Geothermal Heat Pumps

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GEOTHERMAL OPTIONS LLC

Overview

- Geothermal heat pumps 101
- Case study
- Costs and benefits of geothermal
- Financing and tax incentives

Geothermal Heat Pumps 101

What is geothermal?

- Geothermal Power Generation: tapping underground sources of heat in exceptional locations (e.g., Iceland, Hawaii) or deep earth (up to 5 km) to generate electrical power
- Geothermal Heat Pumps: heating and cooling buildings efficiently by moving heat from the ground (0-1500 ft deep) into the building (heating), or the reverse (cooling), by circulating a fluid using electrical power

What is a heat pump?

- Examples: Refrigerator, window air conditioner, central A/C system, central “heat pump”
- Can move heat from a colder place to a warmer place
  - Like pumping water up hill, so we call it a “pump”
  - It uses a fluid often called “Freon” to carry the heat
- But efficiency decreases as temperature difference increases
  - Cold air makes a poor source of heat!

What is a geothermal heat pump?

- It is a heat pump that uses the ground as its heat source
- Why is that good?
  - Because the ground is the same temperature all year long
- In the Metropolitan Washington Area, the ground is a consistent 55-57 degrees Fahrenheit
- A fluid circulating in pipes in the ground absorb heat and bring it into the house

Geothermal Heat Pump Technology

- Heat pumps operate by moving heat instead of creating it
- 1 unit of energy can create no more than 1 unit of heat
  - combustion of gas or oil 80-94% efficient
  - electric resistance 100% efficient
- 1 unit of energy can move 2-5 or more units of heat, depending on conditions
  - What determines this efficiency?

Geothermal Heat Pump Technology

- Heat moves from a hotter place to a colder place, just like water flows from a higher place to a lower place
- Reversing the flow of heat requires the input of energy to “pump” the heat back “up hill”
- The higher the “hill” (the greater the temperature difference) the harder the heat pump has to work and the less efficient it is

Geothermal Heat Pump Technology

- Every heat pump has a source and a sink
  - Source: object or substance where the heat comes from
  - Sink: where the heat is moved to
- In an air source heat pump in heating mode, the source is outside air
- The efficiency of a heat pump is highly dependent on the difference in temperature between source and sink

Geothermal Heat Pump Technology

- An air source heat pump heats a home on a moderate winter day using a heat source of 40 deg and a sink of 70 deg (30 deg difference)
- A geothermal heat pump on the same day uses a source of 55 deg and a sink of 70 deg (15 deg difference)
- Halving the difference in temperature greatly increases the efficiency
- Smaller hill to climb = less energy required

Geothermal Heat Pump Technology

- Heat pumps are also dependent on flow of heat within the source and sink
- An air source HP must use a fan to circulate the outdoor air
  - Air that doesn't move is a great insulator
- A geothermal heat pump can rely on the natural thermal conductivity of the soil to move heat
- No fan required

