Cold Climate Housing Research Center

CCHRC

Ground Source Heat Pumps

in Cold Climates: Year Two

While ground source heat pumps are gaining popularity in cold climates, there are still questions about how they perform in cold soils. For example, how much heat do they remove from the ground and how does this affect their performance over the long term? To help answer these questions, the Cold Climate Housing Research Center installed a ground source heat pump at its facility in Fairbanks, Alaska in November 2013. CCHRC will monitor the heat pump for a 10-year period.

The CCHRC demonstration ground source heat pump has been running for two years. The heat pump replaced an oil fired boiler and is heating office space in the CCHRC building.

The efficiency of a heat pump is measured as the Coefficient of Performance, or COP–which is the ratio of how much heat is produced for each unit of electricity added. For example, a COP of 3 means the heat pump produces 3 units of heat for every 1 unit of electricity it consumes. As the temperature in the ground drops, the COP of the heat pump is expected to drop as well.

The COP of the heat pump dropped from 3.6 the first winter to 3.3 the second winter. There was a corresponding drop in the ground temperature. The center of the ground loop decreased from 34.5°F (1.4°C) in Oct. 2013 to 32.4°F (0.22°C) in Oct. 2015 at the level of the heat extraction coils (based on monthly average measurements).

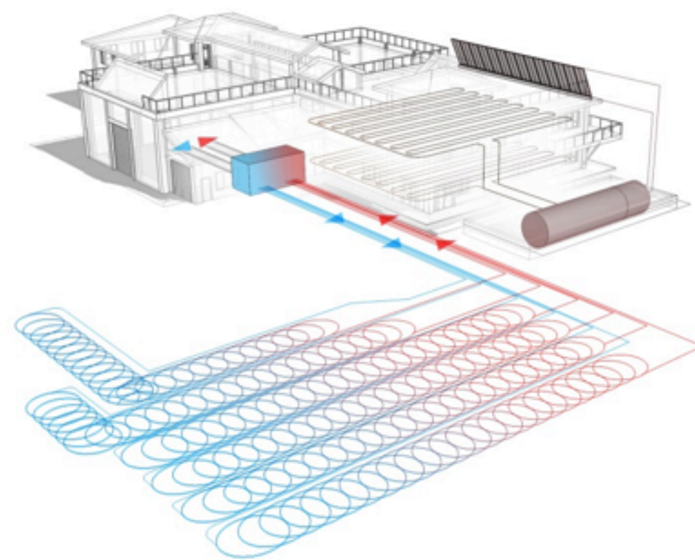


Figure 1.Graphic representation of ground loop location at CCHRC.

	million BTUs (mmBTU)	kilowatt-hours (kWh)
Heat produced	86.7	25,417
Electricity used	26.5	7,767

In its second year the heat pump supplied 86.7 mmbtu (25,417 kWh) of heat and used 7,767 kWh (26.5 mmbtu) of electricity. This is equivalent to a COP of 3.3 averaged over the course of the year.

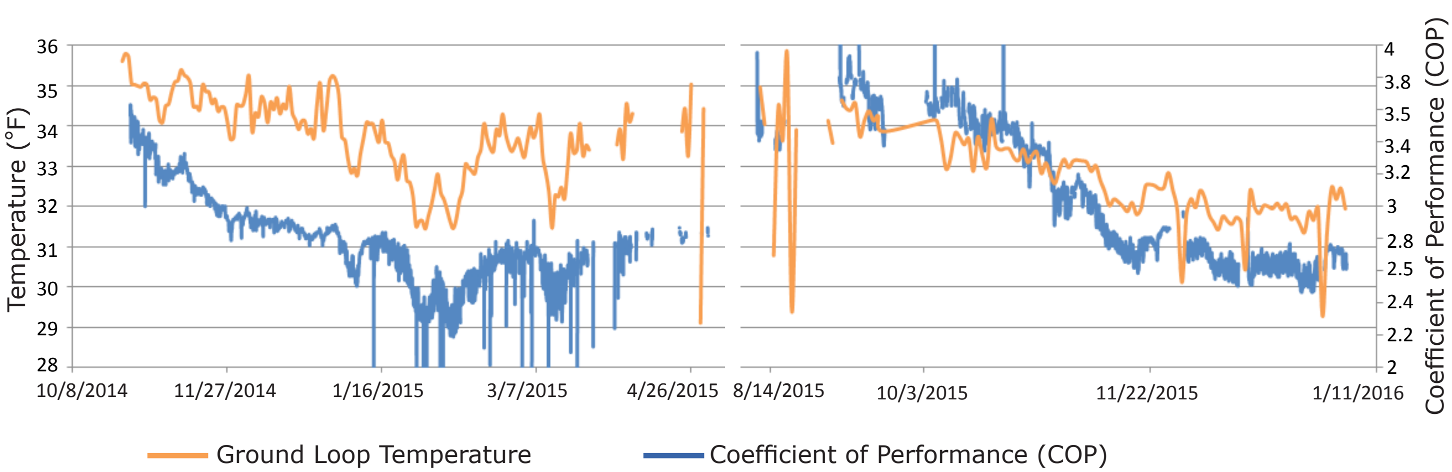
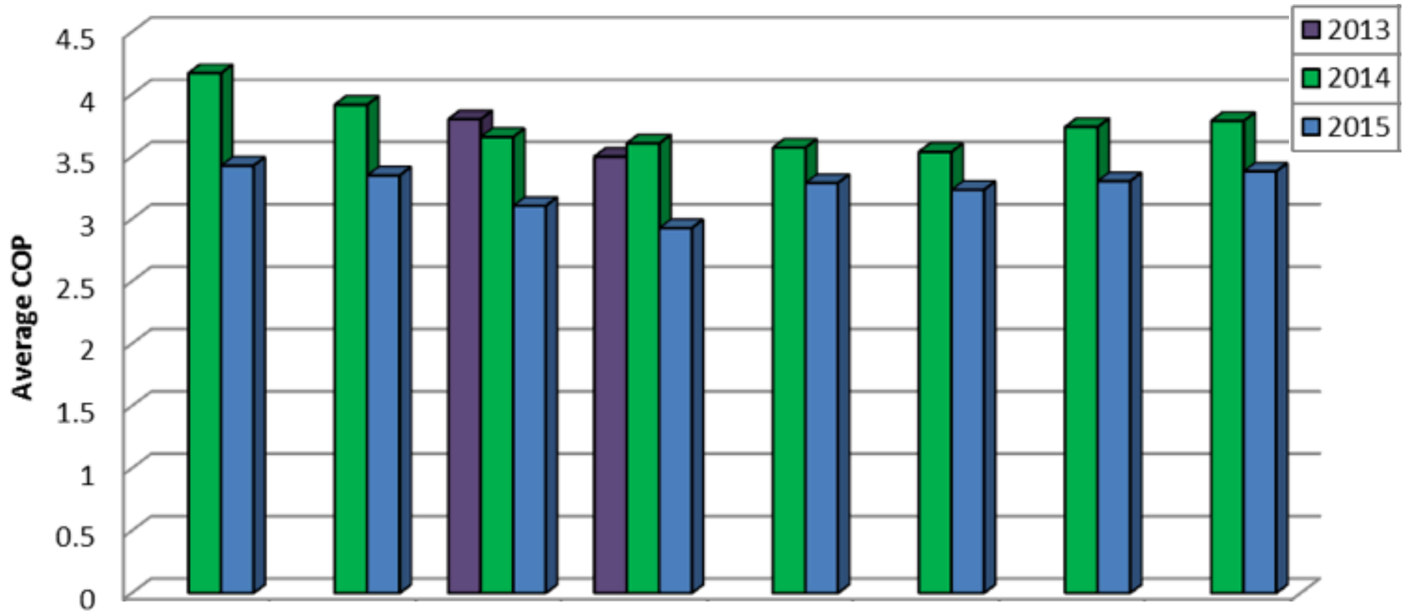


