

**Measured Performance Data for
113 Woodland Ave.**



Figure 1. Photo of House

Battery powered data loggers to measure the parameters listed in Table 1 at hourly intervals. This report summarizes the data collected from May 5, 2010 to June 16, 2011. The homeowners installed a 2½ ton air conditioner at the beginning of June 2011. During the previous summer window air conditioners were used. The HERS index for this house is 56.

Table 1. Monitored Points Measured at Woodland

1	Hot Water Heater Runtime (hrs)	Veris Current Switch
2	Furnace Stage 1 Runtime (hrs)	Veris Current Switch
3	Furnace Stage 2 Runtime (hrs)	Veris Current Switch
4	Total House Power (kWh) L1	Wattnode Power Mtr
5	Total House Power (kWh) L2	Wattnode Power Mtr
6	Furnace Electric Power (kWh)	Wattnode Power Mtr

The variations in daily power use for the house are shown in Figure 2. There are considerable daily fluctuations. The house used about 7,472 kWh for the year. Some AC use is apparent in the summer.

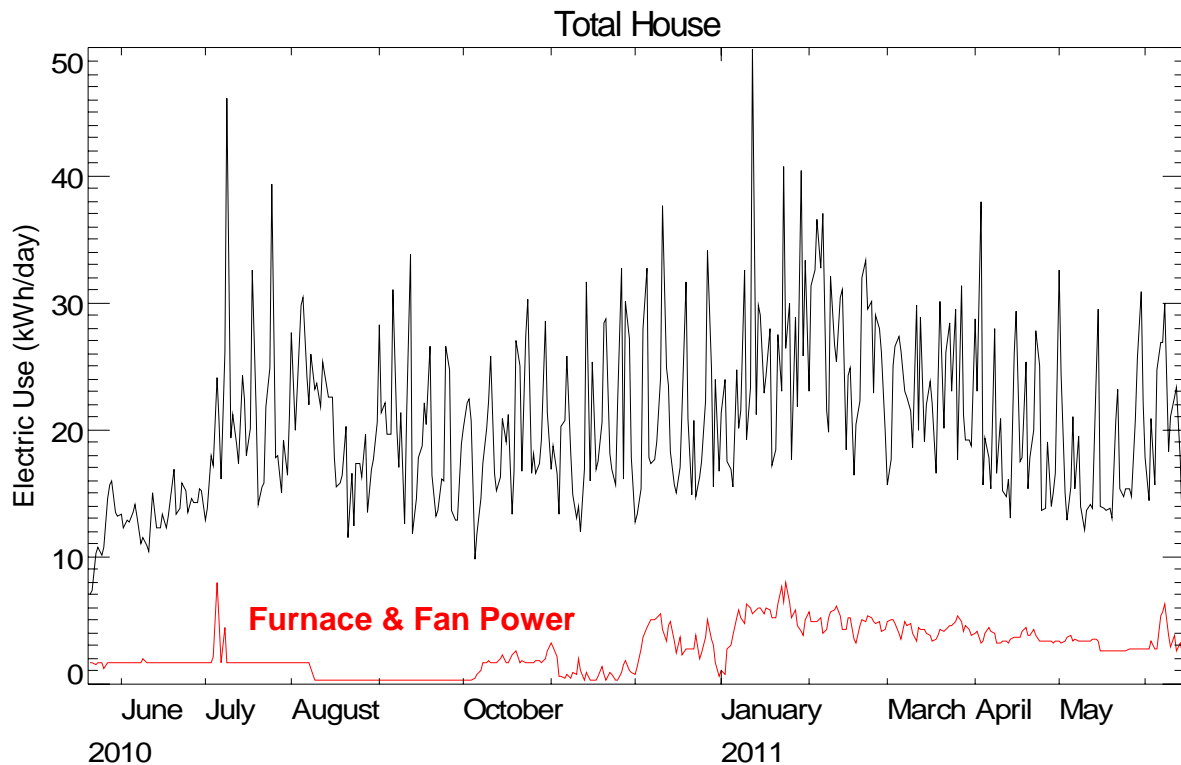


Figure 2. Total House Electric Energy Use

Table 2. Measured Electric Use Compared to NGRID Bills

Date	NGRID Electric Use (kWh)	Measured Electric Use (kWh)	Furnace Use (kWh)
30-Jun-10	392	391.6	47.7
30-Jul-10	625	628.2	62.7
31-Aug-10	646	647.4	22.4
29-Sep-10	571	570.2	8.7
29-Oct-10	576	574.6	43.7
30-Nov-10	652	654.0	34.2
29-Dec-10	612	607.4	101.1
30-Jan-11	793	792.6	156.1
28-Feb-11	787	792.8	139.7
30-Mar-11	697	698.6	130.7
29-Apr-11	604	600.8	110.2
29-May-11	517	521.1	91.8
Annual	7472	7479	949

