Residential Geothermal Heat-pumps – a case study

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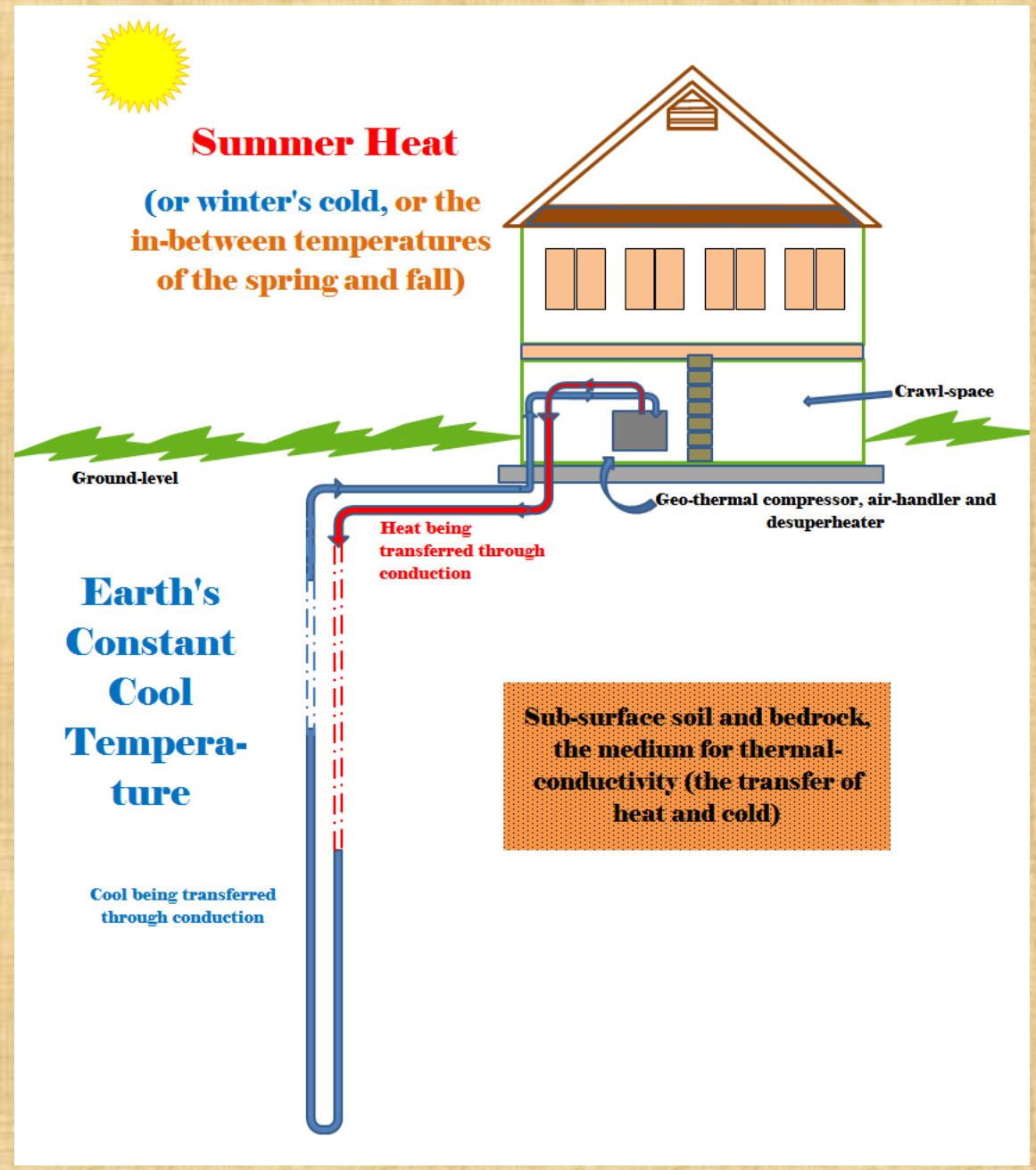
Summer Heat
(or winter's cold, or the in-between temperatures of the spring and fall)
Crawl-space
Ground-level
Geo-thermal compressor, air-handler and desuperheater
Heat being transferred through conduction
Earth's Constant Cool Tempera-ture
Sub-surface soil and bedrock, the medium for thermal-conductivity (the transfer of heat and cold)
Cool being transferred through conduction

Our Experience with geothermal

- In this article I share our experience in exploring and ultimately deciding to invest in a geo-thermal heat-pump. Planning considerations are described as well as pre-installation economic expectations. Post-implementation performance is then presented followed by treatment of several topics that relate to energy efficiency, air quality and comfort.

Introduction/Background

- Fall of 2009 began educating myself about geothermal heat-pumps;
  - Last longer than air source (20-30 yrs. Vs. 10-15 yrs.);
  - Use relatively constant temperature of the earth (about 60°F in the Richmond area) instead of the highly varied air temperature;
  - Most efficient heating and cooling systems according to the U.S. Depart. of Energy;
  - 30%-50% cost savings typical;

Intro. continued

- On the negative side – they cost a lot more than air-source units (more than double);
- But, there is a federal tax credit of 30% available through December 31st, 2016;
- To qualify for the credit, geo-thermal heat pumps must be installed in a home you own and use as a residence (it does not have to be your main home) and rental units do not qualify.

