

GEOTHERMAL HEATING APPLICATIONS FOR RESIDENTIAL HOMES©



**GAGNON HEATING & AIR
CONDITIONING**
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GOODWIN WELL & WATER, INC.
2282 AUBURN RD., P.O. BOX 661
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1-888-779-0888
goodwinwellandwater.com

What is “geothermal heating”?

- “Geothermal heating” uses solar energy stored in the earth to heat your home.
- The earth is a giant solar collector, absorbing heat energy from the sun that is stored in the rocks, soils and ground water below the ground surface.
- This stored solar energy is available every day of the year, regardless if the sun shines or not.
- A geothermal heating system utilizes this stored solar energy to heat the living space and domestic hot water in your home.

What does Geothermal Heating Consist of?

There are three major components of a geothermal heating system:

- a geo-exchange well
- a ground source heat pump
- the heat distribution system

Ground Source Heat Pumps transfer heat from one place to another by evaporating & condensing refrigerant using a compressor & an expansion device

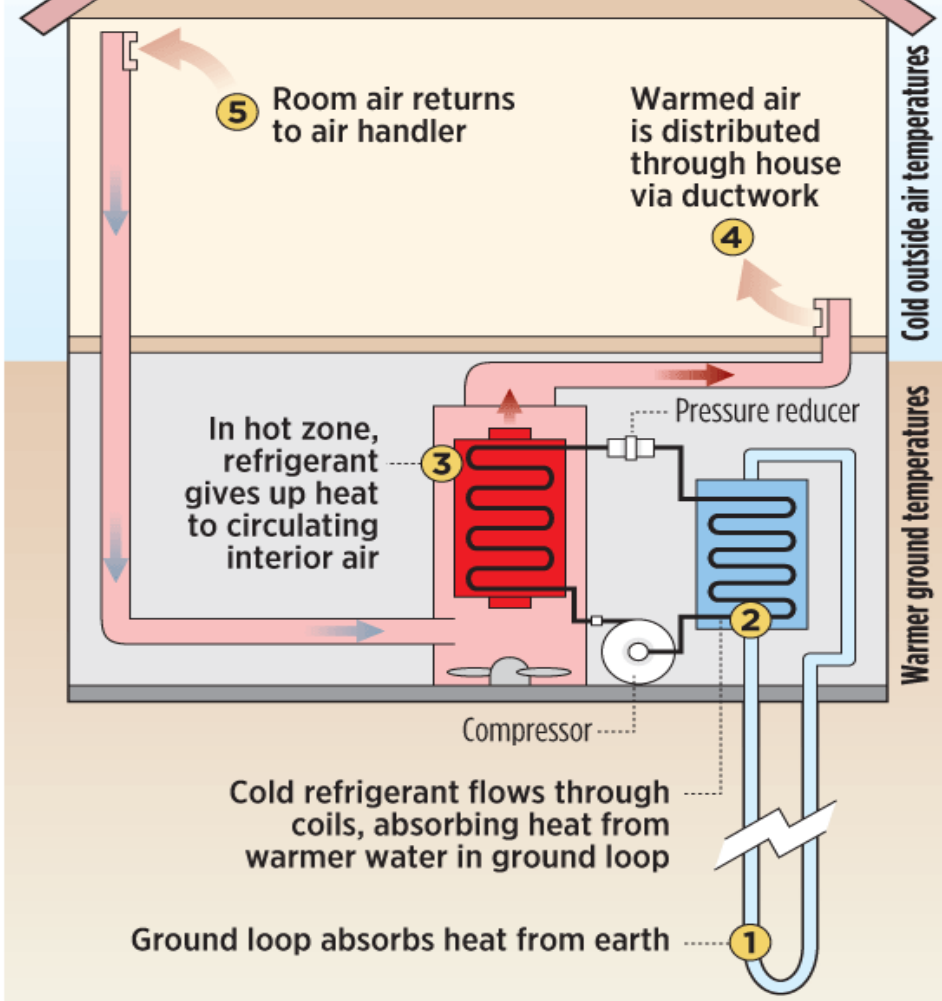
Ground Source Heat Pump

- Most of us routinely rely on heat pumps to keep our food cool (refrigerators) and to cool our homes and/or vehicles in the summer (air-conditioners).
- Refrigerators keep our food cool by removing heat energy from the food and air space inside the refrigerator and discharging it into the air space of our home.
- Air-conditioners keep us cool by removing heat energy from the spaces inside our homes and/or vehicles and discharging it into the outside air.
- Ground source heat pumps use the principles of the refrigeration cycle to move heat energy from the ground water in the earth to the inside of your home where it can be used to heat both your home and your domestic hot water