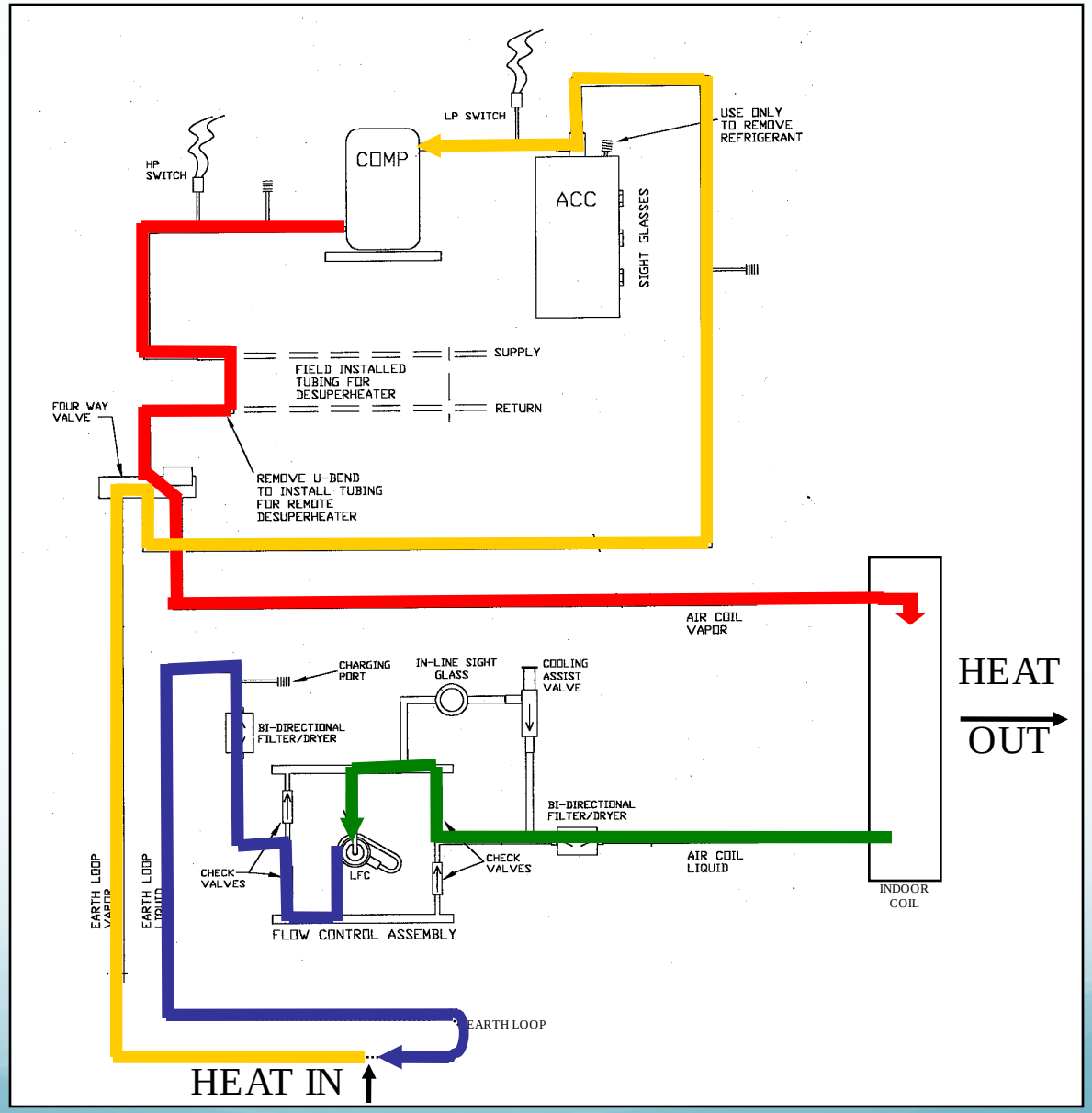
Geothermal Heat Pump Technology

- A HP operates by circulating a refrigerant fluid such as Freon (R-22), R-407C, or R-410A
- The refrigerant can be a gas or a liquid inside the system, depending on its temperature and pressure
- The refrigeration cycle is what allows heat to be moved up hill from a colder place to a warmer place

