

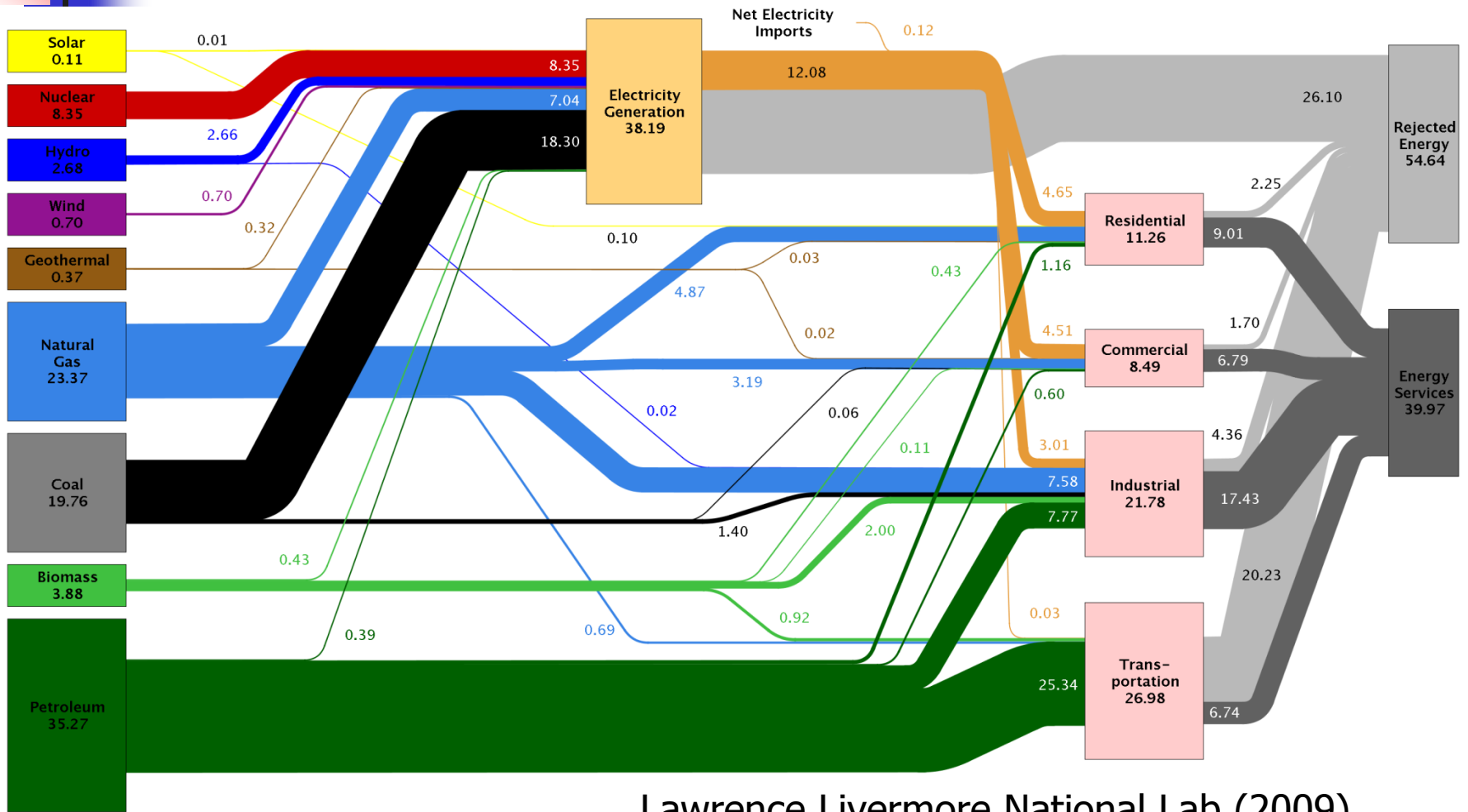
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# Ground Source Heat Pump Systems and Energy Piles

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Built Environment and Energy Advisory Committee Meeting  
May 19, 2016

