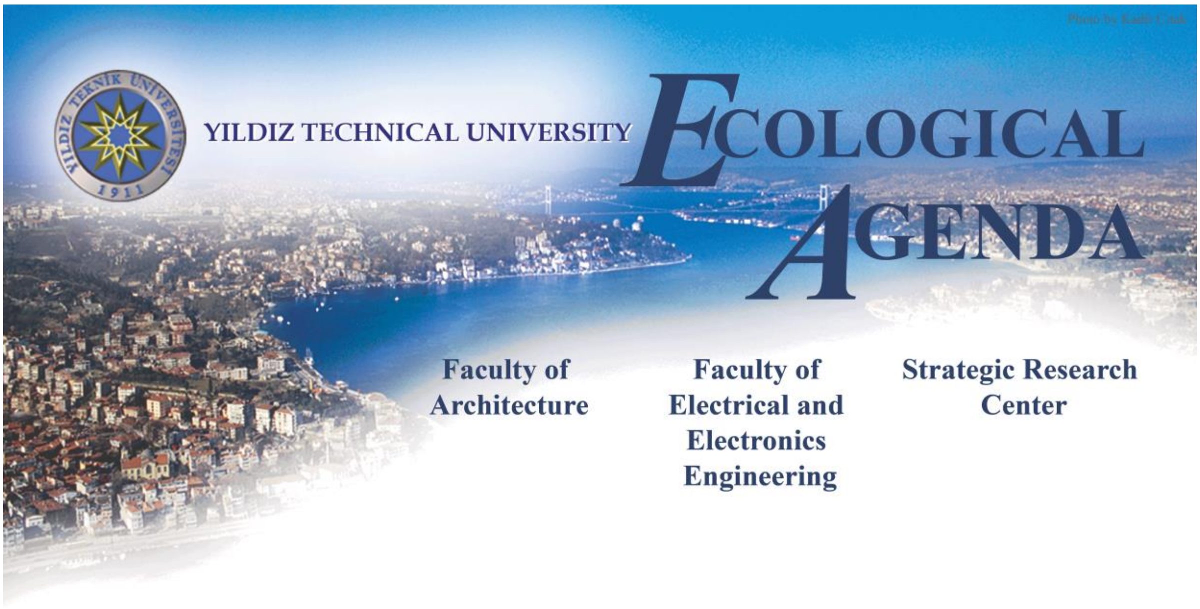

NEW PERSPECTIVES in ECO-TECHNOLOGY and ECO-ECONOMY

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GEOTHERMAL ENERGY – A LUCRATIVE SOURCE OF ENERGY

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Abstract

The standard technology to install ground source heat exchangers is based on deep vertically oriented boreholes, thus causing drilling costs that might represent up to 50 % of the entire investment into a geothermal well.

GRD is a drilling method where inclined borehole heat exchangers become radially installed in a depth range of less than 35 m below surface. Hence, the thermo-dynamics of a GRD-heat well are predominantly characterized by a temperature regime that follows seasonal climatic changes. This is because the inflow of atmospheric energy in this depth range is 2600 times higher than the amount of energy provided by the geothermal heat flux. All dimensions are used to provide sustaining and efficient heat supply.

The GRD method is designed to be environmentally friendly. The fuel consumption is low and the system's inherent flexibility in planning a geothermal source allows the driller to leave drinking water bearing strata untouched. By means of thermally activated grouts and coaxial borehole heat exchangers assuring turbulent brine flow the thermal borehole resistance is significantly reduced.

With this drilling technology the target group "existing property" can be accessed, i.e. a market that is four times bigger than the market segment "newly build property" (in Germany, presumably the same in Turkey).

Altogether, GRD is a highly interesting alternative to existing technologies in terms of thermodynamic design, economical heat extraction, drilling performance and marketing.

1. Introduction

Geothermal energy is a cheap source of energy that is becoming more and more state of the art. In addition, new developments in drilling technology and heat mining methods foster the widespread market penetration. The standard technology to harvest geothermal energy is based on vertically oriented boreholes up to 100 m in depth (Fig. 1). This is expensive, presupposes a well trained drilling team and very often causes damage to land and gardens. In addition drilling costs regularly represent more than 50 % of the entire investment, hindering potential customers from investing in geothermal heating systems.