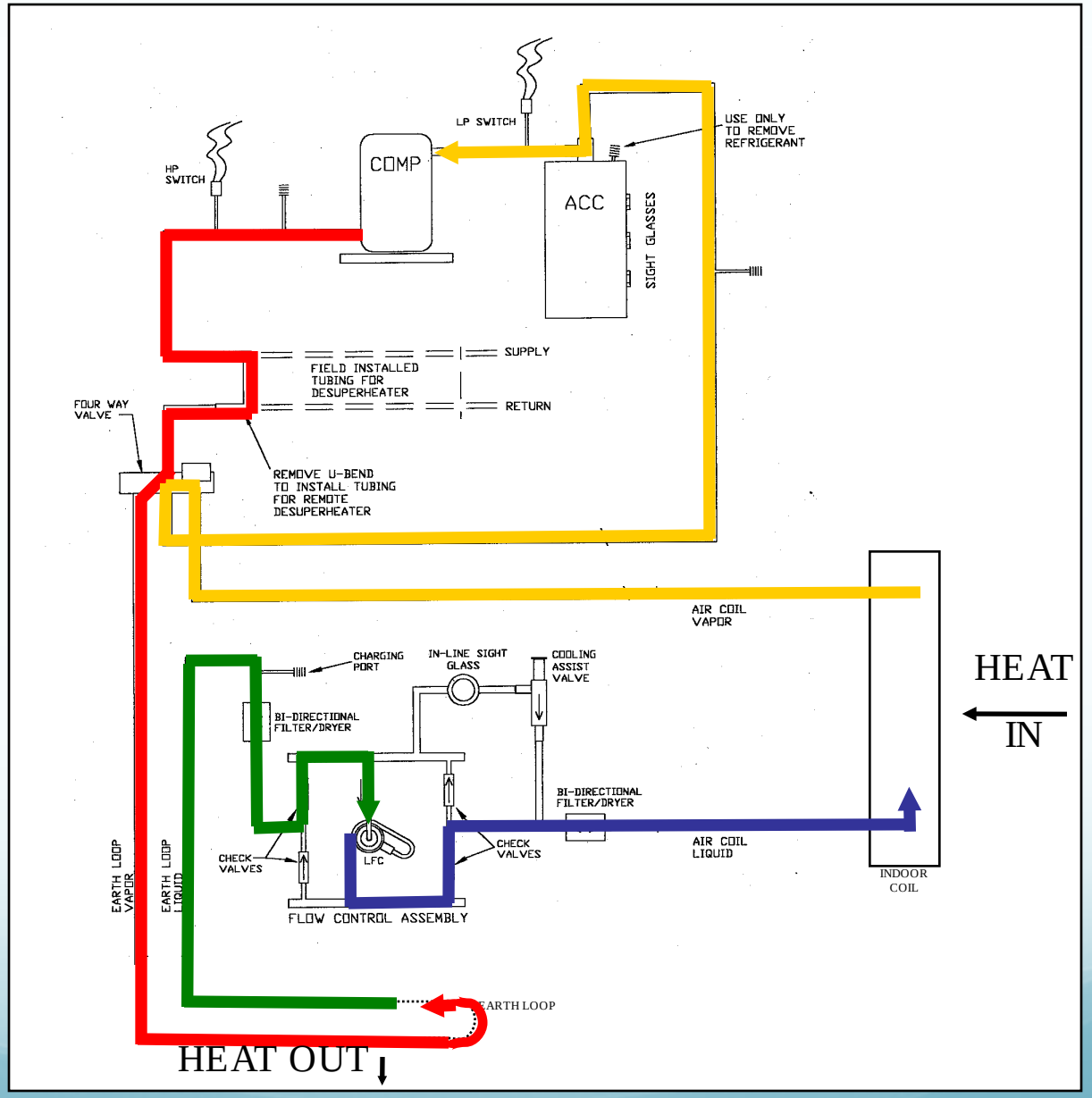
Geothermal Heat Pump Cut-away View

Compressor Unit and Ground Loops

GEOTHERMAL HEATING CYCLE



GEOTHERMAL COOLING CYCLE



DIAGONAL EARTH LOOP

- Small footprint (3 to 8 feet diameter).
- 1, 1.5, 2, 3 or 4 loops per ton.
- 50, 75 or 100 feet drilling depth per loop.
- 15 to 45° drilling angle for D1, D1.5, D2 loops (from vertical).
- 30 to 45° drilling angle for D3 and D4 loops.
- 3 inch (min.) bore hole diameter.

VERTICAL EARTH LOOP

- 1, 1.5 or 2 loops per ton.
- 75 or 100 feet drilling depth per loop.
- 0° drilling angle (from vertical).
- 3 inch (min.) bore hole diameter.

HORIZONTAL EARTH LOOP (PIT)

- 5 loops per ton.
- 100 feet length per loop.
- 4 to 6 feet typical depth of pit.

HORIZONTAL EARTH LOOP (TRENCH)

- 1 loop per ton.
- 250 feet length per loop.
- 4 to 6 feet typical depth of trench.

