Effects of Imbalanced Loads on Long-Term Entering Water Temperatures in Closed Loop Ground-Source Heat Exchange Systems

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Background/Objectives. Increasingly, ground-source heat exchange (GSHE) systems are being used to reduce or eliminate fossil fuels in building heating, ventilation and air conditioning (HVAC) systems. Commercial buildings often have reasonably balanced heating and cooling loads; however, cooling-dominated loads are common, even in colder northern climates, due to heat gains from people, lights, computer systems, and appliances. Imbalanced loads can lead to long-term changes in entering water temperatures (EWTs) to GSHE heat pumps, posing the risk of freezing in heating-dominated systems, or unacceptable efficiency declines in cooling-dominated systems.

Approach/Activities. GSHE bore-field modeling software was used to parametrically model the effects of imbalances in annual heating and cooling loads on long-term trends (i.e., 25 years) in GSHE EWTs for a range of ground thermal properties derived from the authors' experience thermal testing systems in the eastern US, and three common GSHE loop designs – u-bend, double u-bend and concentric.

Results/Lessons Learned. For a given bore-field configuration (depth and spacing), nomographs of EWTs over time were produced for a range of thermal conductivity values that the authors have compiled from thermal testing of sites in the northeastern United States. Long-term EWT trends vary according to GSHE borehole configuration, spacing, and depth, and thermal conductivity. In many cases, cooling:heating imbalances ranging from 1.1 to 1.3 lead to unacceptable changes in EWTs (i.e., outside of the typical targeted design range) over the 25-year modeling period. Results of this parametric exercise illustrate the importance of balanced heating and cooling loads on long-term GSHE performance, particularly in geologic settings that are at the low end of the range of thermal conductivity values encountered in this region.