The Litho-Jet method - the economical realisation of the geothermal power systems

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Litho – Jet metóda – ekonomická realizácia systému geotermálnej sily

Currently, there is a global problem of an increasing need of energy. There will be less fossil fuel, which will be more expensive in the future. The regenerative energies are becoming more and more important. The subject deals the problem of economical feasibility of geothermal energy systems. Its goal is to analyze necesary conditions and aspects of realizing geothermal energy systems in comparison to and competition with traditional energy sources.

The geothermal energy recovery is economically advantageous if the investment costs, esp. the drilling costs, could be reduced significantly. It only seems possible to open up a big opportunity for realizing geothermal energy systems by using a rock melt drilling technology, to reduce the investment costs significantly.

Key words: *Litho-Jet method, regenerative energies, geothermal energy*

Introduction

With increasing lack of fossil fuel and with acceptation problems of the nuclear energy grows the importance of renewable energy resources. Within these has the geothermal heat important position, because in contrast to the other renewable energy resources, its potential is globally, continually and sustainably available.

The effective utilization of geothermal energy could significantly contribute to the solution of the actual economical and ecological problems, or even resolve them partially. Nevertheless should be the earth crust utilised economically and purposefully as the inexhaustive energy resource. From the experience with the continual deep drilling we have learned that the earth crust in the middle third consists of an inexhaustive staem reservoir, which could theoretically enable all the countries of the world to use explicitly own geothermal energy resources on the principles of Hot-Dry-Rock.

For this purpose are developed new geothermal energy systems which in comparison to the actual utilization of the geothermal energy require a giant leap in technical and economical realisation. The essential technical elements that are important for the realisation of such systems have been developed differently. The current primary bottleneck for realising such geothermal energy systems is a useful drilling technology.

The drilling technology – as the keytechnology and important condition of the economical realisation – is based on the long-year experience of the Rotary drilling method practically and economically developed in oil industry. Though it is not enough for depths necessary to achieve there are effective and economical solution for such geothermal energy systems. The purposeful method that meets the economical reguirements seems to be the Litho-Jet method, based on the flame melt technology, developed in Slovakia and Germany. It takes advantages of the natural givenesses of the underground mineral block, what enables a relatively fast, economical and direct progress.

The economically relevant boundary conditions

Whether the geothermal energy systems will be in the foreseeable future economically competitive in comparison to the existing technologies, depends mainly on two circumstances:

a) the development of fuel prices,
b) the employment of the economically relevant drilling technology. The best actual choice seems to be the Litho-jet technology.

The determining factor could be also the better price situation in the production of the geoenergy per consequences of the global costs decreasing by reason of faster building of geothermal devices in Europe.

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The sensitivity analyses and the cost analyses, which were executed, depend on the medium-term exemplary market development scenario in Germany. Then the presumption is valid that in the following 15 years there are going to be built about 20 geothermal devices with a year's production of ca 50 GWhth/a with the heat output untill 100 °C and the aggregated invested capital 200 Mio.€/a there. The literature says that from the potential 1000 PJ/a = 278 TWhth/a would be used about 3 % by 2020. This scenario seems to be quite optimistic. But it suits the prognosis done by experts that expects in 2005 a profit 500 GWhth from geothermal sources.

As to the estimation of the expectable medium-term costs of the heat energy production in the geothermal systems in Germany – without using the inovative Litho-Jet drilling technology, refers Tab. 1. based on a sensitivity analysis

Tab. 1. The expected medium-term costs of the the heat energy production in the geothermal systems in Germany.

2500 m – gradient in °C/100 m total output in MWth heat production costs		€/MWhth 3,5	14,6	26
Total investment Drilling expenses Duties Full utilization time Pumping of thermal water Reduction of Drilling costs	5,5 – 11,05 – 13 Mio. € 2,3 – 4,5 – 5,4 Mio. € 2 – 6 – 10 % 2000 – 6000 – 8000 h/a 25 – 75 – 100 m³/h -15%	21 24 23 53 40	26 26 26 26 26 25	28 27 30 23 24

Source: Schaumann G. (2002), S. 32 i.V.m. appendix 2

a) The costs of the energy production in the conventional devices according to the present prices