Ground Source vs. Air Source

- Air source requires outdoor fan coil
  - Exposed to weather, prone to failure
  - Emits noise
  - Subject to icing below 40 deg outdoor temperature
  - Defrost cycle is inefficient
- Ground source requires ground loops
  - Expensive drilling or digging

DX and Water Source

- All heat pumps use a refrigerant fluid like Freon to carry the heat “up hill”
- To understand water source heating and cooling, replace the ground loops with the refrigerant/water heat exchanger
- Water circulates from this heat exchanger to the plastic ground loops, moving heat into or out of the ground depending on the mode

DX and Water Source

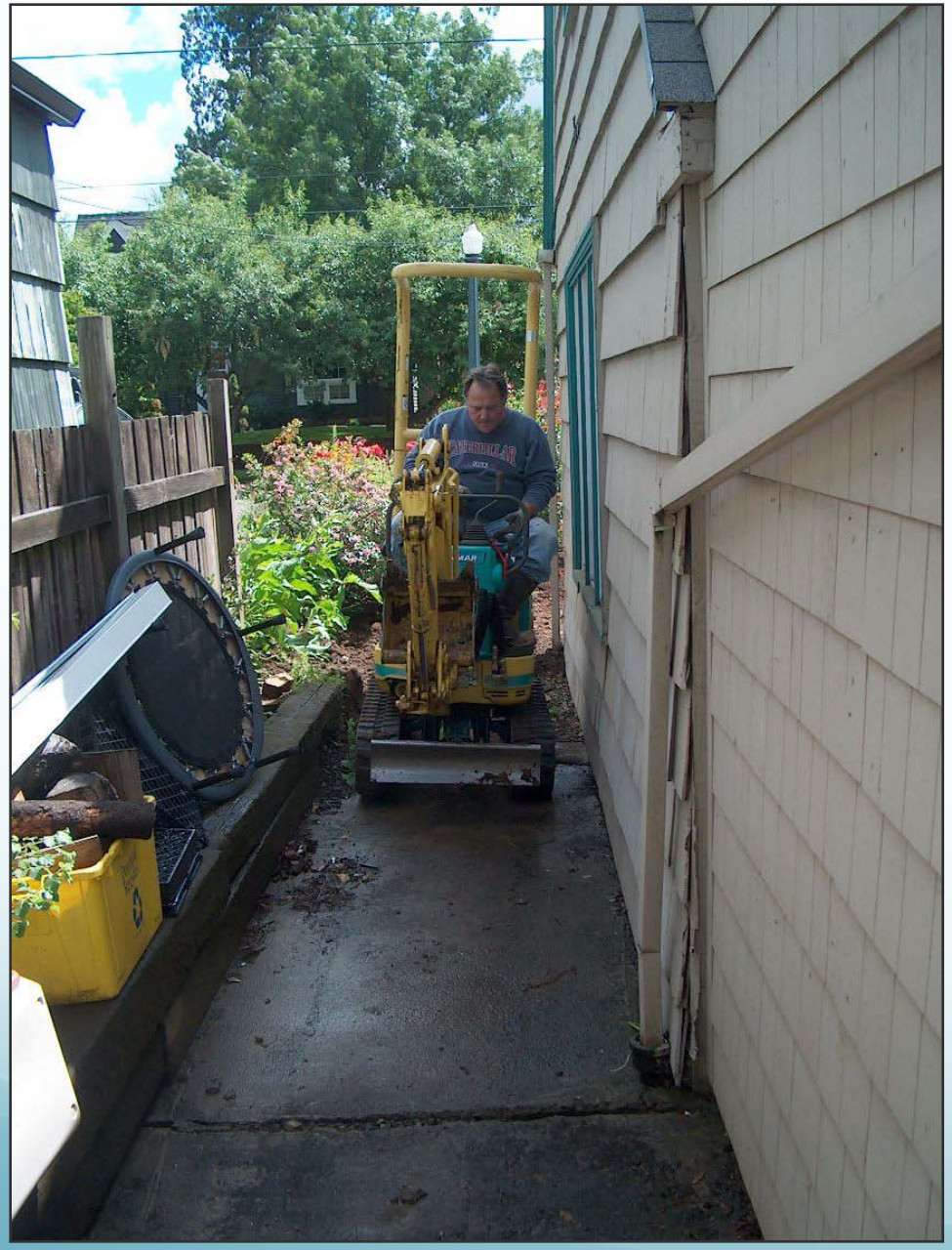
- DX Advantages
  - 20-25% more efficient than water source
  - Less drilling per ton
  - Fewer moving parts
- Water source advantages
  - Water tubing can reach deeper and farther
  - Water circulation system is more flexible: can form backbone of heat exchange system for one large, integrated commercial system

