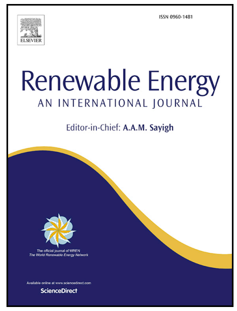
Accepted Manuscript



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PII: S0960-1481(18)30109-5

DOI: 10.1016/j.renene.2018.01.099

Reference: RENE 9704

To appear in: *Renewable Energy*

Received Date: 9 October 2017

Revised Date: 16 January 2018

Accepted Date: 25 January 2018

Please cite this article as: Naicker SS, Rees SJ, Performance analysis of a large geothermal heating and cooling system, *Renewable Energy* (2018), doi: 10.1016/j.renene.2018.01.099.

Performance analysis of a large geothermal heating and cooling system

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Abstract

Ground Source Heat Pump systems can play an important role in reducing carbon emissions associated with building heating and cooling. The efficiencies and carbon emission savings achieved, partly depend on the optimization of the design, the control of the system and its reliability during extended operation. This paper reports the detailed investigation of the performance of a large system that includes fifty-six vertical borehole heat exchangers and four large heat pumps that provide both heating and cooling. High frequency data have been collected during the initial three years of operation that allow seasonal performance factors to be derived and detailed analysis of system operation. Annual performance has been found to be satisfactory overall but is highly variable depending on operating conditions and control system actions. A series of analyses have been carried out to investigate the roles of circulating pump energy, control system operation and dynamic behavior. A series of recommendations concerned with better design for part-load operation, reduction in pump energy demands and more robust control systems, are made with a view to improved system design and operation. Data from the study are being made available for further work on performance analysis and model validation studies.

Keywords: Geothermal, Ground Source Heat Pump, System Performance Factor, Borehole Heat Exchanger, Performance Analysis

Geothermal heating and cooling systems or ground source heat pump (GSHP) systems are seen as a low-carbon technology that can play a role in mitigating energy demands and carbon emissions from both residential and non-residential buildings. For example, in the UK, residential heat pumps and large-scale ground source heat pumps in heat networks have been proposed in the future of heating strategic framework [1, 2]. A recent worldwide survey [3] suggested there were more than 4.5 million systems in operation—mostly in residential systems but also a number of high capacity non-residential systems in Europe [4], China and North America [5].

For many countries, the effectiveness with which carbon emissions can be reduced relative to conventional heating and cooling technologies, is firstly dependent on the carbon emission factor of grid electricity and, secondly, on the efficiencies of alternative technologies in realistic operating conditions [6]. This is particularly the case for countries with relatively high usage of fossil fuels in the primary energy mix. Consequently, evidence-

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