The Furnace fan was set to run constantly (in the “ON” position on the thermostat) for most of the period to provide ventilation in the house. The fan originally ran at low speed and used about 60 Watts. At first stage heating the fan power increases to about 315 Watts (based on a hand-held measurement in 2010). Figure 4 shows that the off-cycle fan power increased to about 100 Watts starting in December 2010 and stayed high for the rest of the period. Figure 3 and Figure 4 show the furnace & fan power over the 12-month period. The fan was switched to the “AUTO” mode in early August until early October and then again for most of November. Otherwise if operated in the ON position.

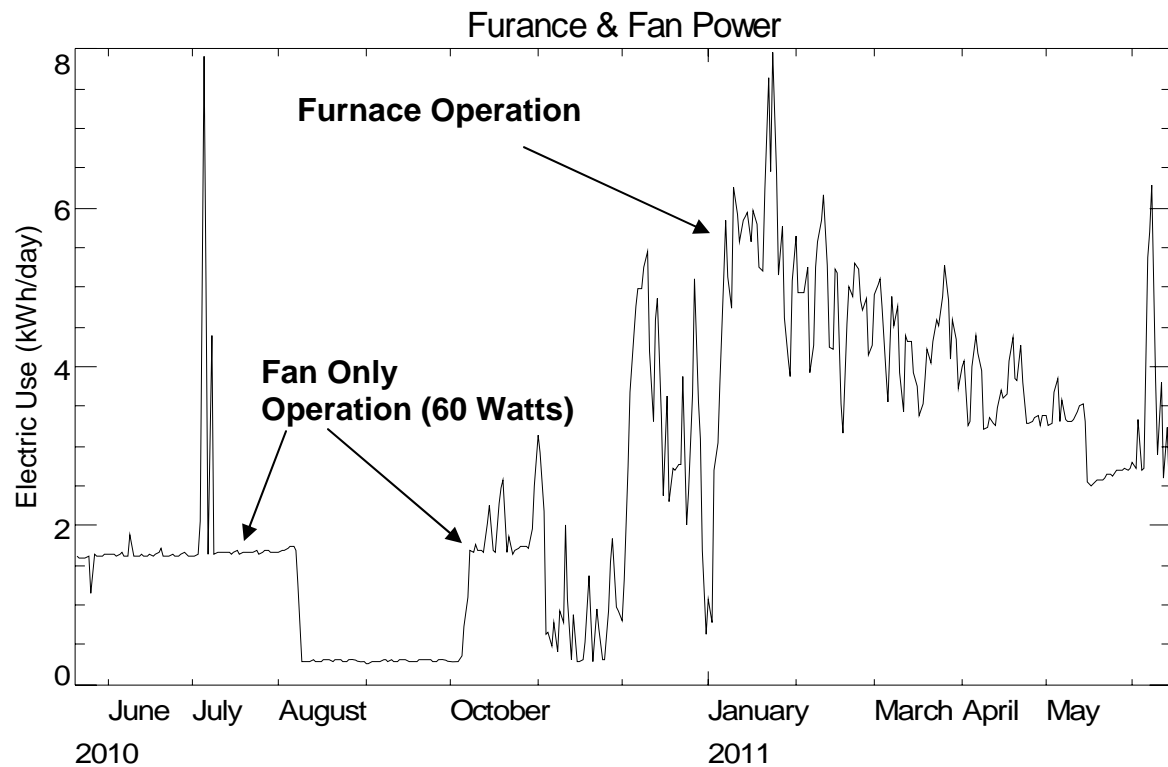


Figure 3. Furnace and Fan Power –kWh per day

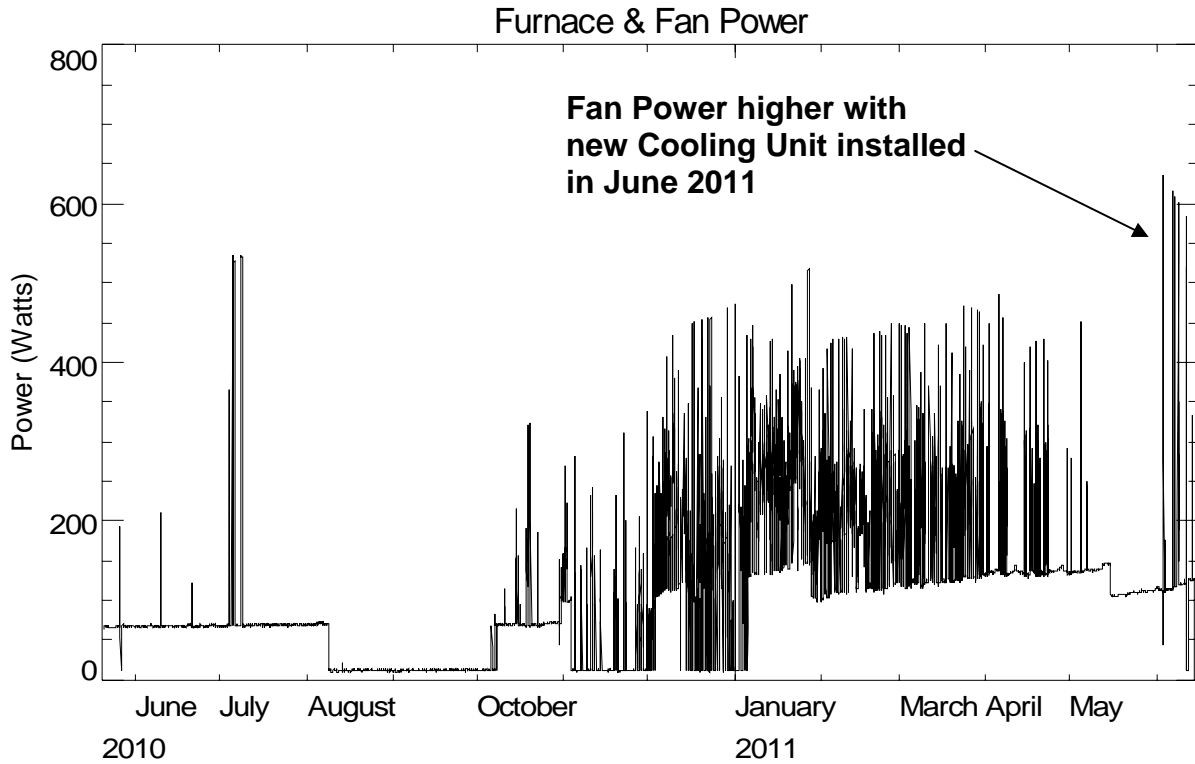


Figure 4. Furnace and Fan Power - Watts

