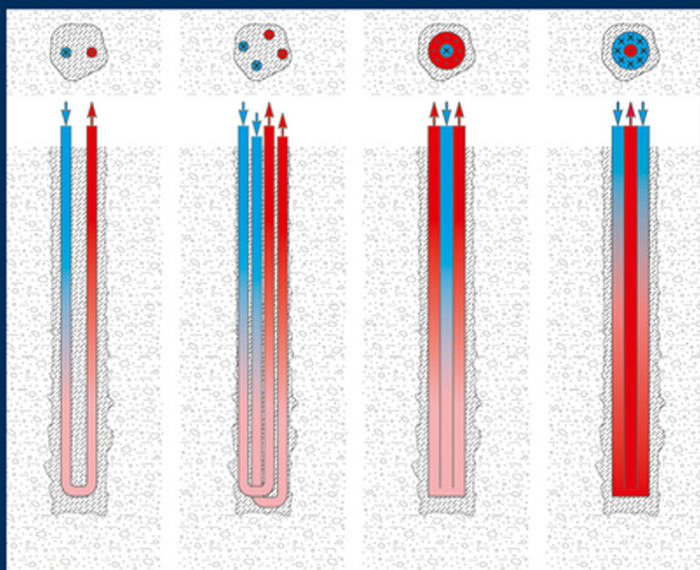


# Shallow Geothermal Systems – Recommendations on Design, Construction, Operation and Monitoring





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Of the Geothermal Energy Study Group at the specialist Hydrogeology Section of the German Geological Society (FH-DGGV) and the Engineering Geology Section of the German Geotechnical Society and the German Geological Society (FI-DGGT/DGGV).

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## Preface

The use of shallow geothermal energy has increased enormously over the past ten years. As the number of geothermal energy installations has risen, so has the number of technical developments in the field. There have been cases of damage in connection with the construction and operation of geothermal energy systems which have attracted much attention in the media. In particular, the cases of damage that have become public show that drilling to depths of several hundred metres is a technical activity that calls for responsible procedures in the sense of quality-assured design, construction and operation of the systems. Avoiding damage caused by shallow geothermal energy installations is a top priority for sustainable geothermal energy uses, especially when bodies of groundwater have to be protected against adverse effects. The recommendations in this book should be regarded as contributions to the quality-assured realisation of such systems. One of the aims of the Geothermal Energy Study Group at the specialist Hydrogeology Section of the German Geological Society (DGGV) and the Engineering Geology Section of both the German Geotechnical Society (DGGT) and the DGGV is to promote the widespread use of geothermal energy as an environment-friendly energy source while prioritising the protection of bodies of water. The authors as well as the DGGV and the DGGT have conceived these recommendations as advice and not as a set of technical regulations in the sense of a standard. Therefore, the recommendations of the Geothermal Energy Study Group include a number of textbook-like passages and much information on the legislation that affects approvals and permits. At the time of going to print, the preparation of a standard for shallow geothermal energy was not in sight; such a standard is, however, still regarded as essential.

The authors and their assistants in the study group are hydrogeologists, engineering geologists and engineers from design consultants, the construction industry, the building materials industry, authorities and universities. They drew up the recommendations over a number of years and all were well aware of the fact that some of the content could certainly trigger controversy in technical circles.

In order to guarantee the technical quality of the recommendations of the Geothermal Energy Study Group, the content was subjected to a peer review process. Prof. Dr. Ingrid Stober (Freiburg Regional Authority), Prof. Dr. Rolf Bracke (International Geothermal Center, Bochum) and Prof. Dr. Dmitry V. Rudakov (National Mining University, Dnipropetrovsk) undertook this important and demanding task, approaching it from different perspectives.

Their remarks and comments were carefully considered in the preparation of this current edition of the recommendations.

Besides the peer review process, the publishers made the recommendations publicly available on the Internet for three months. Anybody who was interested was invited to submit their remarks, comments and suggestions for improvements within those three months. The authors read and evaluated every single contribution received, which resulted in many improvements being made to the text and illustrations. We are very grateful to all who made contributions to the work of the study group in this way.

