



Gipe Associates, Inc.
CONSULTING ENGINEERS

Geothermal Heating and Cooling Fundamentals ASHRAE – Philadelphia Chapter

Geothermal Heating and Cooling –
Is It Right for your Building or House?

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LEED AP, Cert. Geo. Designer
Gipe Associates, Inc.



Today's Agenda

Introduction

Commercial Geothermal Systems

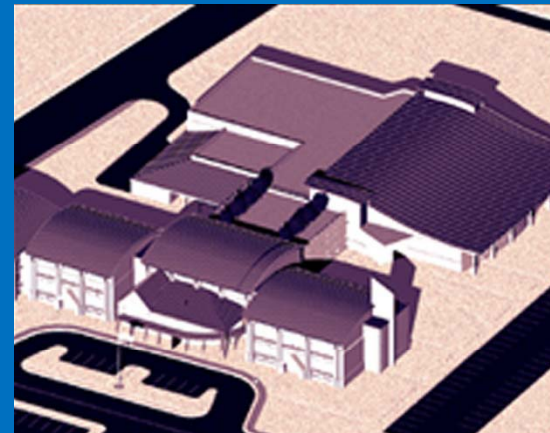
Lessons Learned

Residential Geothermal Systems

Typical Costs

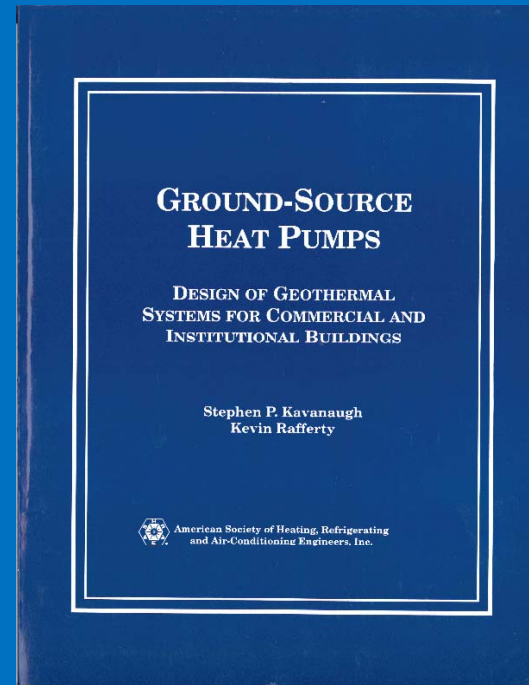
Rules of Thumb

Emerging Technologies



Need to Thank:

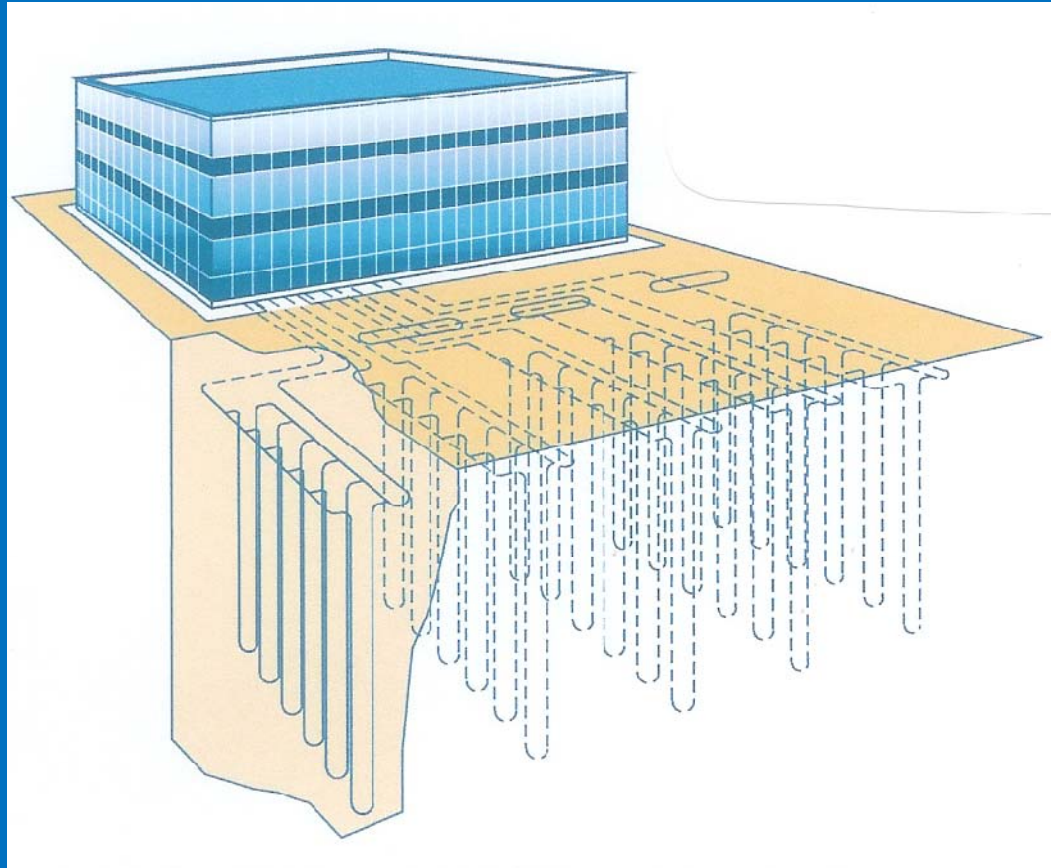
Dr. Steve Kavanaugh



The Well Drillers



Geothermal and Commercial Applications

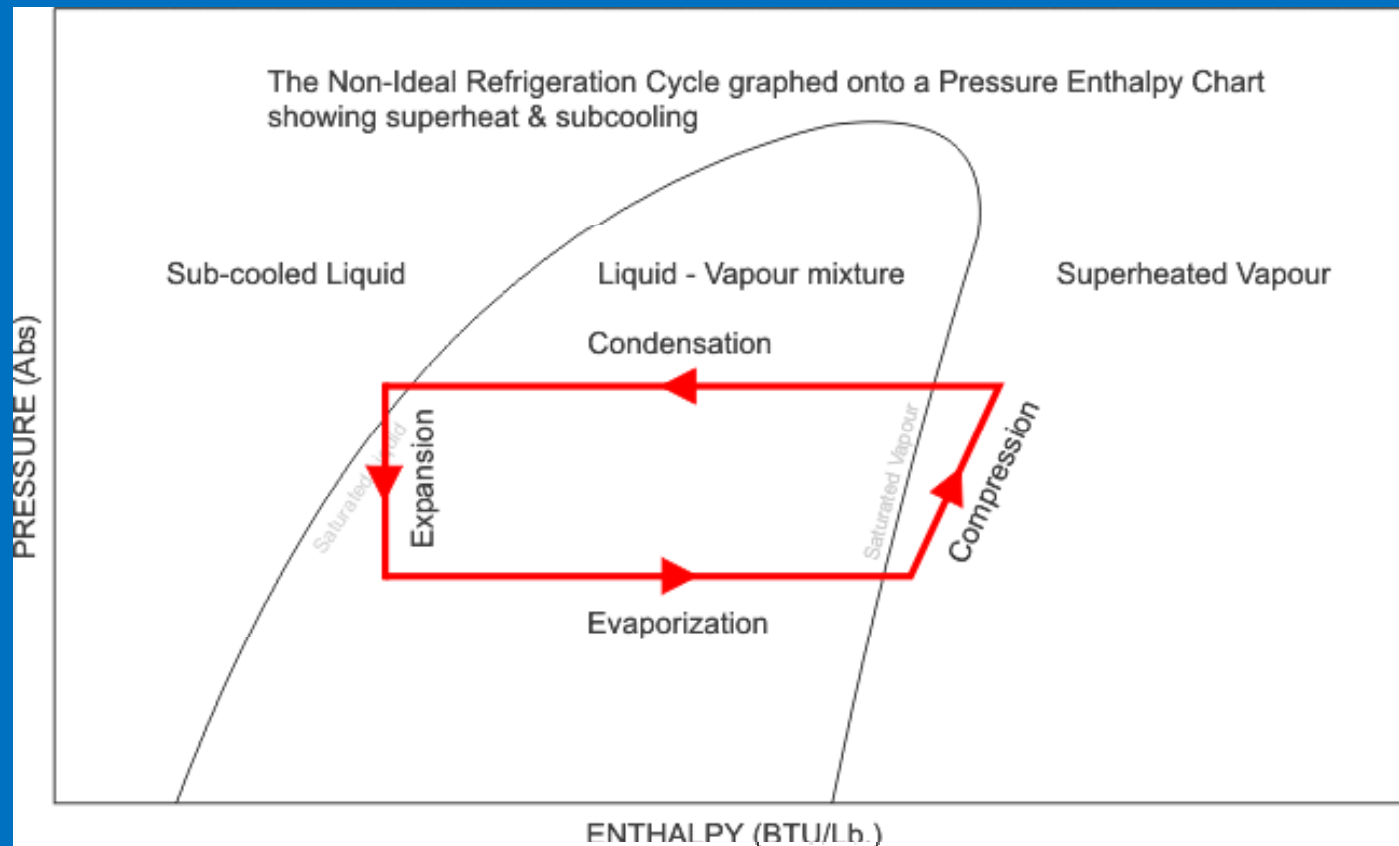


Gipe Associates has been involved in over 120
Geothermal Projects

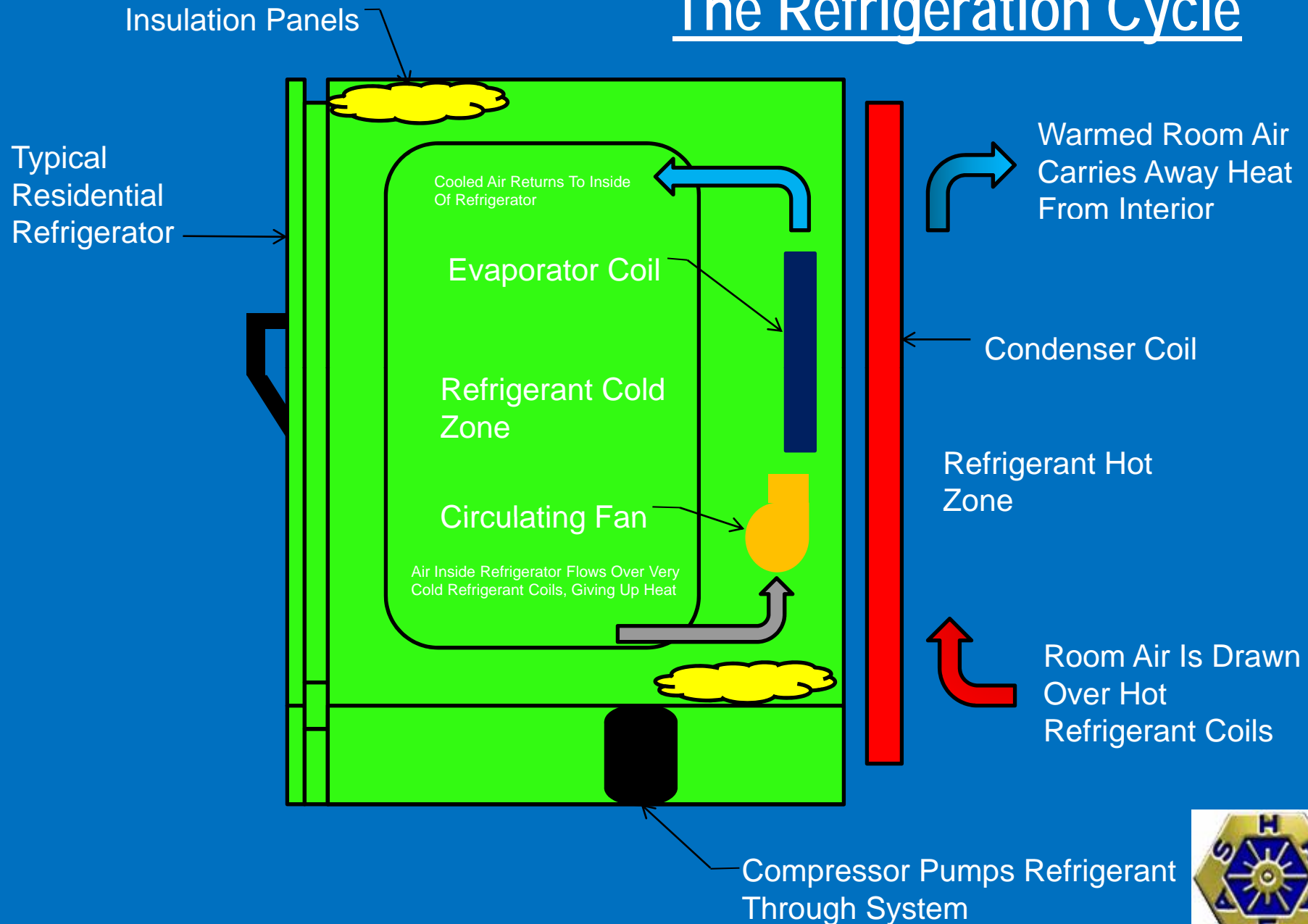


