An introduction to the most efficient (by far) and greenest heating/cooling technology known today

Geothermal 101

Today's Agenda

- What is Geothermal heating & cooling?
- Cost and savings incentives
- Health & Environmental benefits
- How to begin your geothermal journey!
- GrowGeo Chicagoland Group Buy program

How Geothermal Heating & Cooling Works

Geothermal Energy Systems are Called Many Things

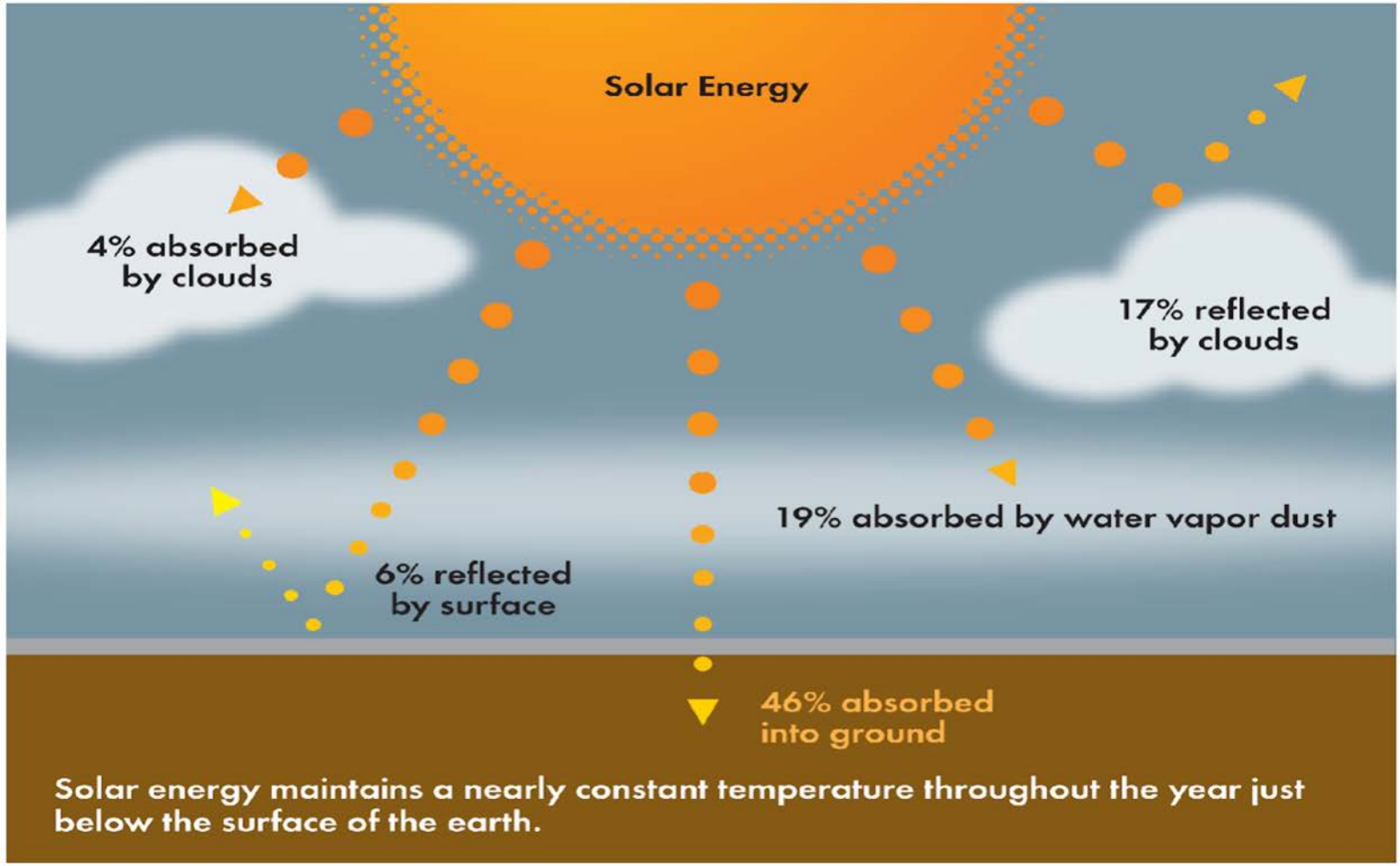
- Ground-source heat pump
- Geo-exchange
- Geothermal heat pump
- Earth-coupled heat pump
- Geo
- Earth Energy

Geothermal Heat Pumps Produce On-Site RENEWABLE Energy

- Geothermal systems use the ground as a moderate-temperature heat source during the winter and a heat sink during the summer
- Geothermal systems draw RENEWABLE thermal energy from the ground during the winter to heat buildings and reject excess heat from buildings back into the ground in the summer

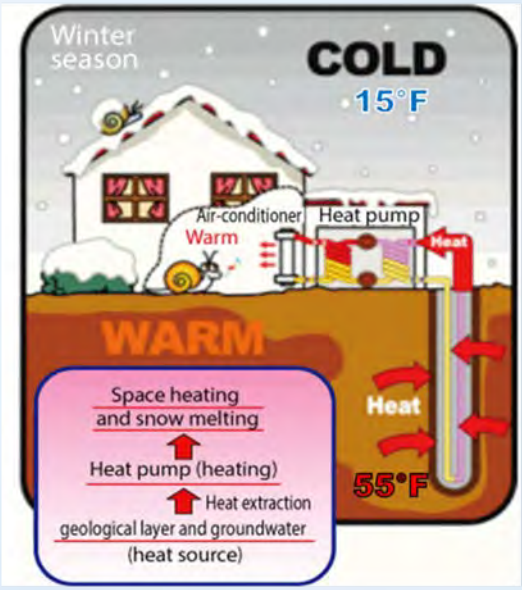
SO, in the summer, Geothermal systems RENEW the Heat that they tapped from the ground during the previous winter season

Earth is a Vast Solar Collector



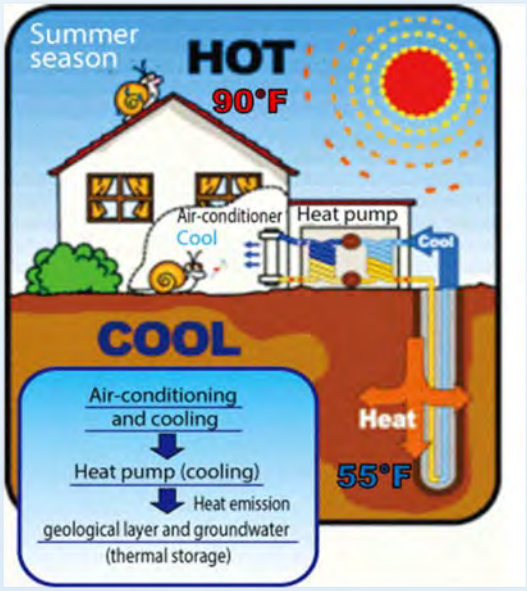
The Earth is a Source of Heat in Winter…

Geothermal heat pumps transfer moderate heat into the building to provide heating



