Seasonal Thermal Energy Storage

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ASHRAE
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Energy Planning for Resilient Communities – Best Practices

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Underground Thermal Energy Storage

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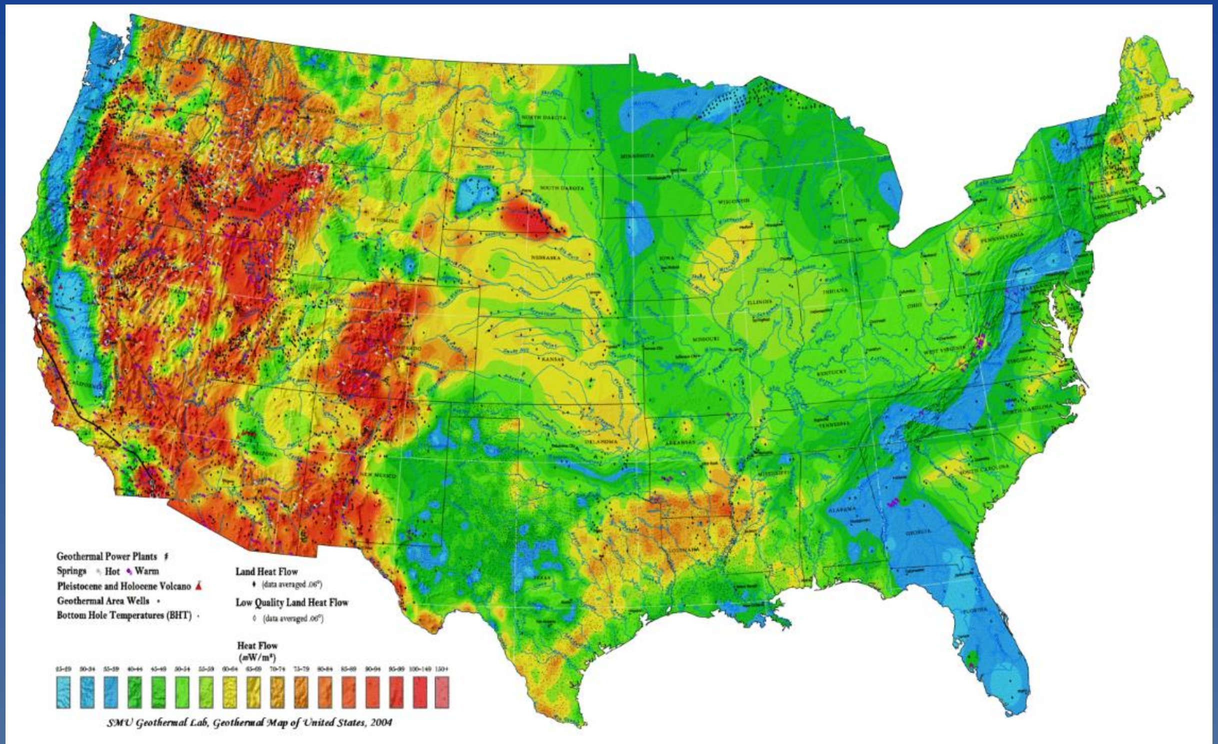
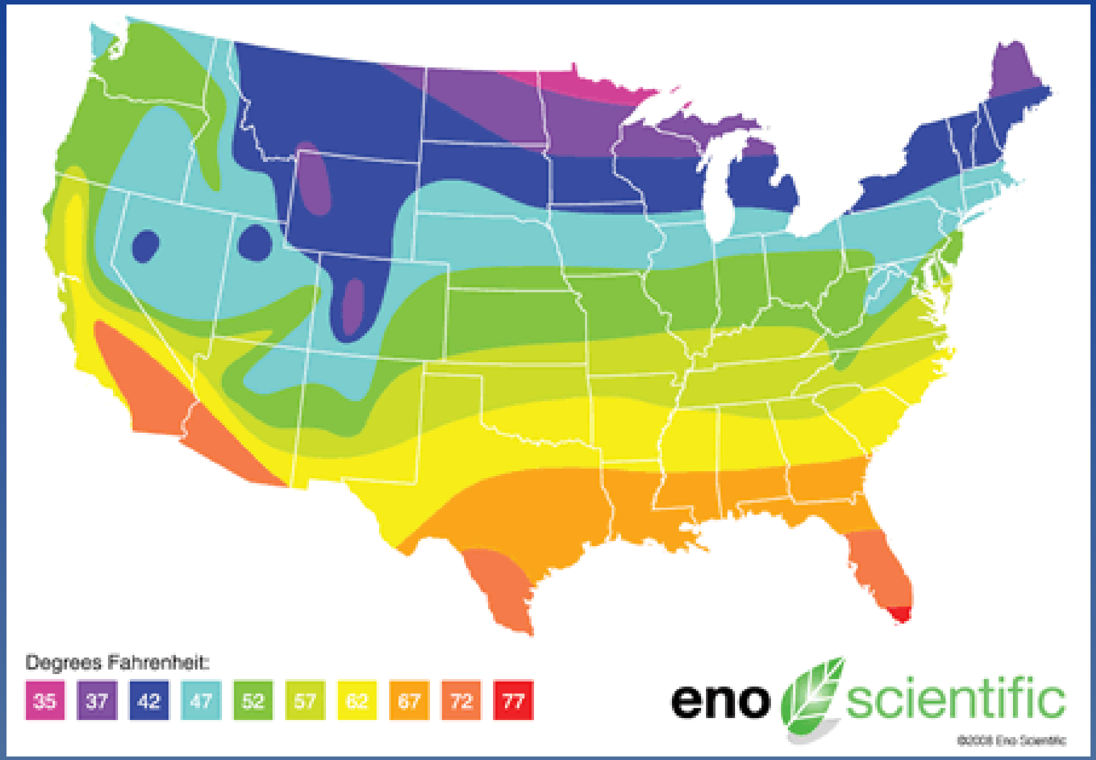
Seasonal Thermal Energy Storage

