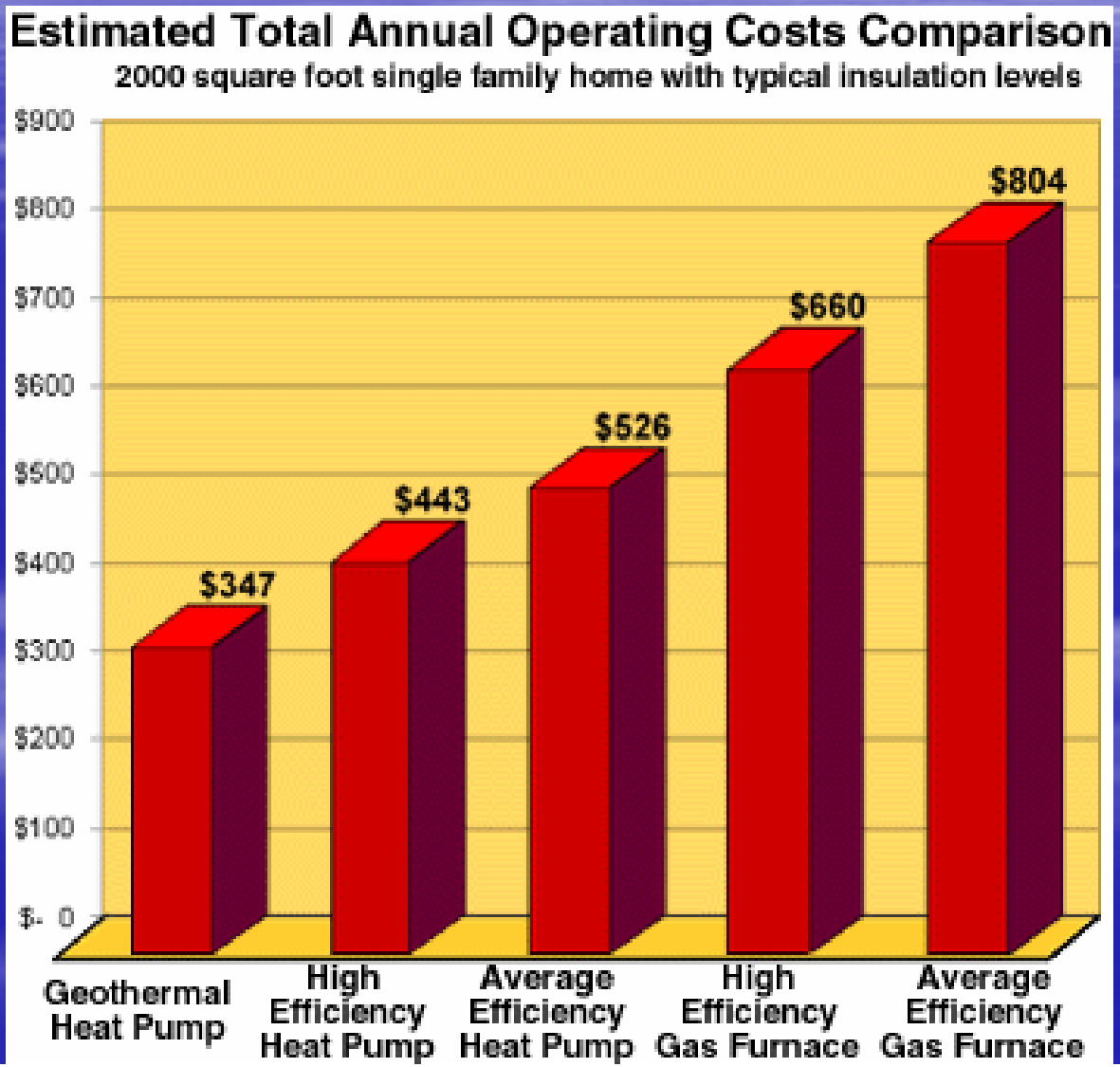
Designing Closed-loop Heatpump Systems

How to get it right