Heat Flow Fundamentals

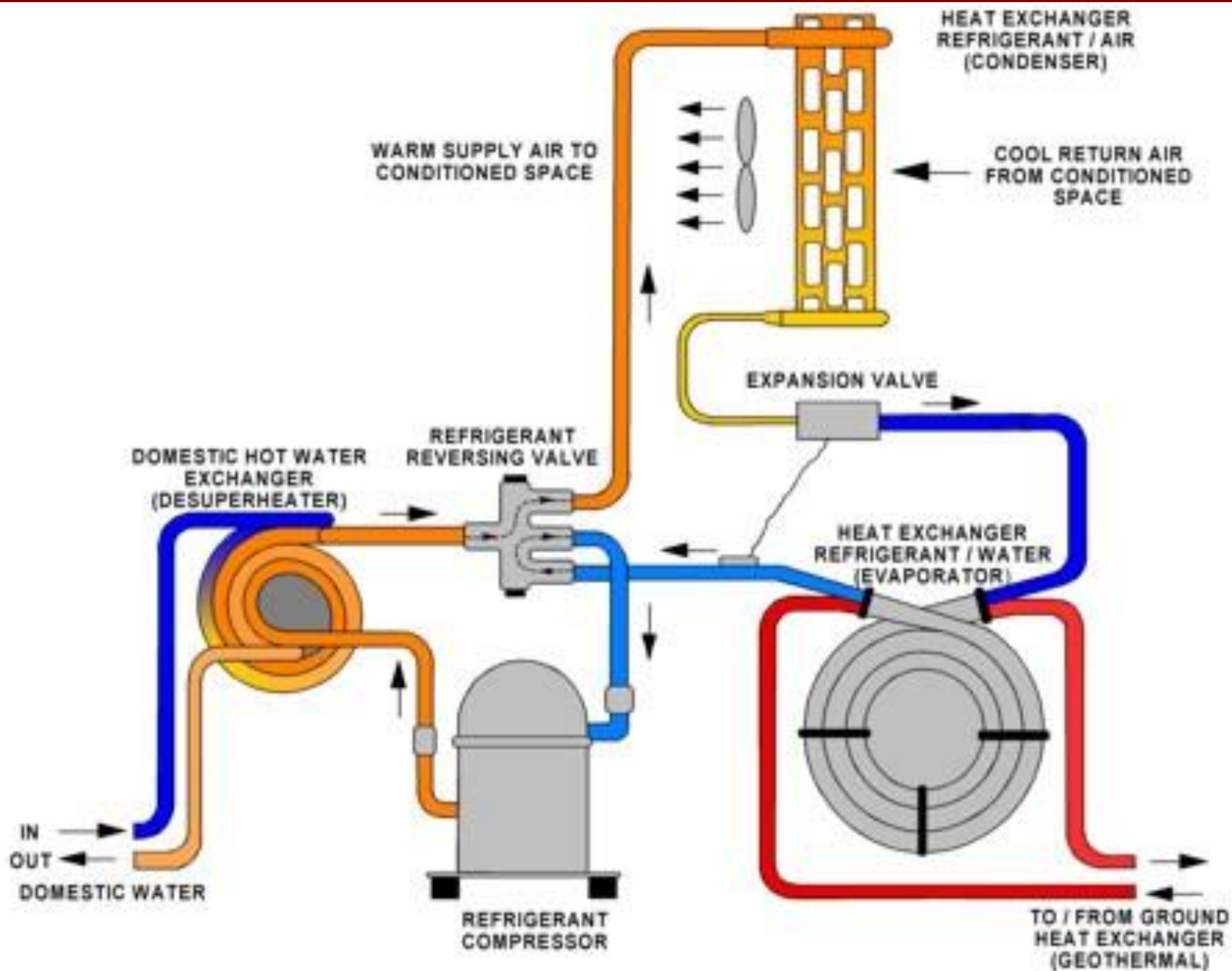
- All objects have heat energy.
- Objects that have higher levels of heat energy have higher temperatures.
- Objects that have lower levels of heat energy have lower temperatures.
- Heat energy naturally flows from objects with high temperatures to objects with lower temperatures.

Some basics of geothermal heating



How does a geothermal heating system work?

- In heating mode the heat pump extracts heat out of the water flowing through it and passes it to the refrigerant
- The refrigerant then enters the compressor where the pressure & temp. are boosted
- This high evaporated temperature crosses through the condenser heat exchanger and heats the cooler air from the home
- This warm air is then distributed through ductwork to the house
- The refrigerant gives up its heat to the air and is condensed back into a liquid and pushed through an expansion valve
- This valve drops the pressure & temperature of the refrigerant where it starts the cycle over again
- In the cooling mode this process is reversed



What Does the US EPA

Have to Say About Geothermal Heat Pumps?

- **Lowest Cost Heating & Cooling**
- **Best for the Air Environment**
- **Best for Electric Utilities**

EPA Report 430-R-93-004,
Space Conditioning the Next Frontier



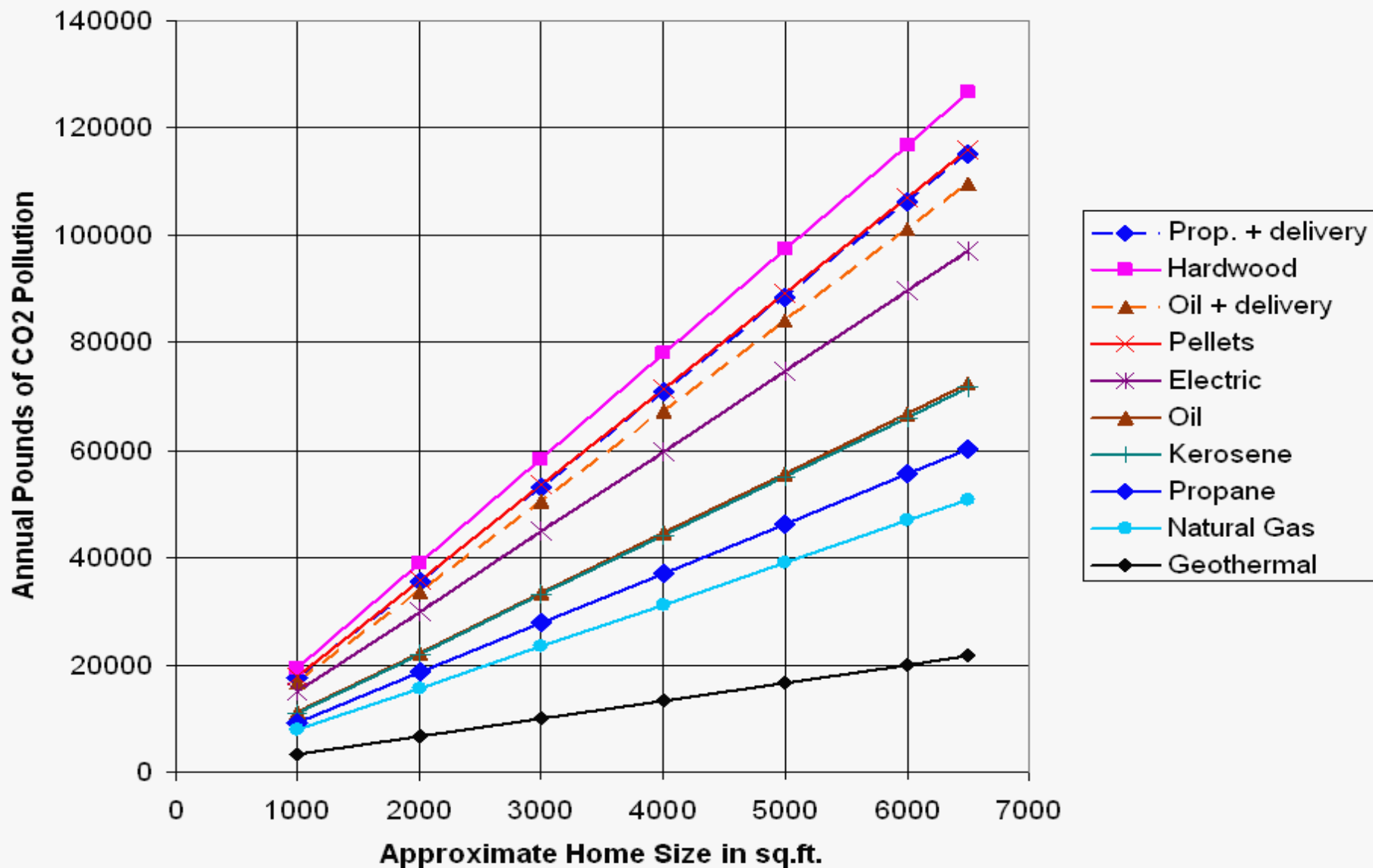
GEOHERMAL AND FOSSIL FUEL CO2 CONTENT FOR 2000 sq. ft. HOME