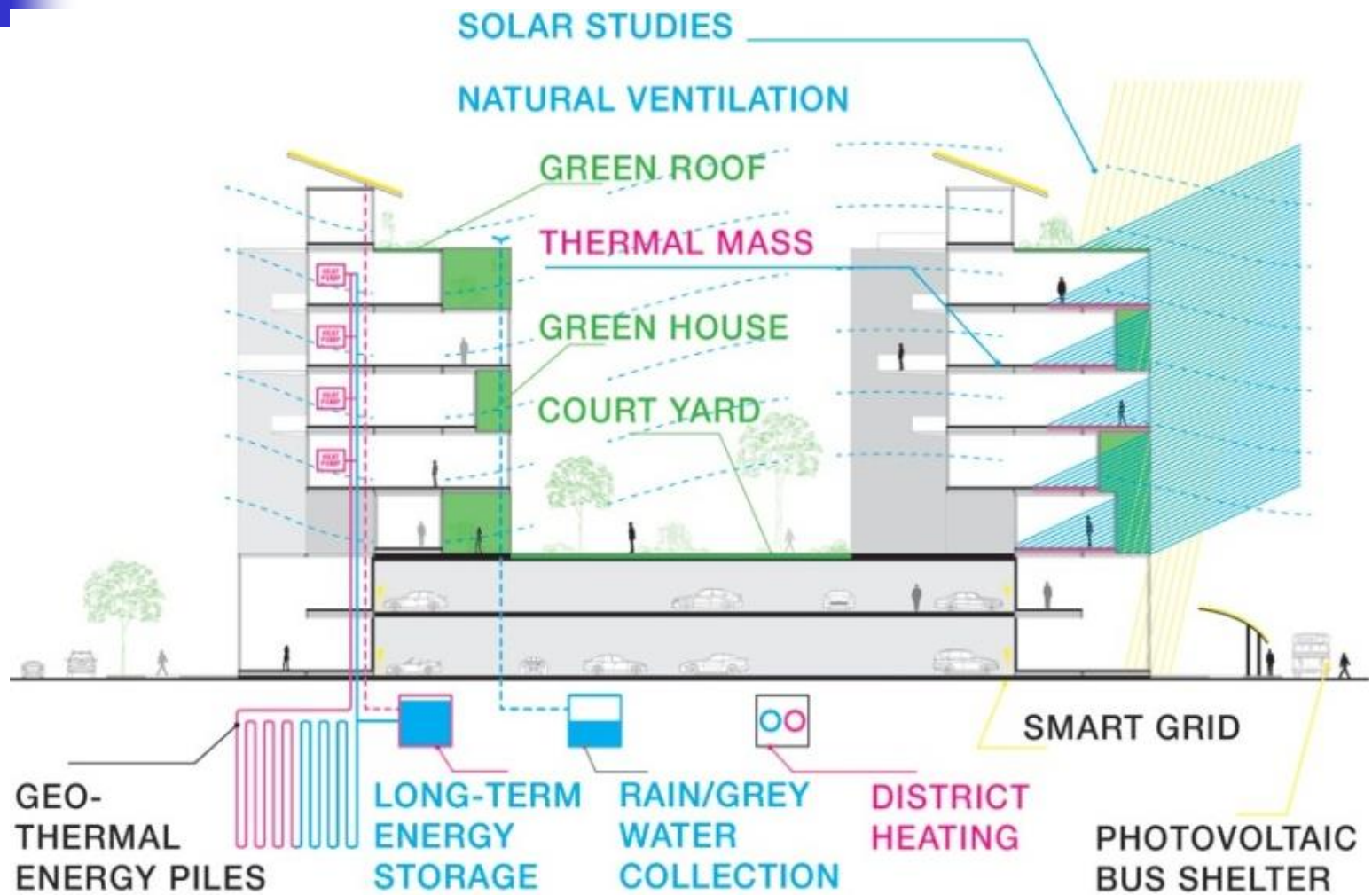
# U.S. Energy Flow Chart



Lawrence Livermore National Lab (2009)

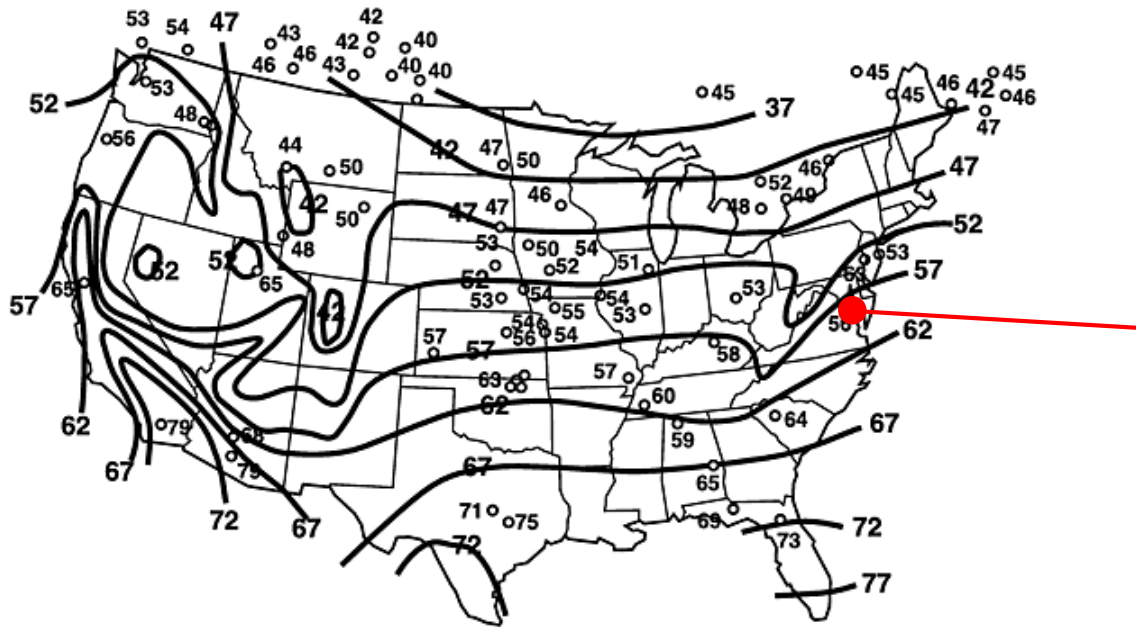
Significant energy consumption in buildings mainly for heating and cooling