...And an Efficient Place to Reject Heat in Summer…

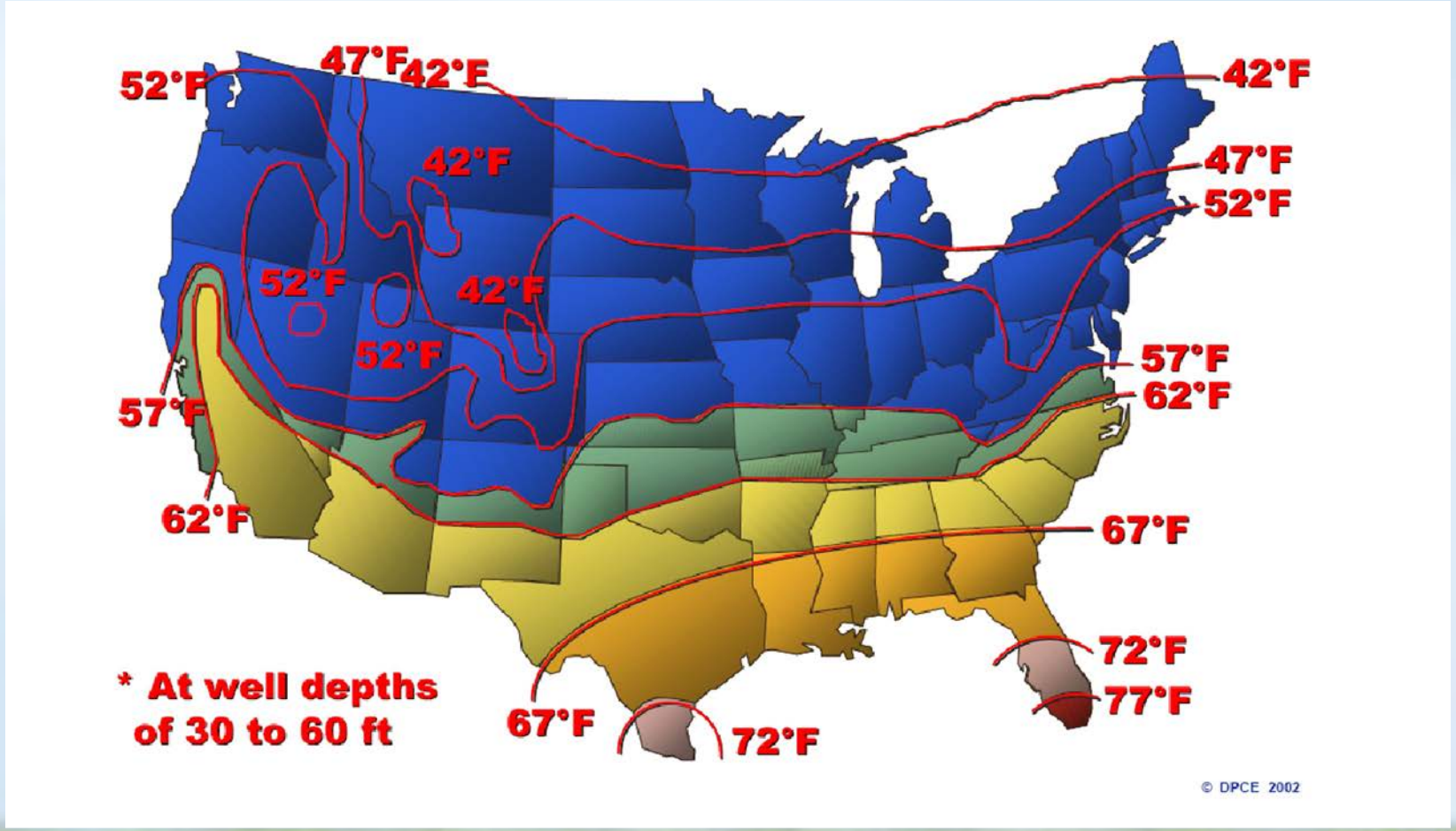
Geothermal heat pumps transfer excess heat from the building to the ground providing cooling



Using Geothermal Technology

Geothermal heat pumps (GHP) circulate water through a sealed underground piping loop where it is naturally warmed (or cooled) by the earth

U.S. Underground Temperatures



GHPs Transfer Heat Efficiently

1 kWh of energy purchased from the grid to operate a GHP system

Yields
4-6 kWh of energy for the building

3 to 5 kWh of RENEWABLE energy absorbed from the earth
IS FREE

400-600% Efficiency

Geothermal is not a New Technology

Geothermal is not a New Technology

FIRELESS FURNACE

It pumps heat from earth to house

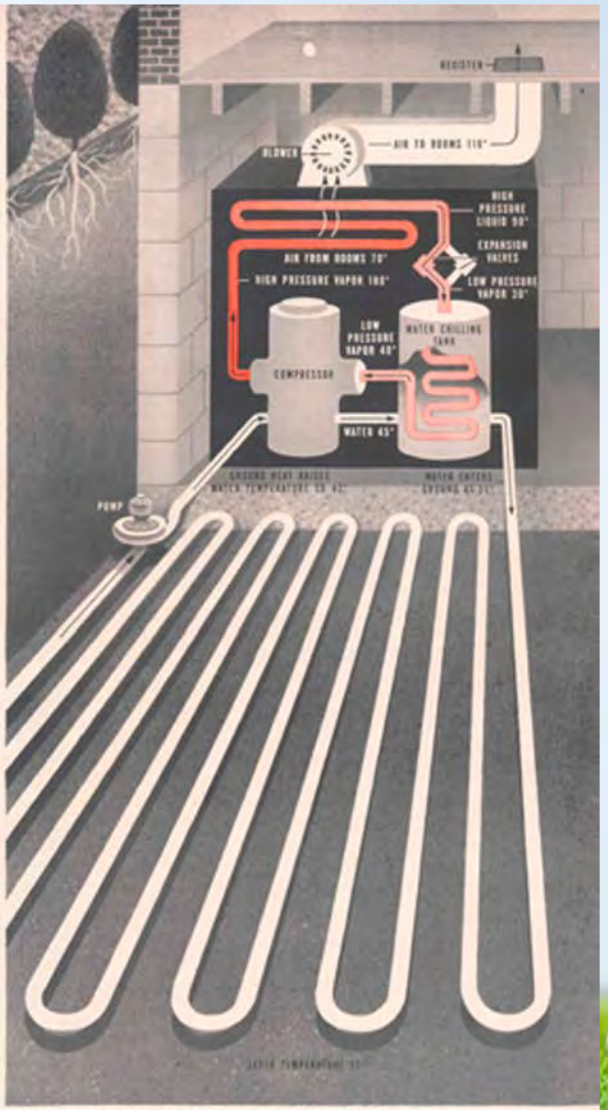
The machine shown at the bottom of the page and explained in the diagram at right burns no fuel, yet it can heat a house in winter, cool it in summer and in at the same time a humidifier. It produces no ashes, nor or smoke and needs no chimney. It is called a heat pump.

