BULETINUL INSTITUTULUI POLITEHNIC DIN IAȘI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iași
Volumul 62 (66), Numărul 1, 2016
Secţia
CONSTRUCŢII DE MAŞINI

MODERN SOLUTIONS TO EXPLOIT THE ENERGY POTENTIAL OF COMBUSTIBLE GASES CONTAINED IN GEOTHERMAL WATERS, WITH LOW POWER COGENERATION PLANTS

BY

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Received: April 15, 2015
Accepted for publication: June 1, 2015

Abstract. The paper focuses on thermal potential utilization of the geothermal resources from the Olt Valley (Romania, Călimăneşti, Căciulata area). The three existing drills ensure low enthalpy geothermal water (92–95°C) having, at the exit of the wells, a high content of combustible gases. At present, the gases from the geothermal water, having a rich content of methane (88%), are released into the atmosphere. The paper proposes a few solutions concerning complete exploitation of the energy potential of this geothermal water, using the modern technology of low power cogeneration. We highlight that it is possible to extend the exploitation of the geothermal energy by a viable solution, via which the investment can be recovered in a short time. This work provides solutions in total accordance with the European Directives regarding the increase in energy efficiency, the use of the renewable resources and the environment protection. It was performed a comparative study regarding the efficiency and the costs on energy unit produced, assuming the implementation of these solutions in the central heating system of Călimăneşti Town.

Keywords: geothermal energy; small power cogeneration.

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1. Introduction

Geothermal energy has been used for centuries, for spa treatments, preparing domestic hot water and heating. It reduces greenhouse gas emission, using an inexhaustible and continuously available source. The European energy policy in this field has never been more important. Renewable energy plays a crucial role in reducing greenhouse gas emissions and other forms of pollution, diversifying and improving the security of energy supply. It is for this reason that the leaders of the European Union have agreed on legally binding national targets for increasing the share of renewable energy, so as to achieve a 20% share for the entire Union by 2020 (EU Commission - Directorate General for Energy, 2011). The problem of the integration of the renewable energy sources and micro cogeneration into a heating or a district heating system is of great interest worldwide. Examples of such applications concern hybrid micro-cogeneration systems (an internal combustion engine integrated with a high efficiency furnace) designed to satisfy both the thermal and power needs of a building (Entchev *et al*., 2013), or renewable energy systems using low enthalpy geothermal energy for district heating (Østergaard and Lund, 2011).

In Romania, the geological research carried out between 1960 and 1980 has proved the existence of significant geothermal resources, mainly in the western part of the country, with an annual geothermal usable potential of about 7,000 TJ (Roşca and Antics, 1999). The Table 1 presents the main characteristics of the most important geothermal deposits from Romania (Roşca *et al*., 2010).

Table 1

The Main Parameters of the Most Important Romanian Geothermal Systems

Parameter	um	Oradea	Borş	Beiuş	Western Plain	Olt Valley	North Bucharest
Reservoir type		carbonate	carbonate	carbonate	sandstone	gritstone	carbonate
Area	km^2	75	12	47	2500	10	350
Depth	km	2.2...3.2	2.4...2.8	2.4...2.8	0.8…2.4	2.7...3.2	2.0...3.2
Drilled wells	tot	14	6	2	88	4	17
Well head tmp.	°C	70…105	120	84	50...90	70...95	51...84
Temp. gradient	°C/km	35...43	45...50	33	37...42	30...35	23...26
Mineralisation	g/l	0.8...1.4	12...14	0.46	2...6	15.7	2.2
Gases	m^3_N/m^3	0.05	5...6.5	−	0.6...2.1	1...2	0.1
Prod. type		Artesian	Artesian	Pumping	Art+Pump	Artesian	Pumping
Flow rate	l/s	4…20	10...15	13...44	4...12	8.5...22	22...28
Oper. wells		11	2	1	18	3	1
Inst. power	MW	58	25	10	30	12.5	35
Main uses:							
space heating	dwellings	2000	−	10500	350	2250	−
sanit. hot water	dwellings	6000	−	10500	1750	2250	−
greenhouses	ha	−	−	−	10	−	−
industrial uses	operation	−	−	−	1	−	−
health bathing	operation	2	−	−	4	6	1

