Interview - Prof. Peter Bayer, Germany

Innovative topics in Shallow Geothermal Energy research

Peter Bayer is professor in Geothermal Energy at the Ingolstadt University of Applied Sciences, Germany. He has a strong interest in subsurface heat transport processes, has published more than a hundred research papers and a textbook on the "Thermal Use of Shallow Groundwater". More info on www.bayerpeter.com

Are there any links between Shallow and Deep Geothermal Energy in university research?

There are clear links. Both subjects deal with heat transport in porous and fractured media, with uncertainty in the description of subsurface conditions, and both are tightly linked to the fields of hydrogeology and geophysics. In addition, shallow and deep geothermal energy are often taught together in one course at universities. Finally, there is a growing interest in geothermal energy use and storage at intermediate depth, which combines the expertise from the area of deep and shallow geothermal energy.

However, universities often set a focus on one of the fields. Some of the major reasons include the different maturity of technologies for deep and shallow geothermal energy (SGE) development, along with the availability of research funds.

University research is strongly driven by funding opportunities, and clearly, deep geothermal energy development does not come cheap. Research projects on deep geothermal energy deal with the development of sophisticated numerical modelling-techniques, innovative field-testing techniques and field labs that are operated specifically for understanding the complex coupled processes at the depth of kilometres. Thus, special field-based studies on deep geothermal energy are much more expensive, often conducted as collaborative projects by several complementary partners and over several years. In essence, deep geothermal energy research, such as on engineered geothermal systems and deep hydrothermal resources can be summarised as a large-scale subject addressing many aspects of fundamental scientific relevance.

Shallow geothermal energy technologies are not only small-scale, but they are also much cheaper to implement. Many of them are already established on the market, and there is no pressing demand for technological developments. Having already established operations, however, creates new research questions, which may one day also become relevant when deep geothermal systems become established in Central

Europe. Among these questions we find how to deal with the increasing competition for the underground space, how to formulate proper regulative boundaries, how to gain technological efficiency and how to sustain efficiency for a long period of time. In summary, shallow geothermal energy research is barely dealing with those fundamental issues that deep geothermal energy research is dealing with. Shallow ground, though, can be easier accessed and thus can serve as a learning opportunity for facing challenges at a greater depth, in research and in practice.

Can the contribution of SGE in reducing the ongoing global change be quantified somehow?

Yes, of course, it can! Once, we conducted a survey on the savings of greenhouse gas emissions by geothermal heat pumps in Europe. For the nineteen European countries studied in 2008, 3.7 Mio t CO_2 (equivalent) were saved by the heat pumps in comparison to conventional heating technologies. A global survey, taking in more recent numbers would be useful in order to see the current contribution of SGE in mitigating climate change.

Due to the use of heat pumps, however, the potential for SGE to aid the avoidance of greenhouse gas emissions is limited and strongly depends on the primary source of energy used for running the heat pump. Our review on the conditions in Europe revealed, for instance, that savings of more than 30% of greenhouse gas emissions from conventional practices would be possible, given the current CO2-heavy European electricity generation practices.

Are there any significant negative environmental impacts of SGE installations?

SGE technologies are installed because of their technological performance and because they are considered as technologies that provide renewable energy. However, no renewable energy resource is free of any negative environmental impact. This is because, for SGE, a heat pump needs to be operated, material and electricity are consumed and boreholes or wells manipulate the conditions in the ground. Negative impacts are ideally quantified and contrasted within a life cycle assessment framework. Such assessments have already been conducted, and they demonstrate a mostly favourable environmental performance with respect to global warming, acidification, resource use and land use-related impact.

Significant local environmental impacts from SGE installations are unusual, but they do exist. Failed installations, such as the famous case that occurred in of the town of Stauffen, Germany, where SGE boreholes most probably created pathways for groundwater that induced the *in-situ* swelling of gypsum, are extremely rare, and in some sense, part of our learning curve. We should not forget the several millions of safe SGE installations that provide environmental benefits.

What the future brings and how systems operated densely over decades will change the thermal regime in the shallow ground is yet to be seen. Being the host for a sensitive ecosystem, which is not well understood, the shallow ground and groundwater may experience some ecological impacts, which can hardly be predicted. In my opinion, this is a relevant subject for science and practice, but I am confident that *in-situ* environmental effects, for the most part, reveal to be acceptable. My arguments are that we can afford to exploit local volumes of the ground. Is it reasonable to consider all the ground beneath us as a safeguard environment, while we are at the same time burning fossil fuels everywhere in the atmosphere?

What are the most innovative issues covered by SGE researchers today?

There are many thrilling subjects, and I think that my personal list of innovative issues is highly subjective. I am highly attracted by understanding, predicting and managing the thermal conditions beneath cities, where we can find large-scale subsurface heat islands. These have evolved over decades of urban evolution and represent waste heat accumulated beneath our feet. Finding strategies for "recycling" this energy and for accelerating replenishment of thermally used ground volumes on local, district and city scale is certainly a topic that will keep us busy for the next decade. In this context, SGE research will be embedded more and more in integrated energy management, e.g. for smart energy solutions of urban areas. This will create new interdisciplinary research topics, such as finding strategies for dealing with combined ground use for heating and cooling, and for optimal management in hybrid systems.

Another thrilling subject is simulation. Even though a plethora of different modelling techniques exist for SGE applications, the development of more efficient and more suitable analytical modelling techniques offers a continued innovational potential. Tuning these modelling techniques for handling heterogeneous ground conditions and groundwater effects will demand our attention in future research. Also, bringing different co-existing simulation concepts together may be an appealing future project.

Which kind of technical improvements could lead to having even more environmentally friendly SGE installations in the future?

Considering their enormous potential, I see the role of energy storage in shallow ground as underrepresented in most countries and in most research in general. There is a need for new, innovative concepts, and also a need to deal with complex geological boundary conditions for safely storing heat and cold, especially in seasonal applications. In addition, there is a need for more field applications and large-scale as well long-term testing. This would certainly open up new doors in SGE research and visibility. My opinion is that the effect of an economy-of-scale also has the potential to generate more environmentally friendly SGE use.

GRETA is co-financed by the European Union through the Interreg Alpine Space programme.