The conventional heat supply is nowadays being realized for ca. 20 €/MWhth in a low temperature heating network (70 °C/45 °C) at 1900 h/a and for about 10 €/MWhth in an industrial heating network (110 °C/60 °C) at 3500 h/a. As the heating networks usually dispose of delivery temperature 90 °C and the return flow temperature 55 °C and more, in the analysis the geothermal devices were quivalently designed. The calculated gas price was 25 €/MWhbs. For the consumption in amounts comparable with the geothermal heating plants is the price of Gas about 20 €/MWhbs. These prices are interconnected with the oil prices and they underlie their development. As the geothermal energy substitutes the gas as the fuel, should its price be considered as the competitivness. On the other hand the geothermal energy should not be sold for more than 20 €/MWhth to stay competitive without a subsidy.

The only logical conclusion, how it is possible to compete with the conventional heat production (with normally developing oil prices) is a significant cut-down of the investments, and the drilling costs as well, what expects an important technological drilling innovation using the Litho-Jet technology.

b) the costs of the heat production in other regenerative energy systems

The acquisition of the geothermal energy in Germany is in comparison to alternative regenerative ways of heat productin relatively advantageous. Geothermal heat is in contrast to another regenerative energy systems globally and continually available, what implies that there are no problems through the accumulation or transportation.

An optimisation of a common production of electricity and heating seems to be possible but the competition at the world energy market has to be free from public regulations like subsidies or subventions. Currently, the price of geothermal energy should not exceed 20 €/MWhth to be competetive with traditional energies.

The geothermal heat production is according to the present technological possibilities still an expensive option. Its costs lie today above the costs of wind energy, water energy and bioenergy but high above the production costs for the fossil fuel. The estimated costs of the production of geothermal energy are in a large degree influenced by applied assumptions. The advantageous conditions result in lower costs. The costs of the effect of change for the Litho-Jet technology is currently non-chargeable, because its practical use has been realised only in laboratory.

From the enviromental point of view is using of geothermal energy almost harmless and has a lot of advantages. Amongs all quantitatively examined effects on the environment – the greenhouse effect, acidification, the consumption of primary energy- is the geothermy at least as advantageous as the others renewable energy resources. Concerning the CO_2 emissions, is the geothermal energy production, in comparison with the energy production from the fossil fuels, much better.

Economical aspects of the production of the geothermal energy

The economical effect of the geothermal energy on the electricity production is on Tab. 3.

The greatest potential for the geothermal energy results from the earth (terrestrial) heat, which is fixed in dry and waterproof hot rock in the underground (Hot-Dry-Rock (HDR) system).

Although have been reached depths until about 10 000 m, the geological experts estimate the frontier of current technical and economical possibilities on 7000 m.

In principle it means that independently of the economical efficiency of the drilling method is for the competitive production of a HDR-system relevant:

- The temperature of the underground mineral massif in the depth of 5000 m should be at least 180 °C to enable the relevant technical and economical degree of effectivity of the heat transfer.

- The effectively usable heat transfer surface in the underground should exceed 3 km^2.

- The free width of the heat transfer interstice should be at least 1,5 mm, so that the energy input would be economical for the water circulation

- The relation between minimal and maximal main tension should be higher than 0,75 so that the system could operate without a significant water loss

- The circulation rate should be optimally reviewed. With an usable heat transfer surface of 5 km^2 the circulation rate 75 untill 100 $l.s^{-1}$ seems to be more efficient

The model calculations are here expecting very low costs of the geothermal electric power. Accepting the more realistic entries about the output of an underground HDR-system, we get costs of 0,107 €Cent for one kilowatt-hour. The output of a HDR-heat exchanger must be stable over a long period of time. On the other hand are the HDR-systems still in the beginning of their technical and economical development.

To achieve a competitive working of HDR-systems, the following (not yet realised requirements) have to be accomplished:

- The formation of the heat transfer surfaces of 5 km^2 an more in appropriate underground environs. Currently the largest one in Soultz-sous-Forets is 3 km^2.

- The circulation rate through a HDR- heat exchanger between 50 and 100 $l.s^{-1}$. Already realized is 20 – 30 $l.s^{-1}$.