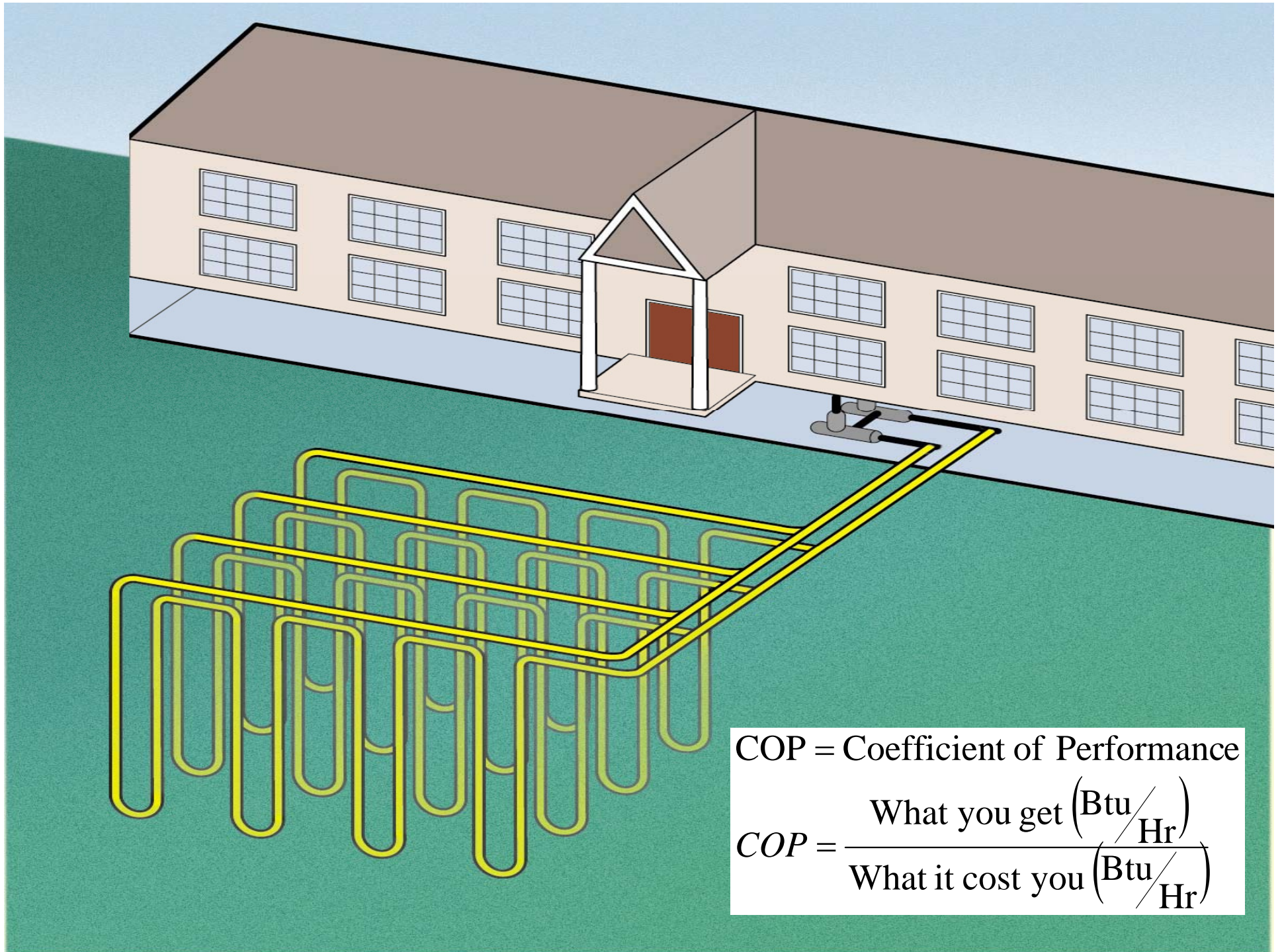
Basic Fundamentals

The Refrigeration Cycle



The Refrigeration Cycle





COP = Coefficient of Performance

$$COP = \frac{\text{What you get } \left(\frac{\text{Btu}}{\text{Hr}}\right)}{\text{What it cost you } \left(\frac{\text{Btu}}{\text{Hr}}\right)}$$