# Energy Efficient Buildings

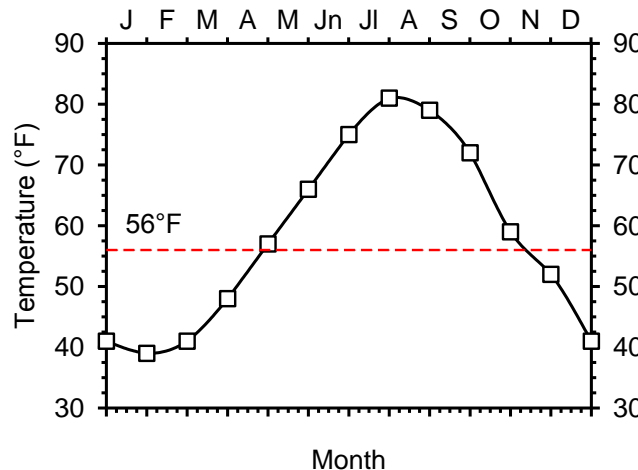
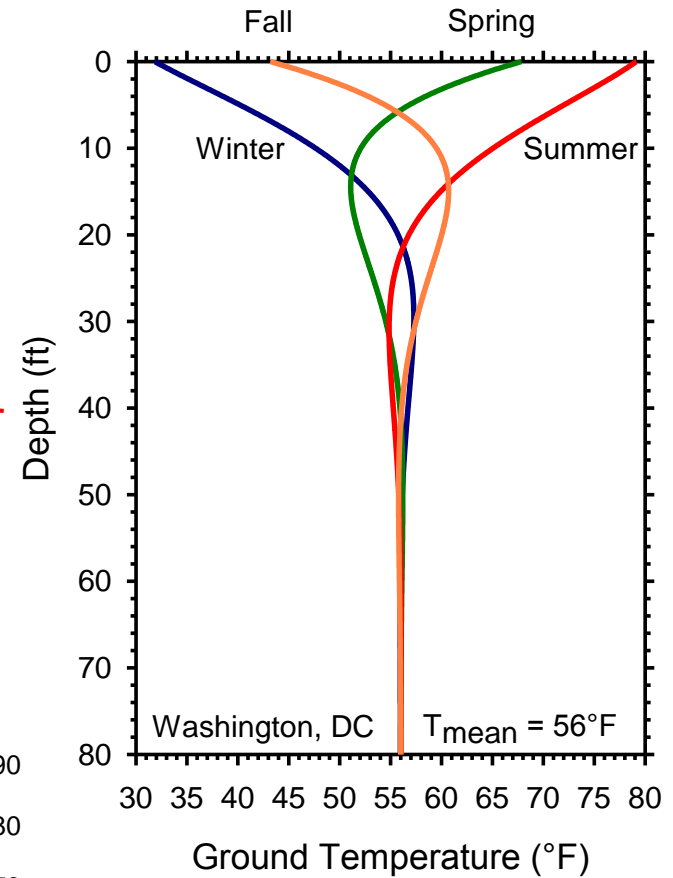