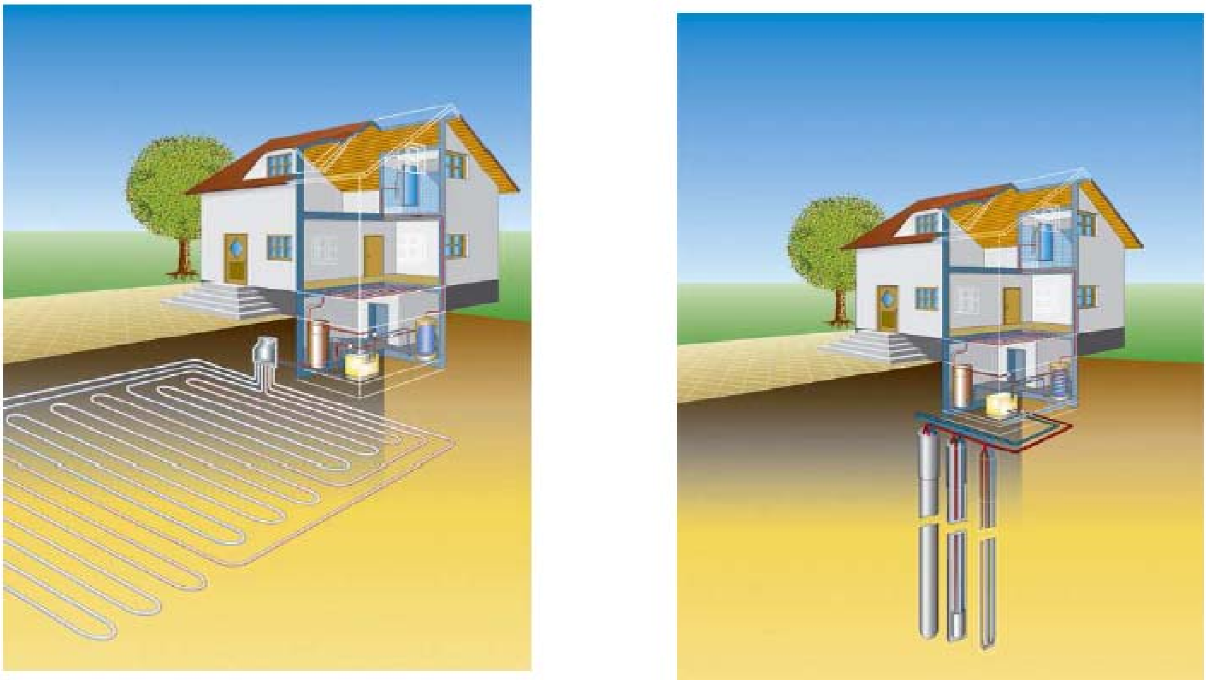

Fig. 1: Schematic sketch of vertical and horizontal oriented heat pipe installations (source)

However, there are good reasons for investing in geothermal heating systems:
- No worries about ever increasing oil and gas prices
- Borehole heat exchangers deliver cost-free energy from the underground to a heat pump, where the earth's energy is transformed into heating energy. At least 75% of the total heating energy comes from the earth. The electrical energy used by the heat pump represents only 25 % or less of the total energy balance. Therefore geothermal energy is environmentally friendly because carbon dioxide is saved
- The operational safety of geothermal heating is impressive – even during long and cold winters
- Reduced building costs: chimney and oil storages become obsolete

2. The rationale behind geothermal radial drilling

GRD is a patented, slanted bore method where one central drill chamber is used to install borehole heat exchangers radially in all directions and angles of inclination, even under existing buildings (Fig. 2, Fig. 4). It's like the roots of a tree: all dimensions are used to provide sustaining and efficient heat supply.

The system utilizes the estate's set-up in all dimensions, implying that there is no need to drill deep vertical boreholes anymore. The depth range is a key issue to address. This is because the "Golden Rule of drilling" applies: the last 30 m of a 100 m deep bore cost the same as the first 70 m.

