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

Contract EIE/04/204/S07.38607

Deliverable 20 :

Proposal for the linkage of incentives to the contribution of individual Geothermal installations to the reaching of energy policy goals

In order to have a good acceptation of incentives for renewable energy in general, but here particularly geothermal energy, they need to be link to an objective.
It is clear for everybody, now with the situation of the energy market and of climate change, the acceptance will be increased but it means too that more attention also…so an efficiency will be more asked.

These financial incentives schemes should be related to the renewable energy delivery firstly because it is the purpose of the subsidy.
Secondly, they need also to avoid incentives of over-dimensioning and to give incentives for high efficiency.

But we need to underline that in non-renewable systems, delivery of heat is usually not measured. So the measuring of heat delivery in RES-H systems should not lead to excessive costs, thus discouraging RES-H.

It's why we have also to work on a reasonable approximation to reach this criteria.

Principles for the linkage of incentives to geothermal installations

Measuring of energy yield should be required as a condition for the Financial Incentives Schemes (FIS) when :

- the systems have a size where measurement of heat delivered is usual also in conventional heating systems
  examples : large heating systems with ESCO contracts…

- or when the measurement of energy yield is a current praxis in the RES-H sector because its costs are lower than the benefits in terms of monitoring & optimisation of the RES-H system itself

When these two conditions above do not apply, an approximation through a calculation based on technical parameters should be applied.

For Geothermal Energy, different possibilities exist to link the FIS :

- for the district heating : the energy delivery, but also the number of buildings and apartments connected (in square meters : m^2)

- for the heat pump : the energy delivery, according to the number of units, the heating capacity, and the Coefficient Of Performance (COP)

- for the drilling costs : the number of meters drilled

For the geothermal energy delivery in district heating systems, the production (TJ) is the difference between the enthalpy of the fluid produced in the production borehole and that of the fluid eventually disposed of (re-injection borehole).
When considering the connected heat load, the number of apartments, area (m^2), etc. can be used as an indicator, not neglecting the fact that there is typically peak load and back-up from other energy sources.

For the smaller systems (mainly geothermal heat pumps, GSHP), the energy output of the installations can be used.

Some basic data permit to calculate the energy production :

- with an average capacity (e.g. 5-20 kW_{th}),
- with assuming a seasonal COP (e.g. 3-4)
- and with a number of equivalent full-load hours per year (e.g. 1,800-2,200 h/a)

A suitable formula is:

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

With :

- P : the annual heat delivery [kWh/a]
- Q_{mean} : the heating capacity (heat output) of the heat pump [kW]
- h_a : the annual operation hours (full-load hours, depending on the climate) [h/a]
- COP . the seasonal mean COP

The heat pump output and efficiency (COP, see appendix) 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.

For the reason of FIS, it is not important to look only at the geothermal fraction of the heat supplied, provided a minimum COP is made mandatory (e.g. an annual average COP of 3.8).

Sometimes, International Institutions consider geothermal energy in reporting only geothermal energy that is for direct use. Production (TJ) is then the difference between the enthalpy of the fluid produced in the production borehole and that of the fluid eventually disposed of (re-injection borehole).

A methodology to link incentives to energy delivery could also be found in the drilling part. The length of the BHE is an important criterion for the installation, its costs and its energy production (see appendix). So by reporting the meters drilled or the meters of BHE installed, a measurement for the success of the FIS can be found.

To link the meters of BHE to heat production, as a very rough approximation it can be said that 1 m of BHE can supply ca. 50 W, i.e. as an annual production ca. 0,1 MWh.

The Financial incentives schemes

There is a wide variety of economic instruments which support the enhanced use of geothermal energy in Europe ; and could be linked to the contribution of individual geothermal installations to the reaching of energy policy goals.

There is an immediate need to highlight the economic discrepancies on the Community level and to urge Member States harmonising financial solutions in reaching their indicative targets, and in improving the energy mix for being less dependent on outside sources.

The arsenal of supporting instruments is colourful, including tax exemptions, guaranteed take-over prices, green certificates, direct subsidies, to mention a few :

* the Swiss Federal Office of Energy sustained a heat pump promotion program in the years 1990 – 1997. For the installation of heat pumps to replace fossil-fuel heating systems a subsidy of 300 CHF (200 €) per kWe was contributed.
Nowadays, a large number of communal and cantonal utilities provide similar subsidies. This led to a veritable boom of ground-coupled heat pumps.
A decisive role in boosting geothermal direct use by heat pumps could be played by the utilities. An example to be followed is given by the Swiss EKZ (Electricity Company of Canton Zurich): it provides "Energy Contracting" which means that EKZ installs, owns, and operates the system and sells the heat (± domestic hot water) at a fixed price to the building owners.