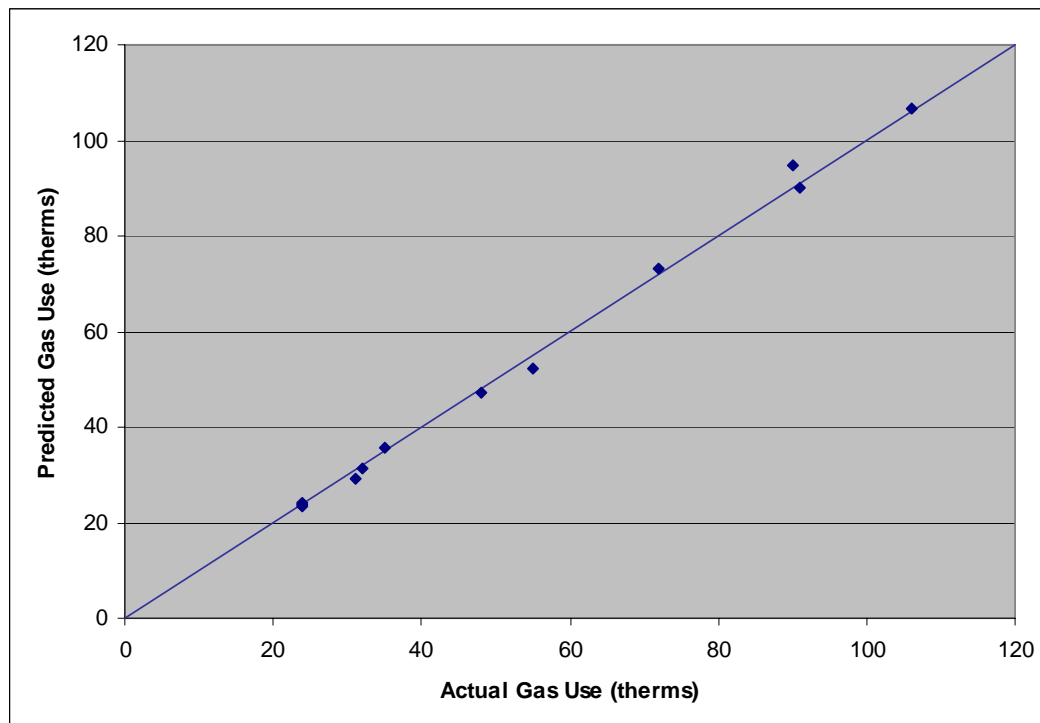
We used the runtime data for the furnace and DHW tank with the rated capacity of each unit to predict the gas use data shown in Table 3. Using these nominal numbers, we are able to predict the actual monthly gas use to within 5% for each month (ignoring usage for the stove; the house is believed to have an electric dryer), as shown by Figure 5. The total gas use for the house was 632 therms per year. The gas use associate with domestic water heating (DHW) was only about 408 therms per year or 1.1 therms per day. This consumption corresponds to hot water use of 90-100 gallons per day. The house had 4 adults and one child for most of this 12-month period.

Table 3. Comparing NGRID Gas Use to Gas Use Estimated from Runtime Data

Date	NGRID Gas Use (therms)	Predicted DHW Gas Use (therms)	Predicted TOTAL Gas Use (therms)	DHW Runtime (hrs)	Stage 1 Runtime (hrs)	Stage 2 Runtime (hrs)