Courtesy J. Wheeler / Virginia Tech

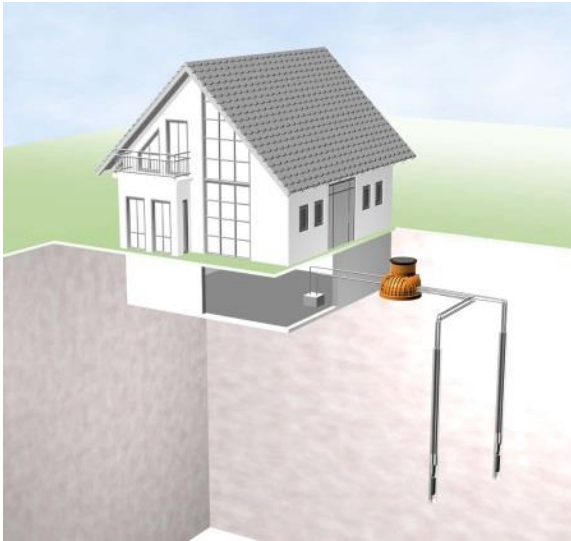
# Ground Temperature Profile



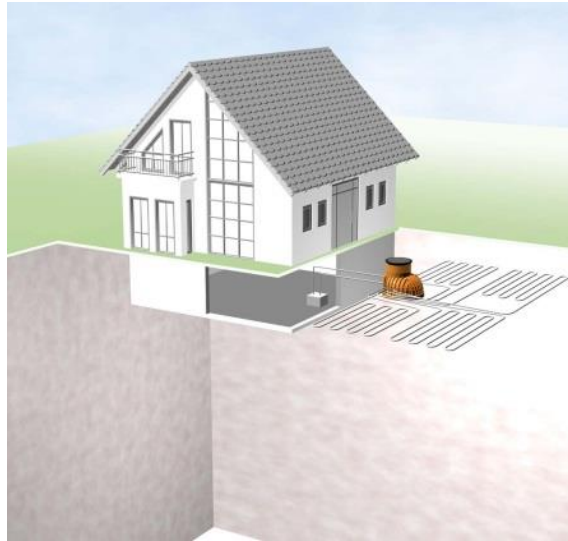
Mean ground temperature



# Ground Source Heat Pump Systems



Geothermal Boreholes

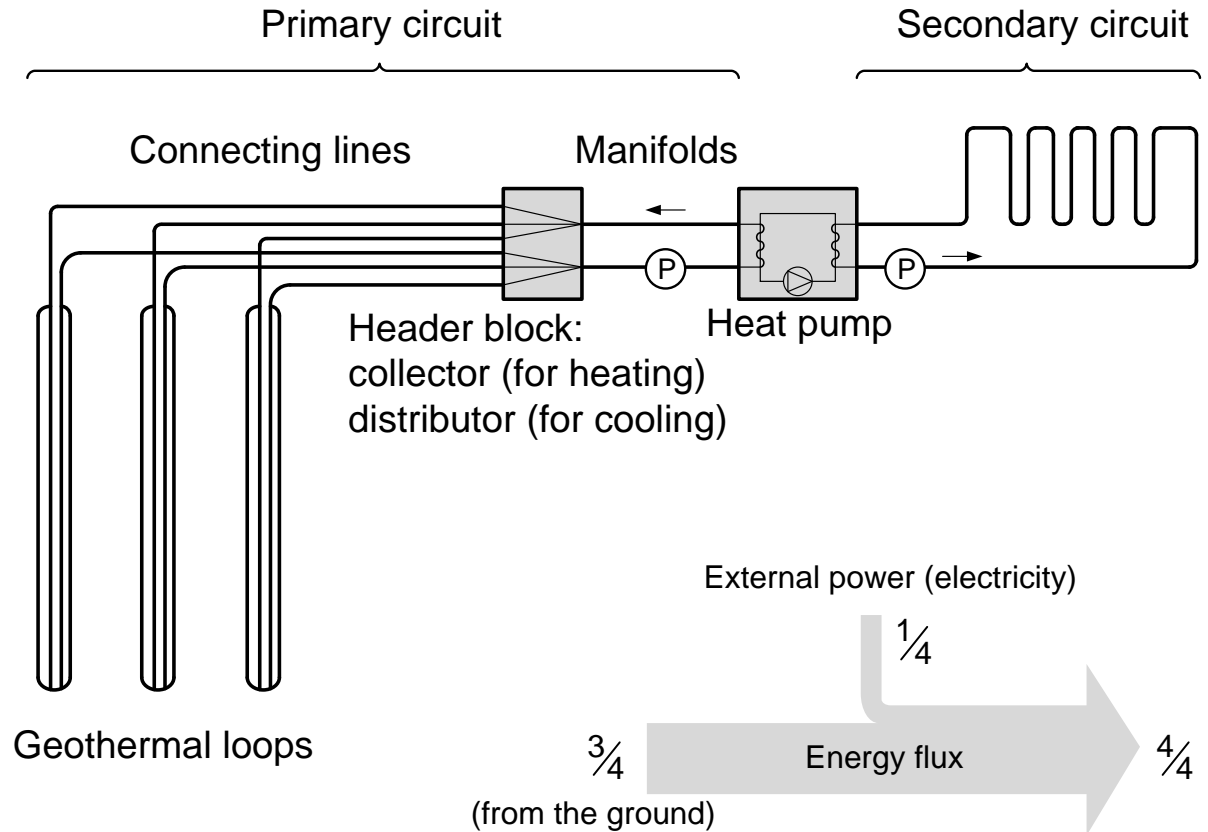
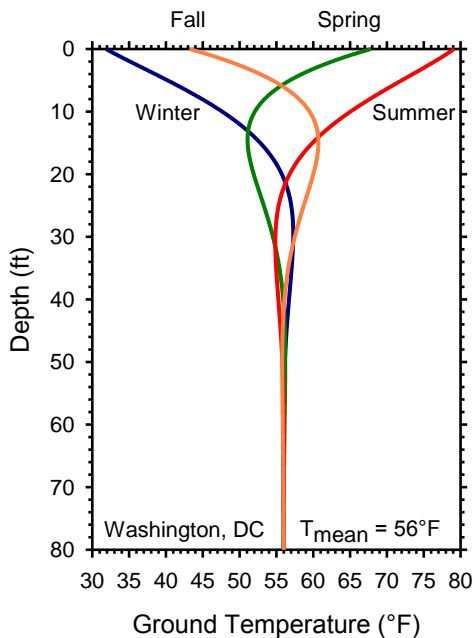