* In Germany :
In Bavaria for example the following subsidies for heat pump systems were available in the year 2003. € 150 for every installed kilowatt of heat capacity in existing buildings, if the heat-distribution system is adapted at the same time € 100 for every installed kilowatt of heat capacity in every other case. The maximum support is 25% of the concerned investment costs but maximum € 12.500 per heat pump system.
In Brandenburg the use of heat pump systems for hot water preparation or/and for heating is supported. The level of supportive measures goes up to 30% of the investment costs, but it is limited to 613,55 Euro/kW proven heat demand. The maximum amount per system is 102.258,35 Euro. The seasonal performance factor of the system has to be at least 3,8. This has to be proven for every concerned project.
The only direct support measure for geothermal heat pumps on the federal level was part of the Market Stimulation Programme. In the years 1995-98, a subsidy was paid per kW_{th} of installed heating capacity. The amount started with 300 €/kW_{th} and was decreasing to 200 €/kW_{th}, before the programme was phased out in 1999.

The subsidies where also subject to certain standards:

- the heat pump installation must be built to achieve a minimum annual COP of 3.5, increasing up to 3.8 during the course of the scheme; this had to be certified in the design plans by an engineer

** France :*

The tax breaks is 40 % for a heat pump. The GSHP needs to have a COP ≥3.

The summary of existing tools in Europe :

- Tax exemptions/reductions exist in Hungary, France
- Loans are possible in Germany, Lithuania (theoretically) and Slovenia
- Direct subsidies in Belgium, Germany (limited), Lithuania and Slovenia
- Indirect support in most countries
- Guaranteed feed-in tariffs (yet for electricity only):
  - Germany: 8-15 €-ct/KWh
  - Hungary: ca, 12-14 €-ct/kWh
  - Slovenia: 5.86 €-ct/KWh
  - Austria: ca. 7 €-ct./kWh
  - Lithuania, Latvia have obligation to purchase power from RES (but not from geothermal in Lithuania)
- Green Certificates in Hungary and Romania
- Carbon credits in Romania (first positive experiences in geothermal, with Denmark as partner; 5 €/t CO_2 avoided); in Germany, Poland etc. they exist, but do not yet have impact for Geothermal
- Covering the geothermal risk, it is crucial for private investors

From this, we distinguish 3 successful tools:

- Loans/subsidies for installation
- Feed-in tariffs (with related regulations on grid connection etc.)
- Carbon credit trading as an external help

CONCLUSIONS

Definitely more supportive governmental policies and efforts are needed to speed up the development of geothermal resources for direct use. Only by these means can their great potential be tapped and utilized.

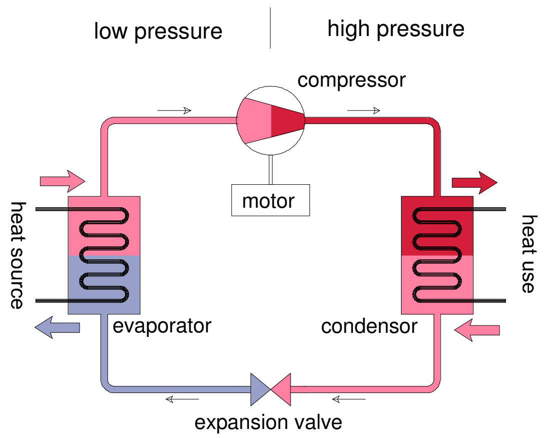
And it is possible to link these incentives to the contribution of individual geothermal installations : deep or shallow geothermal energy.

The choice between measuring or calculating the energy delivered is explained in the deliverable 9 : Clear recommendations how to quantify the energy delivered by single geothermal installations (measuring vs. calculation) for the purpose of financial incentive schemes.

APPENDIX:

The Coefficient of Performance

A heat pump is a devise which allows transport of heat from a lower temperature level to a higher one, by using external energy (e.g. to drive a compressor). The most common type of heat pump is the compression heat pump as shown in the figure.



Schematic of a compression heat pump

The thermodynamic principle behind a compression heat pump is the fact that a gas becomes warmer when it is compressed into a smaller volume. This effect is common experience e.g. for cyclists when adjusting air pressure in the tyres: The air pump gets warmer in the process.

In a heat pump, a medium with low boiling point ("refrigerant") is evaporated by the ground heat, the resulting vapour (gas) is compressed (by using external energy, typically electric power) and thus heated, and then the hot gas can supply its heat to the heating system. Still being in the high pressure part, the vapour now condenses again to a liquid after the useful heat has been transferred. Finally, the fluid enters back into the low-pressure part through an expansion valve, gets very cold and can be evaporated again to continue the cycle.

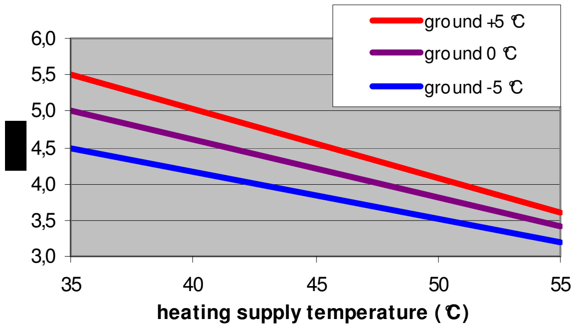
An alternative is the absorption heat pump, where heat at higher temperature (e.g. from a gas burner) is used to activate, by boiling a gas out of a liquid, a desorption-absorption cycle, which again offers a low-temperature side to take in heat from the ground, and a high temperature side to supply heat to the user.