UTES is a low-temperature geothermal technology

High-Temperature Geothermal
Geothermal Gradient Map

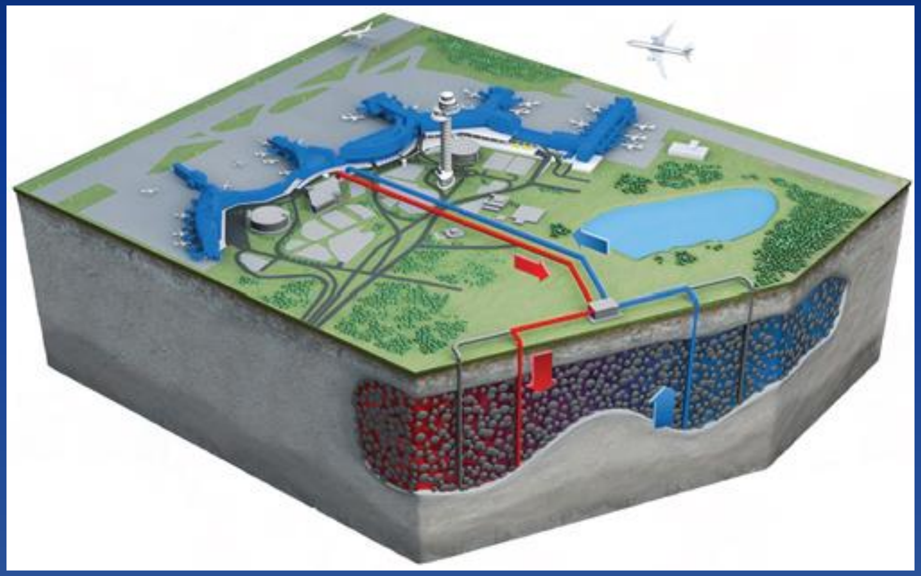


Low-Temperature Geothermal
Shallow Groundwater Temperatures



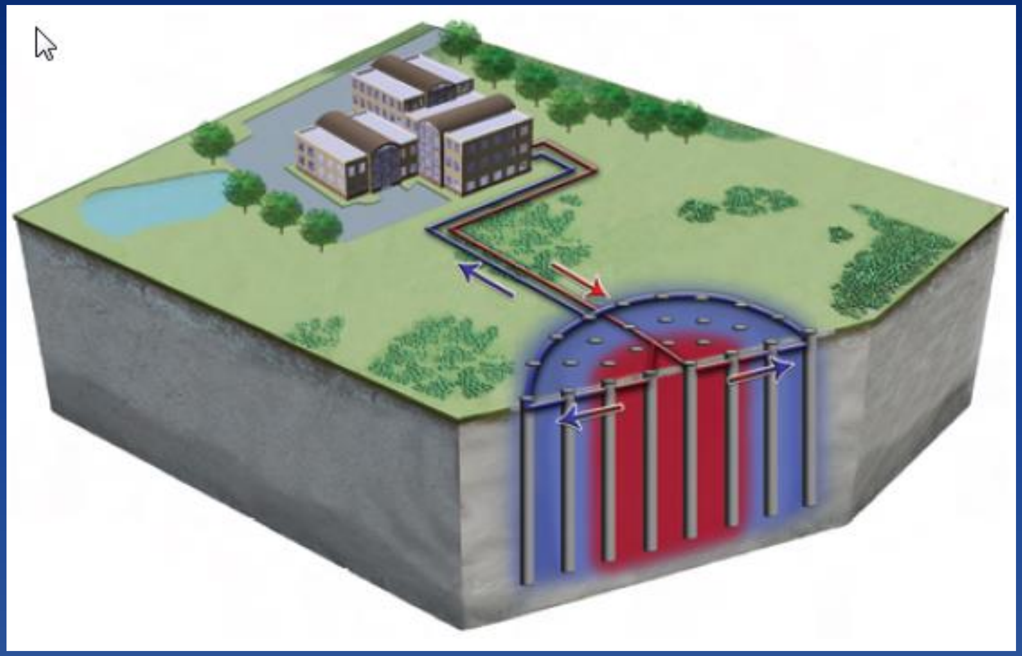
Underground Thermal Energy Storage (UTES)