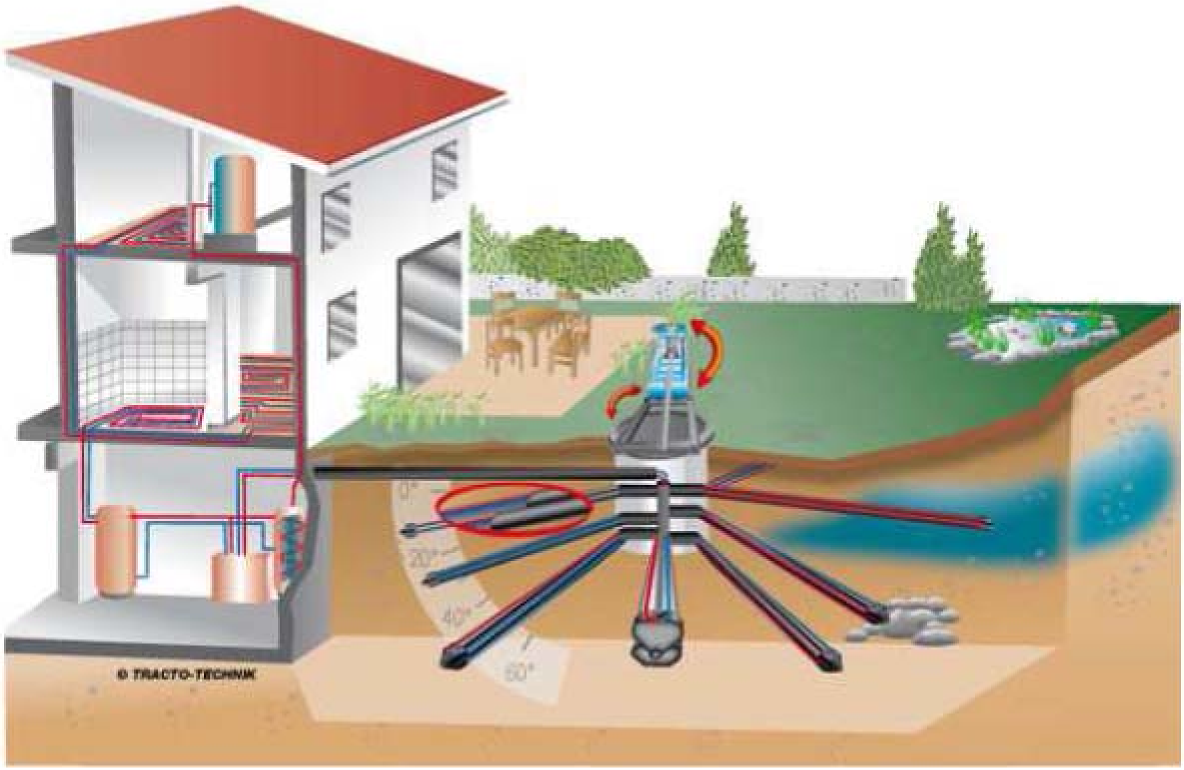

Fig. 2: schematic sketch of a GRD ground loop installation

GRD enables the user to install 5 to 6 ground source heat collectors, each 30 m in length, in a shallow depth range up from 1.5 m to 25 m below surface. The number and depth of the borehole heat exchangers can be easily adjusted to the estate's set-up or legal regulations.

This is enough to provide a stable long-term heat supply while the overall expenditures for installing borehole heat exchangers are cut by app 40 %, making Geothermal affordable for a large group of customers.

What makes the heat supply more stable? As a rule of thumb, the underground temperature is always around app. 10 °C plus/minus 1°C (Fig. 3). But the first 20 m of the underground are characterized by a temperature regime that follows seasonal climatic changes. In other words: the amount of heat that is removed during cold periods will be "filled up" again in warm periods.

