"GOT DATA?"
FOUR-HOUSE COMPARISON OF HVAC OPERATING COSTS

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Figure 1. Four Home Cluster in Stevenson, WA.

Scarcely a month passes without at least one caller to John Geyer & Associates, Inc. seeking "real-world" operating cost data for geothermal heating systems. Cost and complexity of utility-grade monitoring and verification ("M&V") protocols makes such data uncommon and selective. Nobody wants to spend money to document results after installation. As a result, unfounded perceptions, as held by Bonneville Power Administration and West Coast investor-owned utilities are that "Geothermal heating and cooling is not cost effective here", regardless of where "here" may be. This view persists despite 15,000 to 20,000 operating geothermal systems in Northwest service areas and perhaps half as many more in California.

Need to respond to entrenched prejudice prompts geothermal consultant and Certified Geothermal Designer John Geyer of Vancouver, Washington to track actual operating costs for geothermal systems that he designs and installs. A neighborhood in Stevenson, Washington, 30 miles east of Portland in the Columbia River Gorge, provides uncommon opportunity for head-to-head comparison with traditional technologies. With cooperation from customers and neighbors, multi-year operating cost data were compiled for two geothermal, one propane and one air-source heat pump homes on the same street. All residences were reasonably similar in terms of similar age, size, construction quality and occupancy.

The key to cost-effective, practical analysis of geothermal heating and cooling costs is dissection of gross utility bills to isolate HVAC energy costs. Utility payment histories were reviewed for each home. This spanned four and seven years for geothermal homes, five years for the propane home with electric air conditioning, and six years for the air-source heat pump home. Annual HVAC cost for each home is expressed as the average of all years.

Both of the geothermal heat pumps studied provide space heating and cooling and domestic water heating without auxiliary back-up. The propane home uses propane for space and water heating and electricity for air conditioning. The air-source heat pump heats and cools while domestic water is warmed by an electric water heater. Both propane and electric costs were evaluated in the propane home.

To isolate HVAC costs from other electric usage, the two lowest energy payments in each year were identified and averaged. These periods were commonly May-June and mid-September to late-October when ambient temperatures are close to desired indoor conditions; thus, little or no heating or cooling is required. These two minimum payments are averaged and accepted as the structure's "non-HVAC energy use". This dollar amount is subtracted from each bi-monthly utility payment to approximate that billing period's heating and cooling expense.

Geothermal systems heat domestic water but service for occupancy by one or two people was deemed minor compared to energy used for space conditioning. As such, water heating expense was not isolated or excluded during heating cost analysis. It is estimated that subtracting water heating values would reduce geothermal's electric energy use by 10 percent, more or less, but this proxy method of data collection does not lend itself to such precision. A trade-off of classic M&V accuracy for insight to relative HVAC values was deemed acceptable in the absence of answers sought by so many. Magnitude of cost variances in study findings affirms this practice.

Occupancy history of the 2,950 square foot propane home enhanced data analysis and further encouraged combination of space and water heating costs. During two of five years' data, the house was vacant in all months except July as owners worked and lived out-of-country for the balance of year. During vacant periods, no propane was used for water heating and minimal electricity was required. By the same HVAC cost analysis as used in occupied homes, resulting HVAC-only costs during two years of vacancy were ~25% lower than HVAC during occupancy. One-third of the occupancy-related increase (~8%) was assigned to gas-fired water heating and found comparable to water heating's energy allowance in geothermal homes.

Figure 2 . Propane Home

Both geothermal homes were new construction intended for retirement. The first builder drilled a dry water well to 350 feet and asked: "I'm $30,000 into this hole; what can we do with it?" Geyer proposed installing a single 1.25" High Density Polyethylene loop, 710 feet in length, into the cased well bore to support a four-ton Command Air heat pump with de-superheater for domestic water heating. Building size was 3,340 square feet with a daylight basement.

Figure 3 . First Geothermal Home.

The second home had 5,100 under roof with 3,586 square feet of conditioned space. A two-car garage and carpentry shop were not heated. First floor walls were of Insulating Concrete Form blocks and construction quality was "superior". 5,800 feet of 0.75" HDPE piping formed a "slinky 'mat' loop" for a 6-ton Hydron Module heat pump and de-superheater. This loop has two layers of "Slinky-style" pipe coils at -5 feet and -9 feet below grade in a 30 X 70 foot pit. Uncertainty regarding late-summer soil moisture content was offset by over-sizing the ground heat exchanger 20% relative to the heat pump.

Figure 4. Second Geothermal Home.

Figure 5. ASHP home.

Table 1. Average Annual HVAC and Hot Water Expenses for the four homes

	Heating System	Size of Home (sq. ft.)	History	Type of Heating	Cost for Heating	Propane + Electric A/C
Home 1	Propane	2,950	2007-2009 (occupied)	HVAC + DHW	$3,316	$3,933
			2010-2011 (vacant)	HVAC + DHW	$2,449	
Home 2	Air Source HP	2,200	2006-2011	HVAC + DHW	$1,126	
	Adjusted Size	3,000	2006-2011	HVAC + DHW	$1,535	
Home 3	Geothermal #1	3,340	2005-2011	HVAC + DHW	$426	
Home 4	Geothermal #2	3,586	2008-2011	HVAC + DHW	$463	

Shaded boxes are best estimates of "like" comparisons.

Due to panoramic views overlooking the forebay of Bonneville Dam, each home has expansive glazing on the south side. Ventilation features of each include range hoods, indoor spa tubs, fireplace flues, vaulted ceilings, whole house fans and vacuum systems. Of all installed HVAC equipment, only the high-heat burner capacity of the propane house was oversized (+~40%).

Local climate conditions create 5,400 heating degree days with only modest cooling during summer afternoons. Relative humidity is not an issue so all four residential HVAC systems are sized for heating needs. The Columbia River Gorge is a mile-wide, 4,000 deep, water-grade passage through the Cascade Mountain Range known for windy summers and bitterly cold winter storms. Gorge winds routinely seek to equalize pressure and temperatures between dry, continental air east of the mountains and wet, marine conditions on the West Side. Hot and dry or freezing Gorge winds cause seasonal weather extremes in the Portland, Oregon area.

While each home owner provided full or nearly complete records of utility payments, data gaps were filled by payment histories from Skamania Public Utility District No. 1 in Carson, WA. This utility's energy rate is $0.062 per kWh and the bi-monthly service charge is $16.90 with no significant surcharges. Average propane cost over five years (2007-2011) was $2.67 per gallon.

Kilowatt and cost data were complete for each of the four homes studied, with exception of three missing entries that were filled with averages of same-month payments in other years. The review used first-order knowledge of geothermal design and construction and full payment records from original owners/occupants of all homes. While actual costs were computed for the smaller air-source heat pump home, costs were inflated to represent a 3,000 square foot structure for comparative purposes.

These results correlate well with estimates of energy yield and costs for various fuels as prepared by national and regional HVAC authorities and electric utilities. Calculated HVAC percentage of total load in each home is just above 40%.

Previous geothermal installations in the central Columbia River Gorge include the North Bonneville City Library (1997), North Bonneville Hot Springs resort (2000), and 30 to 50 private homes. Continuing research will document costs as they become available but this study confirms that geothermal is, in fact, extremely cost competitive in this long-term, same-street comparison. Monthly heating, cooling and hot water costs below $40 per month for homes greater than 3,000 square feet are "cost effective" in any setting. Anecdotal accounts from Northwest residences on both sides of the Cascade Range are commonly $350 to $450 a year for 2 to 4 bedroom homes of standard construction and 2,000 square feet.