30-Jun-10	24	22.9	23.3	57.4	1.1	0.0
30-Jul-10	24	23.9	23.9	59.7	0.0	0.0
31-Aug-10	24	24.0	24.0	60.0	0.0	0.0
29-Sep-10	31	29.3	29.3	73.2	0.0	0.0
28-Oct-10	32	27.4	31.5	68.4	13.9	0.0
30-Nov-10	55	42.5	52.3	106.3	32.7	0.1
29-Dec-10	91	42.0	90.1	105.1	160.4	0.3
30-Jan-11	106	49.0	106.5	122.6	191.5	0.4
28-Feb-11	90	38.6	94.6	96.6	186.5	0.3
30-Mar-11	72	36.9	73.1	92.3	120.7	0.1
29-Apr-11	48	36.7	47.1	91.7	34.8	0.0
29-May-11	35	34.3	35.6	85.8	4.2	0.0
Annual	632	408	631	1019	746	1.3

Assumptions: Water Heater is 40 Mbtu/h
 Stage 1 Heat is 30 Mbtu/h, 2nd Stage is 30 Mbtu/h

Gas use by the furnace was only 223 therms for the heating season. The furnace ran at low stage for 746 hours with virtually no operation at high stage (the 1.4 hours at high speed corresponds to a combustion air purge at startup, which is discussed in more detail below).