Geothermal Piping Headers



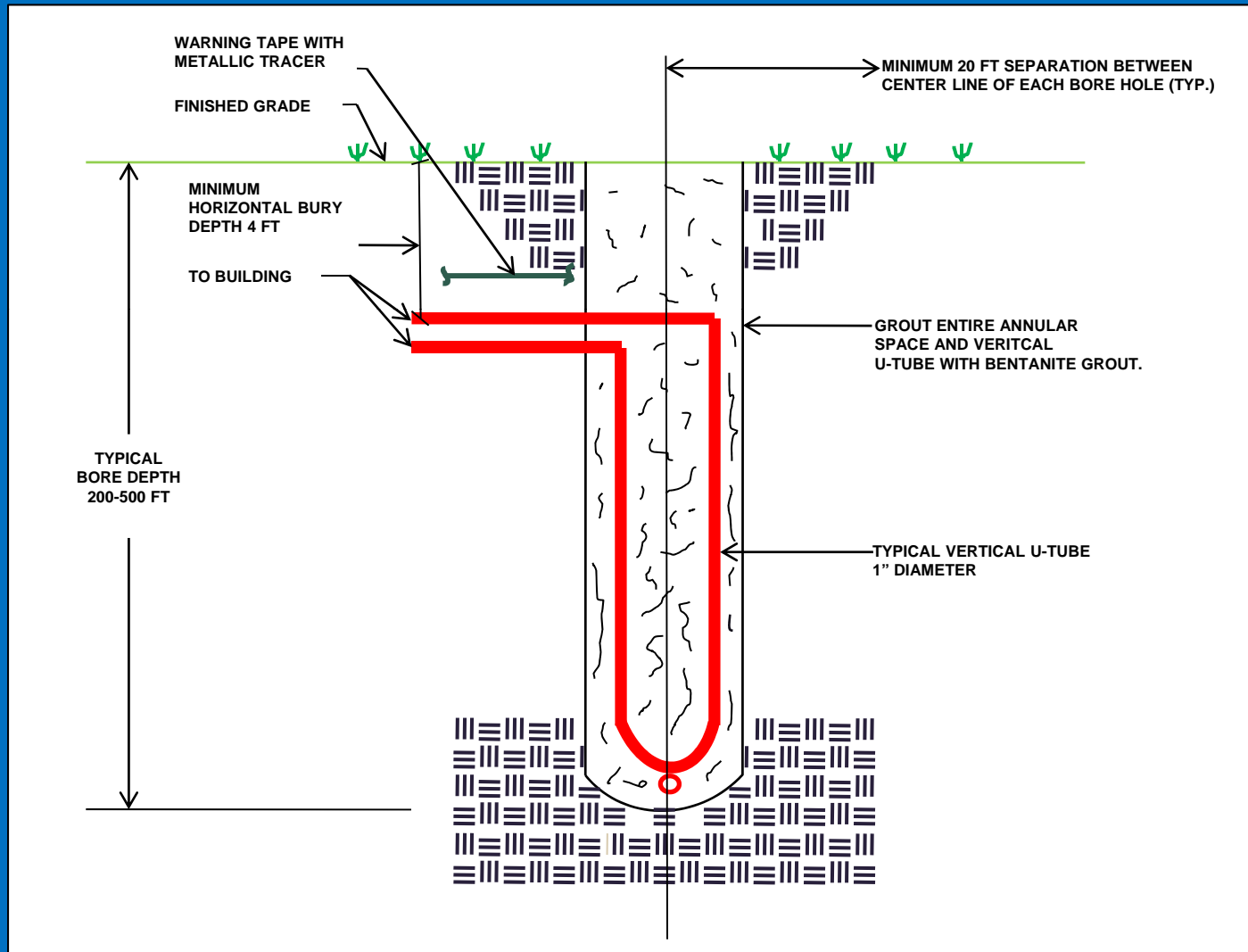
Geothermal Hydronic Pumps



Heatpumps

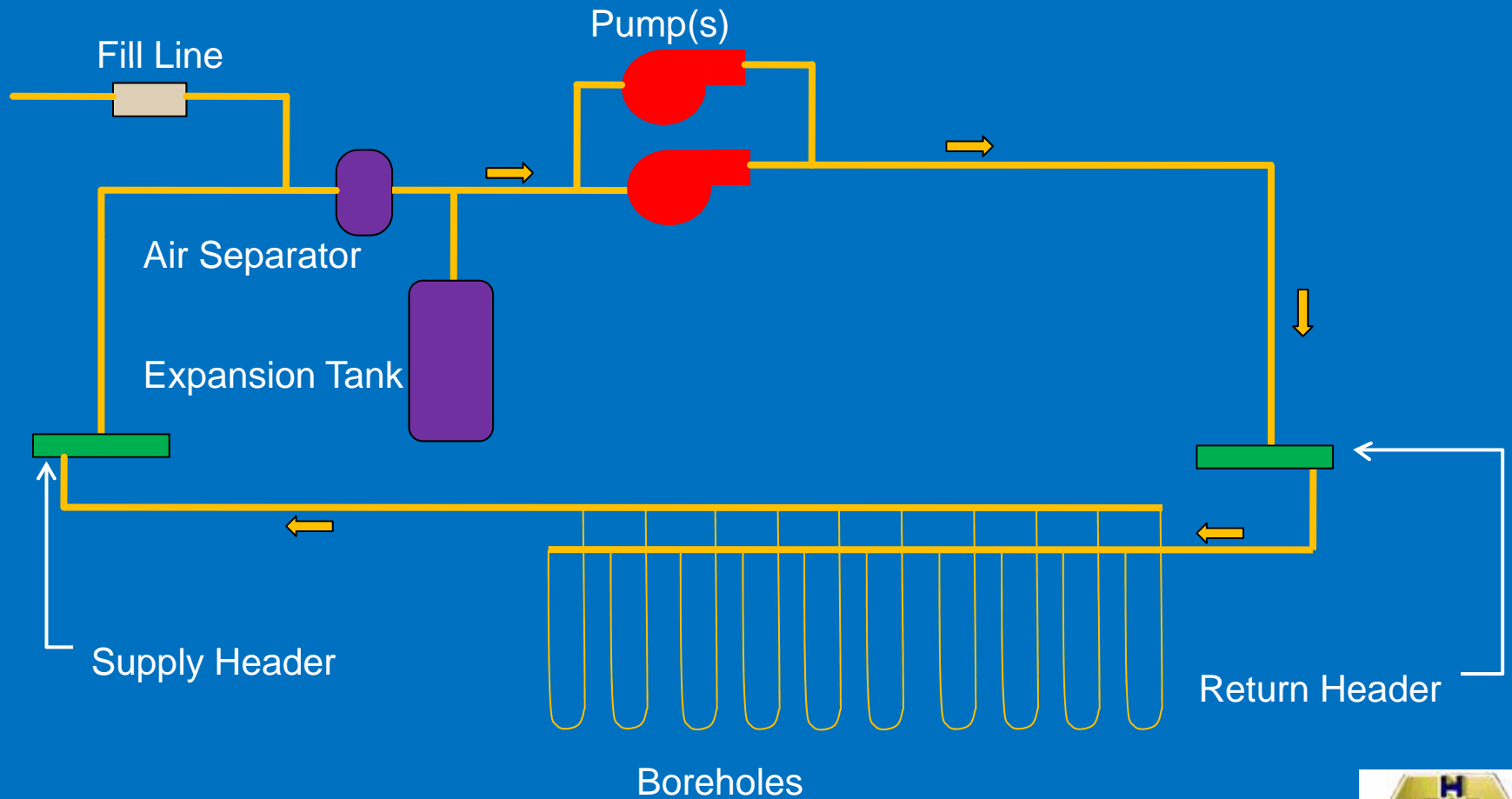


Vertical U-tube Fundamentals & Applications



COMMERCIAL SYSTEM

Geothermal System Flow Diagram



Judy Center in Cambridge, MD Before



Judy Center in Cambridge, MD After



Washington College in Chestertown, MD Before



Washington College in Chestertown, MD After



Washington College in Chestertown, MD

New Residence Halls



Salisbury University

- Pocomoke Hall: Existing Air Cooled Chiller w/ new fuel fired boiler to supply dual temp system
- Manokin Hall: Ground Source Heat Pump system with Water-to-Water Heat pumps to supply dual temp system.

	Pocomoke Hall (Bid Spring of '09)	Manokin Hall (Bid Fall of '09)
HVAC/Plumbing	\$1,681,800.00	\$1,579,500.00
Electrical	\$687,948.00	\$820,000.00
Total MEP Cost	\$2,369,748.00	\$2,399,500.00
Total Construction Cost	\$6,175,440.00	\$5,175,000.00

- Both Projects Similar in Size (21,400 sq.ft.)



Water to Water Heat-Pumps

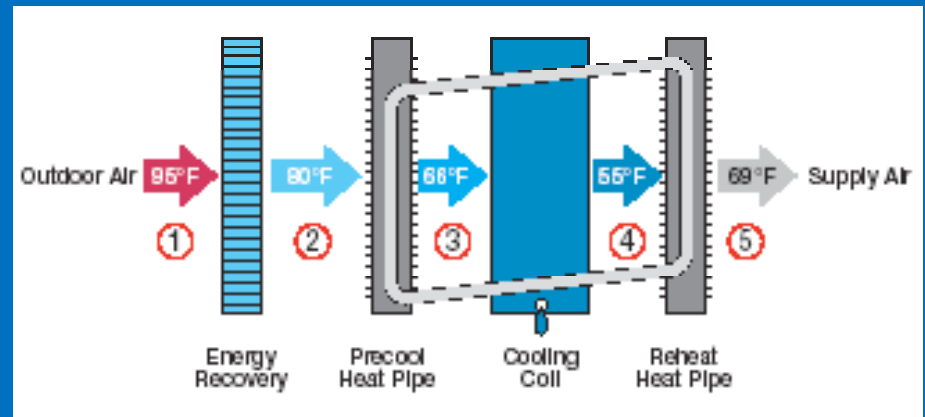


Energy Recovery Units



Energy Recovery Technology

- Variable speed control on Supply & Exhaust Fan
- CO2 Monitoring
- Dedicated Outside Air Tempering Control
- Heat Pipe Technology
- Outdoor Air Reset
- Airflow Monitoring



Domestic Hot Water



Fuel Cost Comparisons

Fuel	True Cost in \$ per 100,000 BTU (corrected for efficiency)
No. 2 Fuel Oil	\$2.00
Natural Gas	\$1.88
Propane Gas	\$3.22
Electric	\$3.52
Air Side Heat Pump	\$1.56
Water Cooled Heat Pump	\$0.70 (Geothermal)



Matapeake Elementary School - *Mechanical Room*



Washington College – 3 Dorm Project

Geothermal Main pipe layout



Tudor Farms – Main House

Geothermal Heat Exchangers



Chesapeake College – Higher Education Center



Project Specifications:

- Building Size - 26,700 sq. ft.
- System Type – Closed Loop Vertical U-Tube
- Borehole Data –
 - 60 Total Boreholes
 - 255' Total depth below grade
 - 4-3/4" Bore Diameter
 - 3/4" U-Tube Piping
- Treatment of Outside Air – Energy Recovery Unit utilizing dual temperature coils for conditioning of air and wrap around heat pump technology

❖ **Unique Design Features**
-Indoor Energy Recovery Units



Chesapeake College Dorchester Administration Building

Project Specifications:

- Building Size - 23,500 sq. ft.
- System Type – Closed Loop Vertical U-Tube
- Borehole Data –
 - 45 Total Boreholes
 - 279' Total depth below grade
 - 4" Bore Diameter
 - 1" U-Tube Piping
- Treatment of Outside Air – 100% Outside Air Water Source Heat Pump Units with hot gas re-heat for dehumidification



- ❖ Unique Design Features
 - 100% Outside Air Water Source Heat Pump Units



Talbot County Community Center

Project Specifications:

- Building Size – 30,000 sq. ft.
- System Type – Closed Loop Vertical U-Tube
- Borehole Data –
 - 190 Total Boreholes
 - 310' Total depth below grade
 - 5" Bore Diameter
 - 1" U-Tube Piping
- Treatment of Outside Air – 100% Outside Air Units utilizing Geothermal Loop temperature for conditioning of code required amount of Ventilation Air.



❖ Unique Design Features

- Ice Rink De-humidifier
- Snow Melt Pit
- Ice Rink Water Treatment



Lessons Learned - Commercial

Well Field

What are some of the “GOTCHA’s”?

- Borehole Diameter
- U-tube pipe diameters
- Pump / Piping Size
- Pipe Schedule
(SDR-11 vs. SDR-13.5)
- Reynold’s Number
(maintain min. 2 ft/sec
velocity in piping)
- Expansion Tank Sizing
- Vaults (When to use?)



Lessons Learned - Commercial

Outside Air – Dual Temperature System

What are some of the “GOTCHA’s”?

- Multiple, small, Water-to-Water Heat Pumps
- Variable Speed Pumping of Water-to-Water Heat Pumps in lieu of Individual In-Line Pumps.
- Dead-band on Dual Temp Loop



Lessons Learned - Commercial

Miscellaneous

What are some of the “GOTCHA’s”?

- Filter Racks on Heat Pumps
- Relief Valve
- Anti-Freeze: Glycol vs. Methanol
- Design Flow Rate - Diversity