Powered by an electric motor, it works on the same principle as a home refrigerator. Just as a refrigerator takes heat from the food and air inside it and deposits it in the kitchen, the heat pump, when cooling a house, takes heat from the house and deposits it in the earth through pipes buried in the soil. To warm a house the heat pump uses the low temperature heat constantly contained in the earth, increases its temperature and puts it in the house. This is done as follows: water circulating through pipes in ground enters a tank in which are pipes carrying a cold refrigerant, Freon. The Freon, being colder than the water, picks up some of its heat, then goes through a compressor. This compression makes the Freon hot. This heat is used to heat house. Freon is then allowed to expand suddenly and as a result again becomes cold. Next it passes back through the water tank, once more picking up additional heat from the ground-warmed water.

It will be some time before most home owners can buy a heat pump right off a dealer's floor. Today each heat pump installation is a separate and expensive engineering problem. The one shown here, called the Miracula, made by the General Engineering and Manufacturing Company of St. Louis, Mo., sells for $2,000. Installation adds another $1,000.

At present the heat pump costs slightly more to operate than an ordinary furnace except in areas of especially low electric rates. In many places, too, installation is totally impractical. However as the efficiency of getting heat from the earth improves, it is almost certain that eventually the heat pump will be able to compete successfully with conventional heaters in most localities. Many large companies have heat pumps under development. Even conservative General Motors admits informally that it is working on a Frigidaire version of the heat pump for the consumer market.

EXPOSED VIEW OF HEAT PUMP shows parts diagramed at right. Compressor is at bottom left, chilling tank at bottom right and blower at top center. Unit is 6 feet 3 inches tall, occupies 6.3 square feet of floor space.



HOW HEAT PUMP WORKS in winter is shown by this diagram. Water circulates through ground pipes, picks up ground heat plus heat from compressor. This warmed water heats special Freon vapor in chilling tank (pink coils). Warmed Freon goes to compressor, becomes hot. Hot Freon goes through coils at top, warms house air. Freon returns to chilling tank through expansion valve. For summer cooling Freon flow is reversed.

CONTINUED ON NEXT PAGE 83

Heat Pumps

- Heat pumps “move” energy from one location to another, instead of creating heat by burning fossil fuels, such as a gas furnace does or a refrigerator
- Geothermal Heat Pumps use the earth or well water to provide heating, cooling and hot water for your home
- A Geothermal heat pump “moves” energy to/from the ground, eliminating the outdoor equipment associated with ordinary heat pumps or air conditioners

Two main parts to typical residential Geothermal system.

Inside

Outside

Geothermal Operation

- Geothermal heat pumps consist of four circuits:
  - **Distribution Circuit**
    - The system that distributes the conditioned air or water solution throughout the home or building and returns it to the unit
  - **Refrigerant Circuit**
    - A sealed and pressurized circuit of refrigerant including compressor, expansion valve, water-to-refrigerant heat exchanger(s), air coil, reversing valve. The refrigerant is either R-22 or R-410A

Geothermal Operation

- Geothermal heat pumps consist of four circuits:
  - **Ground Loop Circuit**
    - The piping system buried in the ground has fluid that is circulated by pumps to and from the geothermal unit
  - **Hot water circuit**
    - Domestic water can be heated in a geothermal unit with a device called a desuperheater. A piping connection is made from the geothermal unit to the water heater

Geothermal Operation

- Each of these circuits is closed and sealed from the others—there is no direct mixing to risk to the environment
- However, heat energy **does** transfer from the refrigeration circuit to the other three circuits
- The refrigerant flow will change direction when the unit changes modes (heating or cooling)

Heating water is the second largest use of energy in the home; ~20%

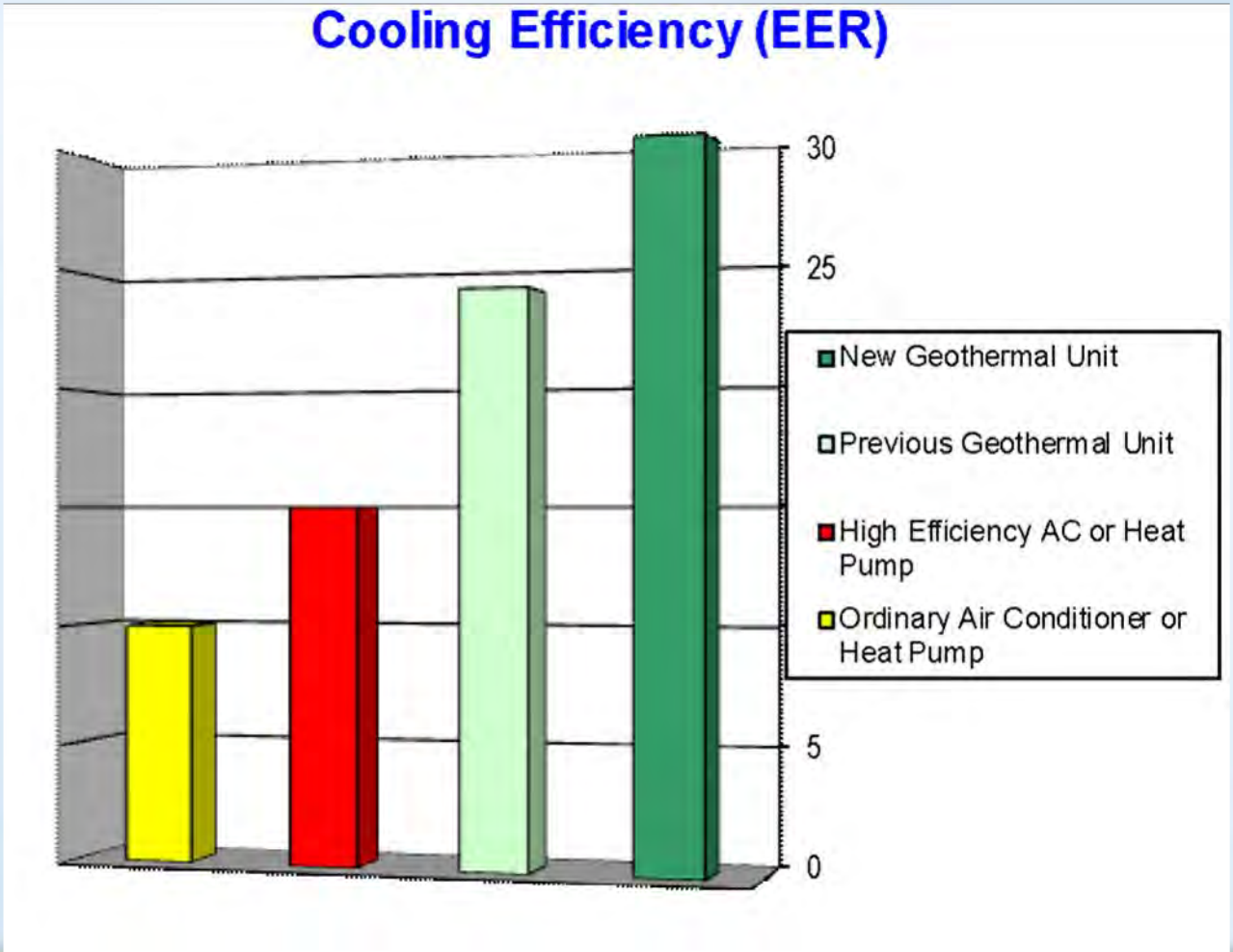
Domestic hot water is a **FREE** byproduct of a Geothermal system