Horizontal Loops



Energy Piles

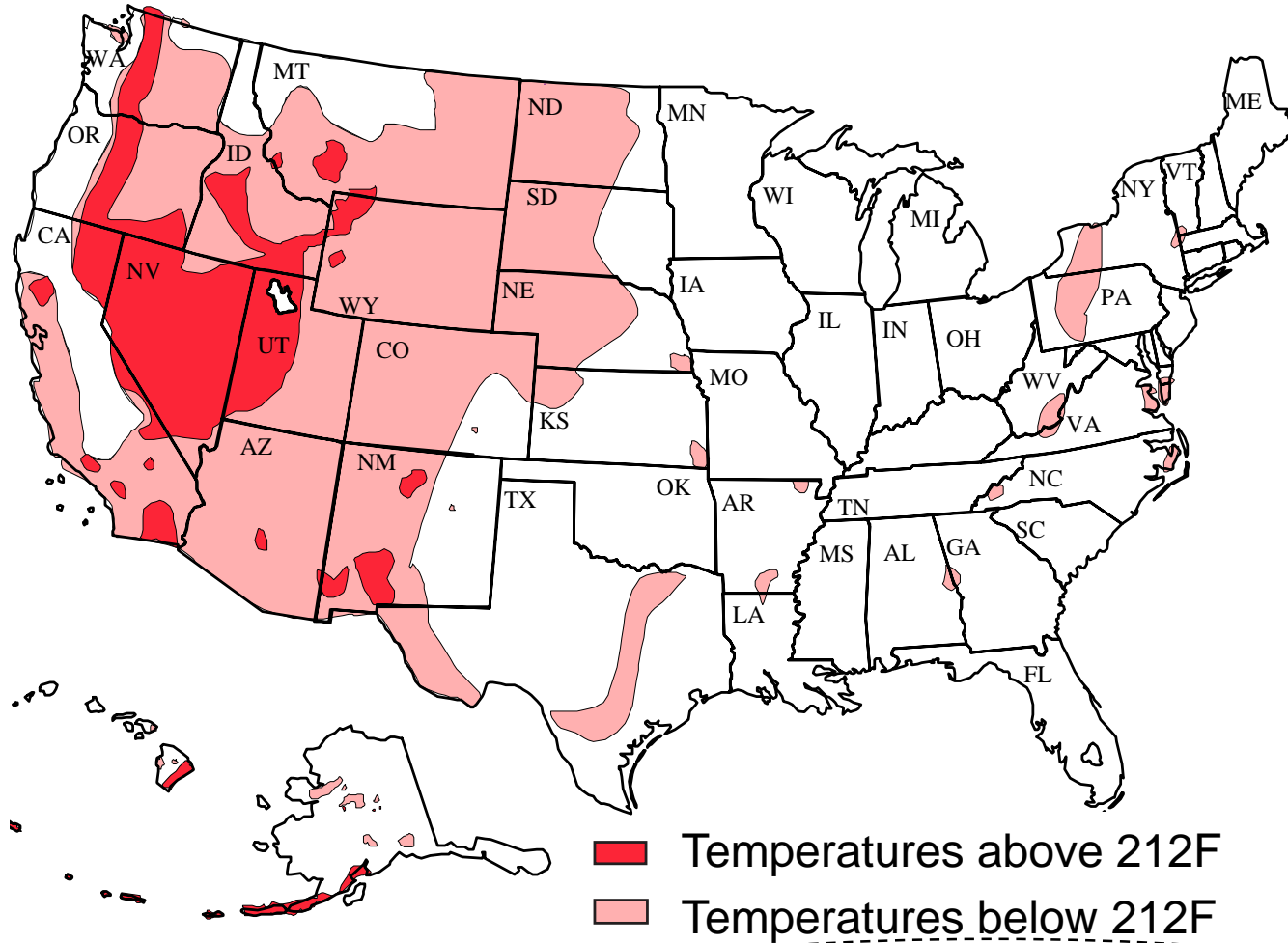
# Ground Source Heat Pump Systems



adapted from Brandl (2006)

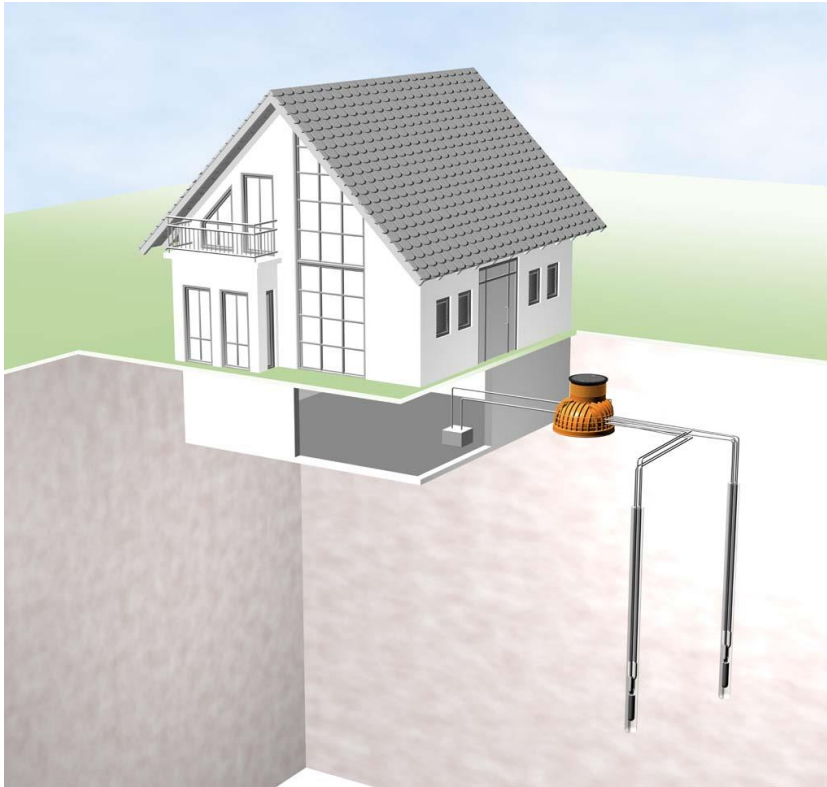
Utilize the relatively constant temperature of the ground and use it for heating in the winter and cooling in the summer

# Geothermal Resources and GSHP Systems



# Geothermal Boreholes

- 4-6 inch diameter borehole
- 100 ft - 500 ft deep
- Small residential to large commercial