More intro.

- Surfed WWW and found these sites helpful:
  - http://www.igshpa.okstate.edu/
  - http://www.geoexchange.org/

    (user forums on the latter site were especially helpful because I had the same questions that others did)

  - Along the way I learned about….

Intro. continued

- Geothermal systems,
- energy audits/reports,
- “desuperheaters” (auxiliary heat exchangers),
- energy and heat recovery ventilators (ERVs and HRVs),
- crawl-space encapsulation and home air quality;

Intro. continued

- See handout summarizing geo vs. air-source heat-pumps;
- Our house compared favorably to southern region and national HH energy consumption estimates according to the U.S. Energy Information Administration (EIA) – 65% of the region and 56% of the national average;

Planning considerations and pre-installation economic expectations

- Air-source alt. would likely need to be replaced twice during the life of a geo-system;
- No outside unit advantage;
- Quieter system advantage;
- Projected cost savings based upon 3-yr. ave. from our 2007-2009 electricity bills;
- 30% Fed. Tax credit included; as well as…
- DMME credit of 20% (not to exceed $2,000);

Planning considerations continued

- Horizontal vs. vertical heat exchange?
- Would our HOA allow drilling in our yard?
- Front, side or backyard?
- Pressurized system or not?
- Desuperheater or not?
- ERV, HRV or none?
- Adequate return or not?
- Existing ductwork or replacement?

Planning considerations continued

- Filter options (at unit and/or at returns)?
- Crawl-space or garage location for unit?
- Programmable thermostat?
- In-house cut-off switch for ERV?
- Condensation pumps or gravity?

Home energy audit

- Definitely useful/instructive/beneficial…
  - Assess how well house is sealed (blower-door test);
  - Assess seasonal heat gain and losses;
  - Including critical losses via thermal imaging scans;
  - Assess overall thermal performance; and
  - How to improve this as well as your home comfort and air quality (health implications);

Go, no-go decision…

- We chose geo-thermal for the following specific reasons: 1) expectation that a geo-system represents a long-term lower cost investment in a home comfort system that would also be less impacted by potential electricity increases in the future (lower risk/exposure to increasing prices and indeed the higher future electricity prices rise, the sooner the break-even point would be achieved, etc.);

Go, no-go decision…

- 2) expectation for a system much less susceptible to performance problems due to temperature extremes (the earth's temperature down deep is constant) and due to the unit being inside and protected from outside elements;

Go, no-go decision…

- 3) expectation for a much quieter system/higher quality of life at home;

- 4) appreciation for the intelligence designed into the system with respect to the two-stage compressor, variable-speed fan, “desuperheater” pre-heating of hot water using heat extracted from the house during the summer and the prospects of enjoying low humidity air in the summer; and

Go, no-go decision…

- 5) I really liked the idea of using the heat and cooling potential of the earth; Now after 4 and a half years of experience, our decision on all of these counts, has proven to be completely satisfying.

Analysis outcomes

- Break-even estimated to occur between 12 and 30 years depending upon a range of initial costs from $20K to $30K and an assumed annual cost savings of 30% (conservative due to having an already very well insulated and tight building envelope – strategic caulk, external storm doors, insulated attic access portal & added insulation);
- Context - the more efficient, the lower the savings; the less efficient the higher the savings (to a point);

Analysis outcomes cont.

- 29% actual cost savings; 21% direct and 8% accounting for enhancements/other changes (ERV, condensate pump, dehumidifier added/all drawing electricity; 2011 was significantly hotter than baseline years; changes in appliances and lightbulbs, water heater, etc.);

Analysis outcomes cont.

- 29% actual cost savings; 21% direct and 8% accounting for enhancements/other changes;
- According to the U.S. Energy Information Administration (EIA), the average annual cost of energy in the U.S. in 2009 (the latest data available) for homes comparable in size to our was $2,088 ($1.24/sq.ft.) and $2,164 ($1.20/sq.ft.) for homes in the Southern Region;

Analysis outcomes cont.

- The U.S. average in 2011 dollars, adjusted for inflation using the Consumer Price Index, equaled $2,197 ($1.30/sq.ft.) and the Southern Region average cost in 2011 dollars equaled $2,277 ($1.26/sq.ft.). Our total annual cost of electricity for 2011 was $1,230 ($0.62.sq.ft.) or 56% of the national and 54% of the Southern Region's average annual costs.

Noteworthy considerations

- Horizontal loops are much less expensive, but need soils up to the thermal conductivity task;
- Crawl-space encapsulation has greatly improved our crawl-space environment and air quality (closed vents and added a dedicated outlet/register to partially heat and cool space and create positive air pressure);


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