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## Preamble

The members of the Geothermal Energy Study Group, organised under the auspices of the specialist Hydrogeology (FH-DGGV) and Engineering Geology (FI-DGGV/DGGT) sections of the German Geological Society (DGGV) and the German Geotechnical Society (DGGT), are pleased that you are interested in the recommendations contained in *Shallow Geothermal Systems – Recommendations on Design, Construction, Operation and Monitoring*. These recommendations represent the results of the ongoing work of the Geothermal Energy Study Group (DGGT Working Group 4.11). The members of the study group are experts drawn from all areas involved with geothermal energy: industry, authorities, consulting, polytechnics and universities.

The publication of this book of recommendations is one of the main tasks of the study group. The recommendations are initially limited to shallow geothermal energy, but the intention is to consider aspects of deep geothermal energy as well. Furthermore, the recommendations are intended to form the technical foundation for basic and further training events aimed at the personnel of drilling contractors and based on standard DIN EN ISO 22475-1: ‘Qualification in drilling boreholes for geothermal purposes and installing closed heat transfer systems (borehole heat exchangers)’ (DGGT/DGGV, 2010).

The study group holds regular working sessions – about four to six times a year. One of the main tasks of the study group is the publication of advice and recommendations for the members of the specialist sections at the DGGV/DGGT and DGGV as well as others who are concerned with geothermal energy issues. The recommendations consider, in particular, the underground parts of the different geothermal energy systems. The most important aspects of the geothermal use of the ground are touched upon, although the focus is clearly on the most frequent types of application – borehole heat exchangers and well systems. Many special methods, techniques or combinations of methods are available on the market. The fact that those are not yet discussed in detail in these recommendations in no way implies that, for example, the various specialities represent ineffective or less suitable systems; it was merely decided to limit the recommendations to the most common systems in order not to exceed the scope of this book.

One specific aim of the recommendations is the quality-assured design, construction, operation and monitoring of shallow geothermal energy installations. The recommendations are intended to help guarantee the protection of

bodies of groundwater without obstructing the further spread of heating and cooling systems based on geothermal energy. Avoiding damage to geothermal energy installations and damage caused by the construction and operation of such systems is central to the issues discussed. In the light of current projects, the book also includes a chapter on dealing with potential risks.

The use of shallow geothermal energy represents a significant, environment-friendly and also safe way of reducing the primary energy consumption of our society. Some 50–60% of the total energy consumption of the industrialised nations of Central Europe can be attributed to the operation of buildings. With virtually no restrictions on location, no direct emissions, the ability to cover the base load and economical operation, this is where geothermal energy can play a role.

## Notation

Symbol	Definition	Common unit
$A$	Area	$\text{m}^2$
$A_f$	net filter area	$\text{m}^2$
$a_c$	dimensionless critical well spacing	1
$b_{wi}$	capture zone width	m
$C_a$	heat capacity of an area	$\text{W} \cdot \text{s} \cdot \text{K}^{-1}$
$C_p$	heat capacity at constant pressure (isobar)	$\text{W} \cdot \text{s} \cdot \text{K}^{-1}$
$C_v$	heat capacity at constant volume (isochor)	$\text{W} \cdot \text{s} \cdot \text{K}^{-1}$
$c_{mp}$	molar heat capacity at constant pressure (isobar)	$\text{W} \cdot \text{s} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$
$c_{mv}$	molar heat capacity at constant volume (isochor)	$\text{W} \cdot \text{s} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$
$c_{sp}$	specific heat capacity	$\text{W} \cdot \text{s} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$
$c_{spp}$	specific heat capacity at constant pressure (= $C_p/m$ )	$\text{W} \cdot \text{s} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$
$c_{spv}$	specific heat capacity at constant volume (= $C_v/m$ )	$\text{W} \cdot \text{s} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$
$d$	diameter	m
$d_{as}$	diameter of annular space	m
$d_b$	borehole diameter	m
$d_{fa}$	filter mesh aperture	m
$d_i$	inside diameter (i.d.)	m
$d_o$	outside diameter (o.d.)	m
$d_{pa}$	particle size	m