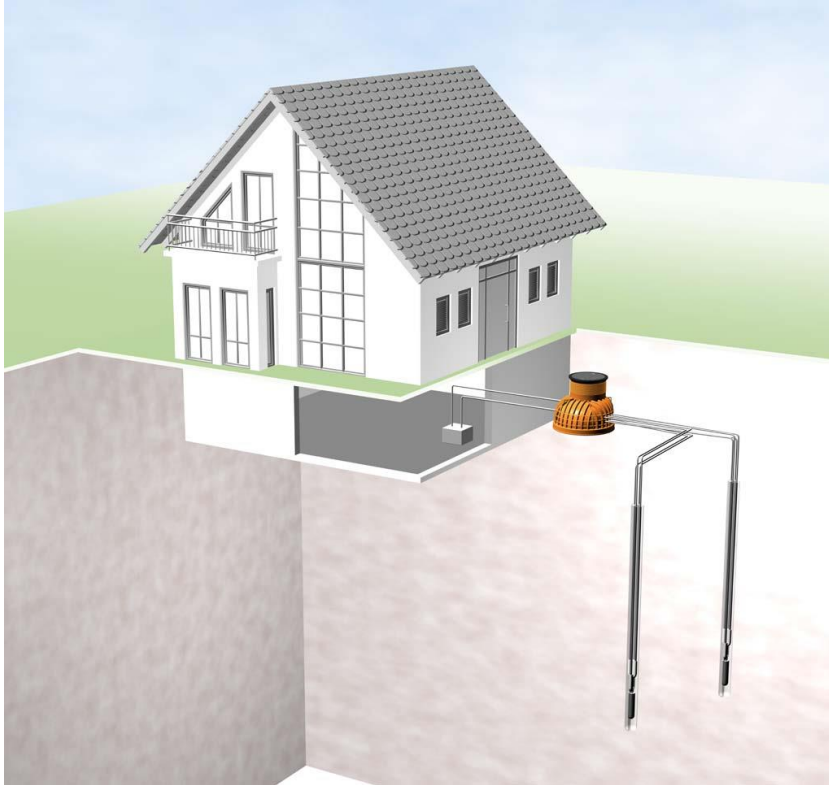


Major cost is drilling and materials

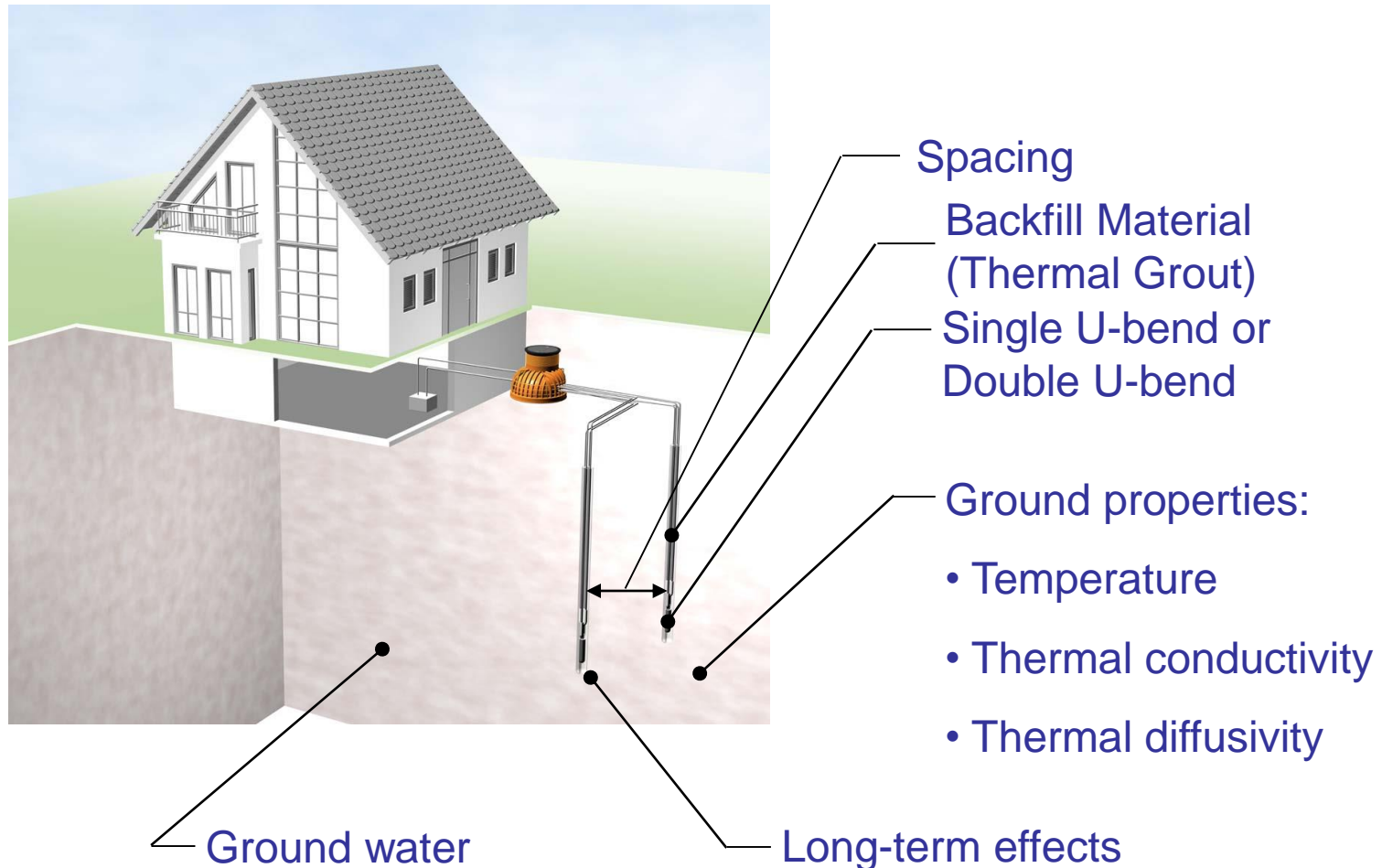




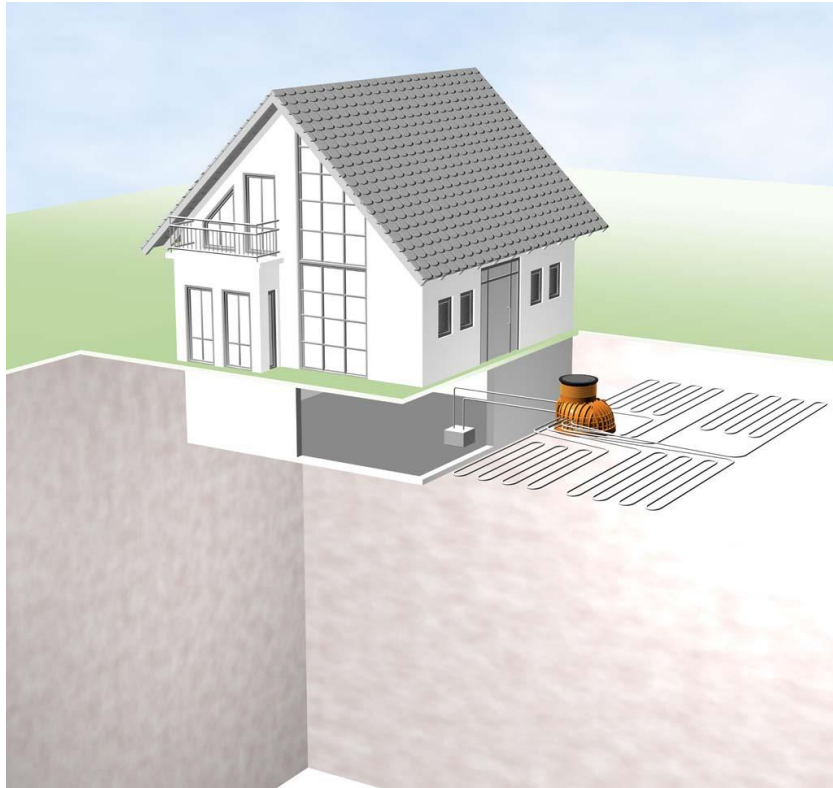
# Geothermal Boreholes



# Geothermal Boreholes – Design Considerations



# Horizontal Loops

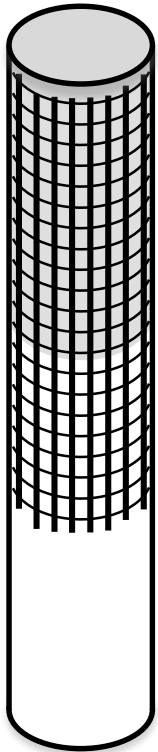