Equipment Performance Ratings

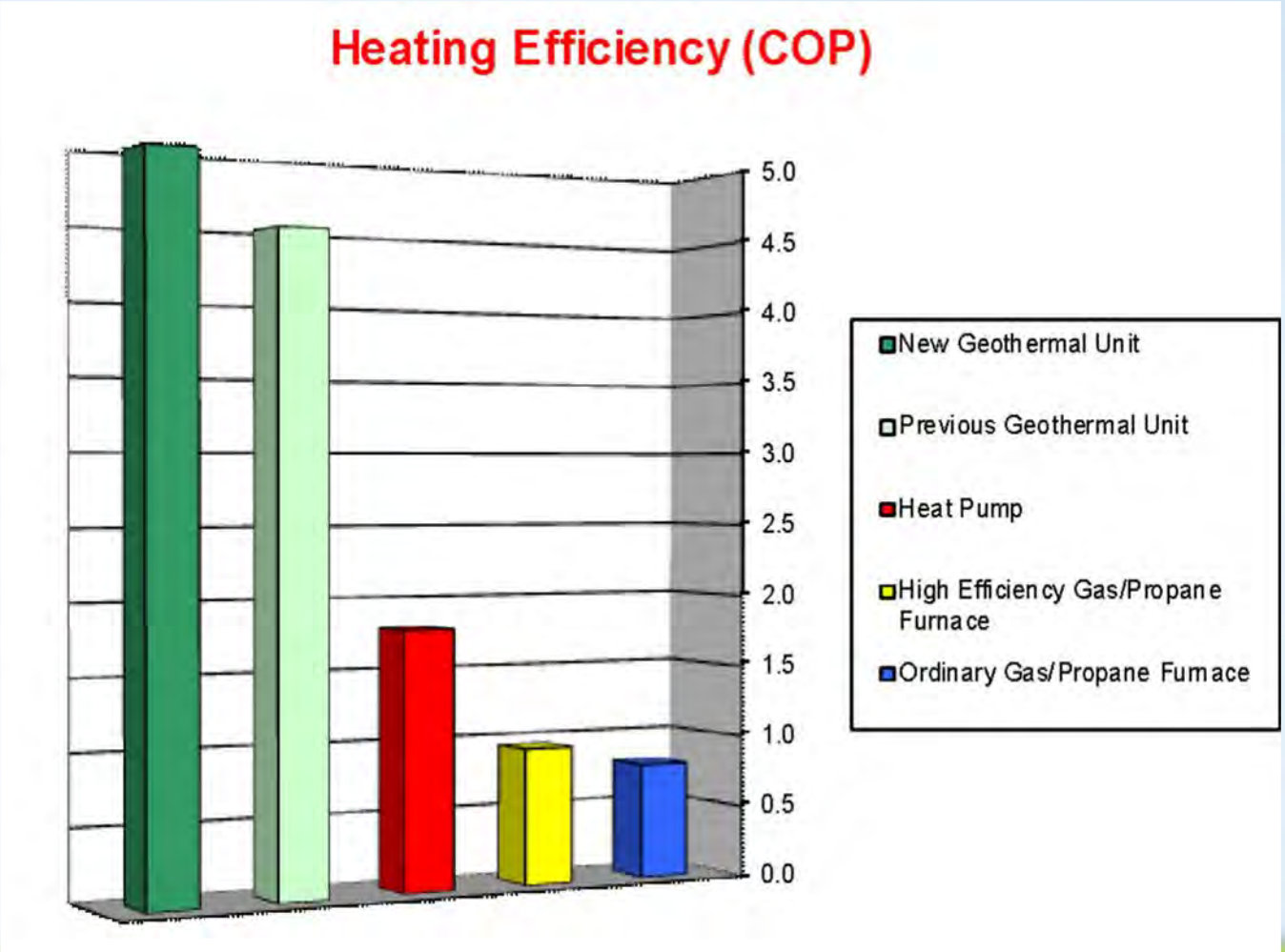
- ARI* has designated the efficiency ratings for water-to-air heat pumps as:
  - **Energy Efficiency Ratio (EER)**
    - EER = BTU output divided by power watt input
    - For cooling operation under steady state test conditions
  - **Coefficient of Performance (COP)**
    - COP = BTU output divided by BTU input
    - For heating operation under steady state test conditions