Water Source Geothermal Drilling (using water well drill rig)

DX Geothermal Drilling (using mini drill rig)

Installation Example


YANMAR
4X4

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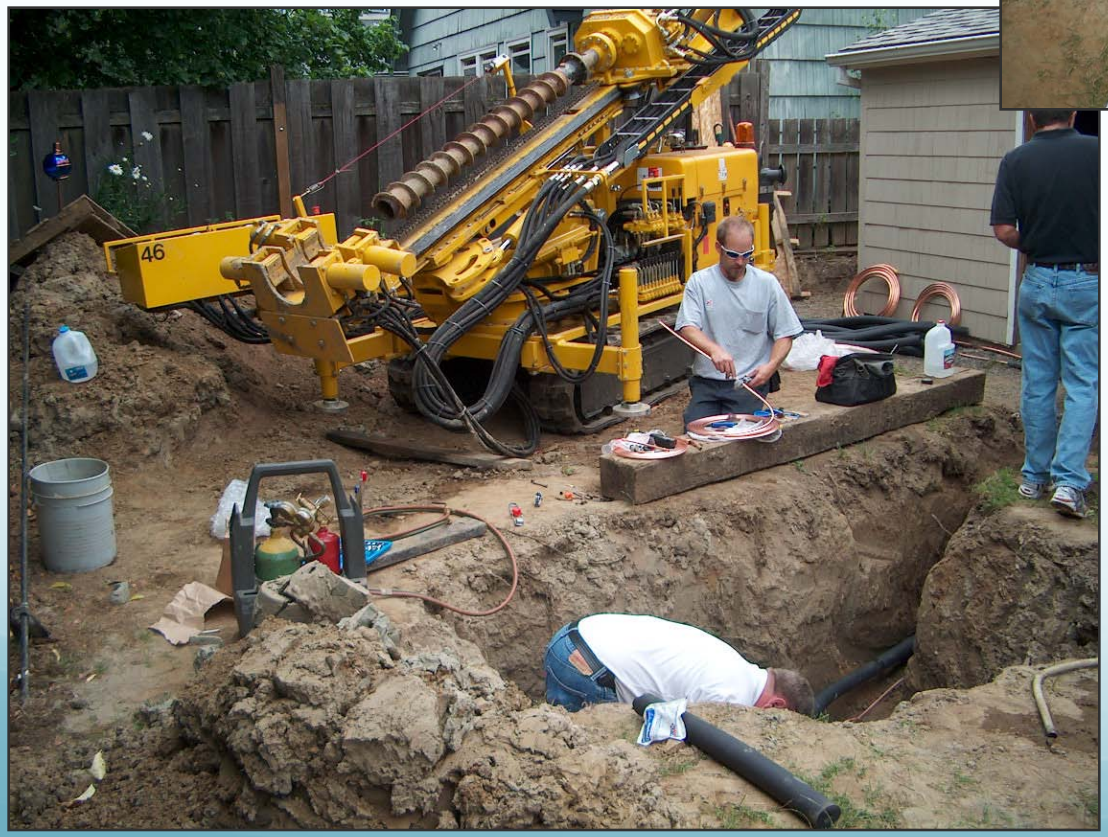
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Geothermal Applications

- Residential, commercial, institutions, government
- Retrofit or new construction
- Forced air, radiant floors, wall-mounted units
- Heating and cooling
  - With optional hot water heating by same system
- Pool heating
- Commercial water heating (laundry, etc.)