**Figure 5. Comparing Actual Gas Use to Gas Use Predicted with Equipment Runtimes**

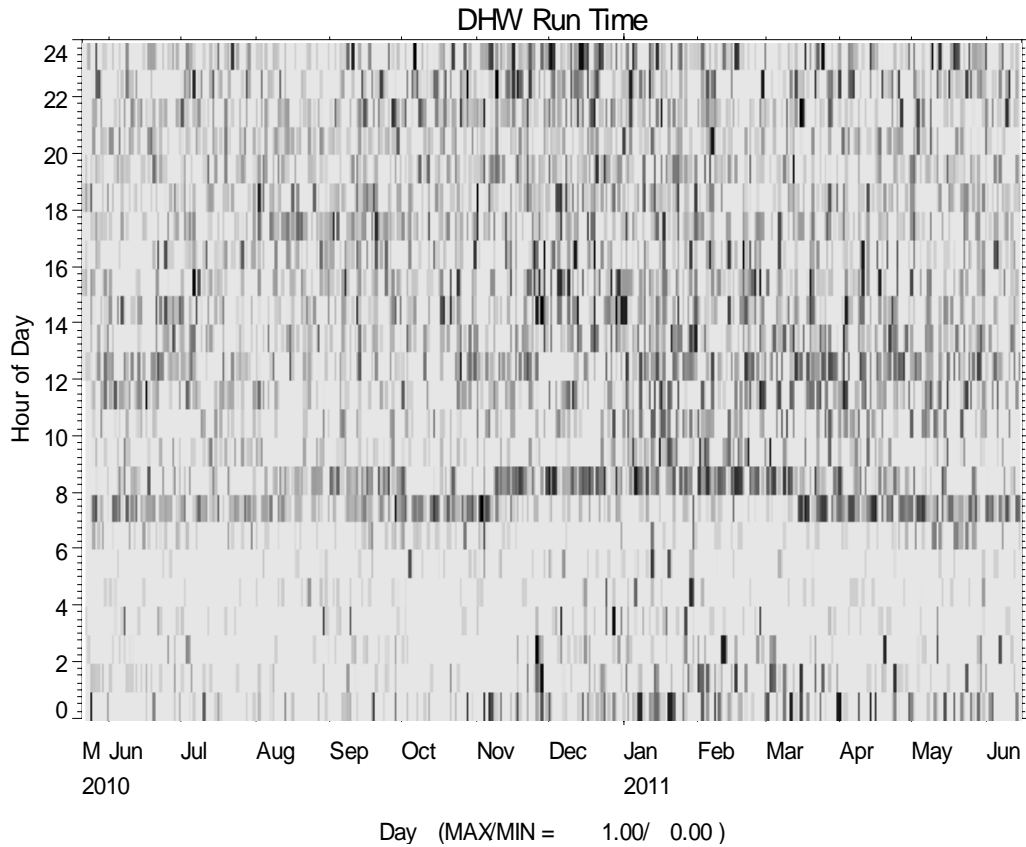


Figure 6. Shade Plot of DHW Burner Fan Runtime

Figure 7 shows how daily gas use by the DHW tank increases as the incoming water temperature gets colder in the winter.

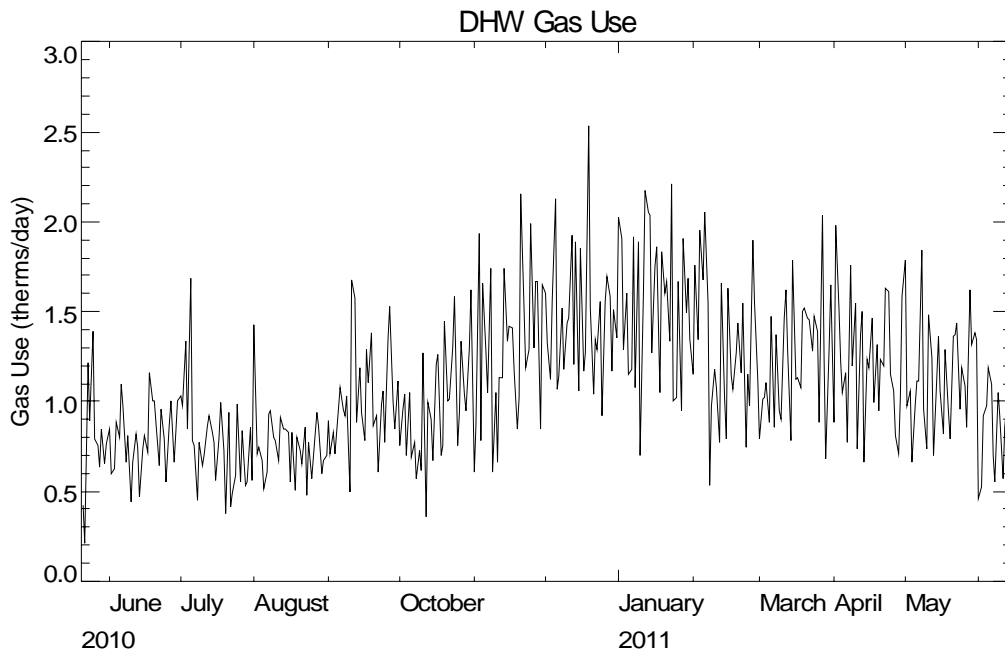


Figure 7. Estimated Daily Gas Use for DHW

The furnace has two stages. So far only stage 1 has ever been required (though the stage 2 burner exhaust fan apparently operates for about 2 seconds at the beginning of each operating cycle; presumably to “purge” the furnace HX of combustion products).