The main uses of geothermal waters are for district heating and the heating of individual buildings, balneology, recreation, greenhouses heating, fishing culture and industrial uses as drying cereals, wood, etc., (ICEMENERG, 2006; Marasescu and Mateiu, 2013). In accordance with EU principles and directives, the Romanian Government approved the “Strategy for the development of renewable energy sources” (HG 1535, 2003). This government decision provides significant increases in research activities and investments to capitalize the geothermal potential with direct economic applications. It has spurred concerns for efficient exploitation and utilization of the geothermal resources but the completion of the projects took a long time and great efforts, due to financial difficulties and problems with the existing laws. Practical projects of the last 10 years are rather modest, being located in some localities of the western part of the country and on the Olt Valley, Vâlcea County. These projects were intended either for modernising the equipment and management of the existing geothermal systems or for the exploitation of new geothermal reservoirs. Some of these projects have involved consultants from Western European countries and received financial support from the European Union (Antal and Roşca, 2008). Given these concerns, the objective of the present paper is to propose a modern solution for the utilization of the energy potential of the geothermal resources, from the area around Călimăneşti Town, Vâlcea County. In this area, the geothermal water is provided by three drillings located on the right-hand side of the Olt River. The three existing drillings provide low enthalpy geothermal water, having the well exit temperature of about 95°C, and a high content of combustible gases, especially methane. A project, developed in 2001–2002, aimed at integrating all geothermal resources from this perimeter into the heating system of Călimăneşti Town (Burchiu *et al.*, 2006). Currently, only one of the wells provides the district heating system with geothermal water. In order to use the entire thermal potential of the geothermal water, the article proposes the recovery of the combustion heat of the gases with modern technology of low power cogeneration units.

2. The Energy Potential of the Gases from Geothermal Water

The Table 2 presents the composition and the amount of gases contained in geothermal water, according to analyses reported at the commissioning of boreholes (Burchiu *et al.*, 2006). The maximum available volume flow for the ensemble of the three drillings is about 50.4 l/s, which is equivalent to an effective thermal potential of 13.2 MW, if the geothermal water after its utilization reaches a temperature of 30°C. It can highlight, at all the three wells, a large amount of gases associated with the geothermal water, having a great content of methane (over 88%) and a low heating value (LHV) of about 32 $\mathrm{MJ/m^3_N}$. The Table 3 presents the energy potential likely to be recovered by burning the combustible gases from the whole flow of the hot water, actually produced by the all the three existing wells. The available thermal power, at the whole capacity of the wells, is about 3.6 MW.

Table 2
Composition and Ratio of Gases from Geothermal Water

Geothermal water well	#1005 Căciulata	#1008 Cozia	#1009 Călimăneşti
The water well working parameters during the sample gathering.	Volume flow 32.4 m^3/h Temperature 87°C	Volume flow 57.6 m^3/h Temperature 89°C	Volume flow 28.8 m^3/h Temperature 85°C
The ratio of gases associated with geothermal water (m^3_N/m^3 water)			
Nitrogen (N_2)	0.2638	0.2928	0.3254
Carbon dioxide (CO_2)	0.0247	0.0198	0.0264
Methane (CH_4)	2.1561	1.6545	2.2389
Ethane (C_2H_6)	0.0200	0.0129	0.0193
Propane (C_3H_8)	0.0042	0.0032	0.0028
i-Butane (C_4H_{10})	0.0002	0.0008	0.0003
n-Butane (C_4H_{10})	0.0007	0.0010	0.0003
·*Total*: ·*Combustible gases*	2.4697 2.18 (88%)	1.9850 1.67 (84%)	2.6404 2.26 (86%)
·*LHV* (MJ/m^3_N)	31.7	30.5	30.6

Table 3
The Raw Energetic Potential Possible to be Recovered from Gases Associated with Geothermal Water