Dare to Compare

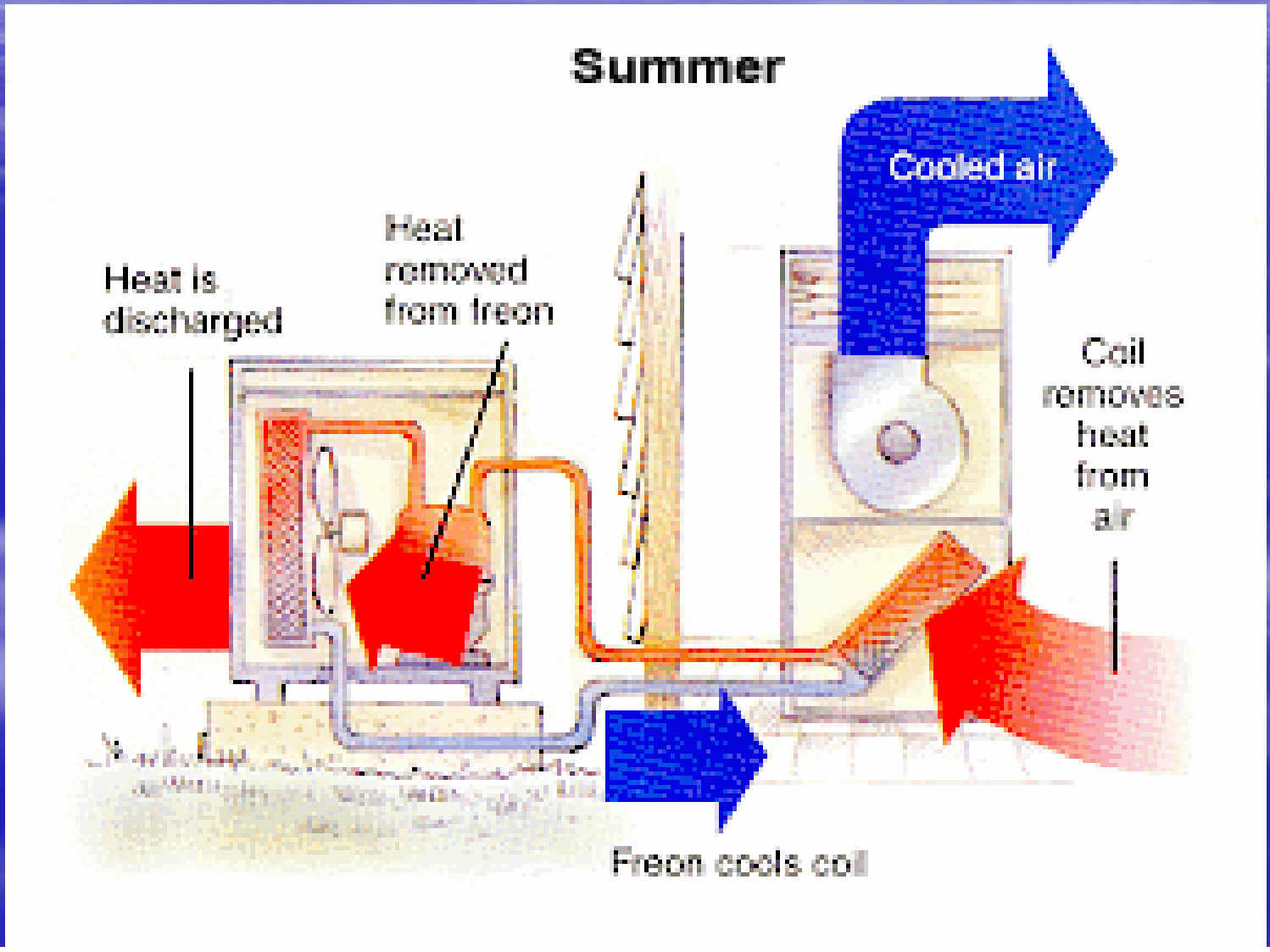
http://www.energyright.com/cgi-bin/dtc?tvaparms