	ANNUAL POUNDS OF CO2		
Hardwood	38964		
Oil + delivery	37709		
Pellets	35738		
Prop. + delivery	35429		
Electric	29894		
Oil	22262		
Kerosene	22041		
Propane	18495		
Natural Gas	15613		
Geothermal	6643		

**IMPORTANT NOTE: IF "GREEN" SOURCES SUPPLY THE
ELECTRICITY THE GEOHERMAL CO2 PRODUCTION IS
ZERO**

HEAT PUMP (COP)		4.5
Winter Heat Pump Run Time in Hours		2500

Estimated CO2 Pollution from Heating Fuels for Different Home Sizes



Heating with Fuel

- With conventional heating systems such as oil, gas, or wood, you have to purchase fuel to provide the energy to heat your home.
- All fuel has energy measured in btu's.
- You can never use more btu's from any form of fuel than you purchase.
- The Coefficient of Performance (COP) of these systems can never be more than 1.0. You will never receive more than 1 btu in heat energy for every 1 btu of fuel that you purchase.

Geothermal Heat Pump Efficiency

**One unit of energy
from the grid**

Yields:

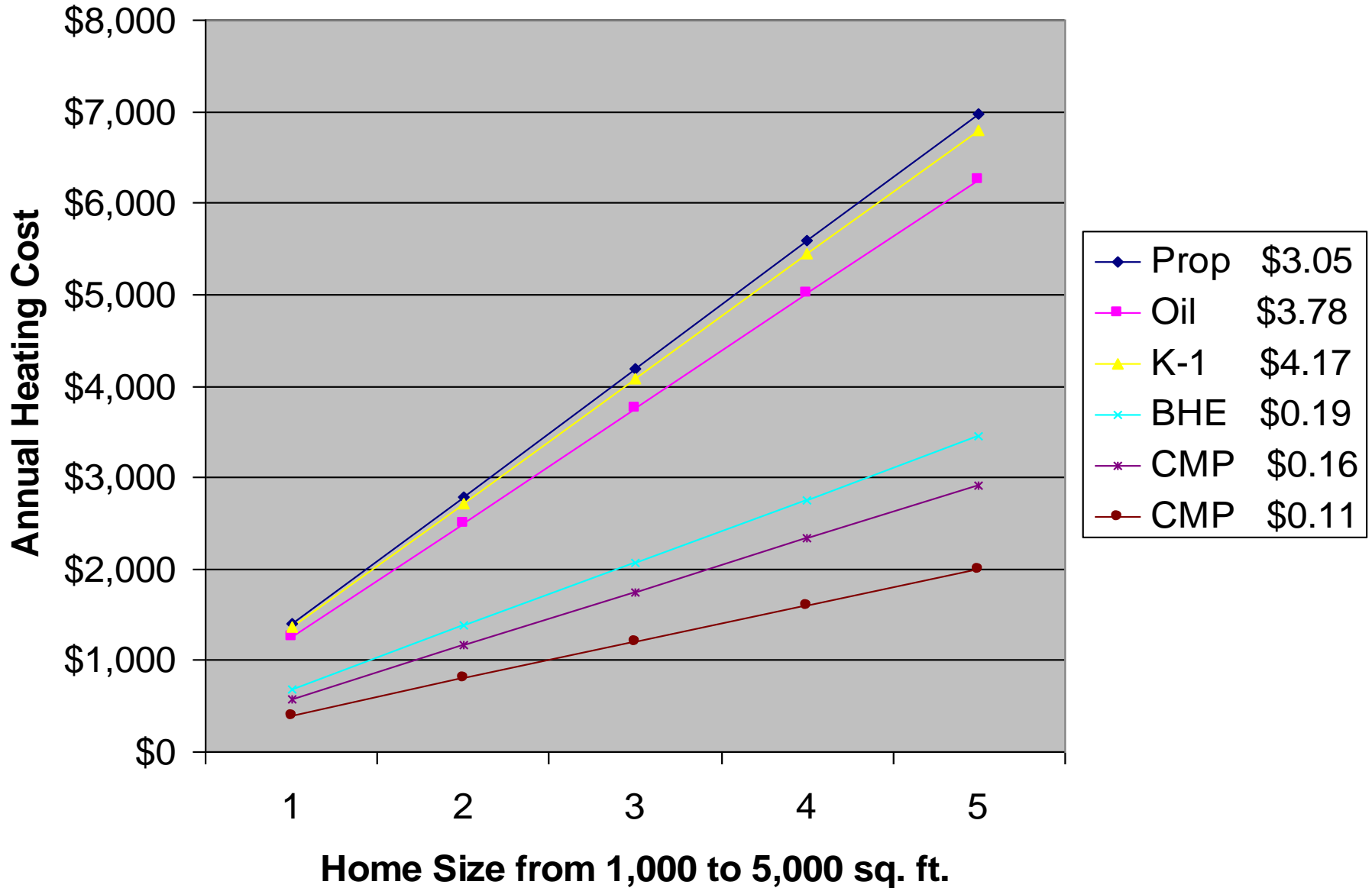
**5 units of energy
for the building**

Plus:

**4 units of energy
from the earth**

500% Efficient

Heating "Fuel" Cost Comparisons



Vintage Control Date 2/6/2009

**Economic Comparison
Oil vs. Geothermal**

Home With Oil Fired Heating System (1)		Home With Geothermal Heating System (1)		Annual Savings
Installed cost of oil fired forced air heating system with cooling	\$17,000	Installed cost of geothermal water to air heat pump system with cooling (3)	\$26,000	
Installed cost of a complete domestic water supply well and pump system. (4)	\$7,348	Installed cost of standing column well and pump system to supply both domestic and geothermal water (5)	\$14,832	
Total Cost of Home	\$250,000	Total Cost of Home	\$266,484	
Annual Mortgage Payments (6)	\$13,620	Annual Mortgage Payments (6)	\$14,634	
Annual Heating Cost with Heating Oil @ \$1.79/gal (7)	\$2,479			
Annual Heating Cost with Heating Oil @ \$2.50/gal (7)	\$3,463	Annual Heating Cost with electricity at \$.15 /KWH (8)	\$1,465	
Annual Heating Cost with Heating Oil @ \$3.00/gal (7)	\$4,155			
Annual Heating Cost with Heating Oil @ \$3.50/gal (7)	\$4,848			
Annual Heating Cost with Heating Oil @ \$4.00/gal (7)	\$5,540			
Total Annual Mortgage and Heating Cost @ \$1.79/gal	\$16,099	Total Annual Mortgage and Heating Cost @ \$.15/KWH	\$16,099	\$0
Total Annual Mortgage and Heating Cost @ \$2.50/gal	\$17,083	Total Annual Mortgage and Heating Cost @ \$.15/KWH	\$16,099	\$984
Total Annual Mortgage and Heating Cost @ \$3.00/gal	\$17,775	Total Annual Mortgage and Heating Cost @ \$.15/KWH	\$16,099	\$1,676
Total Annual Mortgage and Heating Cost @ \$3.50/gal	\$18,468	Total Annual Mortgage and Heating Cost @ \$.15/KWH	\$16,099	\$2,369
Total Annual Mortgage and Heating Cost @ \$4.00/gal	\$19,160	Total Annual Mortgage and Heating Cost @ \$.15/KWH	\$16,099	\$3,061

(1) This comparison is based on a 2,500 square foot single family, well insulated, two story home.

(3) 5 ton heat pump with forced warm air heating

(4) Well is 280' deep with 55' of casing. Pump system is stainless steel, 7 gpm, 3-wire system to provide up to 3 water using fixtures at same time.

(5) Standing column well for 5-ton heat pump with bleed is 585 feet deep, with 55' casing and complete 20 gpm constant pressure pump system

(6) 30-year, 5.5% fixed rate mortgage for 80% of total cost of home.

(7) Assumes heat load of 60,000 BTU/hr and annual oil consumption of 1,385 gallons.

(8) Assumes heat pump COP of 4.5 and 2,500 hours/year operation

Homes built by Symphony Construction, Inc. Heating System Installed by Gagnon Heating Geothermal vs. Propane



Harmony House→

Propane w/ solar for domestic

Radiant in Slab

3100 sq. ft. heated space

\$1450 annual operating cost

←OPUS 2

Geothermal

Radiant in Slab

3750 sq. ft. heated space

\$740 annual operating cost



Types of Geothermal Heat Pumps

- There are two types of Geothermal Heat Pumps
 - Water to air
 - Water to water
- Water to air heat pump utilizes a ducted system in which heating or cooling is distributed
- Water to water systems have a secondary heat exchanger. This system is used for hydronics or radiant heat
- High temperature circuits such as baseboard or radiators require very high water temperatures & are not recommended
- Typical heat pumps will give a max. water temp. of 120 degrees, vs. 180 degrees from a typical boiler

