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State of the Art in Deep Geothermal Energy in Europe

With Focus on Direct Heating

Springer

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ISSN 2191-589X ISSN 2191-5903 (electronic)
SpringerBriefs in Earth System Sciences
ISBN 978-3-030-96869-4 ISBN 978-3-030-96870-0 (eBook)
https://doi.org/10.1007/978-3-030-96870-0

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

As the Earth continuously supplies heat, geothermal energy is a renewable energy source. Since nearly 50% of Europe's energy demand is in the heating and cooling sector (Bertani et al. 2018), it is expected that geothermal energy will play an important role in the transition to a decarbonized energy system.

Currently, geothermal energy in the European Union has an installed capacity of about 24.3 GW_{th} for heating and cooling (Kujbus et al. 2020). This is only a very small amount compared to the total geothermal potential of Europe (ETIPDG 2018; Garabetian 2019). In 2018, Europe had 280 geothermal district heating systems, spread over 24 countries with an installed capacity of 4.8 GW_{th}. However, geothermal energy is currently harvested mainly from high-enthalpy resources, i.e. from resources located in regions with favorable geothermal conditions. Because these areas are geographically limited, using geothermal energy in less favorable regions with low-to-medium enthalpy resources, is essential for unleashing the full potential of geothermal energy, as these resources account for the majority of Central Europe's total geothermal potential (Richter 2017).

This book project arose from a request made by E.ON for a literature review about the state of the art in deep geothermal energy. It relates to an EU call for the demonstration of innovative technologies to reduce greenhouse gas emissions. In this call, E.ON applied for funding for the application of deep geothermal for district heating. We believe E.ON's request reflects the growing interest in deep geothermal energy in general, and among energy companies and communities in particular. In this book, we introduce the opportunities and limitations of geothermal energy usage, particularly in geothermally less favorable regions. To this end, we review the state of the art in deep geothermal energy with focus on direct heating. The book thus provides an overview of technologies used to obtain heat from the deep underground and discusses main technical and non-technical risks associated with deep geothermal projects.

Addressing readers without a geoscientific background, we first lay the foundations of geothermal energy by explaining the heat distribution in the Earth as well as the governing geological and geophysical processes in Chap. 1. Moreover, we introduce the classification of geothermal systems to set the frame for the geothermal

potential across Europe, which we discuss subsequently in Chap. 2. After a general overview, we explain in detail the geothermal potential of three example regions (Sweden, Poland, and Hungary) with different geological conditions. Chapter 3 gives an overview of the technologies applied for harnessing heat from the subsurface. We introduce the geothermal project development process and focus on exploration, assessment, development, and operation of a geothermal reservoir. For non-favorable subsurface conditions, reservoir stimulation is required for producing heat. Therefore, we introduce methods of developing these so-called Enhanced Geothermal Systems (EGS) and give an overview of existing large-scale EGS projects in Europe. We highlight innovative technologies and assess their potential to make heat usable. Associated technical and non-technical risks and barriers are outlined in Chap. 4. Finally, we summarize the findings of our literature study and draw conclusions regarding the technological state of the art for deep geothermal energy and its potential for direct heat use in Europe.

This work was initiated and funded by E.ON. We would like to thank our colleagues Bérénice Vallier, Matthis van Wickeren, and Tobias Ganther for their support with research and writing. Additionally, we thank Thorsten Gleu for the design of some of the figures and several publishers and authors for their permission to use and reproduce images.

Aachen, Germany
October 2021

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