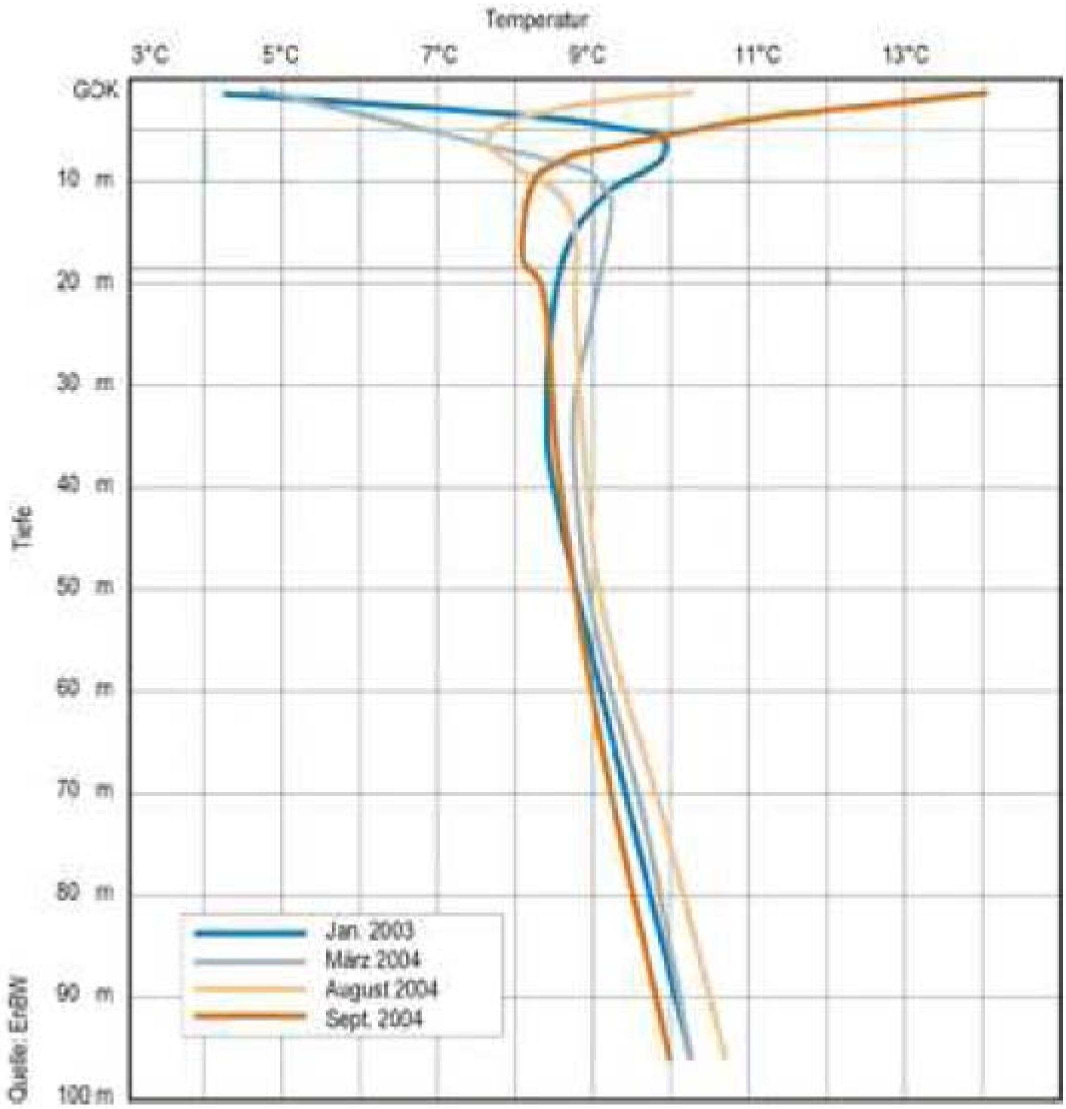

Fig. 3: Underground temperatures at different times of the year

Furthermore, the average atmospheric heat flux due to insolation and rainwater seepage, i.e. the heat that flows from the surface into the ground, equals app 170 Watt/m². The geothermal heat flux, i.e. the heat that flows in the opposite direction (from the inner earth to the surface) equals app. 0.065 W/m². The input of atmospheric energy is 2600 times higher than the amount of energy provided by the inner earth. As illustrated in figure 4 the borehole heat exchangers are radially installed so that mutual influence is minimized. Hence, the amount of extractable geothermal energy is very constant and rewarding, particularly if the law allows the extraction of heat from groundwater bearing strata. The Geodrill GRD 4 T enables the drilling team to head for these horizons. If this is not allowed, deep lying drinking water horizons remain untouched.