Geothermal History

- Geothermal heat pump technology first developed in late 1940s
- First system developed was a DX system in late forties
- Slow development originally due to high cost (and low cost of fossil fuels)
- Water source systems were developed for industrial uses, including cement plants

Geothermal History

- Development and installations accelerated in 1970s energy crisis, then slowed again to a steady pace
- Recent surge in interest during last 5 years, continues to accelerate, technology is now mature
- DX systems now growing in popularity due to compactness, efficiency, and cost

Geothermal Market Outlook

- Rising energy prices have spurred interest
- Federal tax incentives have gone from zero to 30% (residential) and 10% (commercial) within the past 18 months, with the biggest increase in the stimulus bill
- Tax incentives have made geothermal an almost-household word
- Change is happening quickly in the geothermal marketplace

Geothermal Case Study

Case Study

- Home in Reston, VA
- Constructed in 1985, modular construction
- Approximately 2000 square feet inc. basement
- Existing HVAC system was a 3 ton 12.5 SEER heat pump system
- Owner was interested in saving money and reducing impact on environment

Case Study

Case Study

- Replaced air source heat pump with 3-ton DX geothermal system
- Used existing ductwork
- Drilled 3 diagonal boreholes, 100 ft each

Case Study

Case Study

Case Study

Case Study

Case Study

- Average monthly heat/cool expenses
  - Before: $76
  - After: $21
  - Savings: $55 = 72% = 500 kWh per month
  - Yearly savings $660
- Geothermal system efficiency estimate
  - Old system was 12.5 SEER
  - Use cost ratio as efficiency ratio
  - 12.5 SEER x ($76/$21) = 45.2 SEER

Case Study

- System cost
  - $20,000 installation cost
  - 30% federal tax credit reduces that to $14,000
  - New air source heat pump cost: $8000
  - Cost premium for geothermal: $6000
- Economics
  - Payback period: Cost premium/annual savings = $6000/$660 = 9.1 years
  - Return on investment: $660/$6000 = 11.0% annual rate of return

Case Study

- kiloWatt-hrs saved = 30 x 12 x 500 = 180,000
- Premium paid over conventional = $6,000
- Cost per kiloWatt-hr = $6000/180,000 kWh = about $0.03 per kWh

Geothermal Costs and Benefits

Geothermal Costs

- Residential: $7000 per “ton” (for every 500-700 square feet)
- Commercial: $5000-7000 per ton
- Non-monetary costs include
  - longer installation times due to added permitting requirements and drilling process
  - Drilling and trenching add to site impact
    - Noise
    - Re-landscaping requirements
    - Drilling operation run-off
    - Equipment parking, sidewalk closure, etc.

Geothermal Benefits

- Higher efficiency
  - Lower operating cost and life-cycle cost
  - Decreased environmental impact
- No outdoor equipment
  - No outdoor noise
  - No system exposure to weather or vandalism
  - Aesthetic appeal for historic and architectural purposes
- Good for local economy
  - Local drillers and mechanical contractors

Geothermal Benefits

- 40-75% more efficient than other methods of heating and cooling
- No indoor combustion
- Long system life: 20-30 years
- Energy consumption reduced to levels that make green power use more feasible

Comparisons: Operating Cost

System	Annual Cost	Savings with DX	DX Efficiency % Increase
DX Geothermal HP	767	--	--
Water Source Geothermal HP	928	161	21%
13 SEER Air Source HP	1213	446	58%
13 SEER AC / Natural Gas	1900	1133	148%
13 SEER AC / LP Gas	3331	2564	334%
13 SEER AC / Oil Heat	2605	1838	240%

Fuel rates: Electric = $0.11/kWh, Natural Gas = $1.40/therm, LPG = $2.60/gal, Oil = $3.75/gal.
Operating costs based on ACCA Manual J for typical 2000 sq. ft. detached house in Washington, DC area, in 2008 US$.

Comparisons: Life-cycle Cost

System	Initial Cost	System Life	Amort-ization	Mainten-ance	Oper. Cost	Total Annual*
DX Geothermal HP	23000	25 yrs	920	100	767	1787
Water Source Geothermal HP	26000	25 yrs	1040	150	928	2118
13 SEER Air Source HP	10000	10 yrs	1000	200	1213	2413
13 SEER AC / Natural Gas	8000	10 yrs	800	200	1900	2900
13 SEER AC / LP Gas	8000	10 yrs	800	200	3331	4331
13 SEER AC / Oil Heat	7500	15 yrs	500	200	2605	3305

*Total of amortized initial cost, estimated average maintenance, and Table 1 operating cost.
All costs are based on typical installation, 4-ton heat pump or equivalent sized system, in 2008 US$.