Aquifer Thermal Energy Storage
ATES



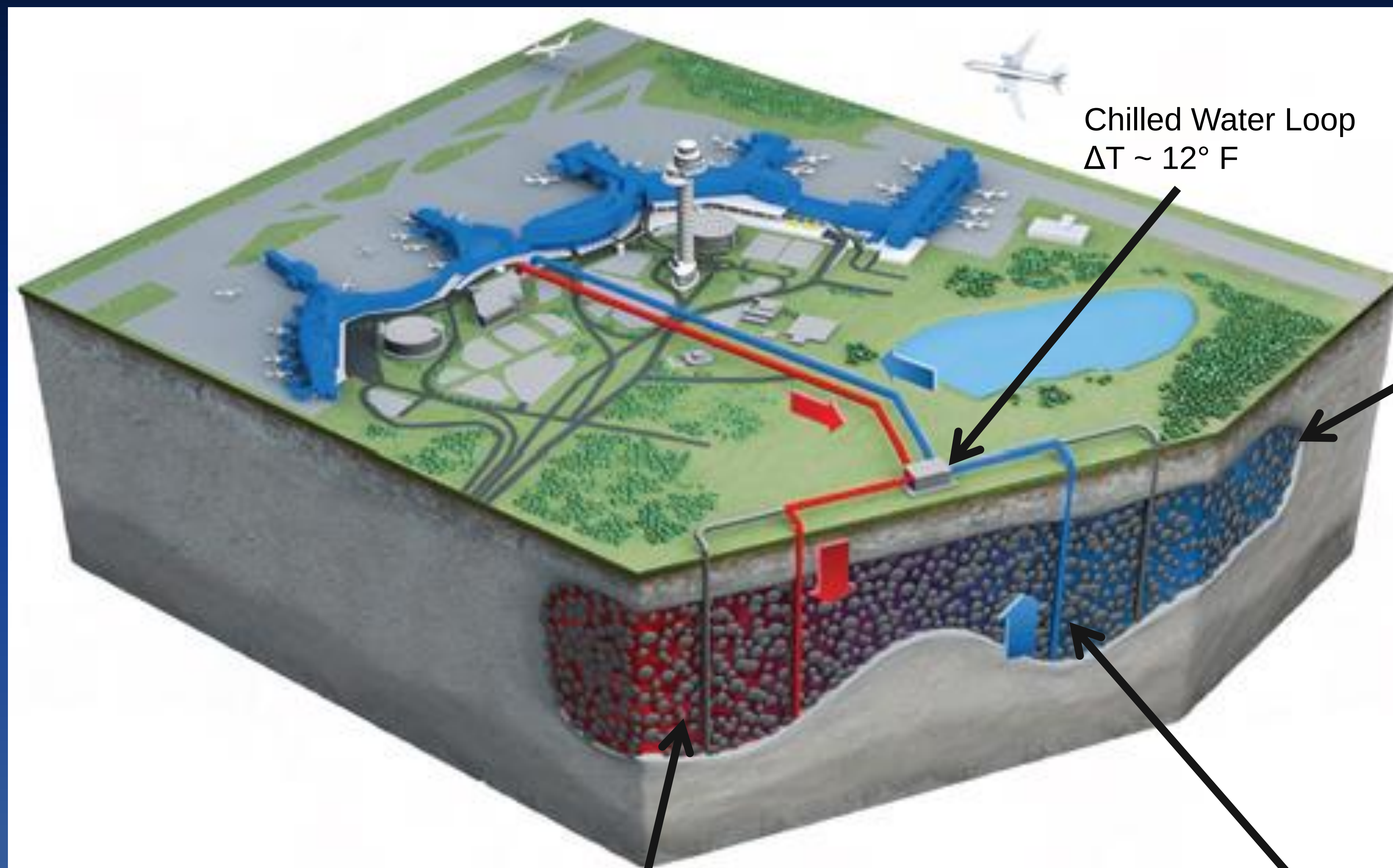
- Open Loop (hydraulically balanced)
- Seasonal flow reversal (well-to-well)
- Groundwater storage medium
- Economic efficiencies of scale

Borehole Thermal Energy Storage
BTES



- Closed Loop (hydraulically balanced)
- Seasonal flow reversal (GHX)
- Soil/Rock storage medium
- Cost Proportional to thermal capacity

