Groundwater Source Heat Pumps

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Closed Loop Geothermal

- Circulating fluid absorbs heat from the subsurface and delivers it to a heat pump inside the building. In summer, the process is reversed.
- The temperature below ground remains the same all year long.
- Heating and cooling distribution system
  - Geothermal heat pump
  - Heating (winter)
  - Cooling (summer)
Groundwater Open Loop
Geothermal heating and cooling: open system (this project)
Heat Pump Efficiency

- Coefficient of performance
- \( COP = \frac{\text{Energy Out (Heating or Cooling)}}{\text{Energy In (Electricity)}} \)
- Heating  \( 3 < COP < 4 \)
- Cooling  \( 3.5 < COP < 6.7 \)
Heating with Groundwater

- COP = 3
- Groundwater in 14° C, out 9° C
- 2000 ft² house
- Inside 20°C, Outside 4°C
Cooling with Groundwater

- 2000 ft² house
- COP = 4
- Groundwater in 14° C, out 23° C
Cooling with groundwater, commercial scale

The NEW Mahomet IGA Food Store

Flow rate 150 gal min$^{-1}$

Hoover (2010)
Potential Yield, Sand & Gravel Aquifers

Wehrmann et al. (2004)
Study area 1

Mason County

Wehrmann et al. (2004)
Mason County High Capacity Wells

Roadcap et al. (2011)
Potential Impact of New High-Capacity Well Fields

Roadcap et al. (2011)
Refrigerated warehouse, Havana

Could use groundwater for refrigeration.

Hermann (2011)
Study area 2

Wehrmann et al. (2004)

American Bottoms
American Bottoms Area

IDOT Dewatering Wells
Total pumpage > 15 mgd

Anliker and Olson (2003)
American Bottoms Transmissivity

Schicht (1951)
Mason County CaCO$_3$ Saturation

![Graph showing CaCO$_3$ Saturation Index vs pH. The x-axis represents pH ranging from 6 to 9, and the y-axis represents the CaCO$_3$ Saturation Index ranging from -1.5 to 1.5. Data points are scattered across the graph, with most points falling within the undersaturated region (pH > 8) and a few points falling within the oversaturated region (pH < 8).]
Calcium Carbonate Solubility

- Depends on Ca, Alkalinity, pH, T
- Solubility product decreases (a little) as temperature increases
- Only a problem for cooling, not heating
- $\Delta T +10^\circ C$, CaCO$_3$ precipitation
  - Mason Co. $\sim$10 mg L$^{-1}$
  - Madison Co. $\sim$15 mg L$^{-1}$
Scale and Heat Transfer Efficiency

10 gal min\(^{-1}\)
\(\Delta T +10^\circ C\)

3-6 months for 2 mm deposit
To-do List

• Area-specific calculations
  – Groundwater temperatures
  – Air temperatures
• Better estimates of heating/cooling requirements
• Calculate potential CO$_2$ savings
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Use to yield ratio, sand and gravel aquifers
IDOT Dewatering Wells

Anliker and Olson (2003)
Uncertainty, Heating Calculations

Effect of $m_{gw}$ on heat values and uncertainty

- $Q_{gw}$ (kW)
- $Q_{hp}$ (kW)
- $W_p$ (kW)

$m_{gw}$ (kg/s)

0.5
0.6
0.7
Uncertainty, Cooling

Effect of $m_{gw}$ on heat values and uncertainty

- $Q_{gw}$ (kW)
- $Q_{hp_c}$ (kW)
- $W_{p_c}$ (kW)

$m_{gw}$ (kg/s):
- 0.4
- 0.5
- 0.6
- 0.7
- 0.8
Geothermal heating and cooling: closed loop
Air conditioner, a common heat pump

Min. COP 3.4