- The resistance in an underground HDR-system about 1 bar pro $l.s^{-1}$. In Soultz-sous-Forets was measured 3 bar pro $l.s^{-1}$.

- The water losses in the underground should be 10 % and less. This was several times achieved but it is determined by tectonic conditions.

- The employment of an innovative, economical drilling technology as a key technology.

The important technical elements that are required for an achievement of an integrated geothermal power production system are nowadays characterized by different development phases.

The drilling technics has been technologicaly improved on the basis of long-term experience with Rotary-drilling in oil and gas industry. Though it is still not enough to reach the economical effectiveness of the underground geothermal energetical systems. The conditions 7000 meter under the ground are for conventional drilling connected with such enormous costs that it would be impossible to reach an energetical effectivity. Here is an innovative, different drilling technology required. Currently it seems that only by using of Litho-Jet technology it is possible to fulfill the demanded economical conditions.

The central costs of realisation of geothermal energetical systems result currently from very high costs of drilling. This is valid for the implementation of underground probes and the construction of deep wells as well. The greatest problem of an effective realisation is the drilling technology.

Tab. 2. The economic importance of geothermal energy

Type	Feature	Technological problems	Ecological stress	Current usage	Accessing potential
Heat from plane underground	Between 8 und 100m depth is the tepmerature of the ground without seasonal swing 10°C untill 16°C.	High Installation costs, bad heat exchange in ground (e.g. ca.50 W pro meter drilling)	any	ca. 2.000 single devices in Switzerland	Supply of decentral housing units with heat; everywhere usable; better utilization of electricity for heating.
hydrothermal natural convective Systems	With water/steam filled permeable reservoir rock of the topmost crust in area of geothermal anomalies; fixed on young magmatic intrusions in underground				
Hot steam		(fully developed, economically feasible)	by incondensable gases, especially CO_2, H_2S, SO_2; medium CO_2-stress 50 g/KWh, 1/20 of the stress in coal power plants; H_2S is in Stretford-process bound and removed	Production of electric energy, currently in The Geysers and in Larderello installed power plant capacity of about 3.300 MW	Dry steam deposits are bounded in several by vulcanism affectet areas; by further accessing of such areas could be in some of lands covered the total energy consumpotion; in the particular depostits, the exhaustion signs indicate a more-year operation.
Hot water (< 90°C)	Filled with water, permeable reservoir rock in area of anomalous geothermal anomalies in underground	Corrosion and precipitation in all power plant componentscaused by high mineralization, mainly chloride, sulphates, carbonate and fluoride (fully developed, economically feasible)	by incondensable gases, especially CO_2, H_2S, SO_2; CO_2-stress is low (50 g/KWh); H_2S is removed in Stretford- process.	Production of electric energy under temperatures of over 180°C, worldwide ca. 3500 MW installed power; few Locations e.g. Wairakei, Philippinen and Kenya.	In many zones affected by vulcanism, there exist extensive deposits; nowadays they are only particullary used; their utilisation could be even hetter, when the problems with corrosion and precipitation would be eliminated.
Warm water (< 90°C)	Filled with water, permeable sediments as deposits in areas with higher geothermal gradient in underground, generally deep settling reseroirs	High Mineralisation (fully developed, economically feasible)	irrelevant	For heating systems and procedural heat in Paris reservoir, Neubrandenburg at Temperatures of over 60°C; for thermal resorts or greenhouses with rising importance at temperatures untill 60°C	Geothermal water can be expected in many deep settling reservoirs; existing hot water centres in Paris or in north Germany are working at the border of economic feasibility, they substitute power plant capacities and contribute to the environmental protection; in the industrial countries the demand for the thermal resorts rises; widespread utilisation in the agriculture.

Source: Rummel F., Kappelmeyer O. (1993), p. 21

Currently only by economically directed selection of drilling technology is a significant change in the expense of reduction possible. The appraisal of suitable drilling technology for an accession of geothermal resources, followed by relevant requirements on expenses in conventional deeps, offers following possibilities:

- rotary drilling ,
- PDC – kit,
- pneumatic hammer,
- hydraulic hammer.

Tab. 3. Costs of alternative energy production.