Figure 2. The COP varies throughout the year and is dependent on the temperature of the fluid coming from the ground loop and the temperature of the delivery water to the heating system. Figure 2 shows how the COP tracks with the dropping ground temperature.



	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Winter 1			3.8	3.5	3.6	3.5	3.7	3.8
Winter 2	4.2	3.9	3.7	3.6	3.3	3.2	3.3	3.4
Winter 3	3.4	3.3	3.1	2.9				

Figure 3. Average monthly COP for two winters. The average monthly COP dropped during the second winter.

The effects of heat extraction at that depth are clearly visible in Figure 4, which shows the temperature in the soil vs. the depth of the area under the center portion of the ground loop. The temperature of the ground near the ground loop coils is colder than other areas of the ground profile. The temperature hovered around freezing but did rise above freezing in October 2015.

The incoming fluid temperatures from the ground loop started at 33.9°F (1°C) in November 2013 and dropped to approximately 31.5°F (0.3°C) in November 2015. The monthly average temperature for November has dropped by 1°F degree every year the heat pump has been running. The system is expected to reach a new equilibrium with the ground at some point, and the ground temperatures will stop dropping every year.

The heat pump will continue to supply heat to the building for the foreseeable future and the system will be monitored for at least 10 years to see if there is appreciable change in the ground temperature and thus in the efficiency of the heat pump.

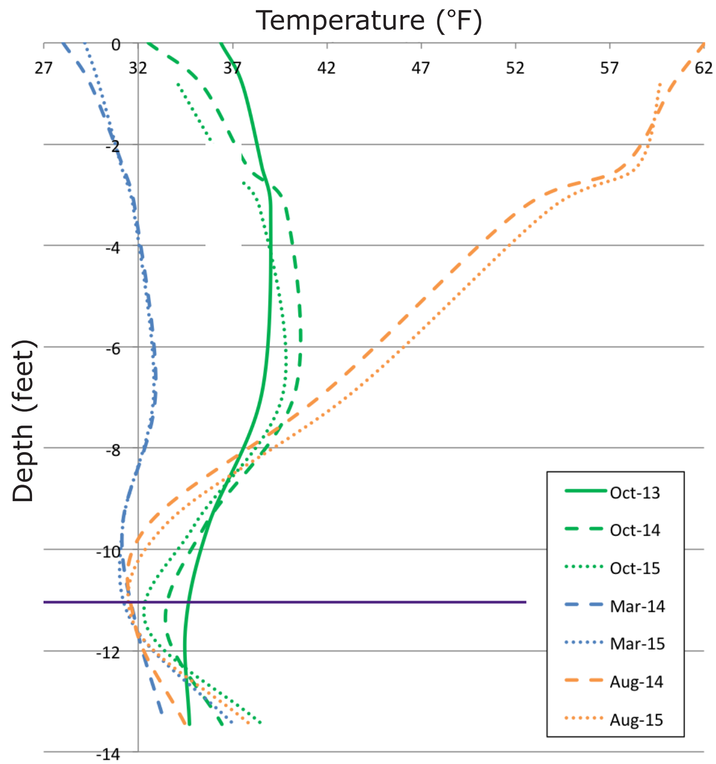


Figure 4. Ground temperatures under the center of the ground loop. The temperature at the level (around the purple line) of the heat extraction coils barely rose above freezing in October 2015.