Coastal underground as a thermal energy source

Geothermal energy is defined as stored heat energy below the solid surface of the earth and is traditionally used for heating purposes. However, the earth or rather the underground offers more options for thermal use as it can also be used as a cold source and even as a thermal energy storage.

Global climate change will presumably increase the mean air and underground temperatures. Geothermal applications can take advantage of these changing temperature regimes by using the stored heat in the ground for a very efficient heating with a heat pump. As not only summers but also winters in the northern part of Germany will most likely become warmer, the overall heating demand will probably be reduced. As a consequence the balance of heat input into the ground in summer and heat extraction from the ground in winter will increase even in northern German climate (today the heat demand is bigger). Therefore a seasonal use of the underground as a thermal storage will become increasingly important.

Heating or cooling with a thermal use of the ground is typically being realised with geothermal heat pumps that are installed within the respective building. For the most efficient geothermal use of the geothermal source system, a good thermal conductivity of the underground is indispensable. Within porous substrates like sand, the presence of groundwater is essential to operate a heat pump cost-effective.

Coastal areas with water saturated sandy undergrounds in direct proximity to the sea fulfill these requirements in an ideal way. For this reason, current research elaborates the geothermal potential of coastal areas. In addition, the possibilities of a direct thermal use of ground- or seawater as well as the possibilities to integrate geothermal technology into coastal protection measures are looked into.

In the frame of such a pilot study, five monitoring wells have been installed at the beach of the German coastal town Warnemünde/ Rostock to acquire hydrothermal parameters of the coastal area (temperature, water level and water salinity). Based on the collected data, a feasibility study and a cost-efficiency study for the combination of a coastal protection measure with technologies for thermal use of the underground will be prepared.

Monitoring data for the period from April 2011 to August 2012 shows the interaction of sea- and groundwater and the seasonal influences at different depths. Those data allows direct conclusions about the feasibility of a thermal use and of the intrusion of sea water into the coastal aquifer.

Furthermore, the monitored temperature and hydraulic data have been used for the calibration of a three-dimensional underground model of the Baltic Sea coast in the region of Warnemünde. With this numerical model, thermal simulations of selected geothermal source systems like horizontal ground loop collectors, vertical spiral heat exchangers and horizontal wells have been conducted.

The first simulation results point towards a very good heating performance of horizontally loop ground collectors placed near surface in the beach area. According to further simulation runs, the best place for a seasonally balanced thermal use (heating and cooling) is in a depth of approximately 2.5 to 4.5 m below a dune. Because of the relatively inexpensive production costs of ground loop collectors, a very good cost-benefit ratio is forecasted for this geothermal system.

The full evaluation of the measured data will be published in a feasibility and cost-efficiency study at the end of 2013.

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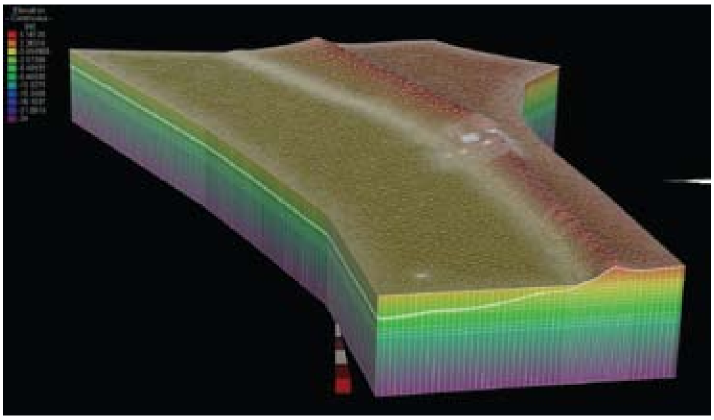

Figure 1: 3d-numerical underground model of the coastline at Rostock-Warnemünde

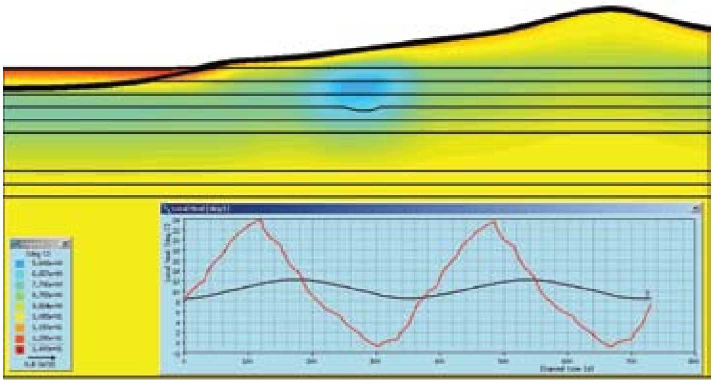

Figure 2: Simulation results for a near surface ground loop collector (timestep: end of heating season)