What to consider about Geothermal Air

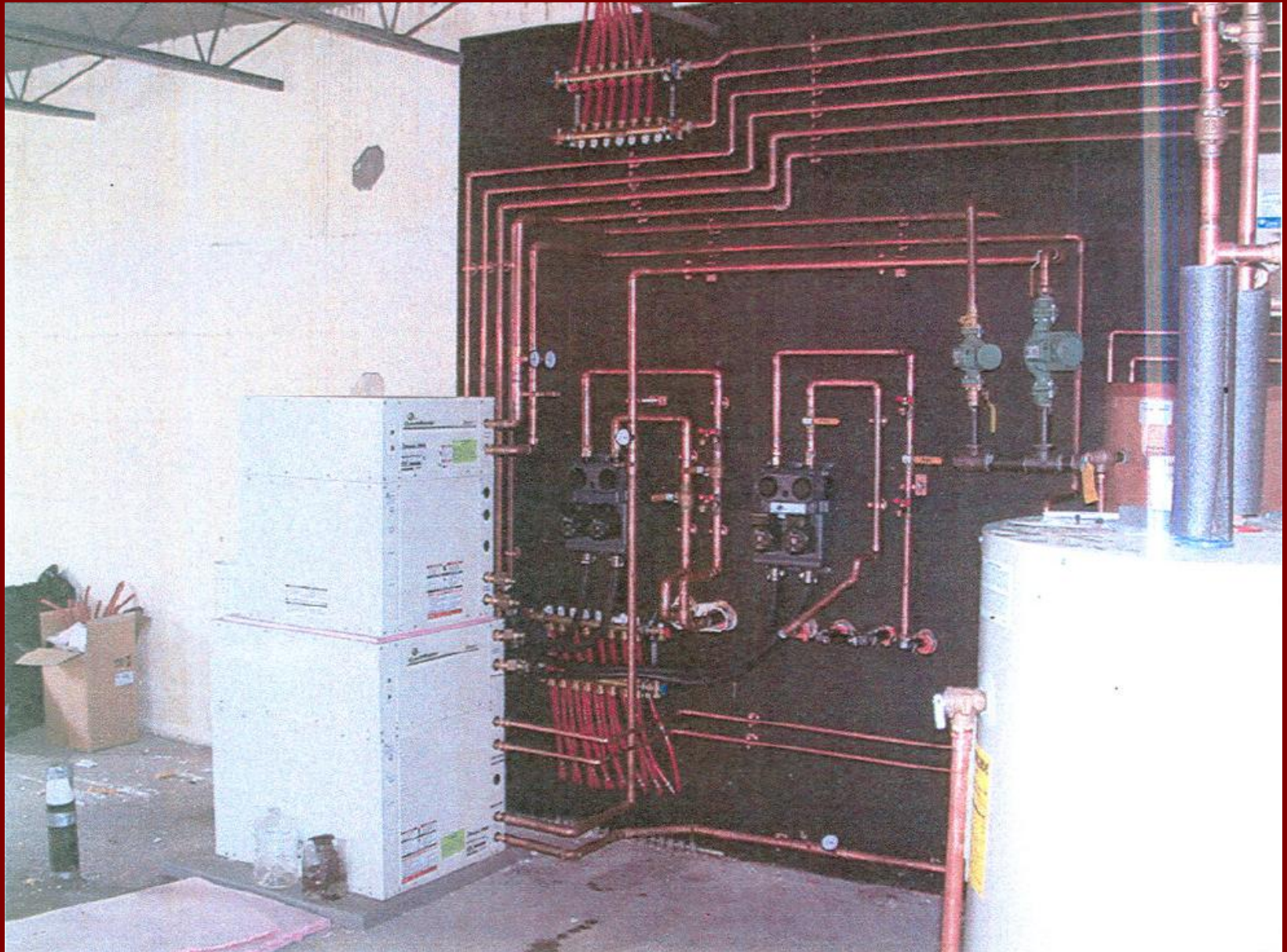
- Is the structure single story or two story
- Is there a full basement with at least 8' ceiling
- If there is a second floor, is there attic space available
- Need space for ductwork



What to consider about Geothermal Radiant

- Radiant in Lightweight concrete:
 - Structural support, sizing of floor joists
 - Partition plates, may want to double them depending on thickness
 - Plumbing rough in
 - Electrical rough in
 - Island base
 - Floor covering
 - Jack & Header heights
- If choose not to use concrete
 - Staple up systems can be done (supplemental heat required)
 - Panelized systems can be done (expensive)

Geothermal Radiant System



Geothermal Related

There are many things that go along with a geothermal system

- Tonnage
- Single or Two Stage Compressor
- Single Speed or Variable Speed Blower
- Desuperheater and Options
- Well Control & Bleed
- Duct Sizing
- Radiant Manifolds
- Water Temperature
- Noise
- Comfort of heat
- Refrigerant Type
- Diagnostics
- Outdoor controls
- Solar Option

Emergency Heat

- Any type of heating system can fail, including Geothermal
- Living in Maine it is a good idea to have a backup regardless of heating system type
- The systems we install have a backup
 - Water to air system – electric duct heater backup
 - Water to water system – electric backup in Accumulator tank

Generator & Electrician Related

- Generator can be used, but needs to be sized for the start up Amp draw or the inrush Amps
 - This is typically 3 times the running load amps
 - Unfortunately we need to size the generator for this 1 – 2 second pull to get the compressor turning
- Electrician needs to know loads for proper sizing
- Electrician needs to be aware of the grounding practices
- It's best to have the electrician contact us for this information

Equipment Sizing

- Sizing a geothermal system is very much the same as a conventional system
 - Floor plans & elevations required, sometimes cross-sections
 - Insulation Type and R-value
 - Window sizes
 - Orientation (more for cooling)
 - Internal loads (commercial only)
 - Duct Design
 - Radiant Design

Construction Process

- Construction process is very similar to conventional heating systems
 - First step should be to have the well drilled
 - Once the roof is liquid tight we can begin
 - Windows not needed but should have plastic if near mechanical equipment
 - Water to Air systems are not recommended to operate while building is under construction
 - Radiant systems can operate while building is under construction

Customer Maintenance Instructions

- What do I need to do to clean my well water filter?
- How do I determine if my heat pump is out on fault?
- What do I need to do to go from Heating to Cooling?
- What do I do with my air filters?
- How do I know if my bleed is working?

Geothermal Projects Completed less Well Costs

Single story ranch, New construction, 1408 sq. ft. \$23,600

- 4 ton water to air packaged unit
- Single zone
- Heating, cooling, domestic hot water

Two story building, New construction, 3792 sq. ft. \$31,100

- 5 ton water to air packaged unit
- 2 ton split unit
- Heating, cooling, domestic hot water, HRV

Two story building, Retrofit, 2052 sq. ft. \$28,600

- 3 ton water to air packaged unit
- 3 ton split unit
- Heating, cooling, DHW

Two story building, New construction, 1683 sq. ft. \$30,000

- 5 ton water to water (radiant)
- Heating, DHW, HRV

Geothermal Projects Completed less Well Costs

Three story building, New construction, 7605 sq. ft. \$89,300

- 13 ton water to water (radiant)
- Heating, chilled water cooling, DHW, Ventilation

Single story building, New construction, 1544 sq. ft. \$23,400

- 3 ton water to water (radiant)
- Heating, DHW, HRV

Two story building, New construction, 5014 sq. ft. \$48,200

- 8 ton water to water (radiant)
- Heating, chilled water cooling, DHW, HRV

Two story building, New construction, 5234 sq. ft. \$46,300

- 5 ton water to air packaged unit
- 5 ton water to air split unit
- Heating, cooling, DHW, HRV