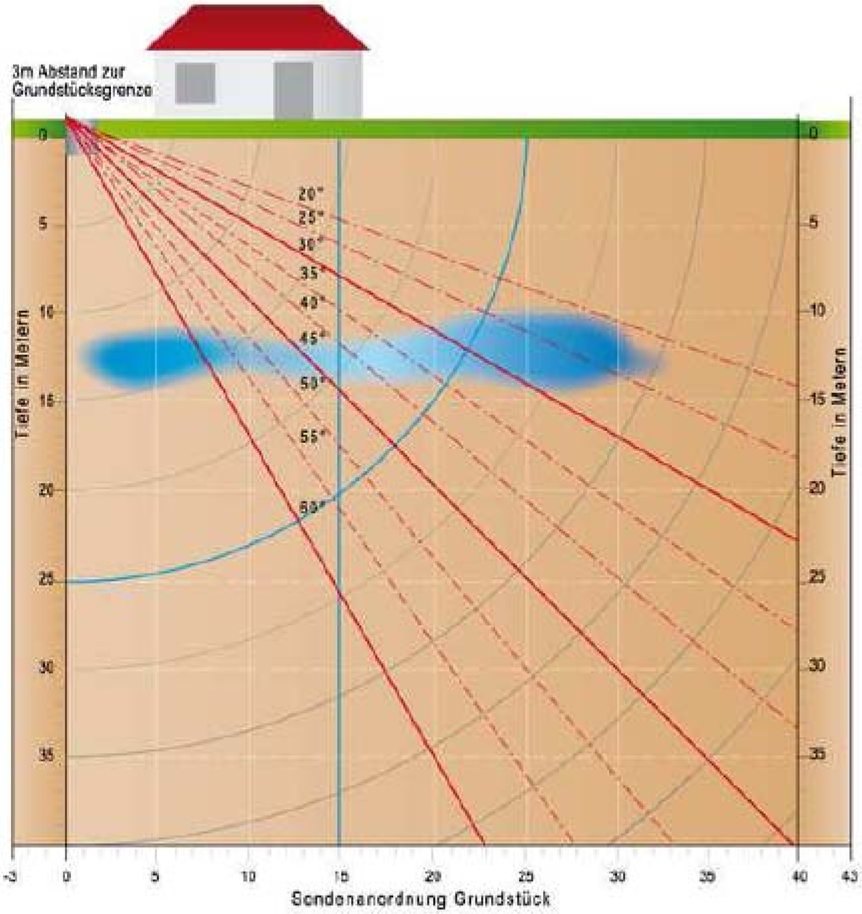

Fig. 4: Slanted heat exchangers under existing property

3. Technical issues

What makes the GRD-technology innovative?

- Optimum underground utilisation: number and depth of borehole heat exchangers can be easily adjusted to the estate's set-up and local geology
- The drill rig can be rotated horizontally 360 degrees. The angle of inclination is also adjustable, with a range between 25 to 65 degrees.
- Utilisation of the groundwater's temperature without harming the scarce resource "water"
- High and stable heat extraction
- The borehole heat exchangers are collected in an accessible drill chamber – a clean solution
- High quality borehole heat exchangers that are state of the art
- minimum damage to land and gardens
- Quick and economical installation of borehole heat exchangers
- Allows the targeting of thermodynamically rewarding groundwater bearing Strata
- Short amortisation period

Fig. 5: The Geodrill 4 T with open rotary ring (left) and at a field testing operation (right; drill performance 2-4 min /metre in shale and paleozoic sandstone)

The drill rig (Fig. 5) is compact and powerful. The system consist of a motor unit, overburden drilling equipment and a rotary ring that is mounted to a manhole made of PE (depth = 1.2 metres, diameter = 1.0 metres). The manhole remains in the ground so that there is always a clean environment for repair and maintenance.
A skilled and well trained team is able to install borehole heat exchangers up to a length of 100 m per day.

4. Planning a GRD-installation

The layout of the underground system is determined by the demand for heat. This demand is influenced by the floor-area, heat insulation, the heating system and its annual operational duration. The demand for heat ranges between 8 to 11 kW for an average family of 4 living in a well insulated, newly built house with 120 sqm floor space.

