

Key Issues for Renewable Heat in Europe (K4RES-H)

Contract EIE/04/204/S07.38607

Deliverable 9 : Clear recommendations how to quantify the energy delivered by single geothermal installations (measuring vs. calculation) for the purpose of financial incentive schemes

The object of this report is to present a monitoring strategy for Geothermal heating plants and for Geothermal Heat Pumps (Ground Source Heat Pumps, GSHP) in order to permit the quantification of energy delivery by these single installations. Indeed, financial incentives schemes could be linked with energy delivered by geothermal energy installations, so by their efficiency.

We propose a comprehensive set of recommendations to quantify the energy delivered ; and so to provide stakeholders and policy makers with a tool to quantify the results of policies and investments in terms of energy delivery.

Our technology has to be divided in two areas. The recommendations have to be differentiated :

- for geothermal direct use systems (typically larger systems with deep boreholes >200 m) and
- for the very low enthalpy systems that use a heat pump (GSHP).

LARGE GEOTHERMAL DIRECT USE INSTALLATIONS

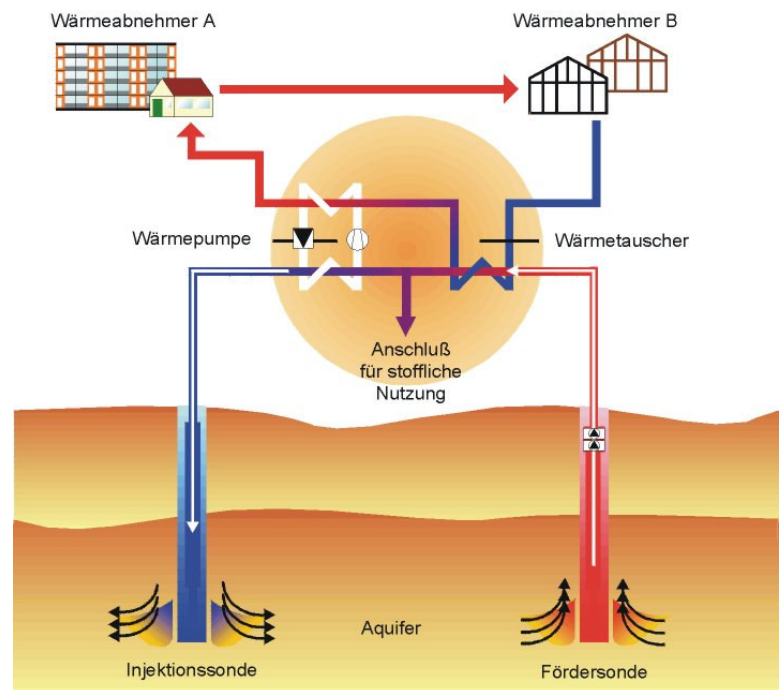
In these systems, quantifying energy delivery by measurement is recommended.

The systems sometimes are quite large (several MW_{th} of heat output) and can have a complex schematic. Here it is important to distinguish between the geothermal part of the system (typically for base load) and the additional, conventional energy systems providing peak load or back-up in case of interruptions of the geothermal production.

In larger geothermal systems, the flow volume of the geothermal water is measured, as well as the water temperatures from and to the wells.

A good measurement point would be the heat exchanger separating the geothermal water circuit from the heating system circuit.

Deep geothermal energy :
doublet system, used since the late 1970s in France and since 1984 in (Eastern) Germany



In case of deep borehole heat exchangers (BHE), the circulation flow in the BHE, and the fluid temperatures at exit and entrance of the BHE are measured.

From flow volume and temperature difference, the heat delivery can be calculated using the formula below, and can be integrated, by continuous monitoring, over the full operation period.

$$P = \rho * C_p * V * (t_{in} - t_{out})$$

With :

- P : the heat delivery [J/h]
- ρ : the volumetric mass [kg/m³]
- C_p : the mass heat capacity [J/(kg*K)]
- V : the flow volume [m³/h]
- t_{in} t_{out} : the fluid temperatures [K]

With this method, the geothermal energy delivery can be quantified rather accurately, as is done already in almost all larger installations. The subsequent steps towards the heat use may have a few losses (circulation pumps), which generally are below 5 %.

