Geophysical Research Abstracts
Vol. 21, EGU2019-1850-2, 2019
EGU General Assembly 2019

Feasibility study of integrated sewage pipe with ground heat exchanger for efficiency estimation

Connor Dacquay (0), Hartmut Holländer (0), Miroslava Kavgic (0), and Graham Fuga (1)
(0) University of Manitoba, (1) Lafarge Canada Inc.

Natural gas and electricity together accounted for 82.5% of all residential energy use in Canada in 2013 with nearly half of the average household consumption from natural gas used for heating. Energy demand is projected to grow exponentially due to population increase. In May 2015, Canada submitted its Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change which included an economy-wide target to reduce greenhouse gas emissions by 30% below 2005 levels by 2030. As of 2016, Canada is projected to significantly miss its 2020 and 2030 climate target with the set of measures it currently has in place. The projected target for 2020 is 622 mega tons of carbon dioxide equivalent (Mt CO_2 eq.) and the projected outcome is 768 Mt CO_2 eq. The projected target for 2030 is 524 Mt CO_2 eq. and the projected outcome is 815 Mt CO_2 eq. This leads to the demand of innovative solutions to reduce fossil fuel usage and to switch to renewable energy. A recent heat extraction system has been developed that combines a typical horizontal ground heat exchanger with a sewage pipe. The heat extraction system is a hollow concrete cylinder with a helical high-density polyethylene pipe embedded within the pipe walls. The high-density polyethylene pipe has an outlet and inlet on each length of pipe which are attached to a heat pump which circulate a heat exchange fluid. As the heat exchange fluid cycles through the system, it extracts heat from the surrounding soil and sewage within the pipe while simultaneously carrying the sewage to a waste treatment plant. A heat pump uses the obtained energy to heat a building in cold weather and cool a building in hot weather. This system has not been studied under transient conditions in an extreme climate. In this study, a numerical model is developed using the finite element solver COMSOL Multiphysics to investigate heat transfer coupled with fluid flow by solving partial differential equations where temperature is the dependent variable. A soil block is initially modelled to simulate a control scenario of ground temperature in order to extract data at specific locations for specific times. Following are multiple simulations which implemented the heat extraction system with various energy demands into the soil block to compare ground temperatures at specific locations. A five year period of sustainability is demonstrated through comparison of temperature differentials of adjacent soil locations to the benchmarks established. The maximum temperature change over the five year period interpreted is 1.8 degrees centigrade at 0.1 meters adjacent to the heat extraction system for 75% energy demand of a bed and breakfast located south of Winnipeg. The system is shown to handle an energy demand of up to 6 typical residential houses in Winnipeg when the sewage temperature is kept constant.