6-10 ft



# Energy Piles – Dual Purpose Elements

Deep Foundation



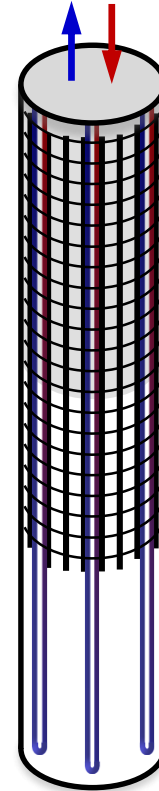
Foundation support  
(micropile, drilled shaft, CFA)

Geothermal Loops



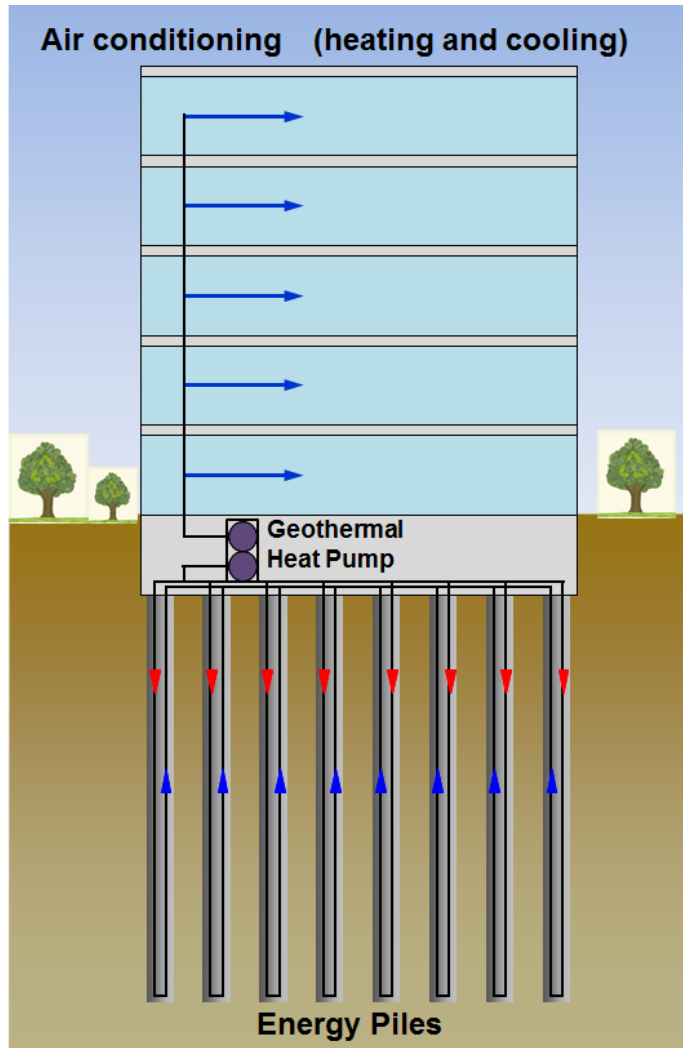
Heating/cooling  
(PEX, HDPE)

