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# Natural Gas as Geothermal Energy Carrier

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## ABSTRACT

In this paper the author wants to point at the possibility of exploiting and using the gas of natural gas production wells as geothermal energy carrier. Some basic calculations were done to demonstrate the amount of heat available at different type of gas storage wells.

## Introduction

Nowadays, when the oil and natural gas consumption grows higher than ever, and the growth of the demands is accelerating, wasting or not using available energy is negligence. Searching for hidden sources of geothermal energy is important, to make this energy available in a wider range. Besides the regular ways of exploiting the Earth's heat we can find some unique possibilities as well.

## The Background

Produced natural gas can be used as a geothermal energy carrier. At the gathering station where the well's pipelines are connected into the gas processing technology the temperature of the gas is still around 30°C – 40°C. This heat is sufficient to apply a heat exchanger along the pipeline, and be gathered.

In my diploma thesis I investigated the effects of cyclic operation of the gas wells on the basis of their longitudinal temperature distribution. The "cold" gas injected into the gas storage intensively cools down along the well bore and the surrounding layer structure. This intensive cooling effect appears in the storing reservoir, too. The petrostructure being heated by the geothermal heat flow cannot get to an equilibrium with the surrounding layers. The effect is caused by the insufficient time between the injection and production periods. The temperature along the well bore being significantly lower than it would be from the hole's environmental temperature. It can be taken into account by a geothermal gradient, lower than the real, measured one. As a summary of my thesis I stated that cyclical operating gas wells (injection/production) have lower gas temperature than the production-only wells. It means that the produced natural gas of production-only wells will prove better as geothermal heat sources than that of the cyclical operating wells. See the comparison of two wells' temperature distribution in Table 1.

**Table 1.** Temperature distribution along the tubing.

| Depth | Well-1 | Well-2 |
|---|---|---|
| | *Production-only well* | *Injection and Production well* |
| **meters** | **°C** | **°C** |
| 10 | 38.4 | 30.5 |
| 350 | 51.8 | 43.4 |
| 750 | 56.5 | 55.0 |
| 963 (bottom) | 72.0 | 49.2 |

My calculations were based on two wells of Hungary's biggest underground gas storage unit at Hajdúszoboszló [Figure 1.]

The time interval of the investigation was the 2005-2006 production period. I analyzed two wells: Well-1 (production-only) and Well-2 (injection/production). These wells output capacity are about the same. See the average output capacity data in Table 2. This table contains the input parameters of the calculations as well.

**Table 2.** Input parameters of the equations.

| Parameters | | Well-1 | Well-2 |
|---|---|---|---|
| Days of operation | [days] | 101 | 151 |
| Average mass flow | [kg/s] | 2.236 | 1.99 |
| Average temperature | [°C] | 39.97 | 28.61 |
| Temperature dispersion | [°C] | 4.02 | 5.57 |
| Specific heat | [kJ/kg°C] | 2.261 | 2.234 |
| Average output | [m$^3$/d] | 286000 | 257,000 |
| Temperature difference | [°C] | 15 | 15 |

The calculation was done applying the following steps. The source of the parameters was an applied Plant Information System which collects data from the Storage units. I used daily averaged data for output parameters and temperature values, and daily aggregated data for gas volume, which were based on hourly data. The average mass flow was calculated (1) in the following way:

$$\dot{m} = \frac{Q}{t} \cdot \frac{p_n}{R \cdot T_n} \quad (1)$$

Where:

$t$ = 86400 s
$p_n$ = 101325 Pa
$R$ = 521 J/kg°K
$T_n$ = 288.15 °K

After defining the mass flow the specific heat was determined using the average temperature.

These two parameters and the temperature difference between the heat exchangers input and output sides permit us to calculate the available heat power. The following equation (2) was used to define it:

$$Q_{avail} = \dot{m} \cdot c_p \cdot \Delta T \quad (2)$$

The product of available geothermal power and time gives us the amount of energy (3).

$$E_{gt} = Q_{avail} \cdot N_{days} \cdot 24 \quad (3)$$

The results are summarized in Table 3.

**Table 3.** Available heat power.

| Parameters | | Well-1 | Well-2 |
|---|---|---|---|
| Available power | [kW] | 75.84 | 67 |
| Geothermal energy | [kWh] | 183,837.86 | 241,202.67 |

The results show us that the production-only type well can provide more heat that can be exploited via heat exchangers than the dual function well does. The reason of this phenomenon is: the injected cool gas cools down not only the reservoir but also the surroundings of the well structure.

The volume of the exploitable geothermal energy depends on the efficiency of the heat exchanger. With a carefully designed heat exchanger it is possible to gain 85% of the energy.

Equivalence considerations:

1 m$^3$ natural gas having 34 MJ calorific value is equivalent to 9.44 kWh energy in the burning processes. Equation (4) shows us the calculation. Table 4. visualizes this equivalence applied for the investigated wells.

$$E = \frac{34\,MJ \cdot 1000}{3600} = 9.44\,kWh \quad (4)$$

**Table 4.** Natural gas equivalence.

| | | | Well-1 | Well-2 |
|---|---|---|---|---|
| Geothermal energy | $E_{gt}$ | kWh | 183,838 | 241,203 |
| Natural gas volume | $Q_{ge}$ | m$^3$ | 19,474 | 25,551 |

This amount of this potential heat energy would be enough for the annual heating of 8 mid-sized family houses in the Carpathian Basin environment.

## Reliability

There is a question always coming up if we are talking about energy sources, especially when the energy we want to exploit is just secondary. And this question is the availability of the source. Is it permanent, temporary or periodic? I would say it is periodic. Natural gas storage wells are in production mode during the fall-winter-early spring period (October 1st – April 15th). In general, we can say it is predictable in our (Hungary, Central Europe) climate. We need gas storages to serve the growing demand in the production period and for peak shaving as well. Meanwhile a regular gas production well's lifetime is strictly limited to its gas volume, an underground gas storage well can produce gas as long as the reservoir gets filled up.

## Usability

Transporting heat without significant losses is difficult. So, the gathered heat should be utilized or consumed right there, close to the source. In an agricultural country, like Hungary, greenhouses can be easily set up and be heated with this "free" energy in the winter time. Thinking nationwide, using alternate sources for heating can strengthen the independence of those countries that do not have significant sources from oil or natural gas

## Conclusions

Eight mid-sized family houses could be heated up by only the carried geothermic power of one gas production well. In Hajdúszoboszló there are 87 gas production wells, producing 1400 million m$^3$ of natural gas in the production period.

Further investigations are necessary to calculate the potential additional energy gain of an underground gas storage unit. This geothermal energy resource should definitely not be left wasted.

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