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LOWERING OF CO_2 EMISSIONS BY USING GEOTHERMAL ENERGY

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Abstract

The article present evaluation of lowering of CO_2 emissions through replacement of the natural gas by thermal energy obtained from geothermal water in Aquapark in Poprad (Slovak Republic).

Key words: **carbon dioxide; geothermal water; greenhouse gas**

1. Introduction

Because of the growing undesirable influence of greenhouse gases concentration in the atmosphere a number of organisations started analyzing carbon cycles in the environment connected also with the environmental impacts of many industrial activities which has a bearing upon the exploitation of fossil combustibles connected especially with emissions of methane and of carbon dioxide. To achieve the limitation of their undesirable influence, an ever growing effort is, therefore, exerted in favour of their replacement for non-traditional or, as the case may be, renewable resources of energy.

One of the up to now little used energetic resources is geothermal energy. Some of the purposefully exploited sources, however, contain – with respect to the existing local thermodynamic conditions – dissolved carbon dioxide – the so called free CO_2 which after reduction of pressure to normal condition is released into the atmosphere. The following communication is devoted to an objective evaluation of the replacement of the burnt natural gas by geothermal energy connected with CO_2 emissions under the conditions of the Poprad region (Slovakia).

2. Consideration of the life cycle

By the notion “consideration of the life cycle” in the sense of the norm ISO 10040 the “stock-taking” of the entry and exit flows and of potential impacts on the environment of the whole system of production meant, whereby for the total system of production the total complex of process units is considered that means of process units that are mutually interconnected by the flow of materials or energies and accomplish one or more defined functions.

This consideration is performed in praxis by a stock-taking analysis and a related calculation (consideration of impacts). In the evaluated case it represents the aggregation of data connected with the burning of natural gas and from its replacement by a process using the warmth from the source of warm water for warming up various substances in the recreational Aquapark in Poprad.

Quite a number of possibilities arose how to judge the specifics. For the usefulness of outcomes and a broad spectre of the linking up applications simplicity and transparency were chosen, because the compiled data were supposed to be the foundation for the support of strategic decisions concerning further exploitation of thermal water, especially from the point of view of atmosphere pollution. One of the targets was also the effort to obtain objective data applicable for trading with CO_2.

3. Theoretical foundations of CO_2 emissions connected with the burning of natural gas

The quantity of CO_2 that results from burning of a certain quantity of the heating gas may be set on the basis of a balance calculation proceeding from the composition of reactants, which means from the respective gas and combustion air, or possibly from the burning equations belonging to the individual substances.

As an example of burning equations we may take equations for the oxidation of methane and for some other hydrocarbons contained in the natural gas:

$CH_4 + 2\ O_2 = CO_2 + 2\ H_2O$
$C_2H_6 + 3{,}5\ O_2 = 2\ CO_2 + 3\ H_2O$
$C_3H_8 + 5\ O_2 = 3\ CO_2 + 4\ H_2O$
$C_4H_{10} + 6{,}5\ O_2 = 4\ CO_2 + 5\ H_2O$
$C_5H_{12} + 8\ O_2 = 5\ CO_2 + 6\ H_2O$
$C_6H_{14} + 9{,}5\ O_2 = 6\ CO_2 + 7\ H_2O$

For technical calculations it is usually sufficient to introduce the simplifying anticipation of an ideal behaviour of all gas substances. In such a case it is possible to replace the mole relations flowing out of combustion equations by volume relations. In case of more exact calculations it is necessary to judge natural gas as a real gas that marks out by variations from the ideal behaviour. An ideal gas as opposed to the genuine real behaviour does not take into consideration the differing proper volume of the molecules of gas substances and the connecting intermolecular forces.

The CO_2 content in theoretical burned substances of natural gas under normal state conditions and under perfect combustion without excess of air may be determined as follows:

$$\left(V_{CO_2}\right)_T = \sum_{i=1}^{N} \varphi_i . x_{C,i} \ ,$$

kde: $\left(V_{CO_2}\right)_T$ is the theoretical volume of CO_2 in burned substances ($m^3.m^{-3}$),

φ_i volume fraction of substance i,

$x_{C,i}$ constitutive coefficients of carbon in substance i.

The constitutive coefficient $x_{c,i}$ expresses in our case the number of atoms of carbon in the molecule of hydrocarbon *i* and affects accordingly the contents of carbon dioxide in the natural gas.

Another alternative of the calculation of the quantity of the arising CO_2 when burning natural gas is the calculation through the emission factor. This will be calculated according to the relation

$$E_{co2} = \frac{(m_{co_2})_{T,\ rel}}{Hi_{,ZP}}$$

where: m_{co2} is the mass of carbon dioxide arisen by burning 1 m^3 of natural gas,

Hi heating power of 1 m^3 of natural gas (101,32 kPa, 273,15 K).

This coefficient in its substance enables comparing emissions of carbon dioxide being released into the outer atmosphere when burning various fossil and alternative fuels, that means including natural gas which is used in Aquapark Poprad as the basic energetic medium (in the evaluated case it includes also emissions of CO_2 which is contained in the natural gas being burned), while permits for CO_2 assigned to Aquapark Poprad respect the quantity of natural gas being burned.

