

Really, what is that Geothermal Energy?

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ABSTRACT

‘There is no internationally accepted definition for geothermal energy.’ – could be read still a year ago on the former website of the IGA that was followed by the remark: ‘This is rather unfortunate.’ I agree. The current IGA website speaks only about geothermal, without energy, saying that it is the natural heat of the Earth. This seems to be all right but the upper part of the Earth, i.e. close the surface is usually cold or cool in terms of the temperature, which humans would never call hot, so using the word ‘heat’ is a bit strange. GRC shares on its webpage similar description for geothermal namely ‘Geothermal Energy is heat (thermal) derived from the earth (geo)’. According to the legislation in force in Europe ‘Geothermal energy is the energy stored in form of heat below the earth’s surface.’ that immediately raises the question how a type of energy, which is ‘stored’ only, can be renewable. After having been puzzled by all this confusion the author attempts to propose an alternative definition of geothermal energy based on the conception of internal energy.

1. INTRODUCTION

‘Why on earth is the writer so interested in such a marginal issue like the definition of the geothermal energy?’ – anybody may ask. ‘Geothermal is simply the heat of the earth, why does anybody want to create a (new) definition on it?’

Well, probably because I’ve been involved in the geothermal business for over 33 years, or probably because I’ve been involved in legislation about the geothermal energy. Due to the fact that geothermal energy is the subject of the mining law in Hungary and, especially, royalty must be paid by any geothermal users that extract heat from the earth, the problem of the proper definition of geothermal energy is quite important.

I personally wouldn’t say that I don’t agree with the definitions above. Certainly, each contains the essence of the geothermal energy. Yet, they are not more than descriptions on the meaning of the word ‘geothermal’, which is, in fact, a definition itself, i.e. the shortest wording of the heat from the earth.

In spite of all mentioned above I’m going to try to give an alternative solution for the definition of geothermal energy based on the concept of internal energy.

2. THE INTERNAL ENERGY

Any mass of material, object or body whose temperature is above the absolute zero degrees (-273°C) contains internal energy. Therefore any of those can be the object of heat extraction.

In thermodynamics, the internal energy of a system is the total energy contained within the system. It is the energy necessary to create or prepare the system in any given state, but does not include the kinetic energy of motion of the system as a whole, nor the potential energy of the system as a whole due to external force fields which includes the energy of displacement of the system's surroundings. It keeps account of the gains and losses of energy of the system that are due to changes in its internal state.

The First law of thermodynamics states that the internal energy can be changed in a system by doing work on it, adding/removing heat from it, or a combination of the two.

The internal energy of a system can be increased by introduction of matter, by heat, or by doing thermodynamic work on the system. When matter transfer is prevented by impermeable containing walls, the system is said to be closed and the first law of thermodynamics may be regarded as defining the internal energy as the algebraic sum of the "heat added to" and "work done by" the system on its surroundings. Expressed by the formula:

$$\Delta U = Q - W$$

where ΔU : change in the internal energy
 Q : added heat to the system
 W : work done by the system

Given that external work on (or done by) a solid geological medium is hardly possible, the change in the internal energy of the earth, i.e. practically only a small part of it, considering a thermal system is directly proportional to the change in its temperature state. In this way, it can be brilliantly described that when, for example, the energetic utilization of groundwater that after having been cooled down is fully reinjected back to the aquifer, the temperature of the rock matrix together with the groundwater contamination of it decreases, so does the internal energy of the earth. Figure demonstrates the interrelation between the temperature and the internal energy of the rock matrix.

