EGW 2014
3rd European Geothermal Workshop
Karlsruhe, 15-16 October 2014

Geothermal Wells for Energy Production

Bernt Aadnøy and Olha Sukhoboka

University of Stavanger, Faculty of Science and Technology, Department of Petroleum Engineering, Stavanger, 4036

bernt. aadnoy@uis.no, olha.sukhoboka@uis.no

Keywords: Renewable sources, geothermal wells, applications, utilization

ABSTRACT

1. INTRODUCTION

Geothermal energy has a vast potential for energy production. It is clean and a renewable source of energy. If we cool off a wellbore over time by extracting heat, energy from underneath will bring the temperature back to initial value if we stop heat extraction. Heat from the underground is a stable source of energy basically without seasonal variations, and wells can be drilled with little environmental footprints. Compared to other renewable sources such as solar energy, wind energy and wave energy, geothermal energy have less variation over time, and is therefore a more stable source.

Shallower geothermal wells can be drilled relatively inexpensive, but for deeper wells in the order of several thousand meters, drilling cost may render the project uneconomical. In many countries a high number of abandoned oil and gas wells can be used to produce geothermal energy at a low cost.

A typical application of geothermal energy consist of a deep well with two tubes installed, one to bring cold water down to the bottom of the well, and another pipe to bring hot water back to surface, where the heat is extracted to for example heat a building. The system can be viewed as a counter-current heat exchanger. One problem is that during the convective water transport up to the wellhead, the water is cooled off. Surface temperature is therefore considerable lower than the bottomhole temperature.

The first part of the project is to review literature and describe the state of the art as:

• Identify the most important solutions to geothermal production.

• Perform thermodynamic analyses of these, and describe the results in terms of relative efficiency

• Establish an economic model to rank the solutions for selected parameters.

The second part is to identify more novel methods to produce geothermal energy that have a potential either for increased energy production, or to obtain more cost-effective solutions, i.e. by being able to produce the same amount of energy from a shallower depth. One example is to use heat pipes instead of convection where the evaporation heat of a fluid requires a large amount of energy, which is released at surface when the vapor condenses back to a fluid.

When a selected number of novel or improved methods are identified, a thermodynamic analysis of these will be derived. Again, a simulator which also includes cost can be the end product of the project.

An important part of the project is to identify suitable fluids for energy transmission. This will include environmentally acceptable fluids, and also the thermodynamic properties of each fluid. Several example wells will be designed, with a suggested fluid that covers the temperature and pressure ranges of each well. Lab experiments will be developed during the project.

2. GEOTHERMAL APPLICATIONS

There are three main types of geothermal resources:

– Hot dry rocks (HDR). Hot wet rock (HWR) and enhanced geothermal system (EGS) are included into variations of HDR

– Liquid-dominated geothermal resources. A major development in the exploitation of “liquid-dominated” geothermal fields has been the application of heat recovery systems in many fields. These systems are typically binary plants, Gallup (2009)

– Vapor-dominated geothermal resources are not as plentiful as «liquid-dominated» or EGS reservoirs and most of the big fields that produce only steam have been discovered and are presently under exploitation, Gallup (2009)

Fig. 1 performs main strategies and practices for utilization of geothermal resources, Franco (2013).

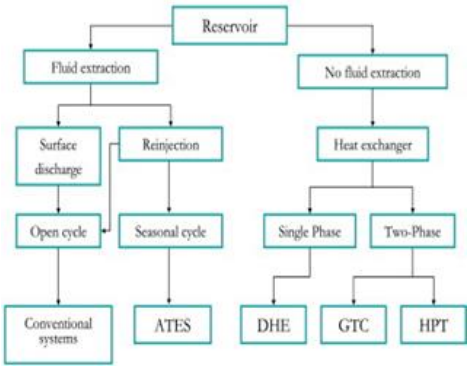

Fig. 1: Pathways for the use of geothermal energy

ATES – Aquifer Thermal Energy Storage

DHE – Downhole Heat Exchanger

GTC – Geothermal Convector

GTC – Geothermal Convector

There are two common types of geothermal energy system design:

– double-pipe heat exchanger that may be easily made by retrofitting well with an internal pipe of smaller diameter and insulation (Fig. 2), Davis (2009).

Geothermal energy can be utilized in different ways such as:

• Geothermal heat pumps;

• Space heating;

• Greenhouse and covered ground heating;

• Aquaculture pond and raceway heating;

• Agricultural crop drying;

• Snow melting and space cooling;

• Bathing and swimming, Lund (2011).

