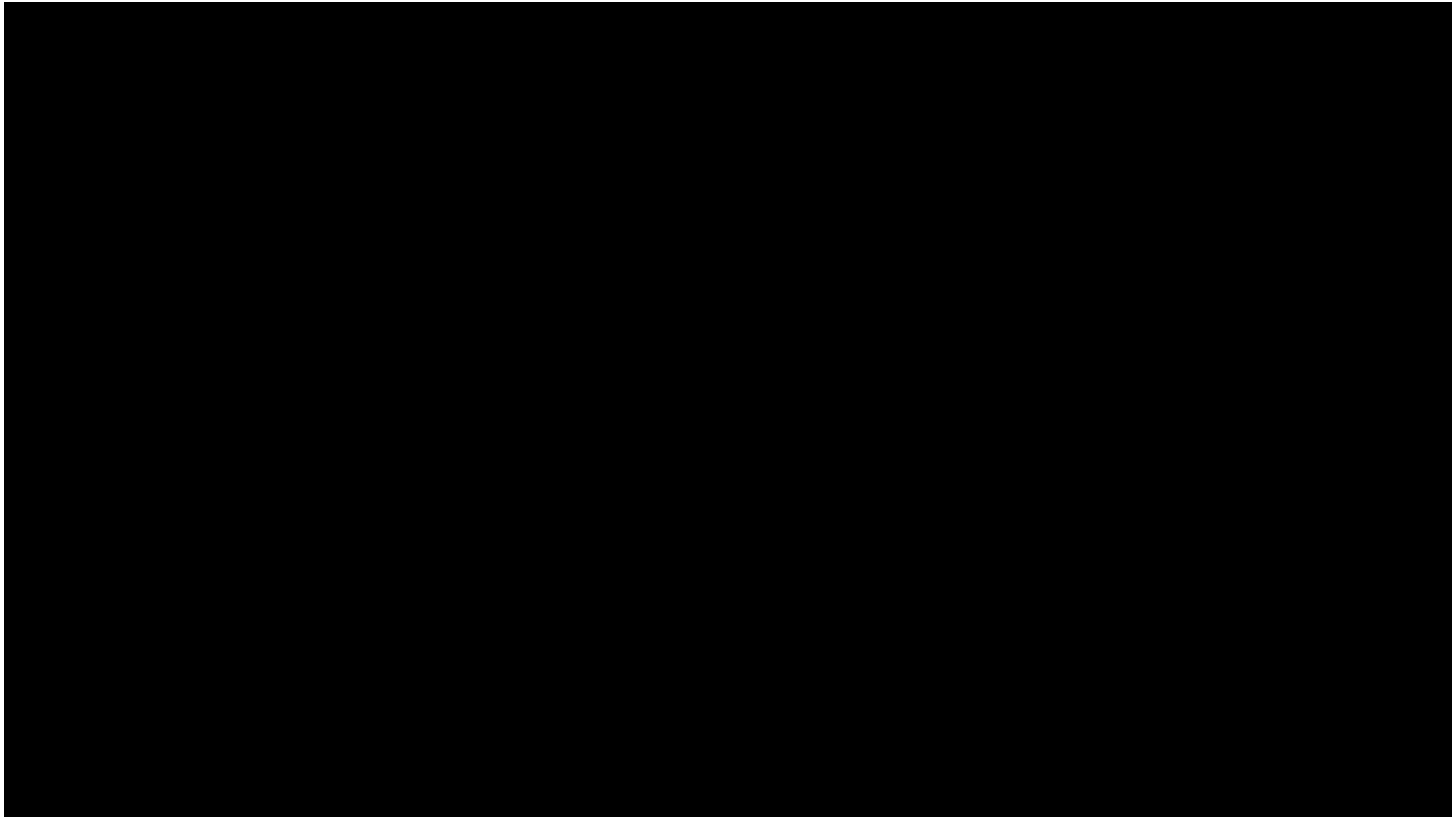

Video of Underground Temperatures from the DTS System

Questions and Answers!

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