Geothermal Heating and Cooling System
First-year Cost Analysis

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Purpose:

The intent of this document is to make clear all of the costs associated with the installation of a "typical" residential Geothermal heating and cooling system and the savings observed after one calendar year.

Background:

Ahead of signing on the dotted line for our first home, my wife (Lynne) and I hired a house inspector for the routine checks and peace-of-mind. The house was nine years old at the time and the oil furnace was likely included in the original build. The inspector was careful to have our full attention when he told us that the furnace was "unpredictable" based on age and obvious neglect. Still, carrying our first mortgage left us with little money for upgrades to the home and we went through the first winter with the oil furnace and the oil hot water tank (a rental).

As first-time homeowners we had little equity in the home and the interest rate on our mortgage reflected what the banks typically offer in this situation. We made a choice to pay an extra $100 per month against the mortgage so we could get into a better rate in a shorter time.

At the end of the first year (October 2004 to September 2005) we totaled the receipts and realized that we'd spent $1,753.79 for oil to heat our home and water, and hot water tank rental fees. With attention to various low-cost energy efficient upgrades to the home (CF bulbs, water-saving faucets) and careful attention to electricity use (elimination of phantom loads, etc.) we kept our cost of electricity for the year to $688.82 for a total of $2,442.61 in utilities. All figures include all taxes and represent the out-of-pocket total expense for the year. The cost of oil for the year was far better than our previous rental property and we were pleased by this though we already had plans for a far more efficient system to look after climate and hot water in our home. After sheer luck prevented catastrophe in multiple cases of furnace failure during the winter, we felt we needed to replace the oil furnace right away and would need to borrow the money to do it.

To install a typical oil combustion system, we would have been looking at the following costs:

- High-efficiency oil furnace: $3,600
- Oil hot water tank, 60 gal: $2,350
- Indoor oil tank: $1,600
- Central Air: $3,000

All figures include taxes and installation[1]. The oil tank is included because our house insurance requires that we change the tank after ~10 years and it was due. Air conditioning would have been an upgrade to our home and it is included for reference.

The installation of all of the above components would have improved our oil consumption bills because of the increased efficiency of the new furnace and hot water tank, though the cost of the system as estimated above works out to $10,550. A nice figure for comparison, but not something Lynne and I ever considered.

Our choice was a "Geothermal" heating and cooling system for our home. This system uses the ground temperature to heat our home in the winter, cool it in the summer and looks after much of our hot water. The technology is known by other names: Geo-Exchange, Ground-source heat pump (GSHP). It represents the single most energy-efficient method of heating and cooling a home.

An important consideration for space heating/cooling is energy efficiency. The most efficient combustion furnaces on the market are quite good at 94% efficient (~94% of the energy generated in the furnace is captured to warm the space). A Geothermal system is considered 250% to 350% efficient (for the electricity used to power the heat pump, 2.5 to 3.5 times that energy is captured for space heating, extracted from the ground). Although electricity is required for the Geothermal system, it is only used to move heat, not to create heat.

Available in slightly different variations, Lynne and I chose a "closed-loop" setup. In this configuration we have arranged for 1500 feet of tubing to be buried in our backyard. The tubing carries an ethanol and water blend (an *antifreeze*) which is circulated roughly six feet below ground. A small, efficient pump inside the home circulates the liquid through the tubing. By the time the liquid re-enters the home it has equilibrated with ground temperature (roughly 4^{o}C in Kemptville). This then proceeds through the heat pump. In the winter months, the heat pump warms the house by extracting energy from the antifreeze. In doing so, the antifreeze is cooled from 4^{o}C to ~3^{o}C. A small change, but the energy obtained from this is circulated through the home via the ducts and is enough to warm our house when the temperature outside reaches -25^{o}C (beyond that, a 10kW electric heater flashes on briefly if required to maintain indoor temperature). In the summer months, the heat pump works in reverse warming the antifreeze and cool air is circulated through the ducts. In both cases, the antifreeze is sent back through the 1500 foot loop and is returned to ground temperature. The system also warms our hot water by running water from the hot water tank near the refrigerant coils inside the heat pump and returning to the hot water tank, giving the electrical heating elements a rest. A great wealth of information on these systems is available at: www.nextenergysolutions.com.

The system as selected was quoted at $21,105 installed and included increasing the size of our ducts to accommodate the extra air flow needed for these systems. An additional cost was required to hire an operator and equipment to dig a trench 5-6 feet deep, 2 feet wide and 750 feet long to accommodate 1500 feet of tubing (750 feet out from the house, 750 feet return). We had a logging trail on our property and chose to bury the loop under this trail. We were told to budget $2,000 though the final cost in the end was $1971.48 for a total installed cost of $23,076.48.

The cost of the Geothermal system was projected at $12,526.48 more than the oil system capable of looking after all of the same climate and hot water needs for our home. So why choose the Geothermal system over the oil system? There were other factors to consider beyond the initial cost of the system:

- Lifetime costs – the Geothermal system is projected to have a much longer life than any combustion furnace.