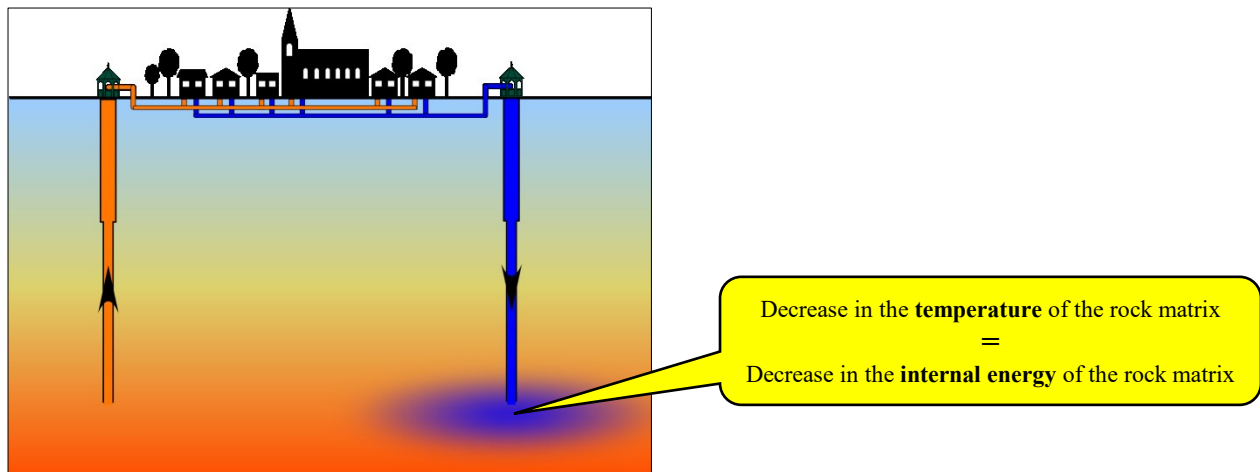


Figure1: Interrelation between the temperature and the internal energy of the rock matrix

Based on the concept of the internal energy a simple definition on geothermal energy can be worded as follows:

‘Geothermal energy’ means the internal energy of the earth.

I’m convinced that it is accurate enough and general and considerably short as well.

3. DEEP AND SHALLOW: NEW PARTITION OF GEOTHERMAL ENERGY

The partition of geothermal energy was not known at the time the IGA was founded in 1988. Geothermal energy at that time was automatically understood to mean a high-temperature source of energy. Up to now, affiliate member organizations of the IGA represent countries primarily engaged in high-temperature geothermal energy utilization. The international geothermal community gathered in the IGA represents the conventional high-temperature utilization of geothermal energy. However, times are changing. What do people think of the geothermal energy today?

If you stop someone in the street of a European settlement and ask him/her what the ‘geothermal energy’ is you will most likely get the answer that it is something that you can heat up your house with. Just then you may get the addition to the response that it requires heat-pump.

If you type the word ‘geothermal’ into an internet search engine most of the matches will be in connection with the shallow geothermal, i.e. the use of the earth’s heat via heat pumps. It is quite understandable if we consider that internet search engines are based on the quantity of something that people use and the number of heat pumps is far more than the number of geothermal applications.

It seems that geothermal somehow binds better to the heat pumps than to the use of really hot resources.

3.1 The Swedish example

If you had visited the IGA’s homepage some 15-20 years ago you might have noticed that Sweden was the second largest use of geothermal energy via heat pumps with the installed capacity of 10 000 MW. However, it was not 100% truth. The 10 000 MW represented the total installed capacity of the heat pumps independently from the source of the heat. In fact, in Sweden, majority of the thermal energy produced by heat pumps based on hydrothermal (surface or sewage water) resources and shallow geothermal systems provided only a minor part of the heat energy. Still, the whole geothermal community celebrated Sweden for achieving such a fantastic result. Nobody cared about the reality that not all of the 10 000 MW derived from geothermal resources. Even the international geothermal community was so fascinated by the rapid growth of energy production that the need for attachment to reality was overshadowed. Those times every single kW_{th} produced by heat pumps was automatically deemed to geothermal capacity. It seemed as if geothermal were equal to heat pumping.

Fortunately, this bad practice has since ceased and statistics have returned to normal. According to the most recent data the heat produced by heat pumps from geothermal resources in Sweden is shown on **Error! Reference source not found.**Figure. It is to be noted that with its 5,6 GW installed capacity Sweden is the second largest producer of direct heat based on geothermal resources.

Interestingly, however, Sweden does not consider itself a geothermal country. Swedish experts hardly participate in international geothermal public life and even the IGA does not have a Swedish affiliate member.

3.2 Deep geothermal with shallow temperature?

Ever since the concept of shallow geothermal was introduced it has been known as an extremely low temperature source of ground heat, which can only be used for heating purposes with the temperature transformation by heat pumps. Sweden is probably the only country in the world where the temperature (20-22°C) of a deep (600-800m) geothermal resource is insufficient for the simple heat

exchange between the geothermal side and the secondary heating loop. The famous geothermal district heating system in Lund uses heat pumps to increase the temperature, too.

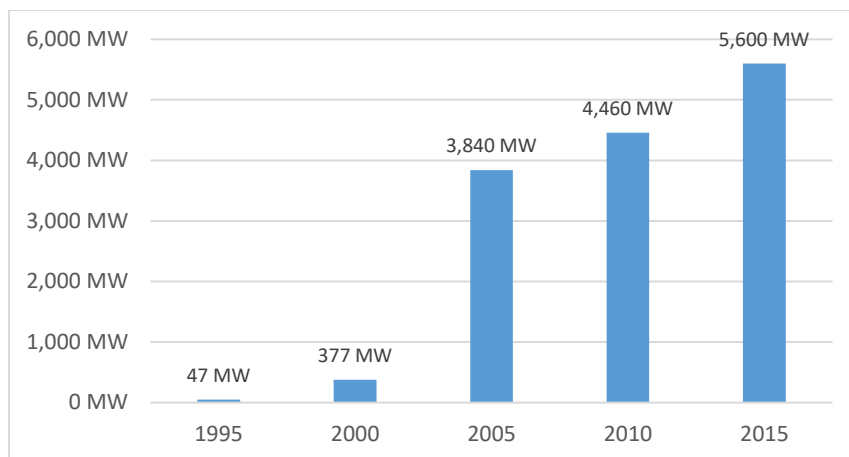


Figure 2: Evolution of the geothermal heat pump capacity in Sweden

4. HOW THE SHALLOW GEOTHERMAL IS DEFINED IN DIFFERENT COUNTRIES?

There are at least three different approaches to determining shallow geothermal energy.