ARI* = Air-Conditioning and Refrigeration Institute

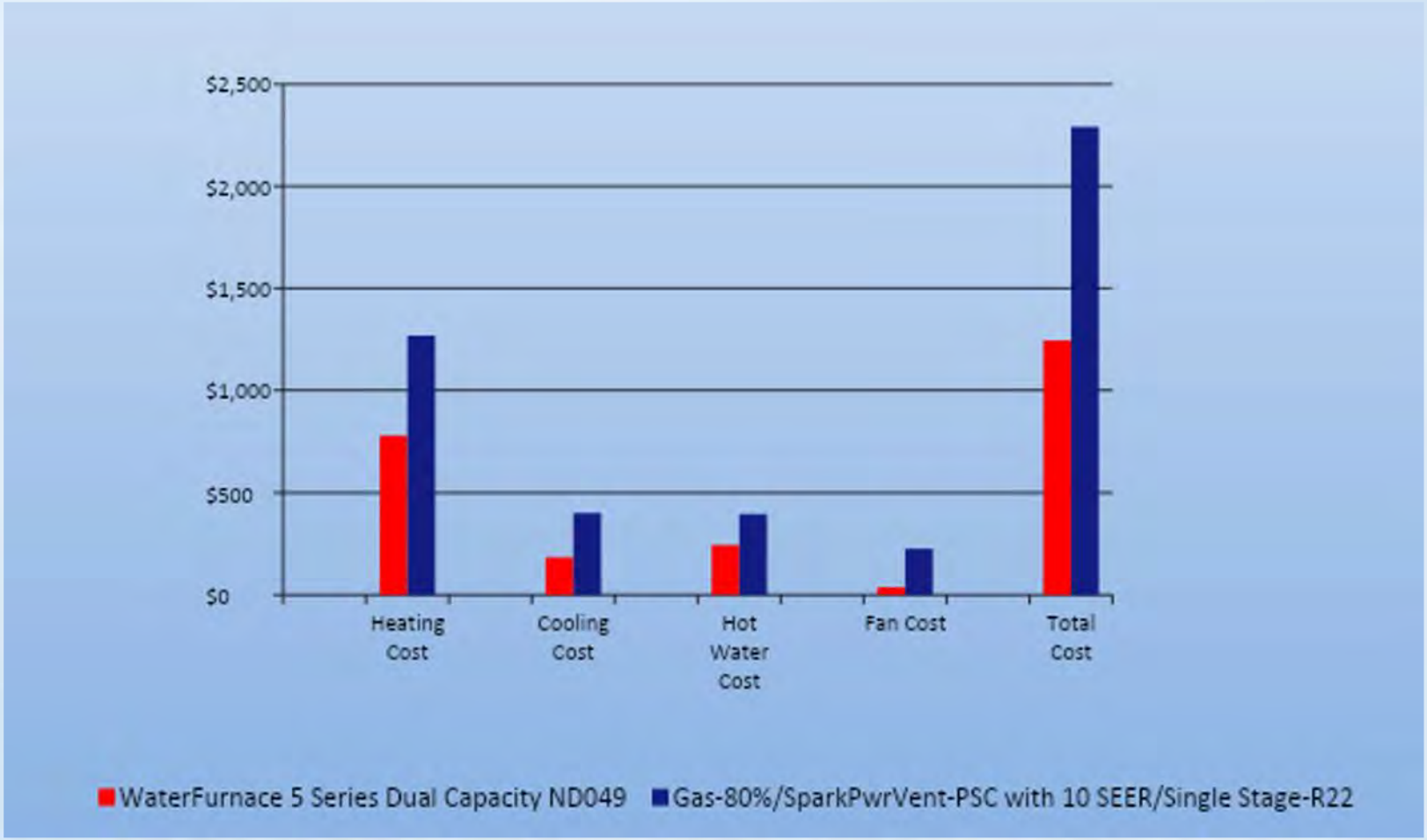
Geothermal Performance Comparison



Geothermal Performance Comparison



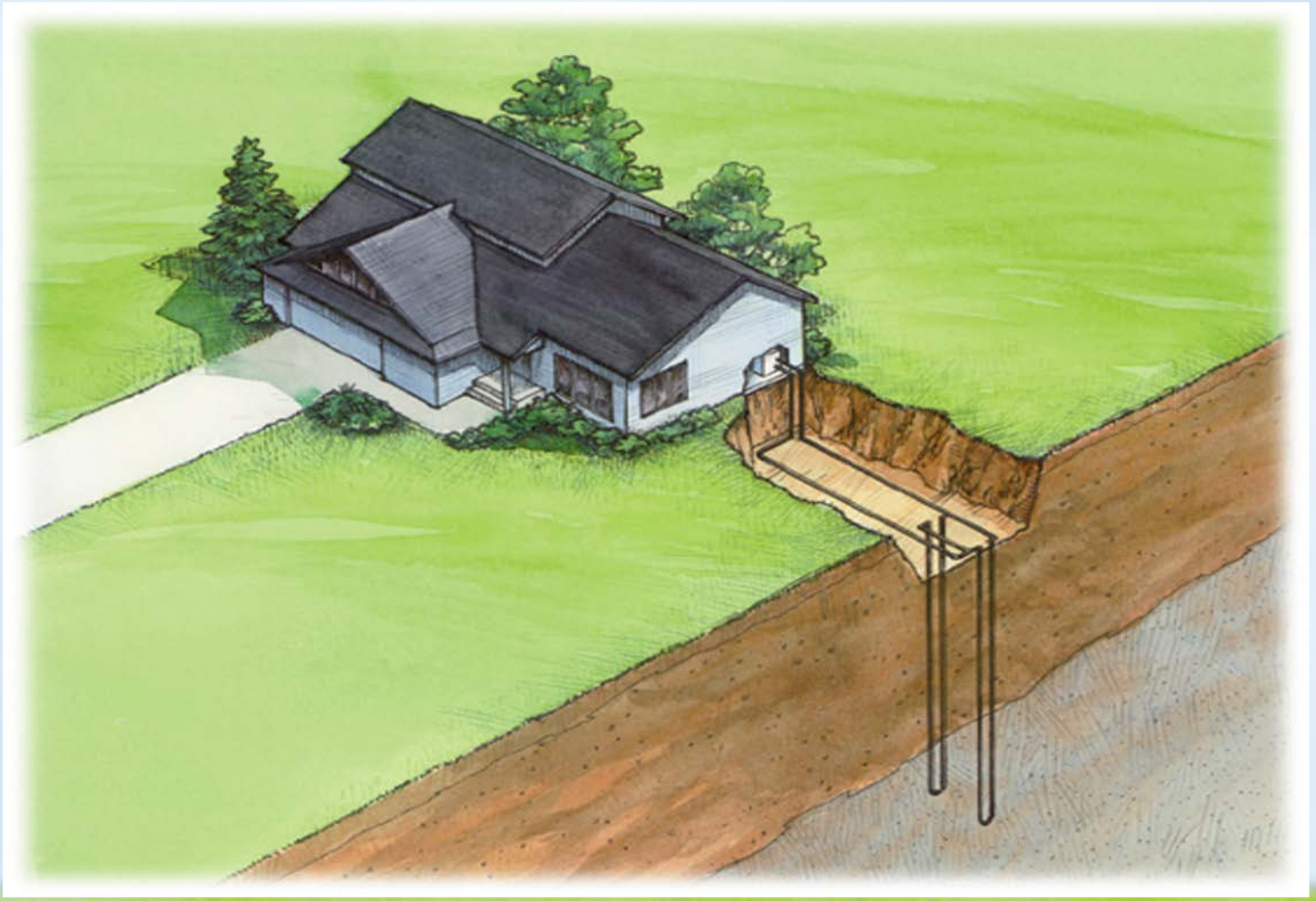
Reduce Your Energy Bill



Loop Types

- Closed Loop (w/ antifreeze)
  - Horizontal
  - Vertical
  - Pond
- Open Loop (w/ groundwater)
  - Well Water

Vertical Loop



Retrofit Existing Home …

What Geothermal Loop Installation Will Look Like

New Home Construction …

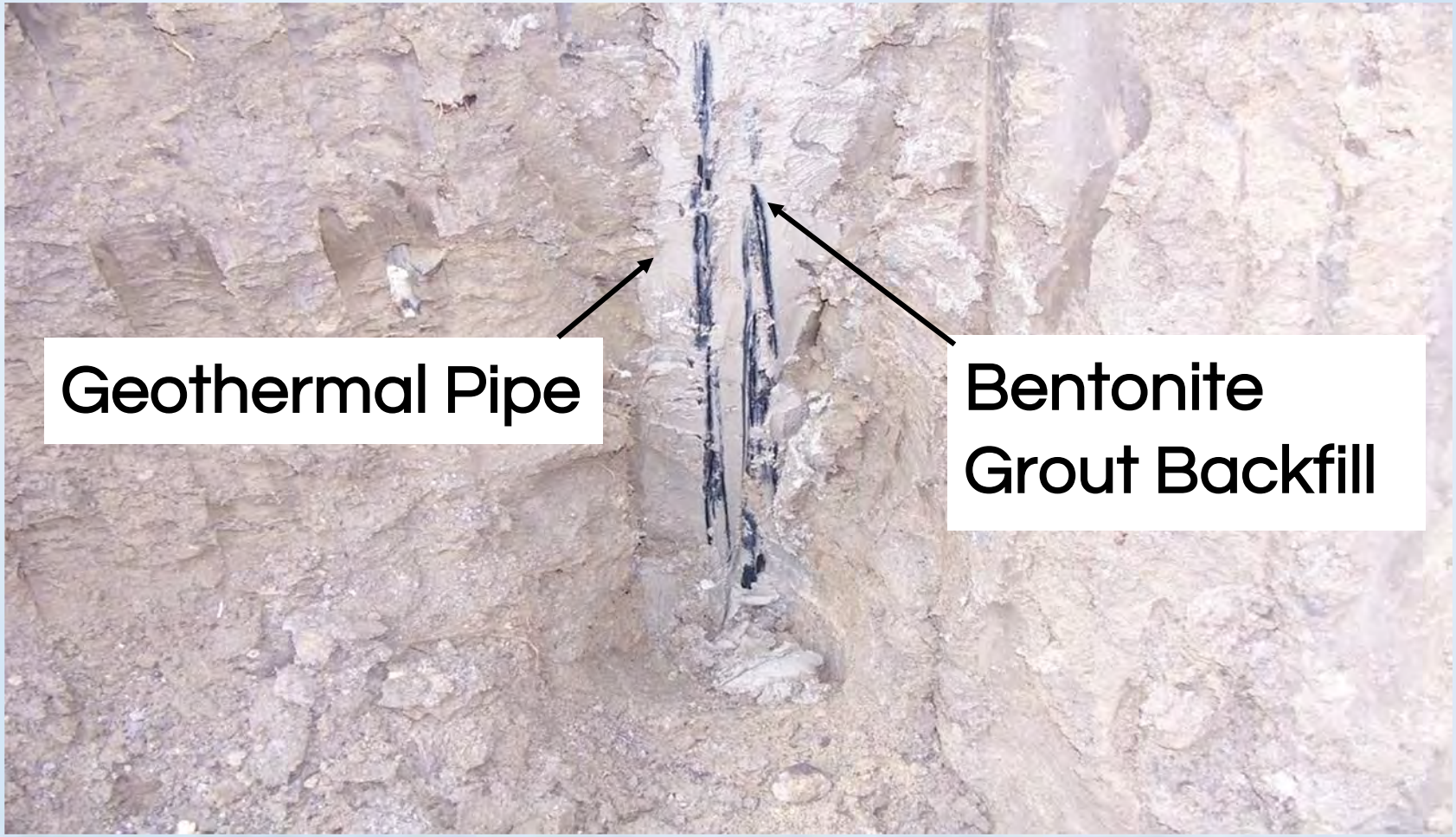
What Geothermal Loop Installation Will Look Like