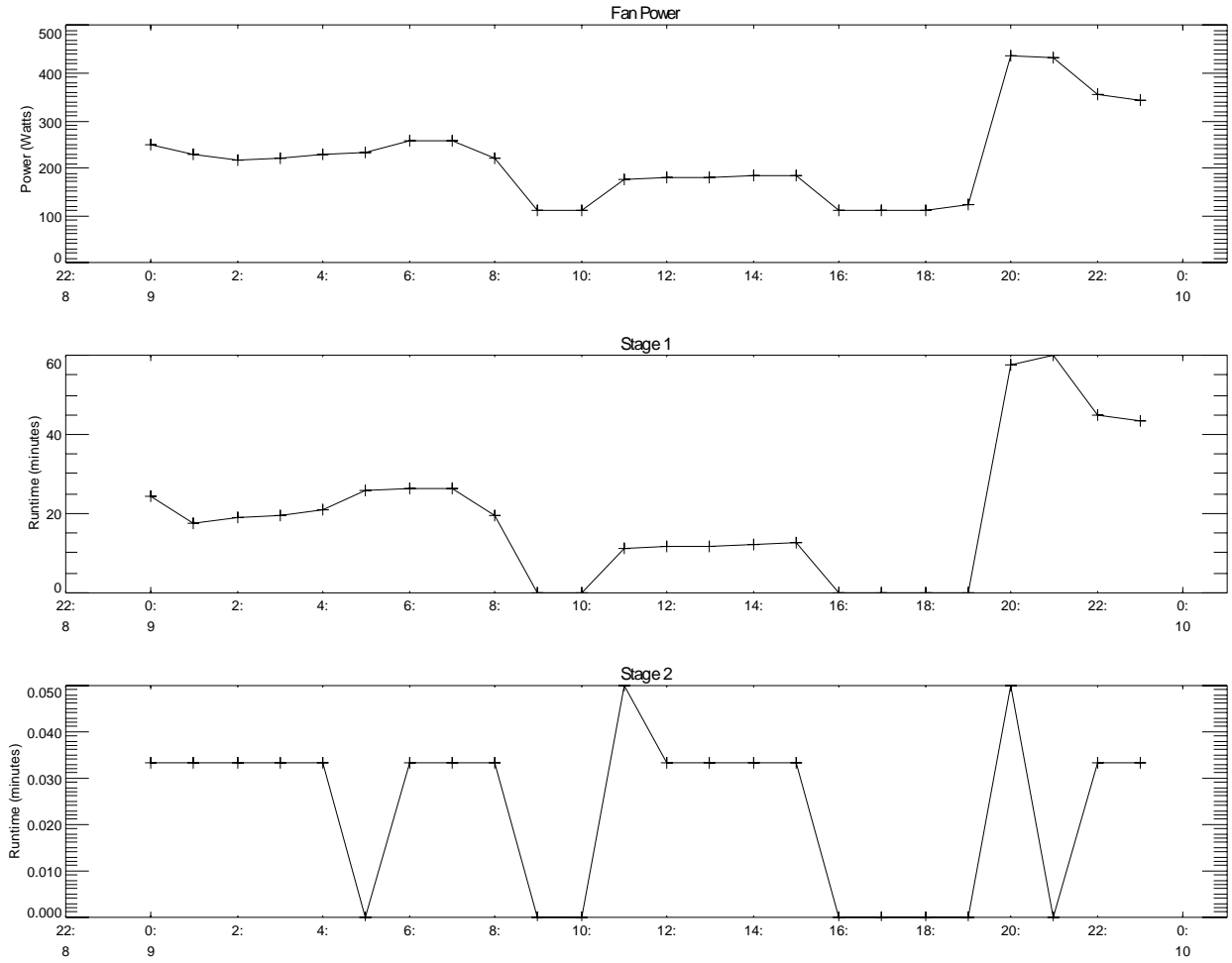


Figure 8. Furnace Power and Boiler Staging for December 9, 2010

The space heating load in Figure 9 shows a fair amount of scatter, which implies that the homeowners frequently change the set point. We measured 69.2°F during our visit on January 5, 2011.