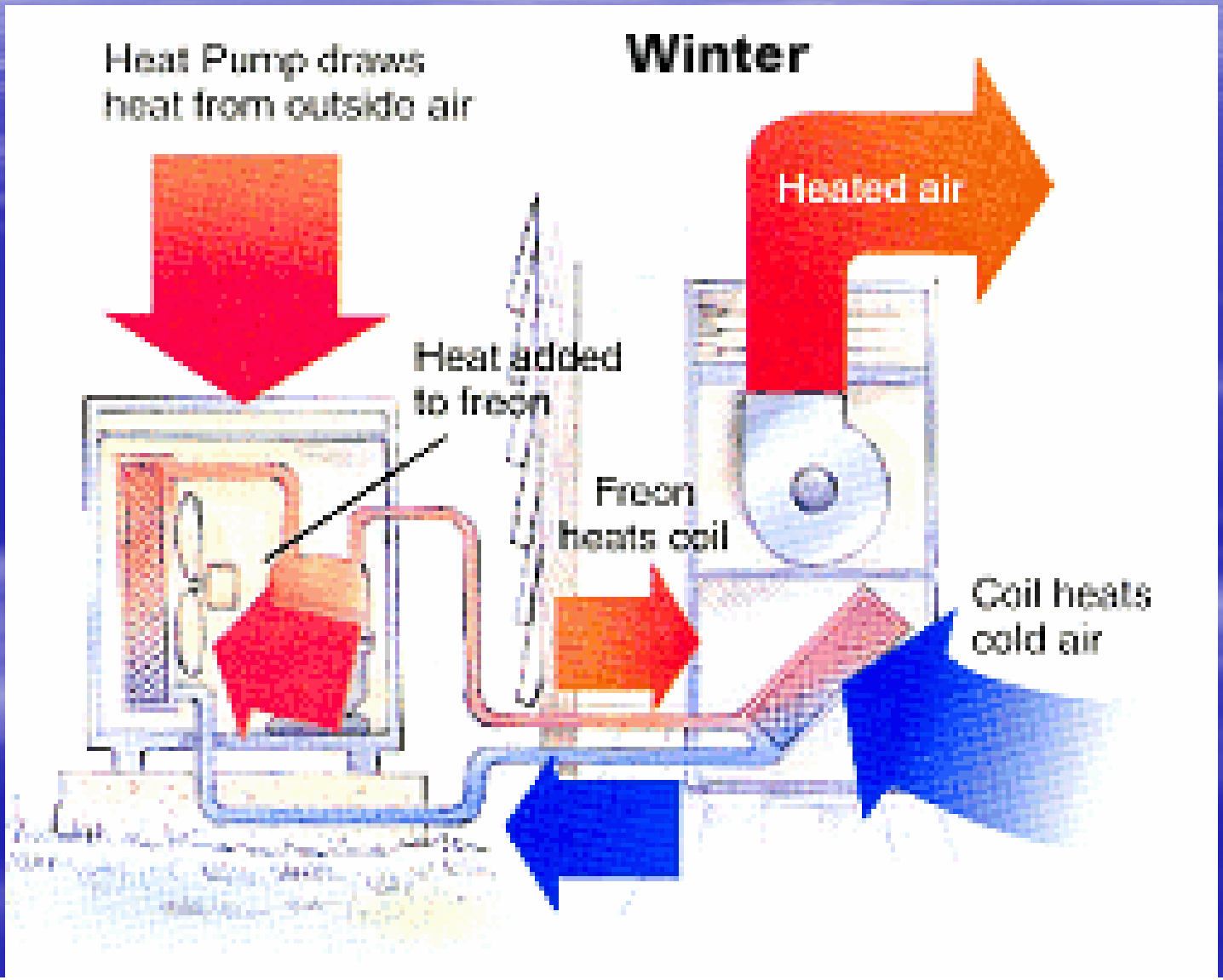
Heatpump types

- Air source or Electric Heatpumps
  - Normally installed with conventional furnace
- Water source or Geothermal Heatpumps
  - Open system (pump and dump) (open loop)
  - Closed system
    - Boiler, cooling tower
    - Earth coupled
    - Pond source