- One is based on the maximum depth of drillings where geothermal energy is extracted from. The deepest known figure is 500 m.
- One is based on the maximum underground temperature. For instance, if it is below 20°C the type of geothermal resource is considered to be shallow geothermal one independently from the real depth.
- One is based on the technology of the utilization. No matter from which depth and at what temperature the geothermal energy is available if heat pump is required to raise the temperature to a suitable level it will be considered to be shallow geothermal resource.

The last example is particularly interesting as it takes us into the field of ambient energy.

5. DOES THE SHALLOW GEOTHERMAL BELONG TO THE GROUP OF AMBIENT ENERGIES?

According to the Directive 2009/72/EC of the European Parliament and of the Council the definition of the ambient energy is the following:

‘Ambient energy’ means naturally occurring thermal energy and energy accumulated in the environment with constrained boundaries, which can be stored in the ambient air, excluding in exhaust air, or in surface or sewage water;

In my opinion, ‘thermal energy’ in the definition could be replaced by internal energy here too, but I don’t want to go into that anymore.

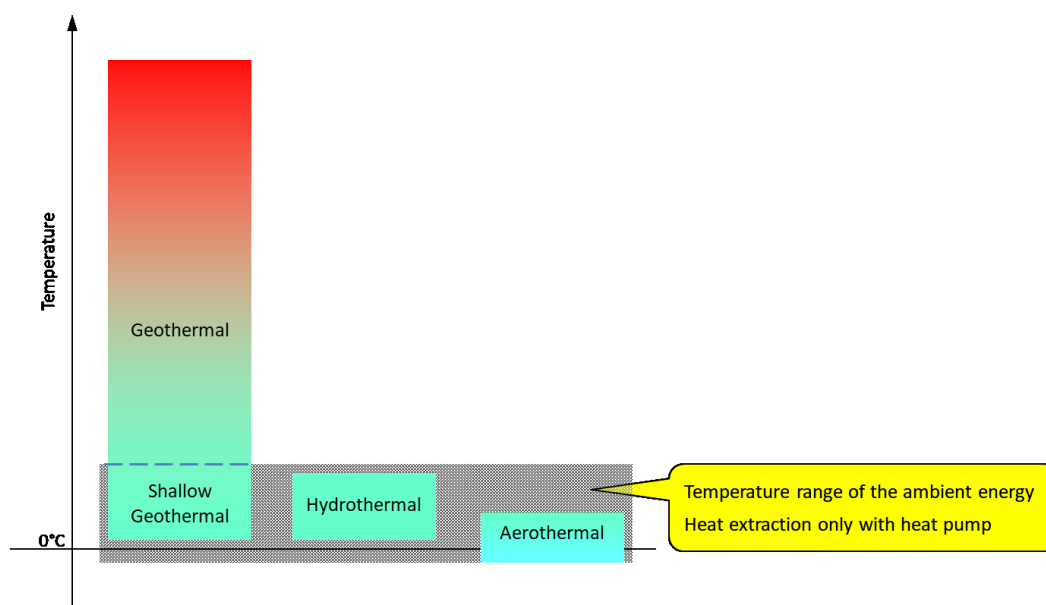


Figure3: Correlation between shallow geothermal, the hydrothermal and the aerothermal energies

What is interesting about our topic is how shallow geothermal energy relates to other ambient energies. The temperature level of shallow geothermal energy and ambient energy are nearly the same, and equivalence between them is created by the need to use heat pumps. **Error! Reference source not found.** demonstrates how the shallow part of geothermal energy extends into the temperature range of the ambient energy where heat extraction can solely be performed with heat pumps.

If we try to answer the question in the title of this chapter we must say that from technical point of view shallow geothermal is one of the ambient energies.

4. CONCLUSION

My goal with this article was to draw the attention of the international geothermal community and the IGA to the unacceptable situation that geothermal energy has no internationally accepted definition. I would like my article to make progress in this area. Of course, I do not insist on adopting the definition I proposed. However, I would find it useful to use the ‘internal energy’ to replace words ‘heat’ and ‘thermal energy’ (also as heat).

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