All other steps only may add energy from other sources (heat pump activation energy, energy in peak load boilers), which cannot be considered part of the geothermal energy delivery.

For the relatively large size of this kind of geothermal direct use systems, the cost for measurement equipment are acceptable.

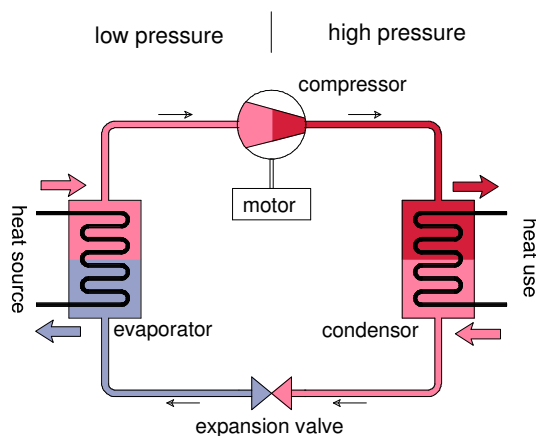
In most cases authorities will require the measuring of flow rate and temperature of water from the geothermal well as a part of the license, so this equipment has to be installed anyway.

Reporting of the data has to be done to the relevant authorities (water or mining); the data could be transferred to the statistical services either through these authorities, or by enforcing a direct communication from the plant operator.

GEOTHERMAL HEAT PUMPS (GSHP)

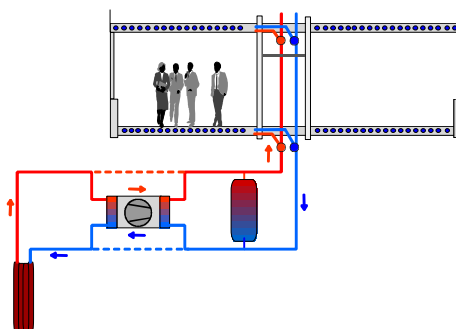
Also for GSHP, a direct measurement can be done, in particular for larger systems.

It is recommended to set a limit of heat pump heating capacity, above which a measurement and reporting should be required (e.g. >250 kW).



Schematic of a compression heat pump

For the measuring of systems using borehole heat exchangers (BHE), in the formula given above, the heat capacity of the water/antifreeze-mixture has to be considered, which typically is substantially lower than that of pure water (10-20 %). To avoid this problem, a standard procedure is to measure the heat delivery side of the heat pump, where only water is used in the heating circuit, and to deduct the energy input for the heat pump operation (usually electric power). This is a good enough approximation of the geothermal heat.



Schematic of geothermal heating and cooling system in Aix-la-chapelle

For smaller units, the measurement equipment becomes relatively expensive compared to the energy delivered, and the reporting of data from a large number of small units can cause a bureaucratic problem.

For this kind of installations, the calculation of energy delivery from the number of installed units, the size and some efficiency considerations is recommended.

For the statistics, it would be perfect to have an exact count of the number of GSHP, and the rated heating output of each; however, the number of units sold in a given year, and an estimation of the average heat output might be the only data that could be expected reasonably in most cases.

In this case, a calculation is suggested using the following formula:

$$P = N_{HP} * Q_{mean} * h_a * ((COP-1)/COP)$$

With :

- P : the annual heat delivery [kWh/a]
- N_{HP} : the number of heat pumps operating in a country, state, region, province...
- Q_{mean} : the average heating capacity (heat output) of these heat pumps [kW]
- h_a : the annual operation hours (full-load hours, depending on the climate) [h/a]
- COP . the seasonal mean COP, as an average for all heat pumps considered

The heat pump output and efficiency (COP) should be given according to standards EN 255, EN 14511, or other applicable standards of the member states. Using this formula will allow to assess only the geothermal part of the GSHP systems.

$$COP = \frac{\text{useful heat}}{\text{electric power input}}$$

For more details on the calculation method, see deliverable 8 on a methodology for the calculation of energy delivery..



CONCLUSION

It is recommended to have :

- for all larger geothermal plants (limits could be e.g.: >200 m depth, >20 °C geothermal water temperature, >250 kW heating capacity), a direct measurement and reporting.
- for all plants smaller than given before (most Ground Source Heat Pumps), a calculation based on the number of installations, mean heating capacity, and average COP.