Applications

Fan Coil units

Dedicated Outdoor Air Systems

Domestic Hot Water

Domestic Hot Water Pre-Heating

Kitchen Hood Make-up Air

Chilled Water

Fume Hood Make-up Air

Chilled Water w/ Storage

Radiant Heat

Hot Water

Hot Water w/ Storage



Buildings

Dormitories

Commercial Kitchens

Science Buildings

Office Buildings

Dining Halls

Vocational Schools

Historic Buildings

Elem./Middle/High Schools

*"Anything done conventionally can be
done with Geothermal"*

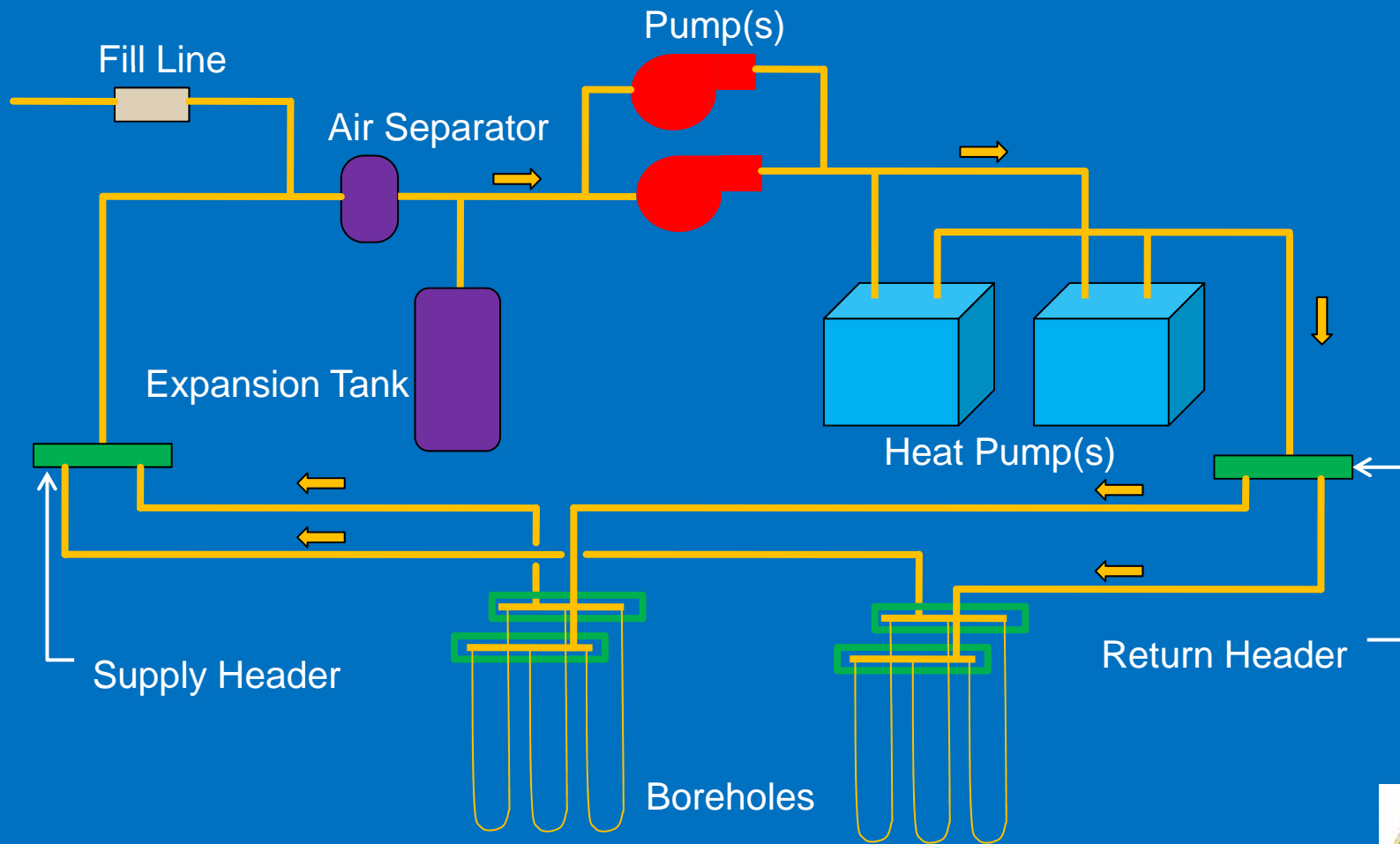


Geothermal in Residential Applications



THE HOFFMAN HOUSE

Geothermal System Flow Diagram



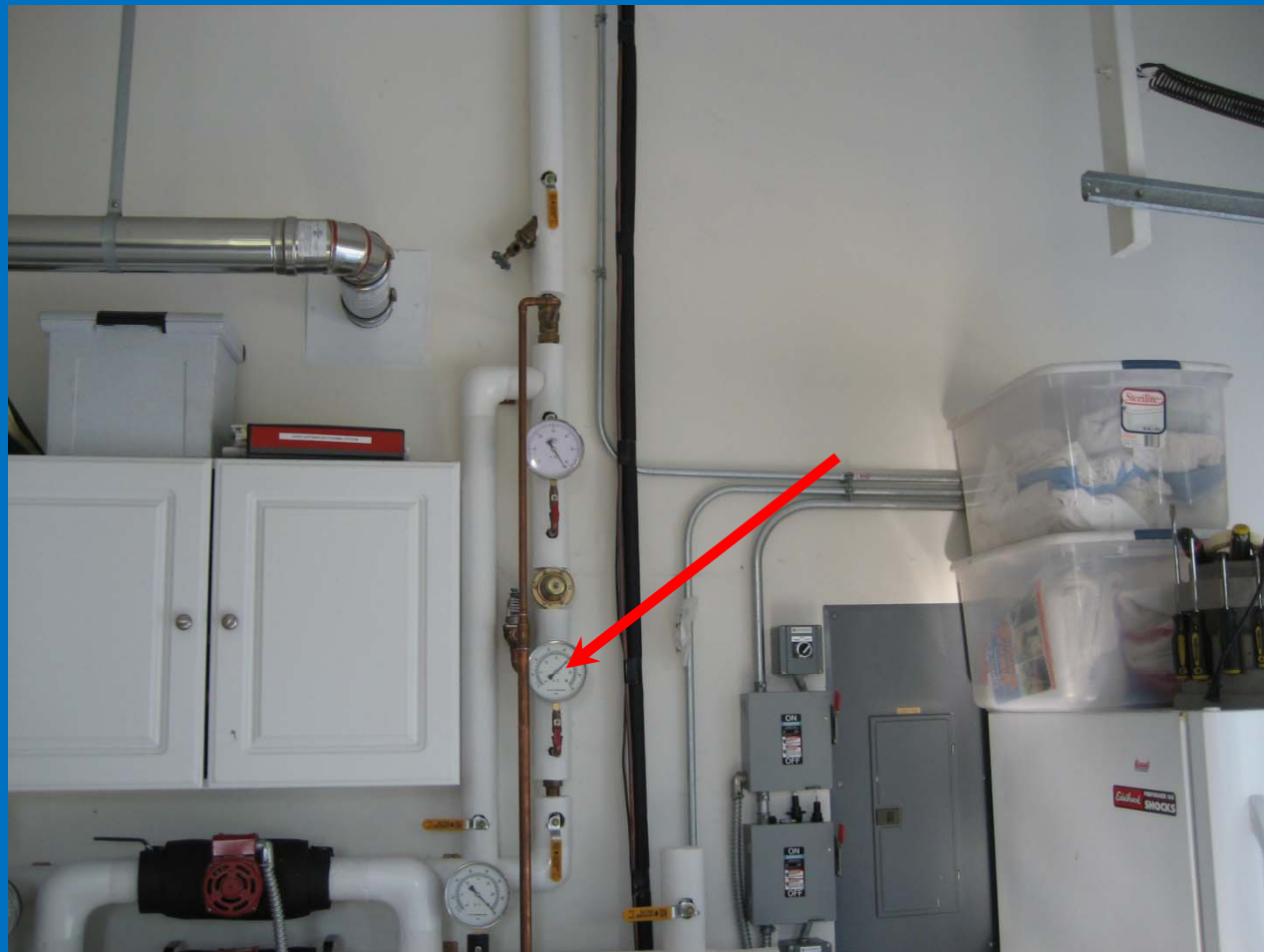
THE HOFFMAN HOUSE

Geothermal Split System Heat Pumps



THE HOFFMAN HOUSE

Domestic Make-up Water Valve Train



THE HOFFMAN HOUSE

Expansion Tank



THE HOFFMAN HOUSE

Geothermal Water Pumps



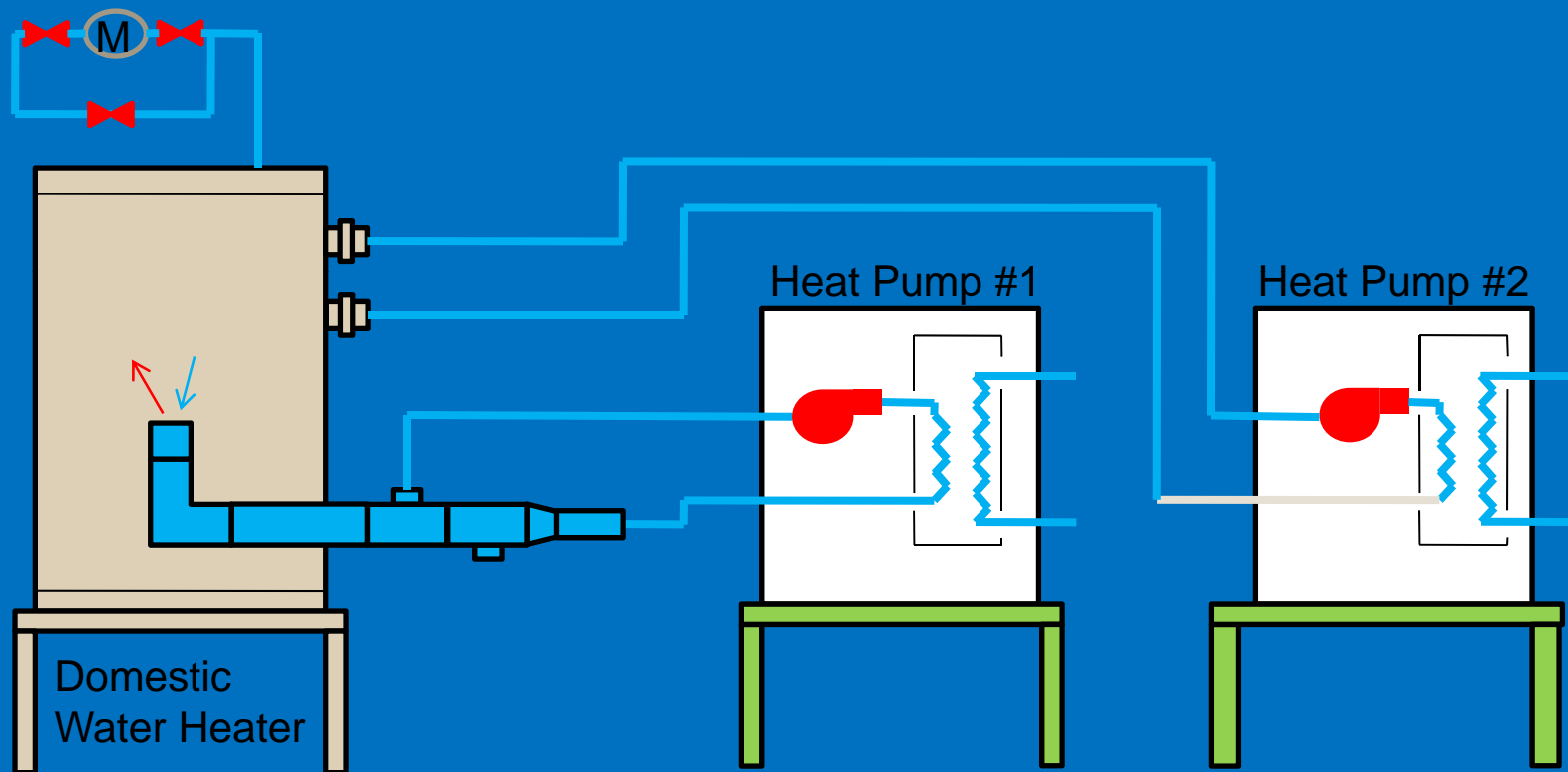
THE HOFFMAN HOUSE

Finished Site



THE HOFFMAN HOUSE

De-Superheater Capability



THE HOFFMAN HOUSE

De-Superheater Capability



Lessons Learned

Residential

What are some of the “GOTCHA’s”?