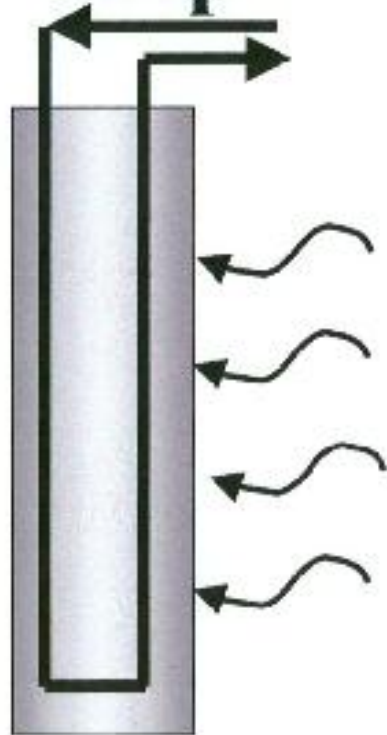
Tax Incentives

Federal Credits

- Up to \$2,000 for systems installed between Jan. 1st 2008 and Dec. 31st 2016
- Income tax credit of \$300 per year
- Form 5695
- www.energymaine.com
- www.dsireusa.org

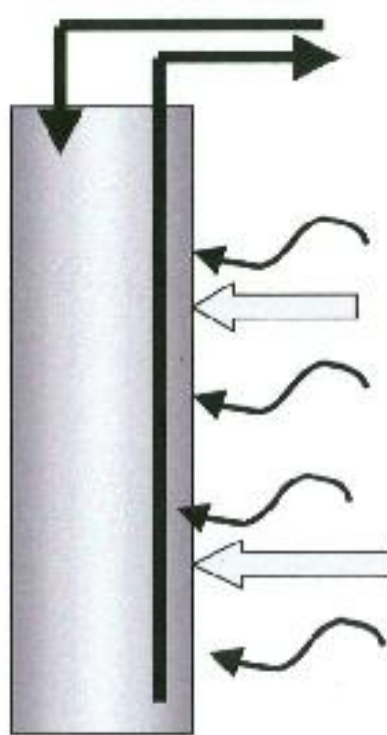
Types of Earth Coupling

Closed Loop



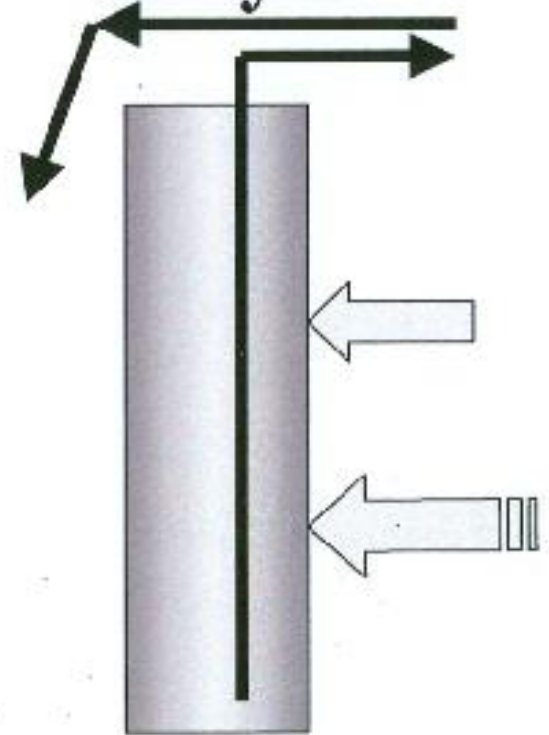
Conductive

Standing Column



**Conductive
& Advective**

Open to Recycle



Advective



Closed Loop

- Typically a HDPE loop grouted into a 200' – 400' borehole
- Multiple boreholes manifolded together
- Requires approx. 175' of borehole / ton
- Requires circulation pump inside home
- Water supplied to heat pump is typically lower temperature than other options, requiring the heat pump to be “derated”.

Closed Loop is the Most Expensive Option

- Requires more total footage of borehole
- Loop must be grouted
- Well can only supply heat pump. A separate well is required for domestic water
- Cost savings of not installing a submersible pump is offset by the need to install circulation pump in basement, plus a higher capacity heat pump

Other Closed Loop Considerations

- Circulating fluid is in a closed loop, not subject to issues of water quality or sediment
- Higher risk of contamination to adjacent water wells if not properly constructed.
- Most common type of geo-exchange well across the USA, primarily because of geology