ATES for Cooling



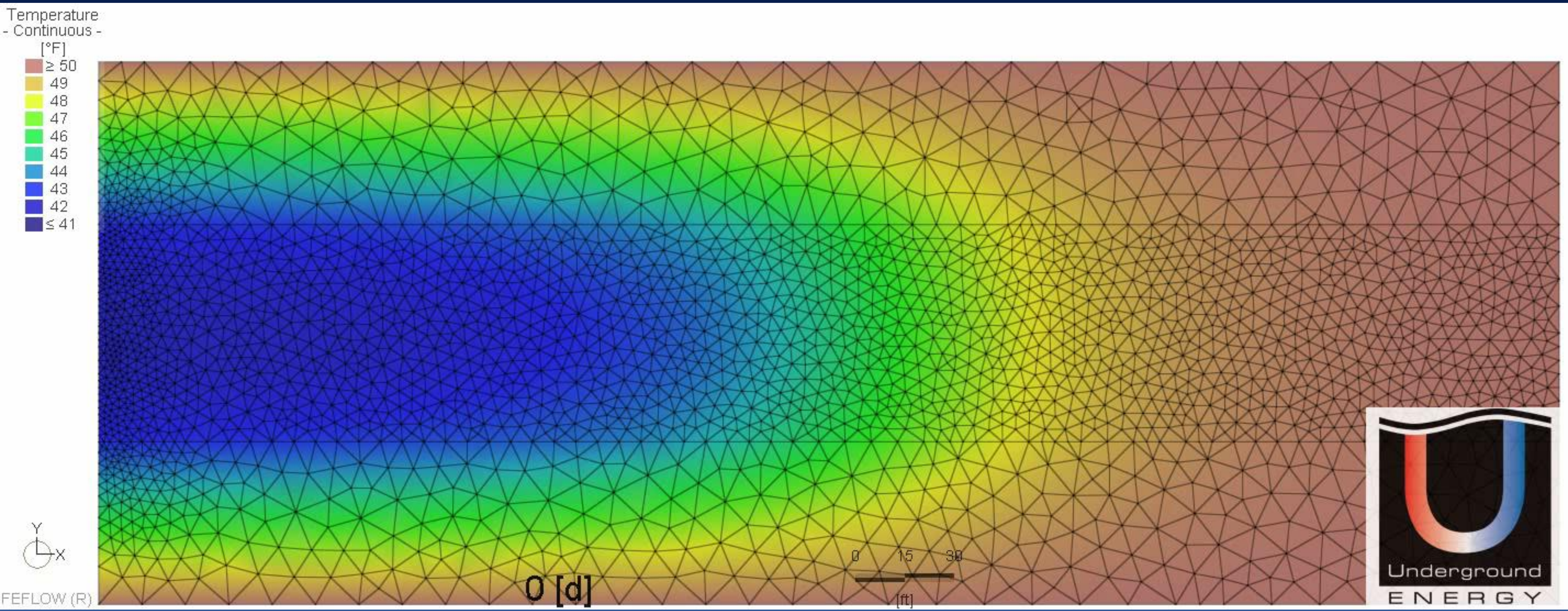
Ambient
Groundwater 50°F

Warm Store ~55 °F

Cold Store ~ 41°F

Aquifer Thermal Energy Storage (ATES)

Cross Section Animation – 5 years



https://youtu.be/N1Wg2ygeWj0

Optimizing the Earth Couple

- The role of advective heat transport via groundwater flow is of critical importance in designing an efficient Earth couple.
  - Groundwater flow is dominant heat transfer mechanism.
  - For large (> 150 ton) systems, evaluation of ground conditions is recommended prior to design.
- Seasonal Thermal Energy Storage significantly increases the efficiency of the Earth couple.

Earth Couple Design Matrix			
Earth Couple Design Matrix	Heat Source / Sink	Thermal Battery	
Application	Conventional GeoExchange	UTES	
		ATES	BTES
High Groundwater Flow Rate			
Low Groundwater Flow Rate			
Aquifer Present			
No Aqifer Present			

ATES Growth in The Netherlands

1990

2000

2010

Source: www.iftechnology.nl/

UTES Financials and Energy Benefits

- BTES well suited for extreme climates with surplus waste heat in summer

- ATES: ~60% savings on cooling energy compared to air-cooled chillers
    - ~80% peak cooling demand reduction

- Findings from Recent ATES Feasibility Study, St Paul, MN
    - 135 ac site; 6.5 M ft^2; 3,450 TR; 5,500 gpm; 2-pipe DES; distributed heat pumps
    - Business As Usual is a new, efficient 4-pipe DES with central plant

  – Savings vs. BAU:
    - – 40% savings in primary energy consumption
    - – 35% reduction in CO2 emissions
    - – 100% reduction in cooling water consumption