The load line in Figure 9 shows that:

- the implied balance point for the house (i.e. the outdoor temperature where heating is first required) is about 53°F.
- The peak gas use estimated for -20°F is about 0.20 therms/h (20 MBtu/h),
- The slope of the line implies the building UA is 255 Btu/h-°F (assuming the furnace is 95% efficient). This value close to the calculated UA for the building of 229 Btu/h-°F (including the basement walls, ignoring the basement floor). The annual space heating gas use is 0.12 therms per square foot per year.

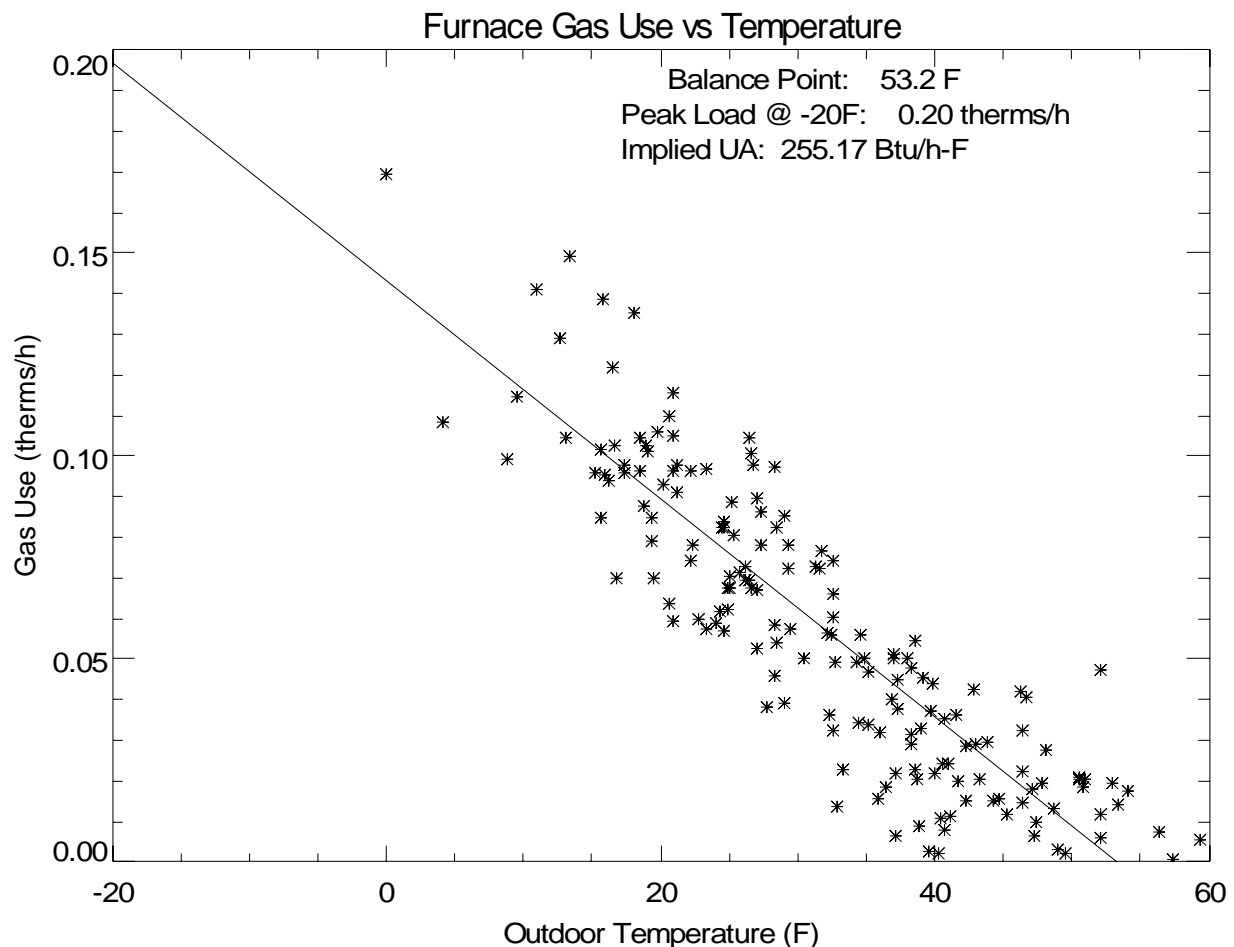


Figure 9. Load Line for Space Heating – Estimated from Furnace Runtimes

Table 4 compares the measured energy use to the energy use predicted by the REMRate model of the home (attached). The REMRate mode assumes a standard amount of water use and electric use in the house. The actual house has much larger electric use and hot water use so the space heating loads are smaller. The additional 3,000 kWh per year provides more internal gains. If we assume ½ of this electricity use occurs during the heating season, then the 1,500 kWh of electric use is equivalent to the space heating provided by 50-60 therms gas with a 90% efficient furnace.

