Introduction

With the Low Unit Cost (LUC) concept we approach geothermal development by optimizing the geothermal potential (MW_{th}) that can be harvested from a specific reservoir in a given area in a safe and cost-efficient manner. The LUC concept avoids the business tendency to maximize the output of individual installations, with associated induced seismicity risks caused by high-volumes and high-pressures. Instead, with LUC each installation is designed to acquire in-situ aquifer data while meeting heat demand at the surface location.

An innovative combination of project management, state-of-the-art techniques and best-practices in well engineering and production technology makes it possible to develop LUC installations at considerably lower costs than alternative designs currently in use. The ultimate goal is to deliver energy at a Unit Technical Cost (CAPEX + OPEX) of € 5/GJ_{th} without government subsidy. To put this into perspective: current unit-cost for high-volume gas consumers in The Netherlands is € 25/ GJ_{th} based on a gas price of about € 0,4/m^3 (partly dependant on the heating-installation these high-volume consumers use).

LUC Methodology

Each LUC development starts with drilling a pilot hole. This exploratory well is drilled with an S-type geometry that drills (near-) vertical through the reservoir target location (Figure 1). The well is logged while drilling and dynamically tested afterwards. Here we reach a decision point. The project can be stopped if the test results show that the required production rates, at low pressures, cannot be achieved when the in-situ aquifer characteristics are below the minimum requirements. If this happens, then only a modest investment is written off. If, on the other hand, the project is continued, economic viability is near-certain. The pilot hole is then plugged back and an optimized side-track is drilled with its bespoke placement in the reservoir. Most likely this well will be completed as production well. In a similar, tailored way, the injector is drilled parallel to the producer. The geometry of both wells (spacing and length in the aquifer) is based on the acquired static and dynamic data obtained from logging and testing.

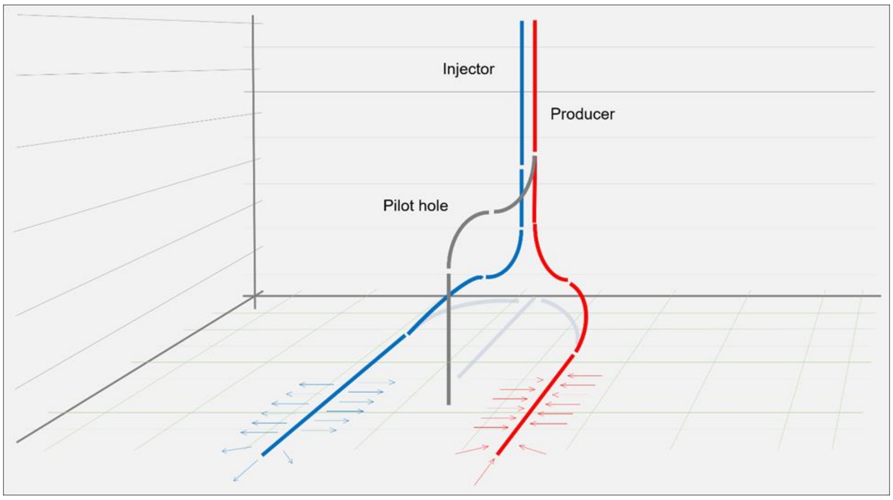

Figure 1 *LUC concept – installation geometry (illustrative, not to scale).*

LUC Benefits

LUCs have a number of distinct benefits over larger-scale developments:

- Development costs are lower and the risk-profile is narrower.
- They have smaller drainage areas in the aquifer; hence installations can be placed closer together and the reservoir can be more optimally harvested.

- Chances of induced seismicity are reduced because: a) there is less uncertainty about the aquifer after extensive production testing in the pilot hole; b) horizontal wells reach the desired inflow performance at lower pressures than deviated wells; and c) LUC installations can be economical at lower temperature ranges which means a reduction in induced stress effect caused by temperature variations.
- Targeting lower production volumes and accepting lower temperatures allow interested parties with moderate heat-demand (1-3 MW_{th}) to develop aquifers that would otherwise not be considered economical energy sources.
- The environmental footprint is smaller because: a) waste streams are smaller and b) LUC installations are very compact with most of the production facilities hidden below ground level in a multi-purpose cellar that is part of the design concept.

Examples

The economic viability of LUCs is discussed on the basis of two examples that are currently in the planning phase.
The first example is a hypothetical case for developing a 3,6 MW_{th} geothermal installation for heating 600 houses in Enschede, eastern Netherlands. The target is the Upper Carboniferous Tubbergen Sandstone Formation at ca 1700m. We estimate the total investment (peer-reviewed) at € 6,5 million. We assume that these costs can be financed against an interest rate of 4% and that heat delivered by the installation receives government funding under the SDE+ program for the first 15 years. Reservoir temperature is estimated at 63 ºC and the return temperature is set at 33 ºC. The Net Present Value (NPV) of this project is € 12,7 million, the Internal Rate of Return (IRR) is 14% and the Total Return 210% after 20 years.
The second example is a 1,5 MW_{th} geothermal installation for heating a commercial greenhouse complex in Erica, eastern Netherlands. The target reservoir is the early Cretaceous Bentheim Sandstone at a depth of ca 1500m. We estimate the total investment (peer-reviewed) at € 3,6 million, with a government participation of 20%, and 50% of the remaining investment financed against 4%. Heat delivered by the LUC installation will benefit under the SDE+ government subsidy program for the first 15 years. We estimate reservoir temperature to be 61°C and the return temperature is set at 26 °C. The NPV of this project is € 6 million, the IRR is 14% and the Total Return 166% after 30 years.

Conclusions

We presented a Low Unit Cost (LUC) concept for harvesting geothermal energy in The Netherlands and we showed the economic viability of two examples. When implemented successfully, the LUC concept can be considered a game-changer. The concept has potential for large-scale implementation for domestic and industrial heating and could provide a significant contribution to meeting reduction targets for CO_2 emission in The Netherlands under the Paris Accord and Dutch Government policy.

References

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