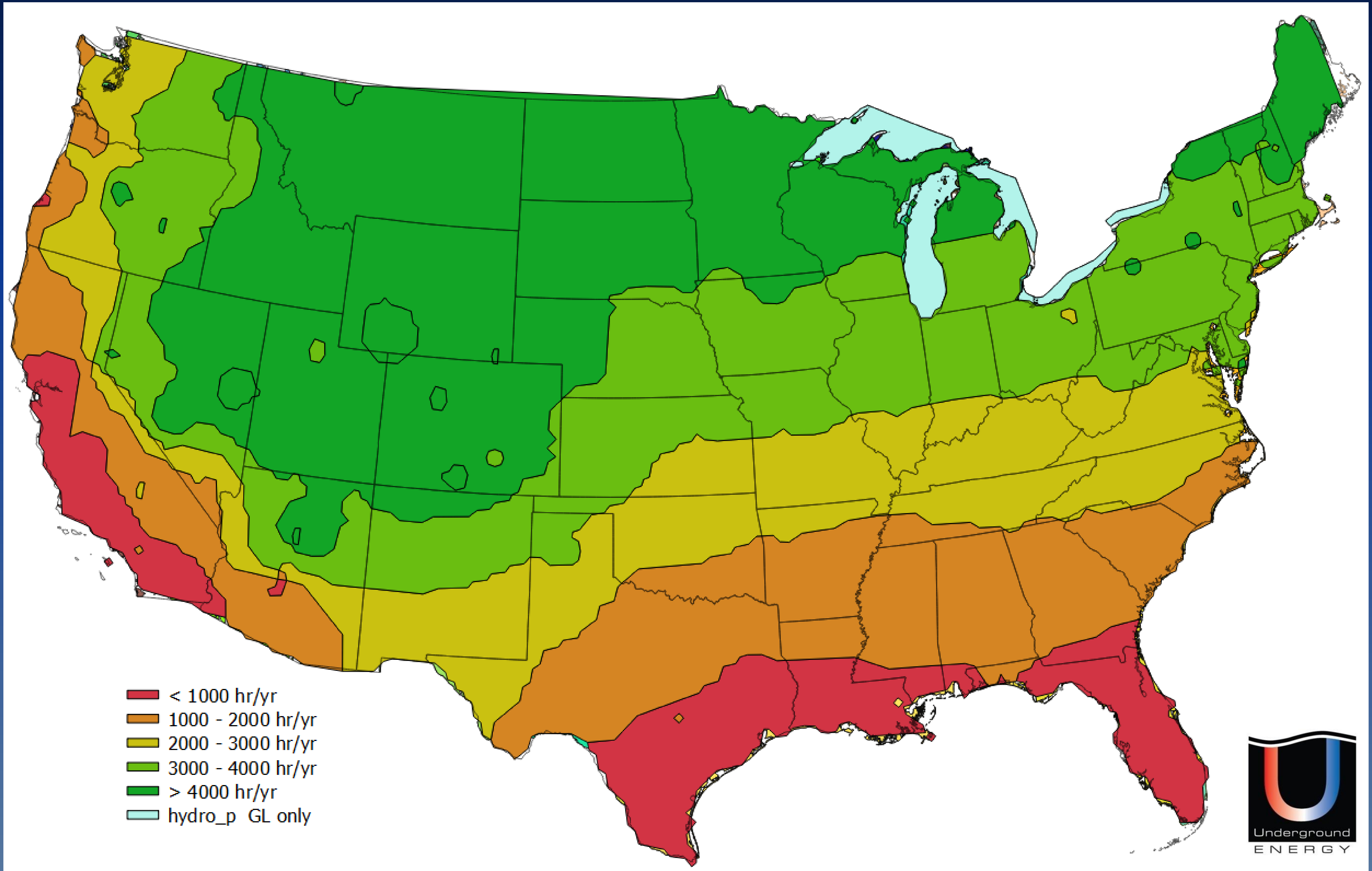
  – ATES Financials
    - – $33 M CAPEX (inclusive of District Energy System; equal to BAU)
        - » $9,600/TR inclusive of DES piping