JOB IDENTIFICATION

Job: 5-ton concept

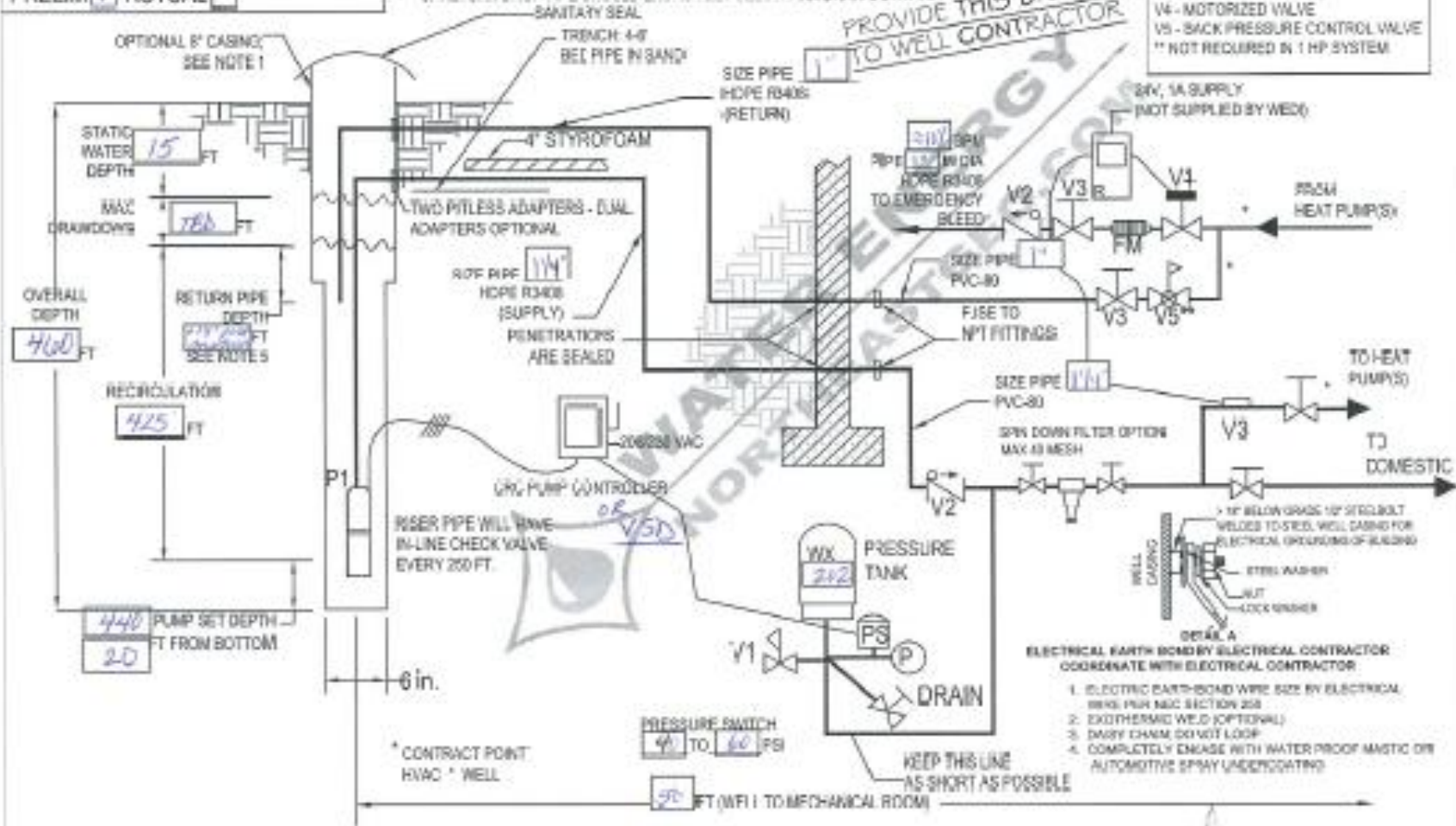
Date: 8/26/08 By: scott

PRELIM ACTUAL

NOTES:

1. TOP OF CASING ABOVE SURFACE: SEE STATE CODE.
2. GROUND TO WELL CASING PER DETAIL A.
3. RISER PIPE WILL HAVE IN-LINE CHECK VALVE EVERY 250 FT.
4. BACKPRESSURE VALVES REQUIRED FOR WELL WITH MULTIPLE HEAT PUMPS.
5. RETURN DROP PIPE SHOULD END 10 FEET BELOW MAX DRAW DOWN MIN.

VALVES	
V1	- PRESSURE RELIEF (100PSI)
V2	- CHECK VALVE
V3	- ISOLATION VALVE(S)
V4	- MOTORIZED VALVE
V5	- BACK PRESSURE CONTROL VALVE
** NOT REQUIRED IN 1 HP SYSTEM	



WELL YIELD 780 GPM

FORM: F-RES-WELL-2 © 2006 WED REV 6

Standing Column Wells

- More efficient heat transfer than closed loop
- Some SCW's use 10% - 30% bleed
- Bleed should only be used when it can be responsibly discharged
- Commonly used to supply domestic water in addition to geothermal water
- Pump can be installed either in bottom or top of the well.
- Well depths range from 75' – 150' per ton

JOB IDENTIFICATION

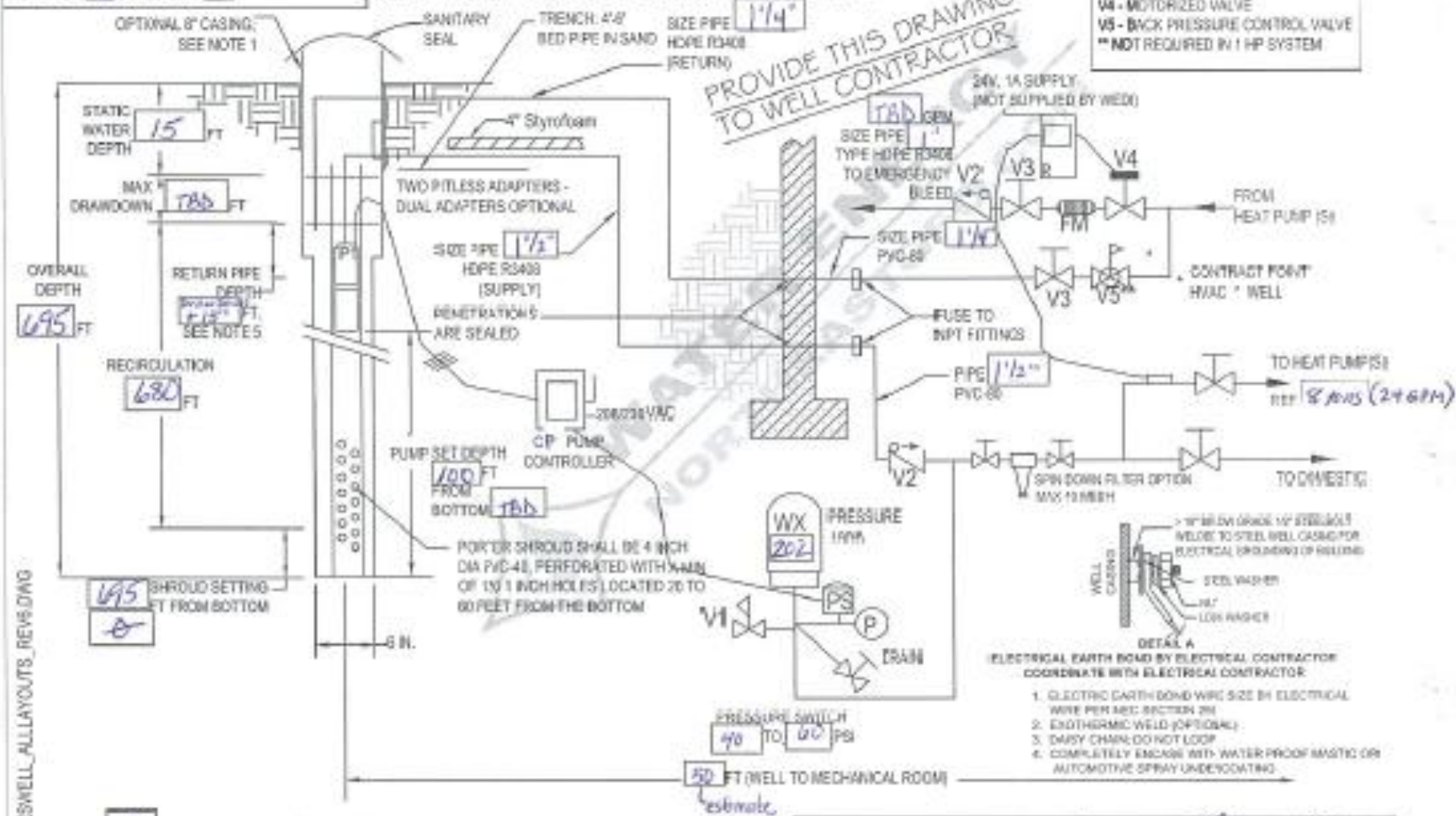
Job: 8 ton Concept
 Date: 2-4-08 By: smc