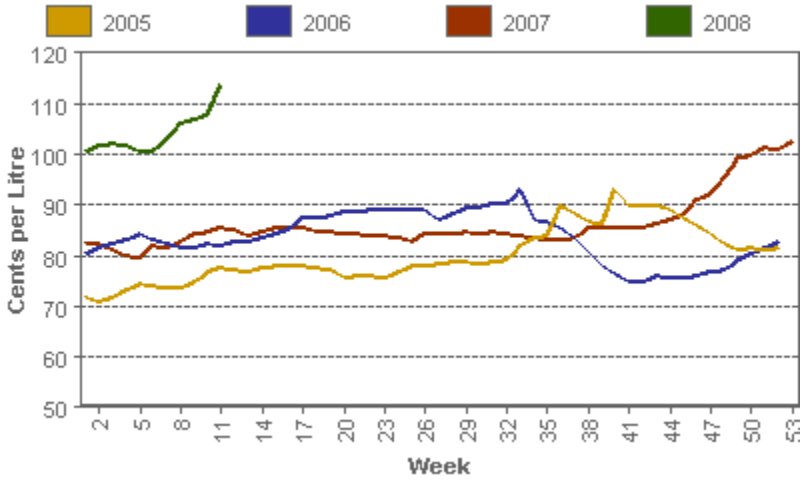
[1] Atel Air. Telephone Conversation with Jimmie Thom, October 2006.

- Energy costs – the high efficiency of the Geothermal system was projected to provide as much heat as our old furnace for the home at $600/year, air conditioning all summer for $39 (no typo) and hot water for $300/year. Quick math shows this well below the $1700+ spent in oil without the benefit of air conditioning in the summer.
- Home value – the Geothermal system, according to the bank, made a dollar-for-dollar ($23,000) increase in the value of our home resulting in…
- A better mortgage rate – due to the bank's incentives, we were offered their best mortgage rate if we installed the Geothermal system. This could potentially see our mortgage-free date arrive almost two years early, depending on how prime rate changes.
- Greenhouse gas emissions – a Geothermal system is enough for a family of 4 to meet the one-tonne-challenge, or equivalent to taking 1.5 cars off of the road.
- Renewable energy heating system – heat can be taken from the ground in the winter months and the sun will warm it again the following summer.

This report summarizes the financial aspects of switching from an oil system to a Geothermal system after just one year.

Summary of Results:

- The total cost in oil for the preceding 12 months was $1,753.79. The total *increase* in our electrical bills after the installation of the Geothermal system was $915.64. **This gives a net savings on utility payments of $792.15 for the year (46%). [March 2008 update: The cost of furnace oil has increased 57% in the last 3 years since the first cost analysis. This would mean the same amount of oil purchased in the first year would now cost $2,650.04 now. Projected utility savings are expected to exceed $1600 this year (60+%)]**



- While the installed cost for the system was $23,076.48, **we received a GST rebate of $692.29 and a grant under the Energuide for Houses program of $957.00 for a total installed cost of $21,427.19. [March 2008 update: Others seeking a retrofit to incorporate a Geothermal system to their existing home will now receive a total of $7000 in rebates from combined federal and provincial (Ontario) programs.]**
- If we were to build a new house we would definitely equip it with a Geothermal system instead of a conventional combustion system (oil, gas, etc.). **It is important to note that**

builders of new homes should not be trying to justify the purchase by the time it takes to save $25,000 in utility costs (the installed cost of these systems). Rather the difference between this system and a conventional system (in our case $21,427.19 minus $10,550 = $10,877.19) is the appropriate target. Energy savings alone, at today's rates, would see this paid back in ~6.5 years, but this ignores lifetime and maintenance costs which offer further savings with the Geothermal system. It also ignores the $7,000 in rebates currently available. Furthermore, for those building or renovating a house with intention to sell, the question to ask is whether or not the home value will be improved by more than the extra investment. The bank considers our home worth much more, but market conditions are the ultimate driver for this analysis.

- The 10kW electric heater was only observed once in the last Kemptville winter. It happened when we tried to increase the temperature indoors while it was -28°C outside. It only operated for seconds at a time and the home was up to desired temperature minutes later. The heat pump kept us comfortable throughout the winter.
- The indoor temperature selected on the Geothermal system was 21°C and was not turned down at night to avoid using the 10kW heater in the mornings (i.e. this system is more energy efficient if it is *not* turned down at night, unlike combustion furnaces which save money when used with programmable thermostats). The oil consumption from the previous year benefited from a programmable thermostat with lower temperatures at night (16°C) and while away during the day (15°C).

Conclusion:

The Geothermal system was an excellent investment. The increased value to our home is not something we focused on because we intend to keep this house for many years, though it is comforting to know we could make this investment back. The utility savings are in-line with the model predictions from Atel Air and amounted to a 46% improvement in the first year. The extra we put towards our mortgage each month is offset by these utility savings.

A Geothermal system is a worthwhile consideration for anybody upgrading their old furnace, building a new home, or renovating a home for resale purposes. All factors considered, it was the most economical choice we could have made. As for the drastic reduction in green house gas emissions – well, it's hard to put a dollar amount on feeling this good about something so important to today's children.