Table 4. Comparing Measure Energy Use of the REMRate Model

	Gas Use (therms)		Electric Use (kWh)	
	REMRate	Measured	REMRate	Measured
Furnace	480	224		
DHW	212	408		
Furnace Fan			287	949
Lights			4,191	6,523
Total	692	632	4,478	7,472

Appendix – Monitoring & Instrumentation Details

Table 5 Logger D21 5A Power Calculation at 1 Hour Intervals

	Logger Connection	Wattnode Type	CT	Logger Multiplier
P1	L1 – Green	Wattnode Power Mtr 3Y-208	100 Amp	0.8333
	Common			
P2	L2 – Black	Wattnode Power Mtr 3Y-208	100 Amp	0.8333
	Common			
P3	Fan/Furnace – Red	Wattnode Power Mtr 3Y-208	50 Amp	0.4167
	Common			
P4	None			

Count = C, Count/Pulse

Next Logger – D38 03

Manual Power Readings

L1 @ 10:22 AM 5/20/2010 = 500 watts

L2 @ 10:22 AM 5/20/2010 = 230 watts

Table 6 Logger D21 4A Runtime Calculation at 1 Hour Intervals

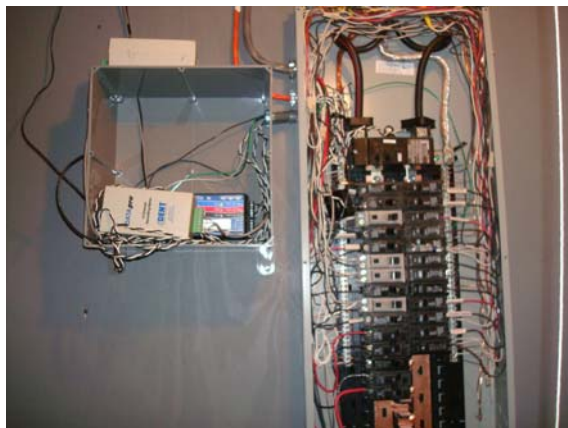
	Logger Connection	Gas Valve Stage	Gas Valve Wire	Power Reading
P1	Black	Low Stage	Yellow	60 Watts
	Red			
P2	Green	High Stage (with Low Stage On)	Blue	315 Watts
	White			
P3	Hot Water heater			
P4	None			

Run = N, Count/Pulse

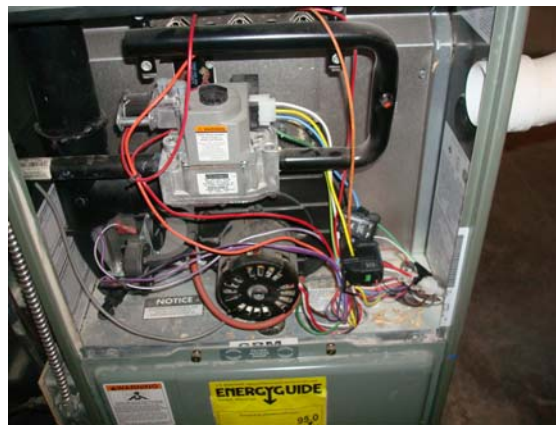
Next Logger – D27 38

Gas Valve 1 + 2

Hot Water Heater



Panel With Metering Equipment Installed



Furnace with Current Switches Attached