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International legal status of the use of shallow geothermal energy

Stefanie Haehnlein [a,*], Peter Bayer [b], Philipp Blum [c]

[a] University of Tübingen, Center for Applied Geoscience (ZAG), Sigwartstrasse 10, 72076 Tübingen, Germany
[b] ETH Zürich, Engineering Geology, Sonneggstrasse 5, 8092 Zürich, Switzerland
[c] Karlsruhe Institute of Technology (KIT), Institute for Applied Geosciences (AGW), Kaiserstrasse 12, 76131 Karlsruhe, Germany

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ABSTRACT

Shallow geothermal energy (<400 m depth) is used in many countries worldwide, with a rising number of installations over the last decades. The use of ground source heat pump (GSHP) and groundwater heat pump (GWHP) systems results in local temperature anomalies (cold or heat plumes). Since groundwater is used in many countries as source for drinking water a balance between its use and protection has to be found. Therefore, to avoid detrimental environmental impacts it is necessary to define groundwater temperature limits for heating and cooling and minimum distances between such geothermal systems. The aim of the present study is to provide a comprehensive overview of the current international legal status for the use of shallow geothermal energy. Therefore, an international survey was performed using a questionnaire, which was sent to more than 60 countries worldwide. The questionnaire requested information on the corresponding national legislation, temperature limits and minimum distances for GSHP and GWHP systems. The answers to the inquiry showed an extremely heterogeneous outcome. Until now national and legally binding regulations only exist in few countries such as Denmark or Sweden. However, all existing regulations show a wide range for minimum distances (5–300 m) and temperature limits for groundwater. The highest inconsistency was observed for the acceptable temperature change with 3 K in Switzerland to 11 K in France. However, most countries have no legally binding regulations or even guidelines, which highlight the urgent need for further research on the environmental impact and legal management of shallow geothermal installations.

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* Corresponding author. Tel.: +49 7071 2973185; fax: +49 7071 5059.
E-mail address: stefanie.haehnlein@uni-tuebingen.de (S. Haehnlein).

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1. Introduction

Energy safety, energy independence and the reduction of greenhouse gas emissions are imperative issues in current and future politics. Many countries support the development of renewable energy technologies such as geothermal energy. While deep geothermal applications (about >400 m depth) are specific and of large size, shallow systems (<400 m depth) require no extraordinary geological settings or high geothermal gradients. They are based on simple, established technological principles and therefore great in numbers and popular worldwide. Especially for domestic cooling and heating, the use of shallow geothermal energy is considered an environmental friendly alternative to traditional heating techniques such as oil or gas fired boilers [1,2]. The major technological variants are ground source heat pump (GSHP) and groundwater heat pump (GWHP) systems (Fig. 1).

GSHP systems are closed systems with a vertical borehole heat exchanger (BHE) or, less common, with a horizontal heat exchanger [3]. A heat carrier fluid is circulated within the buried closed tube system to transport heat stored in the subsurface to the aboveground heating system of a building. By using heat pumps, hot water can be generated while lowering the heat carrier fluid temperatures only by a few degrees. During warm seasons and for release of waste heat in general, the fluid can also be used in reversed mode to convey heat to the ground. In comparison to the well manageable GSHP systems, GWHP systems are less frequently used. They are open systems, with circulated (ground)water between two or more wells. Though attractive because of the efficient direct use of groundwater, GWHP systems are more demanding due to the permanent maintenance of wells, induced hydraulic effects and hydrogeological requirements [4].

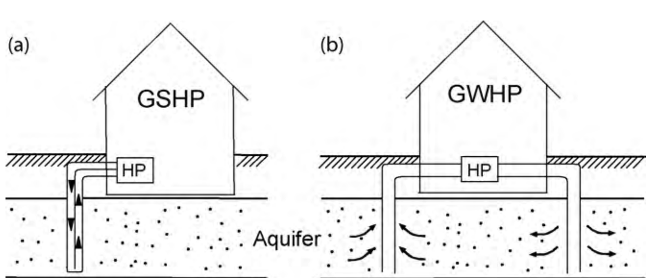

Fig. 1. (a) Ground source heat pump (GSHP) system and (b) groundwater heat pump (GWHP) system, both with a heat pump (HP).

Many synonyms for GSHP systems are used such as closed loop systems and ground coupled heat pump systems. Equivalently, GWHP systems are also called open systems or open loop systems [5–11]. Aquifer thermal energy storage (ATES) and borehole thermal energy storage (BTES) systems are sub-groups of underground thermal energy storage (UTES) systems. The idea is to store the heat or cold when it is available and exploit it when it is needed. The technology of ATES (BTES) is the same as for GWHP (GSHP) systems. The difference is that for ATES and BTES larger systems with multiple boreholes or wells are normally installed [12]. For the sake of clarity, in the rest of the paper we only distinguish between closed and open, i.e. GSHP and GWHP systems.

The number of shallow geothermal installations has been continually increasing over the last decades with a peak in 2006 [1,5,6,9,13–17]. In 2004 the number of installed GSHP systems worldwide was roughly estimated at 1.1 million [17]. Such a number and expected proliferation in the future substantiates the need for a concerted regulative framework. This is particularly crucial, as shallow geothermal systems once installed, are operated for decades. Precautionary principles would require complying with well-defined sustainability standards while minimizing associated adverse environmental impacts [18]. From a more technical perspective, focus would be set on robustness and energy-efficiency. Appropriate directives can guide and also control, since an increase in popularity means also increase in competition, especially in urban areas [19] and for the use of productive aquifers in general. However, if implemented at all, we and others observe that existing regulations in different countries or states are very heterogeneous