Air Source-Cooling



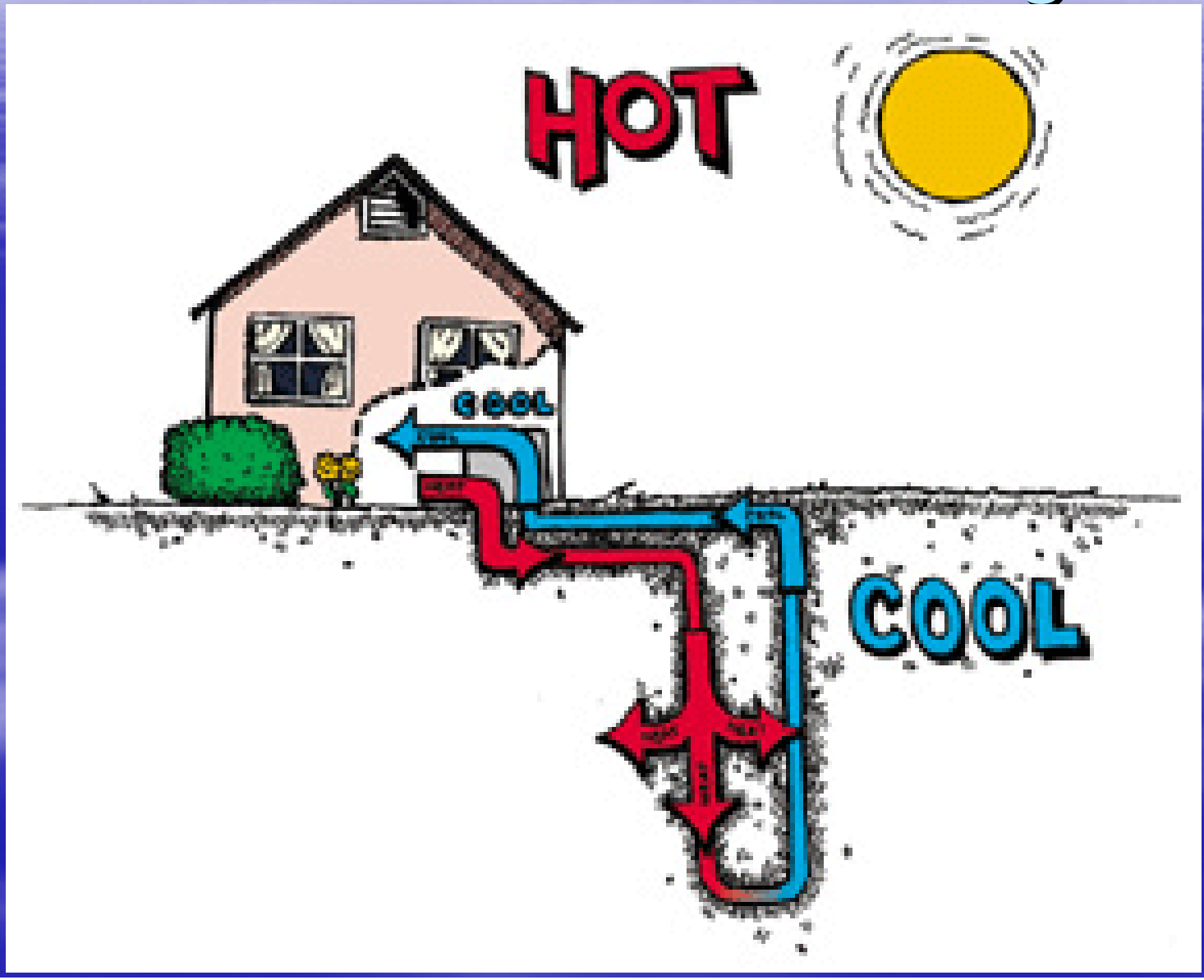
Air Source-Heating



Air Source

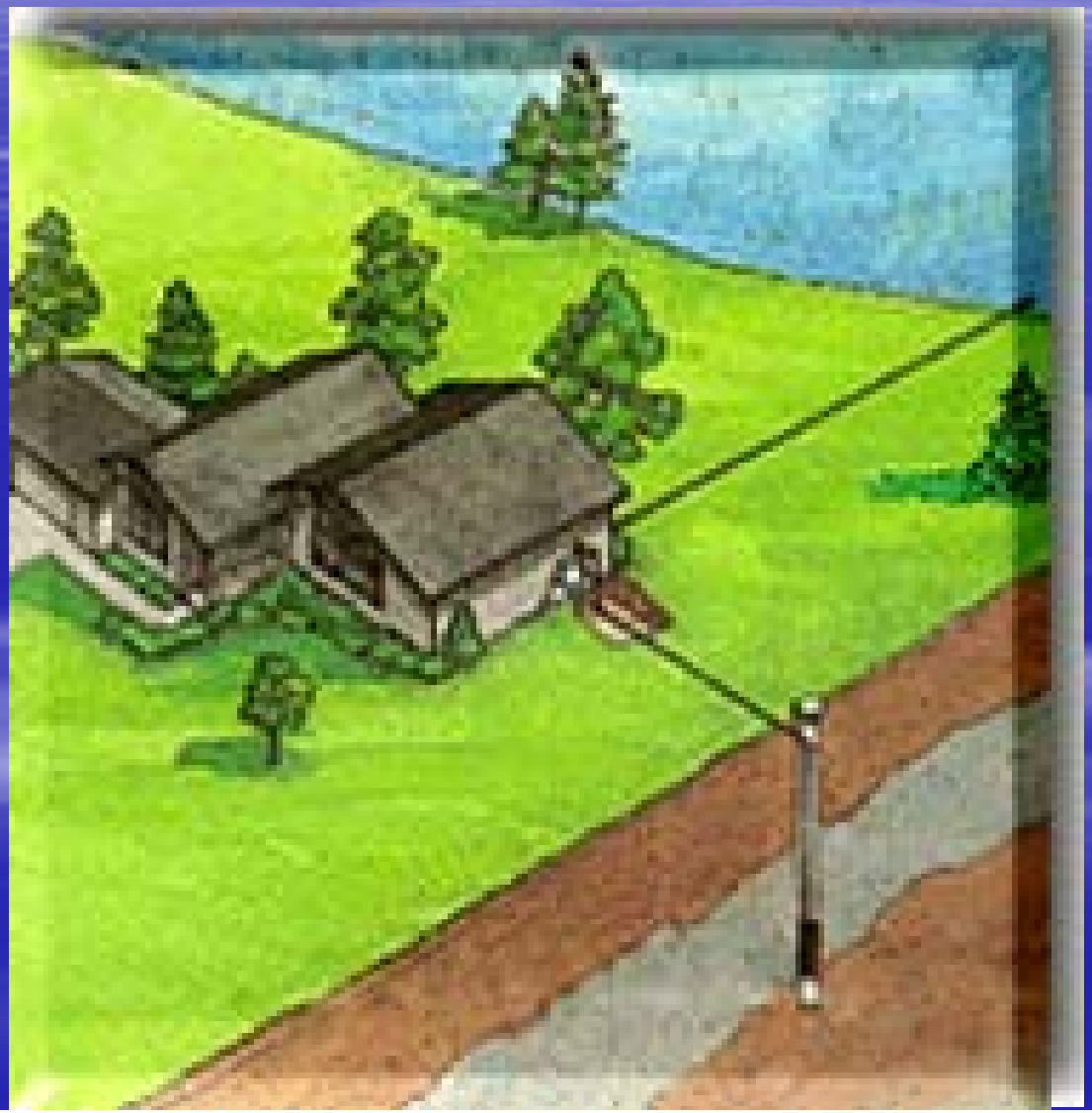
- Pros:
  - More efficient than gas, electric, propane
  - SEER 10-13
  - COP approximately 2.0
  - Easy to install, low cost
- Cons:
  - Least efficient heatpump
  - Loses capacity in extreme temperatures