Energy Pile



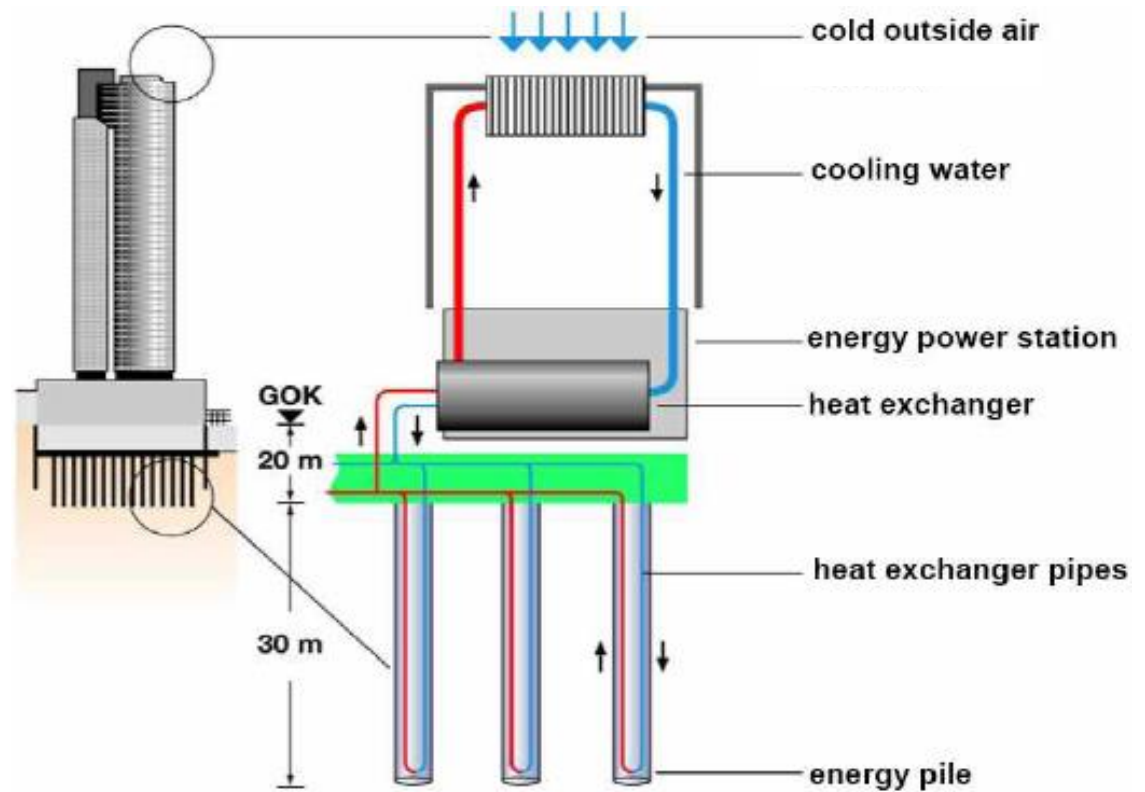
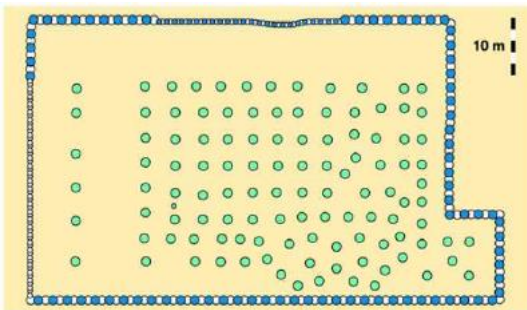
Foundation support &  
heating/cooling

# Energy Piles



- Developed in 1980's in Austria
- Piles, shafts, or caissons
- Diameter: 1 to 5 ft typical
- Lengths: 40 to 90 ft typical

# Frankfurt Main Tower



223 Energy piles were installed  
Power : 500kW  
Courtesy R. Katzenbach TUD

# Performance of GSHP Systems

Geothermal Boreholes



Horizontal Loops



Energy Piles



Poor ground quality

8 W/ft

1 W/ft<sup>2</sup>

8 W/ft

Average ground quality

15 W/ft

2.5 W/ft<sup>2</sup>

15 W/ft

Excellent ground quality

25 W/ft

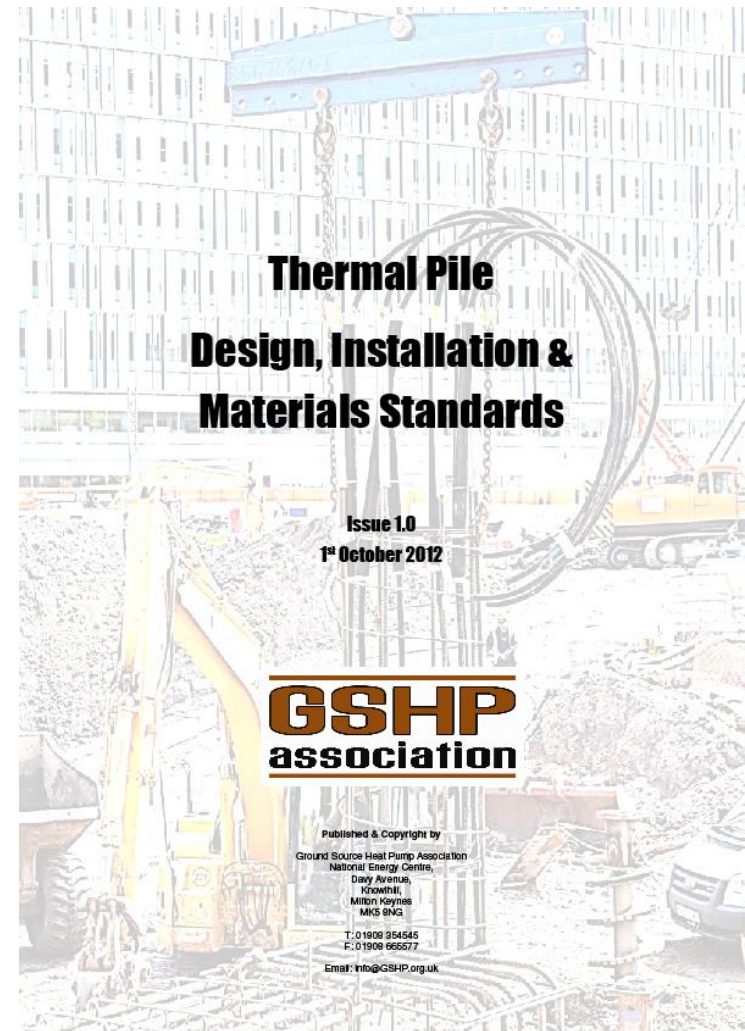
4 W/ft<sup>2</sup>

25 W/ft

1W ~ 3.4Btu/hr

# Design of Energy Piles

- Ground Source Heat Pump Association – Thermal Pile Standard
- Check thermally induced pile stresses
- Pile performance under repeated cyclic loading (annual heating and cooling)
- Estimate pile settlement due to temperature cycles



[http://www.gshp.org.uk/GSHPA\\_Thermal\\_Pile\\_Standard.html](http://www.gshp.org.uk/GSHPA_Thermal_Pile_Standard.html)





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Thank You!

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