Chapter 14
Cooling and Heating with Ground Source Energy

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ABSTRACT

In the recent attempts to stimulate alternative energy sources for heating and cooling of buildings, emphasis has been put on utilisation of the ambient energy from ground source and other renewable energy sources. Exploitation of renewable energy sources and particularly ground heat in buildings can significantly contribute towards reducing dependency on fossil fuels. This paper highlights the potential energy saving that could be achieved through use of ground energy source. It also focuses on the optimisation and improvement of the operation conditions of the heat cycles and performances of the DX GSHP. It is concluded that the direct expansion of GSHP are extendable to more comprehensive applications combined with the ground heat exchanger in foundation piles and the seasonal thermal energy storage from solar thermal collectors. This article discusses the principle of the ground source energy, varieties of GSHPs, and various developments.

INTRODUCTION

Renewable energy sources have one thing in common; they all existed before man appeared on this planet. Wind, wave, hydro, solar, geothermal and tidal power are all forces of nature and are mostly intermittent energy sources, geothermal is the only consistent phenomenon. Geothermal renewable energy sources where probably the first to be fully utilised by man. Early civilisations tapped this heat to cook, fire clay pottery, create baths and spas and even heat their homes. Roman villas had under floor heating from natural hot springs over 2000 years ago.

Shallow geothermal resources (<400 m depth by governmental definition in several countries) are omnipresent. Below 15-20 m depth, everything is geothermal (Figure 1). The temperature field is governed by terrestrial heat flow and the local ground thermal conductivity structure

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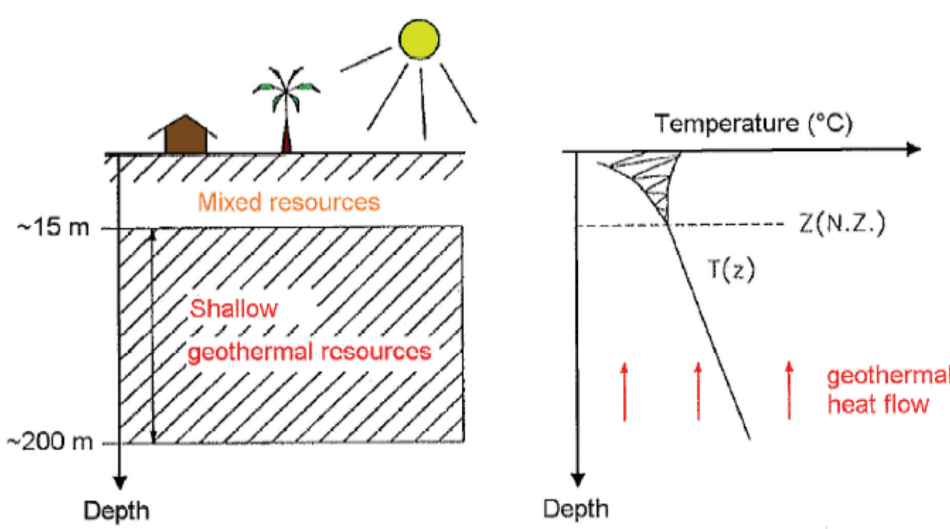
(groundwater flow). In some countries, all energy stored in form of heat beneath the earth surface is per definition perceived as geothermal energy (VDI, 1998). The same approach is used in North America. The ubiquitous heat content of shallow resources can be made accessible either by extraction of groundwater or, more frequent, by artificial circulation like the borehole heat exchanger (BHE) system. This means, the heat extraction occurs–in most cases–by pure conduction, there are no formation fluids required. The most popular BHE heating system with one of more boreholes typically 50-200 m deep is a closed circuit, heat pump coupled system, ideally suited to supply heat to smaller, de-central objects like single family or multifamily dwellings. The heat exchangers (mostly double U-tube plastic pipes in grouted boreholes) work efficiently in nearly all kinds of geologic media (except in material with low thermal conductivity like dry sand or dry gravel). This means to tap the ground as a shallow heat source comprise:

- Groundwater wells ("open" systems),
- Borehole heat exchangers (BHE),
- Horizontal heat exchanger pipes (including compact systems with trenches, spirals, etc.), and
- "Geo-structures" (foundation piles equipped with heat exchangers).

A common feature of these ground-coupled systems is a heat pump, attached to a low-temperature heating system like floor panels/slab heating. They are all termed "ground-source heat pumps" (GSHP) systems. In general, these systems can be tailored in a highly flexible way to meet locally varying demands. Experimental and theoretical investigations (field measurement campaigns and numerical model simulations) have been conducted over several years to elaborate a solid base for the design and for performance evaluation of BHE systems (NASA, 2009; Rybach & Eugster, 1997). While in the 80s, theoretical thermal analysis of BHE systems prevailed in Sweden (Claesson & Eskilson, 1988; Eskilson & Claesson, 1998) monitoring and simulation was done in Switzerland (Gilby & Hopkirk, 1985; Hopkirk, Eugster, & Rybach, 1988), and measurements of

Figure 1. Geothermal energy, comprising geothermal and mixed resources in the shallow subsurface (Knoblich, Sanner, & Klugescheid, 1993)



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