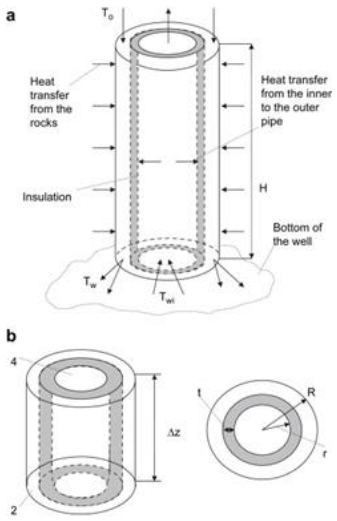

Figure 2

a – schematic representation of the heat transfer in the well

b – the scheme for direction of the flow and the top view of the pipes in the well

– geothermal systems with injection and production wells.

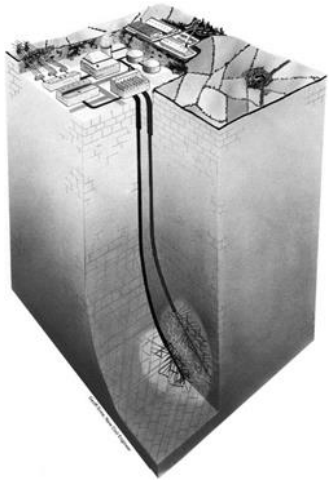

Figure 3: Schematic representation of a HDR reservoir formed by artificial fracturing, Barbier (2002)

Geothermal resources are defined as *"…that part of the accessible resource base that could be extracted economically and legally at some specified time in the future*", Hurter (2003). We need to estimate the amount of heat available in the rock and the characteristics of the reservoir with relation to the heat extraction if we want to quantify geothermal resources. The Lindal diagram in Fig. 4 shows some typical applications of geothermal energy, Hurter (2003).

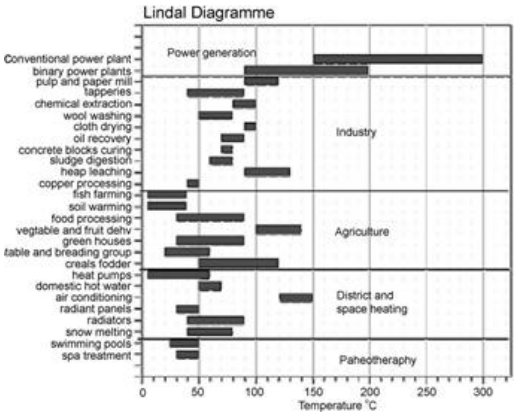

Figure 4: Fields of application of geothermal energy according to water temperature

Heat flow map of Scandinavia is shown on Fig 5.

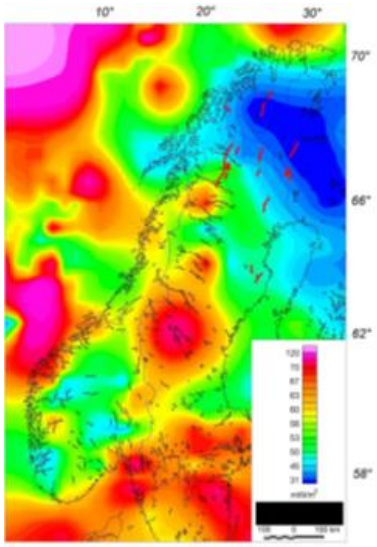

Figure 5: Scandinavia heat flow map, Slagstad (2009)

REFERENCES

Barbier E.: Geothermal energy technology and current status: an overview, *Renewable and Sustainable Energy Reviews*, **6**, (2002), 56.

Davis, A., and Michaelides, E.: Geothermal power production from abandoned oil wells, *Energy*, **34**, (2009), 867.

Franco, A., and Vaccaro, M: On the use of heat pipe principle for the exploitation of medium–low temperature geothermal resources, *Applied Thermal Engineering*, **59**, (2013), 190.

Gallup, D.L.: Production engineering in geothermal technology: A rewiev, *Geothermics,* **38**, (2009), 326-328.

Hurter, S., Schellschmidt, R.: Atlas of geothermal resources in Europe, *Geothermics*, **32**, (2003), 782.

Lund, J.W., Freeston, D.H., and Boyd, T.L.: Direct utilization of geothermal energy 2010 worldwide review, *Geothermics*, **40**, (2011), 162.

Slagstad, T., Balling, N., Elvebakk, H., Midttømme, K., Olesen, O., Olsen, S., and Pascal, C.: Heat-flow measurements in Late Palaeoproterozoic to Permian geological provinces in south and central Norway and a new heat-flow map of Fennoscandia and the Norwegian–Greenland Sea, *Tectonophysics*, **473**, (2009), 341-361.