The geological set-up determines heat extraction performance. The regular specific heat extraction is around 40 to 50 W per meter borehole heat exchanger. The ideal “material” for rewarding and lasting heat extraction is either rock or wet soil/ sand /gravel. Groundwater bearing strata are most rewarding.
Geological maps provide detailed and reliable information about geological parameters. However, it is always a good idea to ask the landlord about the specific local environment of his property.

5. How to calculate the necessary length of a borehole heat exchangers?

A household has a heat demand of 10 kW for a duration of 1,800 hrs per year. The entire energy demand is therefore 18,000 kWh per year. 75 % of the energy comes from the earth, i.e. 13,500 kWh per year. Assuming that one meter borehole heat exchanger delivers around 50 W geothermal energy in 1,800 hrs time, the earth provides the equivalent of 90 kWh per year for every meter installed borehole heat exchanger length.

If the heat pump is also used for hot water supply the annual operational duration is at least 2,400 hrs. This will increase the necessary length and number of borehole heat exchangers.

However it is strictly recommend to thoroughly investigate the heat demand thoroughly before the design of a geothermal heating system is planned. A good source of information are architects and other experts.

6. Borehole heat exchangers

After the drilling operation is finished coaxial borehole heat exchangers, mounted with groutinduction hoses, are installed. A pressure test is conducted to make sure that the heat exchangers are not damaged. The borehole is then filled with heat conductive cement from bottom to top.

GRD does not follow the standard approach to fill boreholes with bentonite and/or sand and/or drill cuttings, although - on a first glance - this seems to be logical and economic. This is because the borehole thermal resistance remains high, thereby reducing the heat extracting performance of the entire system. Furthermore both heat exchangers and the borehole itself can’t be properly secured with non-hardening borehole fillers.

GRD avoids that. Grouting with heat conductive grout fixes the heat exchangers “forever” and significantly reduces the thermal borehole resistance. Hence the heat extraction performance is increased and so that the overall borehole length can be reduced by app. 25 %.

Despite conventional heat exchangers (Single-U, Double-U, smooth-walled coaxials) the GRD-System also allows for the installation of state-of-the-art coaxial heat exchangers with corrugated walls (Amasond, Austria [1]) to assure turbulent brine flow (Fig. 6).

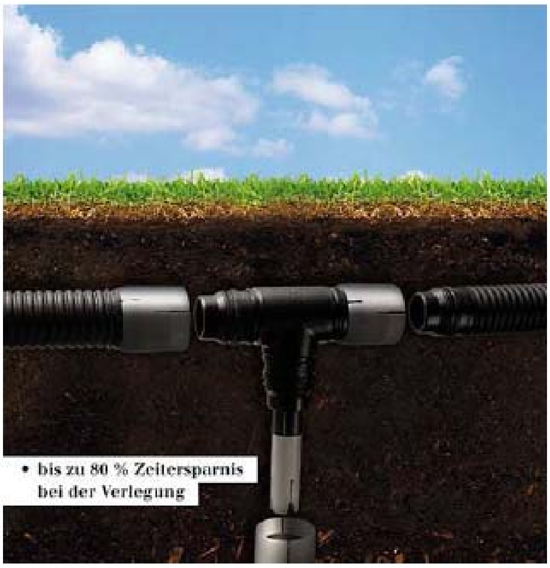

Fig. 6: State-of-the-art coaxial ground source heat exchangers that are easy to connect due to a click-system. The cold brine coming from the heat pump flows through the inner pipe down to the bottom of the heat exchanger and ascents at the inner side of the outer pipe back to the heat pump.

Due to a click-system (Fig. 6) these coaxials are quick and easy to install so that in combination with GRD the overall costs for the entire underground installation are cut by at least 40% in comparison to conventional drill technologies where double-U pipes are standard.

7. Summary

GRD allows to provide private and industrial property with a low cost geothermal system that delivers the same heating and cooling performance as standard vertical or horizontal ground source heat exchanger technologies. In addition the target group "existing property" can be accessed, i.e. a market that is four times bigger than the market segment "newly build property" (in Germany, presumably the same in the UK). Therefore GRD is a highly interesting alternative to existing technologies in terms of thermodynamic design, economical heat extraction and drilling performance.

8. Internet resources

[1] Homepage Amasond, Austria: http://www.amasond.com/de/

9. Literature

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