- De-Superheaters are great!
(Connect Inlet to Coldest Water)
- Heating Dominated Borefield
- Hydronic Specialties
- Pump Noise (Avoid high RPM pumps)
- Variable Speed Pumping in Large Systems
(Wilo / Grundfos)



Typical Costs

First Costs:

Commercial: \$23 - \$45 per sq.ft.

Residential : \$10 - \$14 per sq.ft.

(Does not include Tax Incentives or Rebates)



Energy Costs:

Commercial: \$0.80 - \$1.10 per sq.ft, per year

Residential: \$0.80 - \$1.25 per day



Maintenance Costs:

Commercial: \$0.10 per sq.ft, per year

Residential: \$0.03 per sq.ft, per year



Design Rules of Thumb

Vertical Boreholes

Mud Drilling: 250 – 400 ft. borehole per Ton

Rock Drilling: 200 – 300 ft. borehole per Ton

Equipment Capacities

Commercial Projects: Average = 300 sq.ft./Ton

Residential Projects: Average = 500 sq.ft./Ton

Pumping Flow Rates:

All Projects: 3 Gallons per Minute/Ton

1 Ton = 12,000 BTU/Hr

Pump Horsepower – Goal

Grade	Horsepower/100 Tons
A	5.0
B	7.5
C	10 - 15



Design Rules of Thumb

Equipment Effeciencies

	<u>Heating - COP</u> (Coefficient of Perf.)	<u>Cooling - EER</u> (Energy Efficient Ratio)
Commercial:	3.5	17.0
Residential:	4.5	20.0

Where:

$$\text{COP} = \frac{\text{What you get (BTU/Hr)}}{\text{What it cost you (Electric Energy in BTU/Hr)}}$$

$$\text{EER} = \frac{\text{What you get in (BTU/Hr)}}{\text{Power Input (in Watts)}}$$



Emerging Technologies / Improvements

ECM for Motors

Why?

- Ultra High Efficiency (Energy savings up to 67% average compared to PSC motors)
- Uses DC motors which are significantly more energy efficient than AC motors and are easier to control
- Soft starts and stops
- Fan Laws can be utilized to reduce Energy Consumption
- 10% Reduction in Airflow results in 27% energy reduction.



Emerging Technologies / Improvements

Variable Speed Compressors



Why?

- Reduction in compressor energy and water flow rates
- Improved part load performance
- Enhanced Humidity Control (Lowers the Equipment sensible heat ratio without re-heat).

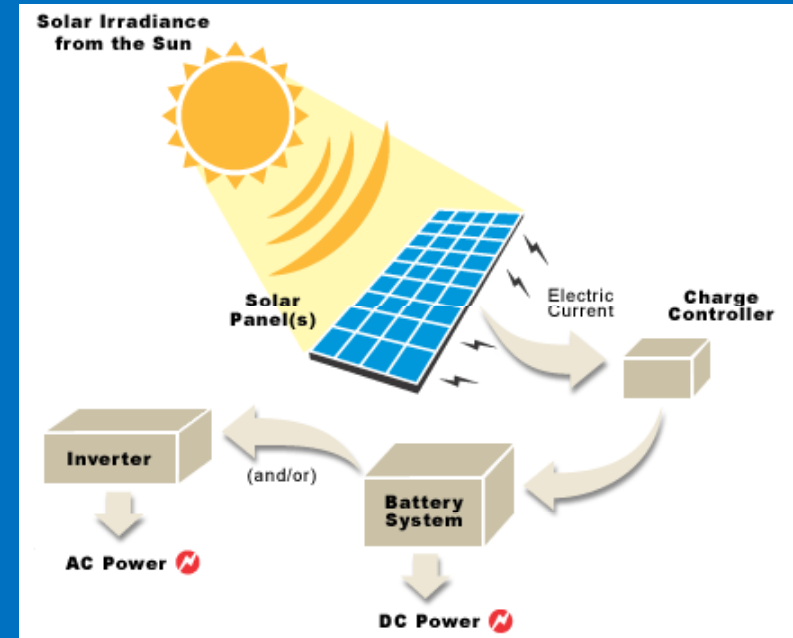


Emerging Technologies / Improvements

Solar

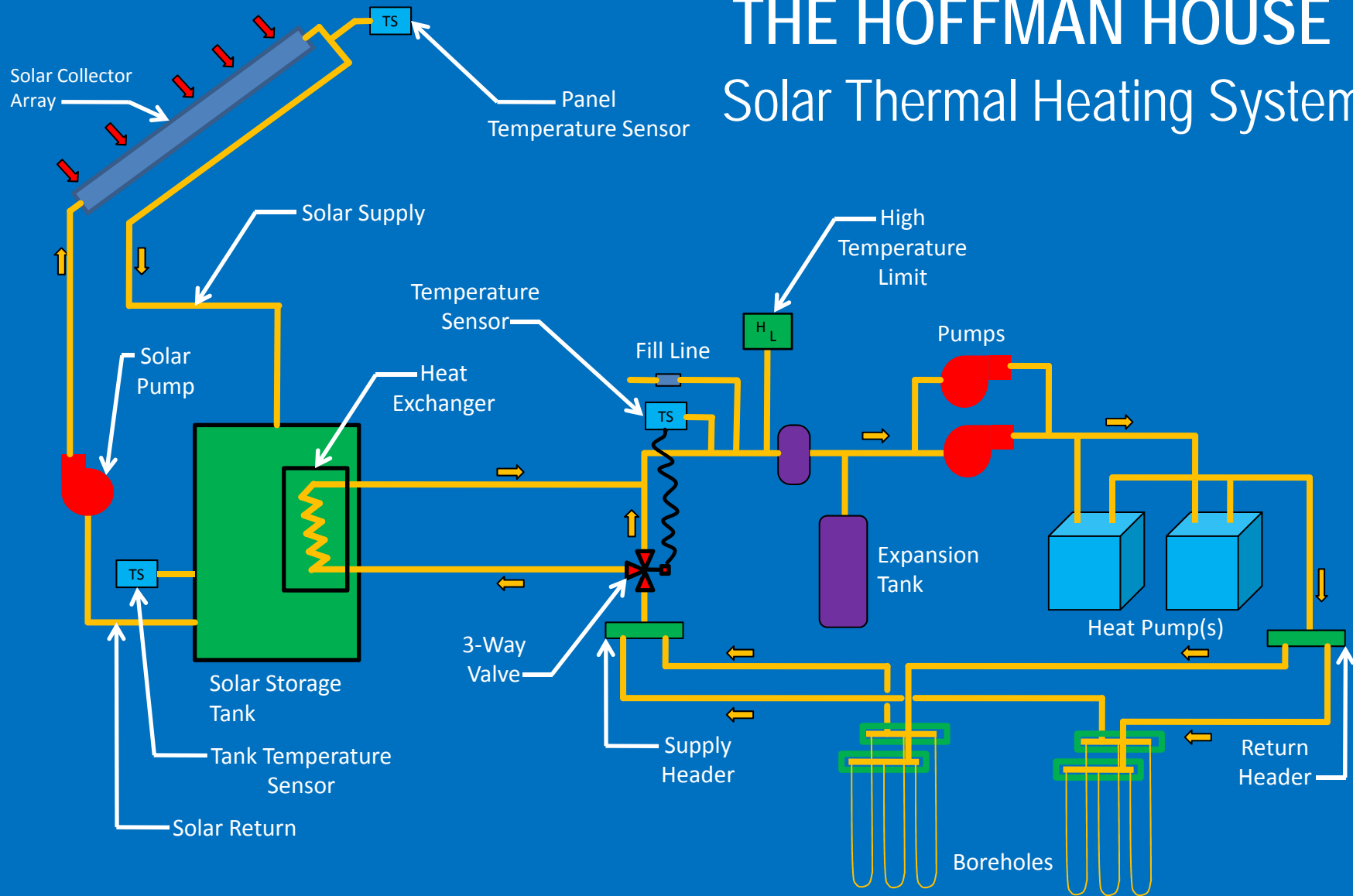
Why?