PRELIM ACTUAL

NOTES:

1. TOP OF CASING ABOVE SURFACE; SEE STATE CODE.
2. GROUND TO WELL CASING PER DETAIL A.
3. RISER PIPE WILL HAVE IN-LINE CHECK VALVE EVERY 250 FT
4. BACKPRESSURE VALVES REQUIRED FOR WELL WITH MULTIPLE HEAT PUMPS
5. RETURN/DROP PIPE SHOULD END 15 FEET BELOW MAX DRAW DOWN MIN

VALVES
V1 - PRESSURE RELIEF (40/60PSI)
V2 - CHECK VALVE
V3 - ISOLATION VALVE(S)
V4 - MOTORIZED VALVE
V5 - BACK PRESSURE CONTROL VALVE
** NOT REQUIRED IN 1 HP SYSTEM



F-RESWELL_ALL LAYOUTS_REV 5.DWG

PRELIMINARY NOT FOR CONSTRUCTION

Typical Cost for for Standing Column Well for Both Domestic & Geothermal

Jan-09

Tonnage

Bleed

No Bleed

3

\$11,800

\$12,200

5

\$14,900

\$16,500

8

\$24,000

\$27,800

Actual costs will vary depending upon amount of casing,
offset distance between well and house, etc.

Open-to-Recycle

- No water is returned back to the well
- Requires responsible discharge of water
- Typically water is returned back into same bedrock aquifer in a second well
- Can also be used for domestic water
- Most efficient heat transfer because average water temperature from well is higher
- Requires well(s) with high flows of water

Driller's Licenses & Regulations

- Currently, no State license is required
- Currently, there are no State minimum construction standards for geo-exchange wells
- Legislation is being presented to require licensing and minimum construction standards
- Highest risk is potential contamination of adjacent domestic water supply wells

Maine Dept. of Environmental Protection

Regulations. (February 2009)

- All geothermal wells are registered by MDEP as Class V underground injection wells
- All geothermal wells must be registered with MDEP, with the exception of wells for single family, detached homes
- The injection of water from a geothermal well back into the aquifer from which it came, is currently allowed without a discharge permit:
 - Injection back into the same well, or
 - Injection back into the same aquifer through a different well

Maine Dept. of Environmental Protection Regulations. (February 2009), cont'd.

- The discharge of bleed water from a geothermal well for a single family detached home is currently allowed to be discharged in any of three different ways without the need of a discharge permit or any required treatment as follows:

- Back into the same aquifer that it came from through a second well,
- Onto the ground, or
- Into a dry well or approved subsurface system

However, if the discharge leaves the property, enters a surface water of the State, or for some reason contain types or p\levels of pollutants that exceed ambient levels when returned to the ground water source, it would potentially require a Maine Waste Discharge License

Maine Dept. of Environmental Protection Regulations. (February 2009), cont'd.

- All other discharges of bleed water must be individually approved by MDEP after submission of required water quality analysis along with all other registration information
 - Discharge permit may, or may not, be required
 - Approval or disapproval of discharge, including possible water quality treatment requirements, will depend upon the State of Maine Water Quality Classification of the water body that will receive the discharge
 - Some State Water Quality Classifications will not allow any discharge to that water body, regardless of the quality of the bleed water

Pump Systems for SCW's

- Primary concern is efficiency and low electrical consumption
- Constant pressure system with 3-phase motor
- Proper sizing of pump
- Proper sizing of pipe diameters to reduce friction

Constant Pressure Pump Systems

- Pump Controller converts 1-phase power to 3-phase
- Controller varies the speed of the pump by changing the hertz of the 3-phase motor.
- Controller maintains constant pressure through a pressure transducer
- Pump starts at half speed and ramps up to speed necessary to maintain pressure.
- As flow increases or decreases, controller either increase or decreases speed to maintain constant pressure
- Pump only runs at speed necessary to meet system pressure and demand
- Controller has built in diagnostics and pump protection



WELL #1
HEAT PUMP
SumpPro

Pressure Control

WELL #2
HEAT PUMP
ONLY

Pressure Control

HydroPro
Water Systems Tank

ITT

HydroPro
Water Systems Tank

ITT

Furnace

HVAC Contractor & Well Driller

- Coordination and team work between HVAC contractor and well driller is critical
- Ability for both HVAC contractor and driller to provide emergency service is important

Customer Testimonials

“The geothermal system, coupled with a radiant floor heating system, was an excellent choice of heating systems for our home. It offers a much lower operating cost than fuel oil or gas, great comfort level compared to forced hot air or baseboard, and an environmentally responsible choice. As we did, I would recommend using an experienced well driller and heating contractor familiar with the system requirements for optimal performance”

John Hinkley, South Livermore Rd., Turner.

Customer Testimonials

“I heat my 2800 sq. ft. home for only \$190 in the coldest month of the year.”

Doug Horsman

“Without exception, from the initial telephone contact, to estimation of work, to superb drilling crew, through the trench work and the entire scope of work was beyond words.”

Jim Kirsh