Other Comparisons

System	Outdoor Noise	Indoor Comb-ustion	Imported Fuel	Complex/Dual System	Most $ Goes to...
DX Geothermal HP	No	No	No	No	Local Biz
Water Source Geothermal HP	No	No	No	Yes	Local Biz
13 SEER Air Source HP	Yes	No	No	Yes	Elec. Util.
13 SEER AC / Natural Gas / LP	Yes	Yes	No	Yes	Gas Indus.
13 SEER AC / Oil Heat	Yes	Yes	Yes	Yes	Oil Indus.

Compare Cost of Electricity

- Geothermal cost per kiloWatt-hr = $6000/180,000 kWh = about $0.03 per kWh
- Compare to going rate of electricity
  - DC: $0.12 per kWh
  - MD: $0.14 per kWh
  - VA: $0.11 per kWh
- Compare to solar PV: $0.30 per kWh
- Compare to caulking (!): about $.03 per kWh

Geothermal Financing, Tax Incentives, and Regulation

Financing

- Biggest marketing problem of geothermal is the initial cost
- Few dealers can provide their own financing
- Banks are unable to finance projects without collateral, such as a second mortgage / home equity loan / refinance
- Current state of many mortgages as “underwater” provides no equity

Financing

- Municipal Financing
  - Passage of PACE (Property-Assessed Clean Energy) bills in states across country
    - Home solar projects financed by municipality, loans secured by tax lien
  - Virginia and Maryland
    - Legislatures in 2009 passed bills, with improvements in recent 2010 sessions
    - Gives each municipality the right to make loans
    - No municipality has yet started their program or begun making loans; probably will not begin until some time in 2010
    - Montgomery Co. and Annapolis are leaders

Financing

- Energy-Efficient Mortgages
  - Allows qualification for larger loan amount based on lower utility bills due to renewable energy and energy-efficiency technologies
  - May be used to purchase a home that is already energy-efficient or extra loan funds go to pay for upgrades by purchaser
  - Available through FHA, VA, or conventional (Fannie and Freddie) loan programs
  - Market for EEMs seems moribund, customers complain that they can’t find a lender who knows about or offers EEMs

Federal Incentives

- There is a federal tax credit (deduct full credit amount from your tax due) of 30% of installed system cost for geothermal heat pump systems
- There is no maximum or “cap” on this credit
- The law runs through Dec 31, 2016.

Maryland Incentives

- Maryland state sales and use tax will not apply to the sale of geothermal systems
- The Maryland Energy Administration (MEA) offers rebates of up to $3,000 for residential geothermal heat pump systems and $10,000 for non-residential geothermal heat pump systems
  - Grants are provided at a rate of $500 per ton of refrigeration capacity

Maryland Local Incentives

- Montgomery, Howard, and Prince George's: These counties offer property tax credits on residential, owner-occupied structures equipped with geothermal
- Equal to 50% of the cost of the system
- Capped at $5,000
- May be rolled over to 2 subsequent years if necessary

Virginia Incentives

- Virginia has a state sales tax holiday in October for EnergyStar appliances, cost capped at $2500
- Virginia last year had a rebate program funded with stimulus funds that have since been depleted
  - State executive branch (Gov. Kaine) program under ARRA that will not renew

District Incentives

- The District of Columbia has a renewable energy rebate program that is to be rolled out in phases according to technology
  - So far, in the first year of program operation, solar PV and wind have been rolled out
  - Administered by the DC Department of Environment, Energy Office

Geothermal Regulation

- Geothermal heat pumps are regulated under mechanical licensing
  - requiring local and state licensing
  - local mechanical permit
- Geothermal drilling is regulated in most states as if it were water well drilling
  - requiring a water well driller's license
  - a water well permit for each site
- Dual licensing/permitting + regulation as water wells = impediment to industry

Geothermal Options LLC

- In operation since Spring 2008
- Providing geothermal consulting services
- Exclusive distributor of EarthLinked DX Geothermal Heat Pumps since July 2008
- Based in Fairfax City, Virginia
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