Type of energy	€Cent/kWh
Oil	3 - 4
Gas	3 – 4
Nuclear energy	1 – 2
Water power	7 – 9
Wind power	6 – 9
Hard coal	3 – 4
Brown coal	3
Solar	6 – 10
Biomass	6 – 7
Photovoltaik	58
HDR- System	0,107

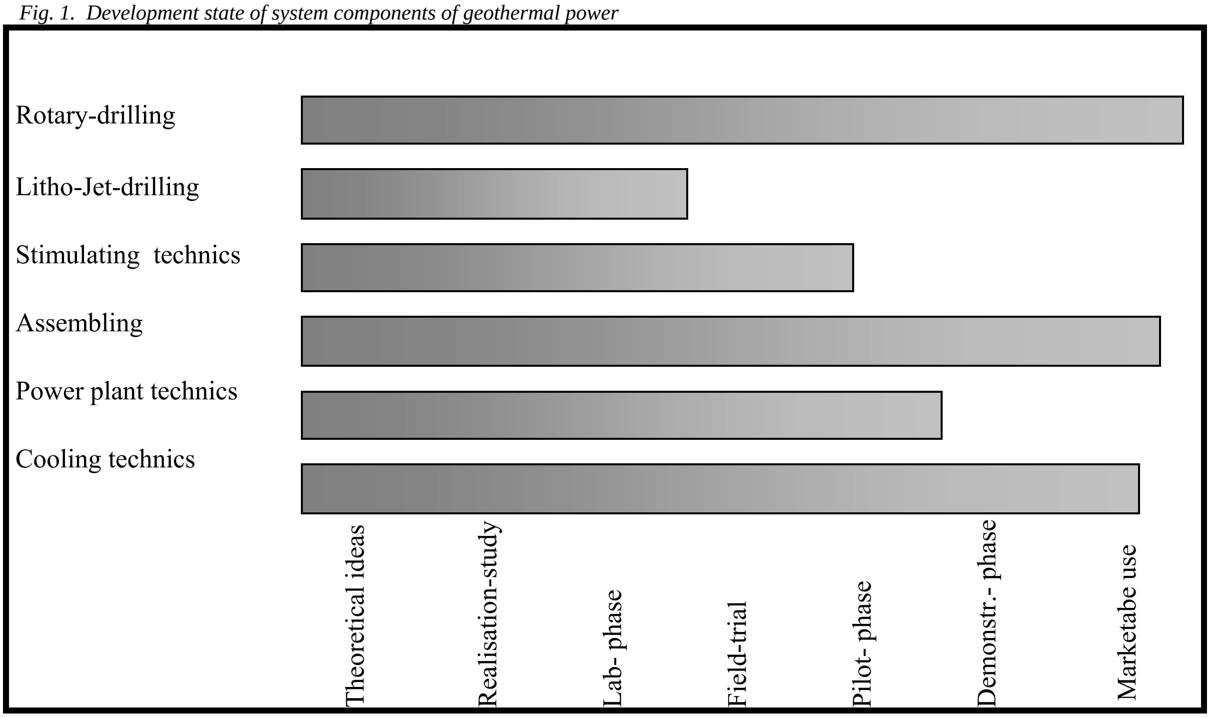
Sources: with reference to Kaltschmitt M., Nill M., Schröder G., Rogge S. (2002), S. 139 ff.; Heinloth K. (1997), S. 364 as well as own estimations.

For accessing depths of more than 4000 m in strategically interesting and relevant geothermal territories, aside from Hot-Dry-Rock (HDR), Hot-Wet-Rock (HWR) or Deep-Heat-Mining (HDM) only the flame melt technology (the Litho-Jet methot) seems to be acceptable especially from the economical point of view.

From the analysis of the prevailing drilling technologies results the following:

- In depths untill 200 m (EWS area) the pneumatic hammer drilling is two times faster than the rotary drilling
- Immersional drilling decelerates with the depth (ROP: 0-30 m = 50 $m.h^{-1}$, 100m = 43 37 $m.h^{-1}$, 200 m = 30 – 20 $m.h^{-1}$)
- Rotary drilling is in first 600 m almost independent on the depth but the progress depends on lithology.
- In contrast to the immersional drilling the progress of rotary drilling getting is better with a higher content of sandstone and siltstone.
- Accessing of depths – an important condition for the advance of Hot-Dry-Rock (HDR), Hot-Wet-Rock (HWR) alebo Deep-Heat-Mining (HDM) energy systems – is not realizable using conventional technologies. In a current state only a progressive flame melt technology is able to ensure the realisation of geothermal energy systems.
- As a special flame melt technology, is the Litho-Jet method very suitable.