In both cases, the amount of external energy input, be it electric power or heat, has to be kept as low as possible to make the heat pump ecologically and economically desirable.

The measure for this efficiency is the COP (Coefficient of Performance). For an electric compression heat pump, it is defined as:

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

The higher the COP, the lower the external energy input compared to the useful heat. COP is dependent on the heat pump itself (efficiency of heat exchangers, losses in compressor, etc) and on the temperature difference between the low-temperature (ground) side and the high-temperature (building) side.



Exemplary graph of COP versus heating supply temperature

COP can be given for the heat pump under defined temperature conditions (e.g. 5 °C ground / 35 °C heating supply), or as an average annual COP in a given plant, also called SPF (Seasonal Performance Factor).

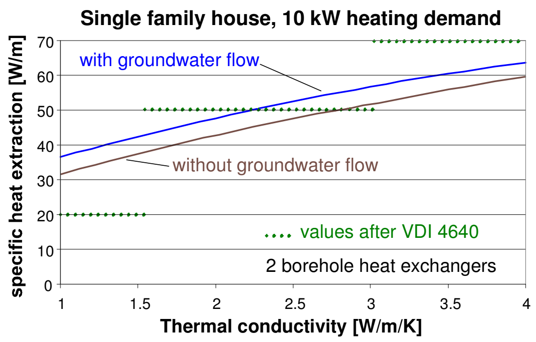
Design of the length of borehole heat exchanger

The design of borehole heat exchangers for small, individual applications can be done with tables, empirical values and guidelines (existing in Germany and Switzerland).

A popular parameter to calculate the required length of borehole heat exchangers is the specific heat extraction, expressed in Watt per meter borehole length.

Typical values range between 40-70 W/m, dependent upon geology (thermal conductivity), annual hours of heat pump operation, number of neighbouring boreholes, etc. With the known capacity of the heat pump evaporator, the required length can easily be calculated:

$$Length\,[m] = \frac{HP\ evaporator\ \ capacity\ \ \ [W]}{specific\ heat\ extraction\ \ rate\ \ \ [W/m]}$$

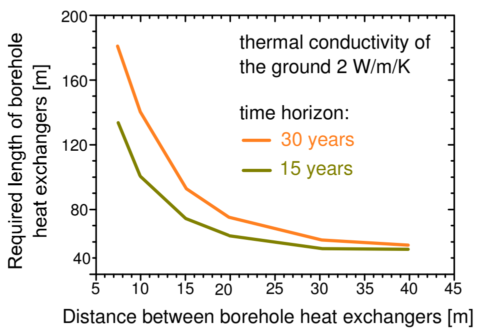


Example of specific heat extraction values for a small ground source heat pump, no domestic hot water (heat pump run time 1800 h/a); VDI 4640 is a German guideline for ground source heat pumps

For larger borehole heat exchanger plants, for all cases with heating and cooling or with more than ca. 2000 h/a of heat pump operation, calculations have to be made to determine the required number and length of borehole heat exchangers. Programs for use on PC exist in USA and Europe, and for difficult cases, simulation with numerical models can be done.

A standard software tool for design of borehole heat exchangers is the "Earth Energy Designer" EED, a Swedish-German development.

With a large number of small plants, a smaller distance between the boreholes makes deeper borehole heat exchangers necessary:

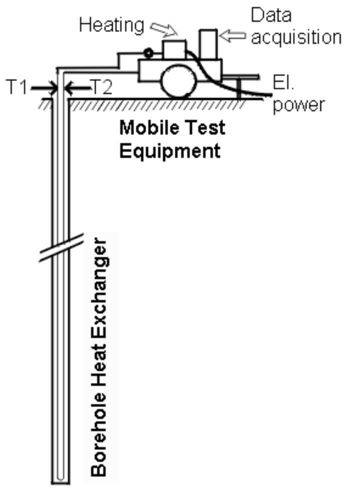


Required borehole length in a field of 60 houses (7 kW heat load each) with 2 borehole heat exchangers for each house; no groundwater flow, no artificial thermal recharge

The main underground parameter for design of borehole heat exchanger plants is the thermal conductivity. This value can be estimated from the type of rock at a given site, but it can also be measured directly in situ.

The relevant tool is called **"Thermal Response Test"**. A given, constant heat load is injected into a borehole heat exchanger, and the resulting rise of temperature is measured over at least 48 hours.

The thermal conductivity then can be calculated using the slope of the temperature curve over logarithmic time.



Schematic of Thermal Response Test