- Electrical Utility Distribution losses are in excess of 70%!
- Local Solar can eliminate the majority of Electrical Utility Distribution losses and reduce cost of energy per KWh.
- Thermal Solar can be utilized to supplement Geothermal loop temperatures in heating mode.



THE HOFFMAN HOUSE

Solar Thermal Heating System



SOLAR HOT WATER HEATING SYSTEM

Notice all pipes/panels are sloped $\frac{1}{4}$ inch per foot



Solar Thermal Drain Back
Tank & Piping



Solar Thermal Flat Plate Collectors

- Completely amazed at Performance
- First Cost including estimate for Labor = \$6,250
- Simple Payback = 5 years
- Return on Investment = 20% Tax Free
- Where to Purchase: Solar Heat Exchange Manuf.

Emerging Technologies / Improvements

Ductless / Geothermal

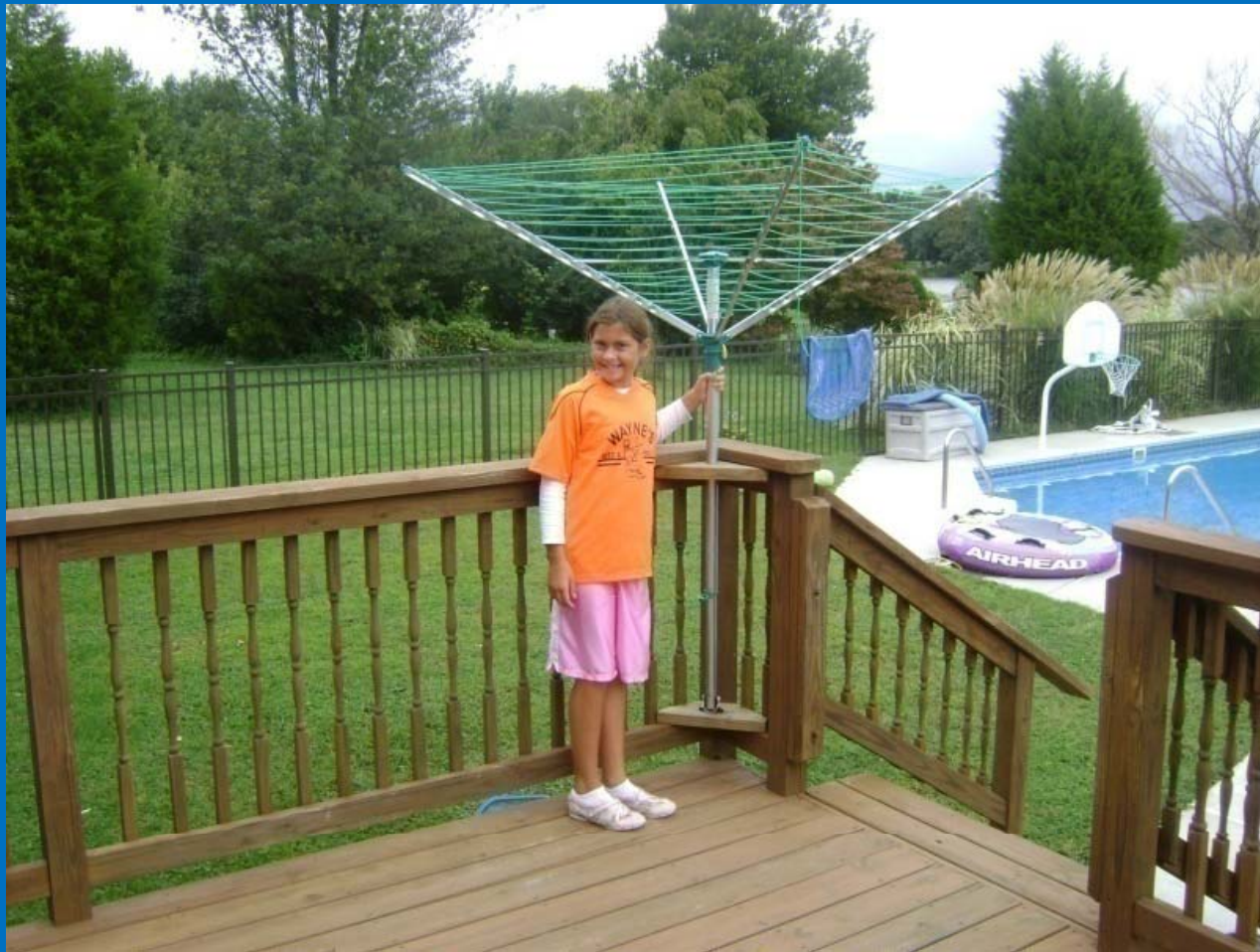
Why?

- Extremely Efficient
- No Duct losses due to conduction or leakage
- Simultaneous Heating / Cooling
- Variable Refrigerant Volume (VRV) Systems



Finally....

A Combination Solar/Wind Powered Clothes Dryer



How Can You Learn More?



Consult the Experts

- Contact

- Gipe Associates, Inc. – Easton (410) 822-8688
- Gipe Associates, Inc. – Baltimore (410)-832-2420

- Websites

- Geothermal Heat Pump Consortium
 - www.gphc.org
- University of Alabama – Geocool
 - www.bama.ua.edu/~geocool
- Intl. Ground Source Heat Pump Assoc.– IGSHPA
 - www.igshpa.okstate.edu
- Geo-Heat Center
 - www.oit.edu/~geoheat
- Phillips Drisco
 - www.driscopipe.com





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Questions and Answers