GEOTHERMAL
ALLIANCE OF ILLINOIS

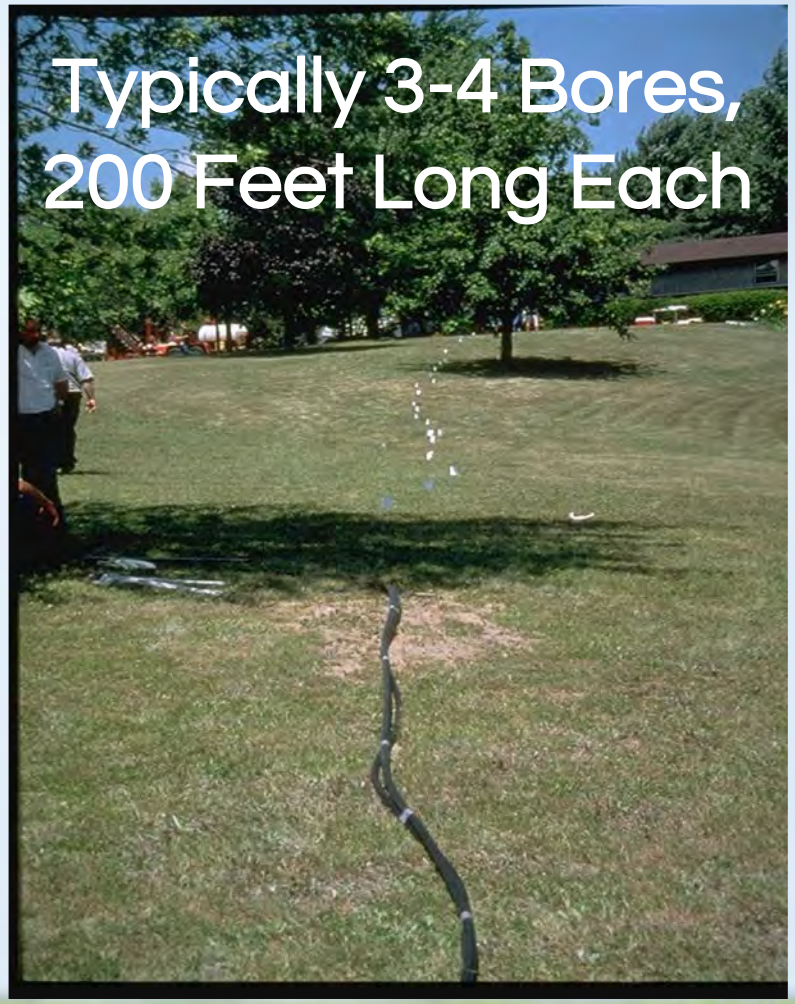
U-Bend Used for Vertical Loops

Vertical Bore Without Backfill

Vertical Loop/Grouted



Horizontal Bore Loops



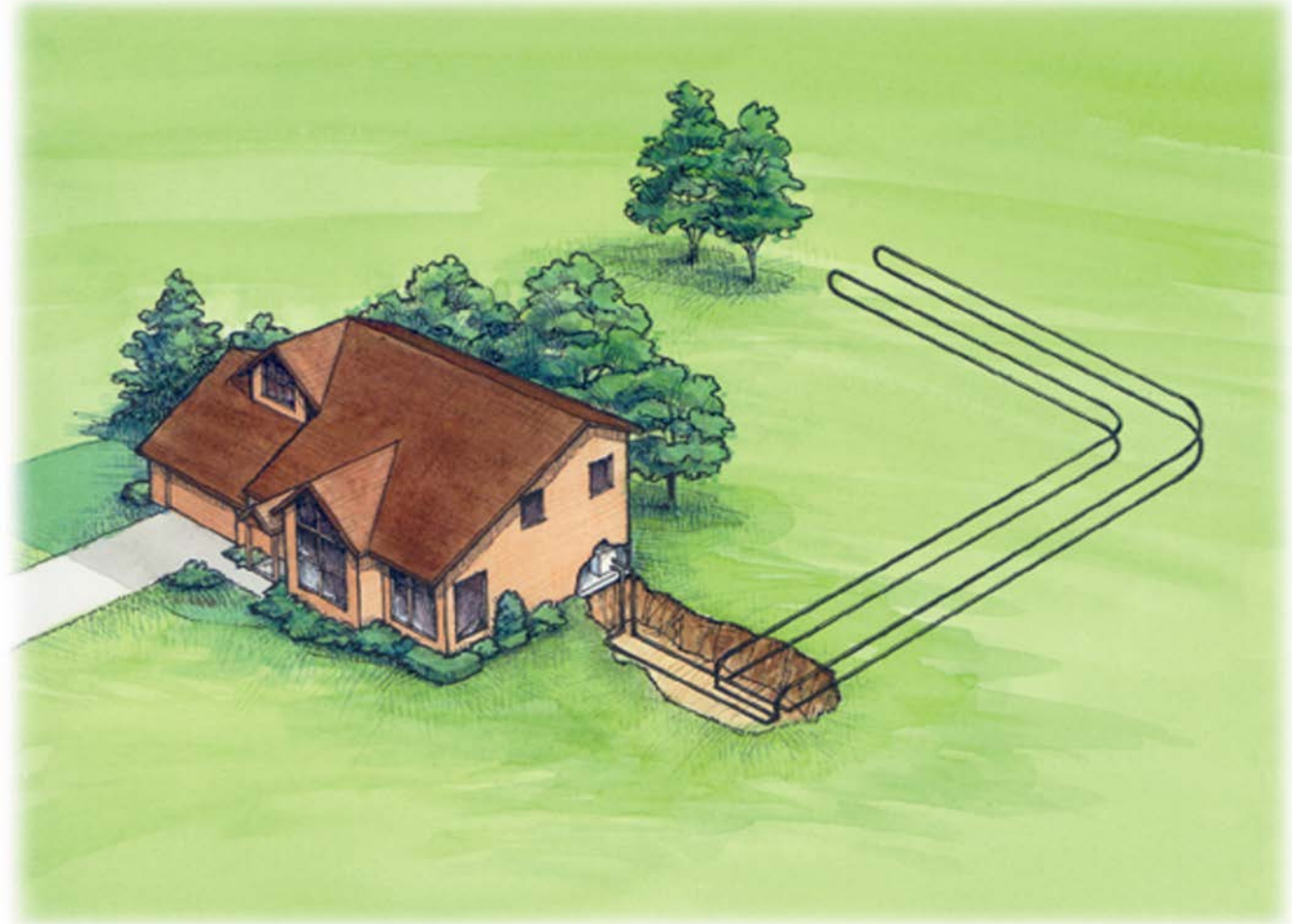
GEOTHERMAL ALLIANCE OF ILLINOIS

Directionally Bored Loopfield…

What Geothermal Loop Installation Will Look Like


GEOTHERMAL
ALLIANCE OF ILLINOIS

Horizontal Loop



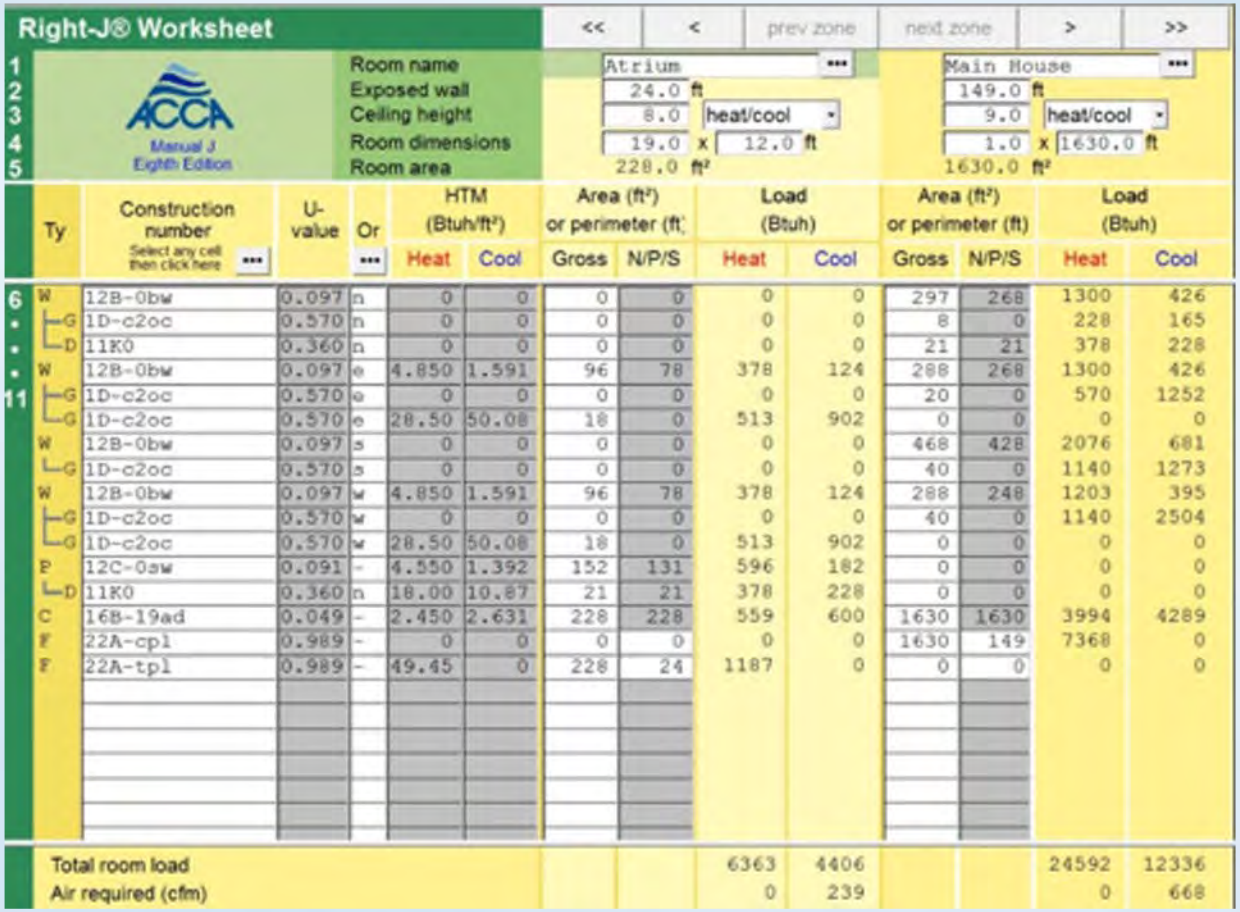
Horizontal 4 & 6 Pipe Loops

Pond Loop

Minimum ½ Acre,
8 Ft. Deep

Racked Loops

Load Calculation is a VITAL First Step



Right-J® Worksheet — << | < | prev zone | next zone | > | >>

ACCA Manual J Eighth Edition

		Atrium	Main House
1	Room name	Atrium	Main House
2	Exposed wall	24.0 ft	149.0 ft
3	Ceiling height	8.0 heat/cool	9.0 heat/cool
4	Room dimensions	19.0 x 12.0 ft	1.0 x 1630.0 ft
5	Room area	228.0 ft²	1630.0 ft²

	Ty	Construction number (Select any cell then click here)	U-value	Or	HTM (Btuh/ft²) Heat	HTM (Btuh/ft²) Cool	Atrium Area (ft²) or perimeter (ft) Gross	Atrium Area (ft²) or perimeter (ft) N/P/S	Atrium Load (Btuh) Heat	Atrium