Fig. 1. Development state of system components of geothermal power



Sources: with reference to Kaltschmitt M., Schröder G., Rogge S. (2002), S. 1 ff. as well as own estimations

Best practices of the geothermal energy

The geothermal heat is an important resource of sustainable and independent energy supply. The technical potential of geothermal production of electric power and geothermal heat exchange is significant. But there are several serious problems standing against the advantages.

A huge problem is that it is difficult to plan very important factors of economical realisation of geothermal energy systems – the production of thermal water and the tomperature in reservoirs.

The goethermal production of the electric power based on current technics is an expensive option.

Mainly from the economical and technical point of view seems to be the interconnected geothermal production of electric power and heat very advantageous.

As the greatest difficulties that stand against an economical realisation of geothermal energy systems were identified:

- excessive investments as a consequence of high costs of conventional drilling,
- calculation of risks incurred – mainly concerning building of an adequate heating distribution system.

Tab. 4. Economical / technical ranking of drilling technologies for accessing of geothermal energy systems.

	Suitability for specific apply fields		
Instruments / method	**EWS**	**Deep Geothermy (1.000 – 4.000 m)**	**Deep Geothermy (≥ 4.000 m)**
Conventional rotary instruments	++	++	o
Optimized rotary instruments	+	+++	+
PDC-instruments	+	+++	+
High-power Direct chisel drive	o	++	+
Sonic-Drilling	o	+	o
Flame melt technology	o	++	+++
Spallation	o	++	++
Pneumatic hammer drilling	+++	++	o
Hydraulic hammer drilling	++	+++	o
Comment: o = unsuitable + = less suitable ++ = suitable +++ = well suitable			

Sources: with reference to Foralith AG (1998), S. 30 as well as own estimations.

Conclusion

The subject of this economic feasibility study is to analyze the necessary conditions and aspects for realizing geothermal energy systems in comparison to and competition with traditional energy sources today or in the near future. The goal is, to check and to criticize the economic feasibility of geothermal energy systems from the current point of view.

This subject is based on the global problems of an increasing need of energy in present and future. There will be less fossil fuels, which will be more expensive in the near future. Nuclear energy loses its acceptance, especially in densely populated areas. In consequence of this situation, regenerative energies are getting more and more important. Geothermal energy systems have a special and significant position because – in contrast to all others regenerative energies – they are globally present and continually have high potentials for disposal which implies that there are no problems through the accumulation or transportation. In contrast to other regenerative energy systems, prospects of the success of geothermal energy systems are assessed positively. The geothermal energy recovery is economically advantageous if the investment costs, esp. the drilling costs, could be reduced significantly.

An optimization of a common production of electricity and heating seems to be possible but the competition at the world energy market has to be free from public regulations like e.g. subsidies or tariff or non-tariff protections. Currently the price of geothermal energy may not exceed 20 €/MWhth to be competitive with traditional energies. Also from an environmental point of view the using of geothermal energy has a lot of advantages.

From deep drilling experiments we know that in a depth of approximately 10 - 30 km we could find resources for heating hot water respectively getting a hot steam, which would theoretically allow every country on this earth to produce (their own) electricity or heat by using the Hot-Dry-Rock technology for the next hundreds of years. The current primary bottleneck for realizing such a geothermal energy system is a useful drilling technology – especially from the economic point of view. Traditional drilling technologies are not able to reach the cost and time level, which is required for getting the necessary competitiveness.

It only seems possible to open up a big opportunity for realizing geothermal energy systems of the types Hot-Dry-Rock, Hot-Wet-Rock or Deep-Heat-Mining – depth of ≥ 4.000 m – by using a (rock-)melt drilling technology, to reduce the investment costs significantly. That assumed a quantum leap in technicological progress is necessary, which currently only seems possible by developing and using the Litho-Jet drilling technology.

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