Water Source-Cooling



Water Source Heatpump

Water Source-Open system



Water Source-Pond

Water Source-Horizontal

Water Source-Vertical

Water Source

- Pros:
  - More efficient system available
  - SEER 17-27
  - COP approximately 4.0
  - Maintains capacity in extreme temperatures
  - Easy to zone large systems
- Cons:
  - Most expensive installation
  - Not well understood by designers, users

System Design

- Residential, Small System
  - Complete Manual J, Spec. Equip. Install
- Commercial System
  - Complete Manual S, Design the system
- Watch out for design pitfalls!!!
- Do not use “Rule of Thumb” sizing

A Design Example

ARDC HQ HVAC Design

- 23,000 Square feet
- 24 Closed-loop heatpumps
- 23 Zones
- 55-182’ Vertical closed loops
- 2-15 horsepower circulation pumps

- Lets look at how the design was completed

ARDC HQ HVAC Design

- Design heating load 436,100 btu, 36.3 ton
- Design cooling load 679,600 btu, 56.6 ton
- Installed capacity 830,000 btu, 69.2 ton
- Circulation pump capacity 213 gpm @120 tdh
- Circulation pump runs continuously, 15 hp

- How did they do on the design?

ARDC HQ HVAC Design

- Considering that HVAC design calculations are conservative the actual heating and cooling loads are less than as designed.
- In all cases at least the next larger heatpump is specified, sometime more.
- Flow rate is designed at heatpump maximum performance.
- Friction loss in all heat exchangers are assumed to be the same.
- A throttling valve is used on the pump discharge to correct flow rate.

ARDC HQ HVAC Design

- This system is grossly oversized!!!
- This results in humidity problems when temperatures are in the 80’s with high humidity
- Excess energy is used to circulate the closed loop fluid
- It is still the most efficient system in the University of Nebraska system

What can be done?

- It is not cost effective to replace installed heatpumps.
- Reducing the flow rate to the design rate will reduce pumping costs.
- The heatpumps only operate about 20% of the time, installing solenoid valves and variable speed drives will further reduce costs.

Estimated Savings

- Reducing the pump size should save $500 per month
- Using variable speed drives on the new pump should reduce the cost to approximately $50 per month
- Current cost to operate pump is $750 per month
- Total utility bill of the ARDC HQ is $1500

Conclusions

- Water source heatpumps are the most efficient method to heat and cool facilities
- Correct design and installation of systems will maximize efficiently
- “Rules of thumb” should not be used for design, but can be useful when reviewing plans
- Correct design is better than conservative design