Load (Btuh) Cool	Main House Area (ft²) or perimeter (ft) Gross	Main House Area (ft²) or perimeter (ft) N/P/S	Main House Load (Btuh) Heat	Main House Load (Btuh) Cool
6	W	12B-0bw	0.097	n	0	0	0	0	0	0	297	268	1300	426
	G	1D-c2oc	0.570	n	0	0	0	0	0	0	8	0	228	165
	D	11K0	0.360	n	0	0	0	0	0	0	21	21	378	228
	W	12B-0bw	0.097	e	4.850	1.591	96	78	378	124	288	268	1300	426
	G	1D-c2oc	0.570	e	0	0	0	0	0	0	20	0	570	1252
	G	1D-c2oc	0.570	e	28.50	50.08	18	0	513	902	0	0	0	0
	W	12B-0bw	0.097	s	0	0	0	0	0	0	468	428	2076	681
	G	1D-c2oc	0.570	s	0	0	0	0	0	0	40	0	1140	1273
	W	12B-0bw	0.097	w	4.850	1.591	96	78	378	124	288	248	1203	395
	G	1D-c2oc	0.570	w	0	0	0	0	0	0	40	0	1140	2504
	G	1D-c2oc	0.570	w	28.50	50.08	18	0	513	902	0	0	0	0
	P	12C-0aw	0.091	-	4.550	1.392	152	131	596	182	0	0	0	0
	D	11K0	0.360	n	18.00	10.87	21	21	378	228	0	0	0	0
	C	16B-19ad	0.049	-	2.450	2.631	228	228	559	600	1630	1630	3994	4289
	F	22A-cpl	0.989	-	0	0	0	0	0	0	1630	149	7368	0
	F	22A-tpl	0.989	-	49.45	0	228	24	1187	0	0	0	0	0
11														
	Total room load								6363	4406			24592	12336
	Air required (cfm)								0	239			0	668