As this factor is used in trading with fossil fuels at the CO_2 bourse, the further calculation for the evaluation of ecological impacts and of the benefit of replacing natural gas by geothermal energy from the pumped warm water will especially proceed from its value. The evaluation used in CO_2 trading will thereby be respected. Emission flows, however, can also be obtained e.g. from the balance of the natural gas being burned.

The Slovak Gas Industry (Slovenský plynárenský priemysel a. s.) Bratislava publishes in the sense of the decision of the European Commission No. 2004/156/EC ES on its internet pages beside the composition of the natural gas and its physical-chemical data for objective actions of subjects at the CO_2 bourse also the respective emission factor in the form of a monthly average [1].

4. CO_2 emissions connected with the use of geothermal water energy

When using the geothermal water energy that in the evaluated case springs under the pressure of 0,5 MPa and temperature of 48˚C, the obtained thermal energy brings in the exchange station the water through cooling to about 21˚C. At the same time the pressure gradually falls till the atmospheric pressure. Because the pumped water is in the deposit saturated to a balanced value (see figure 1) [2] – the concentration of the dissolved CO_2 reaches approximately 2,8 g/l. By abolishing the pressure the dissolved free CO_2 will be released.

The residual concentration of free CO_2 in the water being discharged to the gutter is around 0,3 g/l. The quantity of CO_2 released into the atmosphere with the use of thermal energy of 1 m^3 of geothermal water in the exchange station reaches in this way about 2,5 kg.

The energy obtained in the exchange station from thermal water with the permitted volume of pumping at 33 l/sec. reaches on average 3,5 MW per hour. The corresponding hourly quantity of the discharged CO_2 into atmosphere reaches approximately 300 kg.

When burning the adequate volume of the natural gas distributed in Poprad while taking into consideration the emission factor as stipulated by SPP a. s. Bratislava on the level of 1,61 kg of CO_2/m^3 [1], the hourly emission flow of CO_2 would make 592 kg.

The use of the alternative source of energy at the observed facility represents in the one-year calculation a reduction of CO_2 emissions by 2 400 – 2 500 tons. Having in mind the fact that this represents only one drilling, the reduction of CO_2 emissions is not negligible and deserves to be followed.

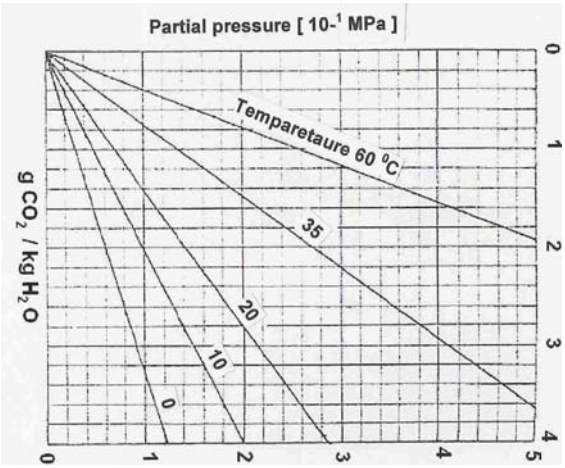

Figure 1. Solubility of carbon dioxide in water

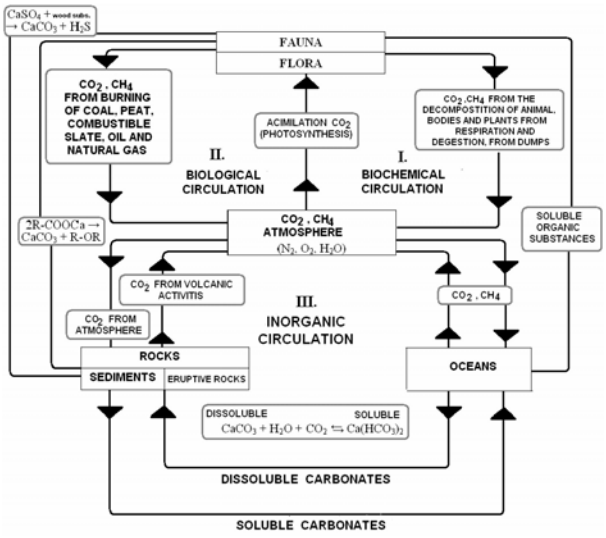

Figure 2. Three basic circulations of carbon[2]

5. Summary and conclusions

During the securing of energy for the successful operation of Aquapark Poprad needed energy is obtained by burning natural gas. By the targeted acquiring of a part of the needed thermal energy from the springing geothermal water the average hourly emission quantity of carbon dioxide will be reduced by 300 kg. In the all-year-round operation of this exchange station having a performance of 3,5 MWh emissions of carbon dioxide will be reduced by approximately 2 400 – 2 500 tons.

Another important and favourable ecological impact of the use of this alternative energy instead of burning natural gas is the reduction of the yearly emission flow of CO_2 by approximately 300 kg, NO_x by 450kg a SO_2 by 30 kg. Therefore that it is evident that the process being evaluated is ecologically very positive and can in case of a greater expansion represent a not negligible impulse for the reduction of CO_2 emissions and of other pollutants in regions where use of other springs or possibly realization of other depth drills is realistic.

By the application of the saved CO_2 in the market with permits, reducing the volume of the natural gas being burned and reducing charges for emissions quite a big economic amount can be obtained, enabling the construction of another part of the energy economy using thermal energy of the geothermal water.

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