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INTERACTION OF GEOSCIENTIFIC, TECHNOLOGICAL, ECONOMIC AND ECOLOGICAL ASPECTS IN THE UTILIZATION.OF GEOTHERMAL ENERGY

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IBSTRACT

The utilization of geothermal resources requires consideration and evaluation of a broad range of aspects, such as geologic, economic, technological and ecological conditions. The objectives of the interdisciplinary Geothermal Project: " Evaluation of geologic and economic conditions for utilizing low-enthalpy hydrogeothermal resources" are to investigate these aspects in terms of their complexity and their interrelations. This approach yields sensitive points for technical optimizing and necessary geoscientific research. The project which is funded by the German Ministry of Education, Science, Research and Technology (BMBF) will therefore provide a basis for political decision making in the process of promoting and installing of geothermal heating plants.

INTRODUCTION

At present direct use of geothermal heat in Germany is restricted to many small decentralized units, mostly earth-coupled heat pumps (EHCP's) and a small number of larger hydrogeothermal installations. Most of these larger installations are operating in the North German Basin, in the South German Molasse Basin and along the Rhine Graben.

Experience with EHCP's is widely spread and their use is to some extend quit common. Long time experience with larger installations is mostly restricted to the former East German part. Due to good geologic conditions and because other energy resources were not available locally here the first geothermal heating plants were installed starting in 1984. Some of these installations are still in use. The experience with them and the strong need for reduction of CO, emissions triggered activities for some new projects after the reunification of Germany in 1991. But only one of these projects is realized as a demonstration plant until now.

Nearly 60 % of Germany's final energy consumption is needed as heat at mostly low temperatures. Thus the theoretical potential of hydrogeothermal energy could contribute more to its supply. So far economic considerations in an energy market which is saturated with cheap fossil energy and a lack of knowledge and acceptance are limits to a widespread utilization.

PROJECT STRUCTURE

At the end of 1995 a multidisciplinary working group was installed at the GeoForschungs-Zentrum (GFZ) Potsdam, which is a national geoscientific research institution. This group consists of geoscientists, an engineer and an economists and is supported by researchers at the GFZ and some German universities, who deal with specific problems. Cooperations with other federal and local authorities and firms guarantee access to the recent technological knowledge and give the possibility of measurements and investigations in geothermal heating plants. These are supplemented by specific measurements in wells and on cores from installations which are finished or still are under construction.

RESEARCH TOPICS

We started work under the premise that any widespread geothermal application must satisfy ecological and economical needs.

Ecological Analysis

At the beginning a life cycle analysis of a geothermal heating unit in Riehen (Kanton Basel, Switzerland) was performed, taking into account the material and energy expenditures and the emissions from con

struction, operation and disposal of this unit. This analysis was compared to that of heating plants operated with fossil fuels.

The comparison showed that for an assumed lifetime of 25 years, the geothermal unit decreases the amount of energy that contributes to the manmade greenhouse effect by approx. 50 %.

Analysis of other geothermal heating plants is on the way and is confirming this fact. While the real amount of energy saving depends on the technical composition of the heating plant an enormous saving of fossil fuels can be achieved under any circumstances.

A first estimation on this basis shows, that the technical potential of hydrogeothermal energy in Germany could reduce the yearly manmade CO_2 emission of 900 million tons by 5 to 8 %.

Economic Analysis

On the basis of a general investigation of geological situation, thermal water loop and consumer structure different geothermal plants were analyzed in detail. As a result most of the possible technical components and combinations are known. They will be input to a complex economic calculation system which can than be used for optimizing the costs for a locality with specific geologic conditions and consumer demands. Investigations are focused on:

Drilling and completion of wells

60 to 70 percent of the total investment for geothermal heating plants operating with a doublet system is used for drilling and completion. A calculation for two locations with different geologic conditions showed that two deviated wells from one drilling-location were in both cases only slightly cheaper than two vertical wells. Resulting heat costs for the consumer can therefore not be reduced remarkable. Nevertheless: this fact might be important when dense urban areas are considered because of legal restrictions and high building land costs.

Influence of heat distribution system

In a study variations of the temperature conditions in district heating systems were considered while the geologic conditions are maintained. The exponential duration curve of the consumer system used was verified by comparison with data from an existing district heating system.

It is evident that the specific costs calculated for the distributed heat are sensitive to the amount of geothermal heat supplied to the system. The results of the calculations for a district heating system with a capacity of 25 MW, showed that the specific cost of the produced heat depends on the tamperature of the network. If return temperatures are minimized a reduction of nearly 25 % can be expected.

The calculated specific heat costs for different temperature layouts are finally transformed into an equivalent investment potential. The results clearly indicate the possibilities for an optimization of the system when investments into the heating network are made.

Reservoir Characterization

Even in well known parts of the North German Basin drilling risk and the related costs are one major obstacle for many projects. There are some German and European initiatives for insurance systems which may cover this risk partially. Precise regional and specially local characterization of relevant parameters like permeability, porosity, aquifer layer thickness, water chemistry and their distribution we necessary for reliable feasibility studies.

Like permeability, some of these parameters are additionally affected by the operation of geothermal plants. For this reason measurements of gas and mineral content are repeatedly carried out during different operational phases of existing installations. Additionally for example percolation experiments under in situ conditions are done in order to investigate fluid-rock interactions. All the parameters are then input to long time modeling of the geothermal reservoir exploitation.

CONCLUSIONS

Despite the fact that geothermal installations in Germany require a big amount of capital expenditure under certain conditions they can operate economically. The essential parameters are consumer structure and layout of the connected heat distribution networks. Parameters of the thermal water loop which are analyzed in operating installations show additional possibilities for system optimization.

If in the future reservoirs which are not yet exploited can be used to satisfy local demands, geothermal energy has the theoretical potential to contribute significantly to the reduction of CO_2 emissions.