Geothermal is a different type of heating/cooling system. Equipment cannot be oversized, nor undersized – unlike a traditional gas furnace. It must be properly sized

WaterFurnace Energy Analysis
Fossil Furnace & AC Performance

Dealer-
HVAC Contractor
Springfield, IL

Notes:

Client-
John Q. Public
Springfield, IL

Notes:

Furnace Data-

Furnace Type:	Propane Pilot, Comb Blwr
Input Capacity:	100000 btu/hr
Output Capacity:	80000 btu/hr
Blower Power:	1/2 Horsepower
Flue Diameter:	3 Inches
Flue Height:	15 Feet
Vent Damper:	No Flue Damper
Combustion Air:	Outdoor

Air Conditioning Data-

ARI Clg Cap @ 95:	48000 btu/hr @ 95 F
ARI EER @ 95:	10.5 btu/watt

DHW System Data -

DHW Type:	Propane
Input Capacity:	40000 btu/hr
Output Capacity:	28000 btu/hr
Flue Diameter:	3 Inches
Flue Height:	15 Feet
Vent Damper:	No Flue Damper
Combustion Air:	Indoor

Design Data:

Heating Load:	63923 btu/hr
Heating Temp Diff:	72 °F
Cooling Load:	45717 btu/hr
Cooling Temp Diff:	25 °F
DHW Temp:	120 °F
DHW Users:	3 People
Constant Fan:	1 Yes
Internal Gains:	12,897

Comfort Conditions-

Heating Setpoint:	72 °F
Cooling Setpoint:	75 °F
Start Cooling Temp:	70 °F

Other-
Weather Location: Springfield, IL

Fossil Furnace & AC Operating Costs-
Residence

Heating-

Load:	88.2 million btu
Propane:	1,451 Gallon
Electric:	827 kwh
Average Efficiency:	66.1% Efficient
Cost of Operation:	$2,597

Cooling-

Load:	44.8 million btu
Electric:	4,726 kwh
Avg EER:	9.5 btu/watt
Cost of Operation:	$425

Hot Water-

Load:	13.6 million btu
Propane:	266 Gallon
Avg COP:	55.5% Efficient
Cost of Operation:	$465

Constant Fan:	$272
Annual Cost:	$3,759

Run Time-

Cooling:	861 hours
Heating:	1,103 hours
Peak Demand kw (CLG & DHW):	4.82

Fuel Costs-

Elec Rate - Cooling:	$0.090 /kwh
Elec Rate - Heating:	$0.070 /kwh
Natural Gas:	/ccf
Propane:	$1.75 /gal
Fuel Oil:	/gal

Geothermal Sizing Software Provides an Energy Analysis

This analysis will provide energy usage projections, paybacks, savings, etc.

Classic Geothermal Residential Retrofit in Old Home

Geothermal can work in virtually any application … some are easier than others

Geothermal Costs & Incentives

Typical Scenario

- 4 Ton basic system
- 10kw Supplement Heat
- Hot Water Assist

Market Installed cost	$48,000
ComEd geothermal rebate	-$4,000
Group Buy incentives?	???
30% Federal Tax Credit	- $14,400
Net cost	**$29,600**

Every Home Is Different

Your Geothermal System Is Tailor-Made To Fit Your Needs

Pricing Varies by Site and Needs:

- System Design and Size
- Supplemental electric heat or gas furnace upgrade
- Geothermal hot water assist and buffer tank
- Surge Protectors

Federal Residential & Commercial Geothermal Tax Credit

- **Tax credit of 30%** on qualified expenditures
- No maximum credit, but requires you have tax liability
- A home must be owned by the taxpayer but does not have to serve as the principal residence
- Incentive details at energystar.gov or irs.gov
- Commercial incentives are EVEN MORE robust than the residential incentives

Home Values

Possible Reasons for Increased Resale Value:

- Immediate Monthly Savings for Buyers
- More and More Buyers Want Green Homes
- A “Low Hassle” Improvement

The amount of energy savings depends on the size of the home, the climate, and the way that the homeowner uses heating and cooling. The U.S. EPA claims that people can save as much as 70% on heating costs and 50% on cooling with geothermal heating pumps.

No home improvement is guaranteed to provide a specific ROI. Ultimately, the way a home is valued depends on the knowledge of the many parties relevant to the transaction. Real Estate agents who understand how geothermal heating and cooling works and average energy savings for the area can help to market the home appropriately.

Health & Environmental Benefits

Reduce Global Warming Pollution

47% of households rely on natural gas as their main heating fuel -EIA

Reduce Indoor Air Pollution

Gas stoves can emit elevated indoor nitrogen dioxide levels often exceeding indoor guidelines and outdoor standards -RMI

Outdoor Standards for NO2	**1-hr avg. (ppb)**
US Environmental Protection Agency	100
Canadian National Standard	60

Measured NO2 from Gas Stoves	**Peak (ppb)**
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82-300
Gas oven - no food	130-546

Source: https://rmi.org/insight/gas-stoves-pollution-health

Geothermal + Solar PV: A Perfect Combination

- The residential sector in the U.S. accounts for about 1/3 of carbon emissions.
- Space heating, air conditioning, and water heating account for ≈70% of energy use
- Geothermal for the heating *and* cooling + solar to power the geothermal and appliances decarbonizes the house.

Grow Geo Chicagoland

A group buy opportunity for geothermal heat pumps: the most efficient and environmentally beneficial heating and cooling systems available today

GROW GEO
Chicagoland

mrea
midwest renewable energy association

CITIZENS UTILITY BOARD
CUB
Fighting for Illinois Consumers

GEOTHERMAL
ALLIANCE OF ILLINOIS

Grow Geo Chicagoland

- A geothermal heat pump group buy program, with multiple geothermal contractor/dealers.
- Open to any residential and small commercial entities in northeastern Illinois region.
- Co-sponsored by Citizens Utility Board of Illinois, Midwest Renewable Energy Assn. and the Geothermal Alliance of Illinois
- Modeled somewhat by group buy programs led by GAOI with the City of Urbana in central Illinois and Jo Carroll Energy in northwestern Illinois.

Thank You for Attending!

Presenter: John Freitag, Executive Director
Geothermal Alliance of IL JFreitag@gaoi.org