The Resiliency Case for UTES

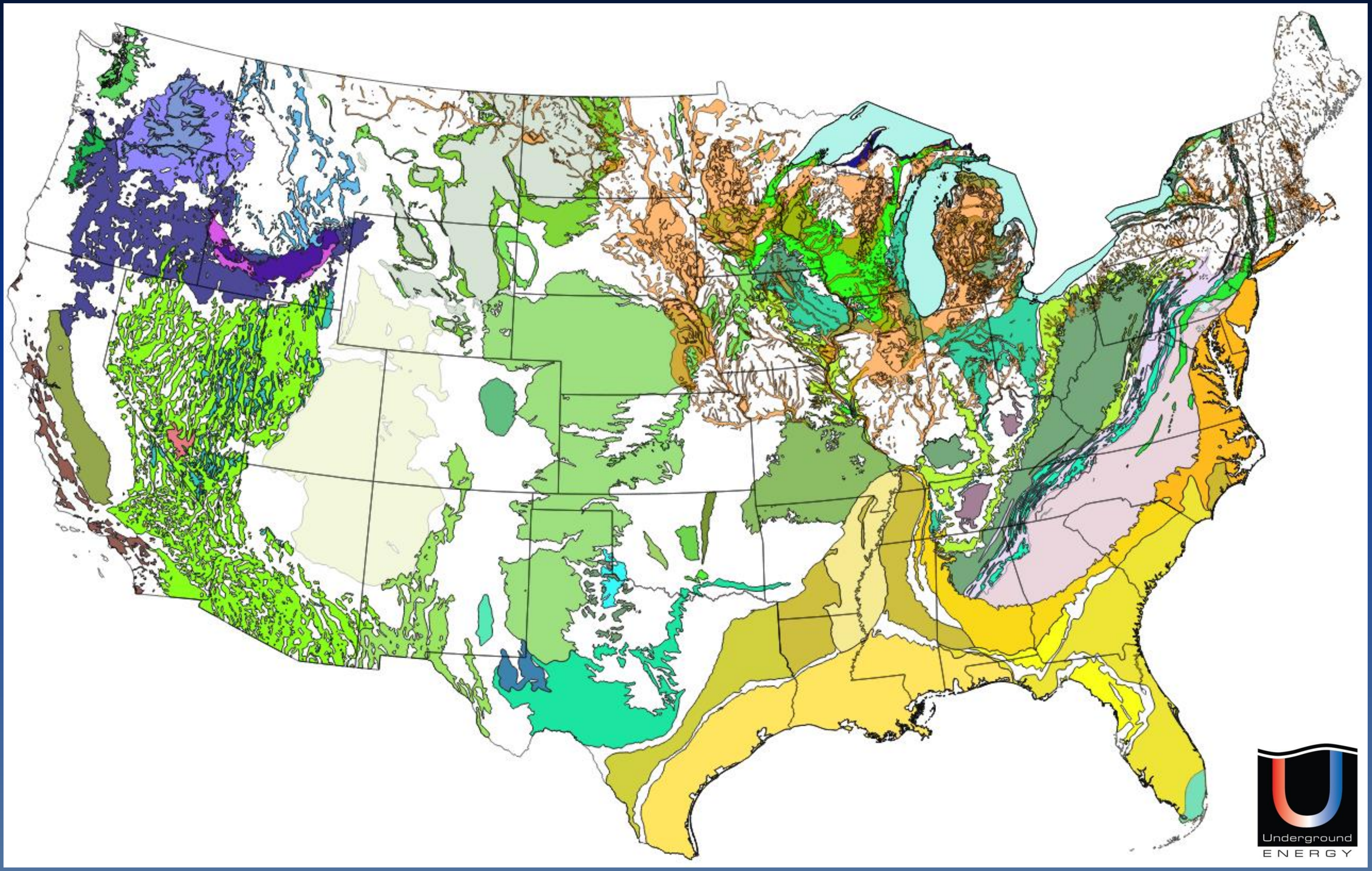
- Reduced and manageable power consumption for heating and especially cooling if the grid goes down and islanding is required.
    - ATES direct cooling COP ~25
- Combined with solar PV, UTES is 100% renewable HVAC
    - good connection in cooling mode in time of day
- ATES wells for emergency water supply and firefighting

Where is the climate suitable for ATES?

Annual water-side economizer (free cooling) hours



Where are the aquifers?



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Thank You!