Geothermal water well	Water volume flow l/s	Gas ratio m^3_N/ m^3 water	Gas temp. °C	Low Heating Value MJ/m^3_N	Thermal power	
					MW	toe/h
Căciulata	9.4	2.470	96	32.0	0.743	0.064
Cozia	23.0	1.985	92	30.5	1.392	0.120
Călimăneşti	18.0	2.645	92	31.0	1.476	0.127
TOTAL	50.4	2.311*	92.7*	30.9*	3.611	0.311

*mean value

3. The Present Utilization of the Geothermal Resources

The drilling located in the neighbourhood of Căciulata and Cozia are used for local needs. The geothermal water provides a group of hotels and health bathing units, for heating and domestic hot water supply. The high thermal potential of the geothermal water leads to its direct exploitation. The geothermal water is cooled in heat exchangers, in a cascade manner, in order to use the entirely thermal potential, the basic scheme of the geothermal water distribution being presented in Fig. 1.

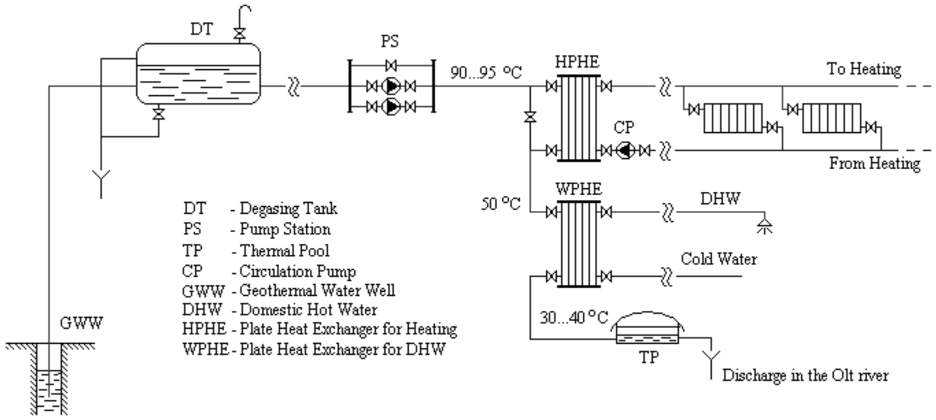

Fig. 1 − The basic scheme of geothermal water utilization.

In the cold season, the geothermal water (having a temperature of 92…95°C) is cooled in a plate heat exchanger, producing the thermal fluid for the heating system. A second heat exchanger produces domestic hot water. The geothermal water, cooled in the two heat exchangers, feeds the thermal pool, after that being discharged in the Olt River at a temperature of about 30°C. In the warm season, the mass flow extracted is reduced, only the heat exchanger for domestic hot water and thermal pool being in use The third drilling is situated at a distance of 1,2 km from Călimăneşti, providing a volume flow of 18 l/s at the same temperature values 92…95°C (Table 3). This locality, beside the tourists which are staying in hotels, has about 8500 permanent habitants; 20% of the habitants are living in apartments connected to a centralized system for thermal energy supply. In the cold season of 2012-2013, 546 apartments were branched to central heating system (ANRSC, 2014). This system has to ensure a thermal need of about 3500 kW for heating and about 500 kW for domestic hot water supply (taking into account the conventional climatic parameters); it was initially designed with three thermal units, equipped with hot water boilers using light liquid fuel. The geothermal water from the nearby well was initially used only for the thermal energy supply of the health bathing units and for the thermal pools. The project of geothermal energy supply was started in 2002 year with internal financing, and was later supported by European funds. Initially, the project included the three wells to provide the centralized heating of Călimăneşti town. Later it was utilized only the available water from the well #1009, situated in vicinity of town. The available volume flow is of 18 l/s, from which about 8 l/s is utilized by a health bathing centre and a hotel; the rest of volume flow (about 10 l/s) being used in the central heating system of Călimăneşti. In order to include the geothermal water into the heating system, a geothermal heating station was built just near the geothermal well; the geothermal water produces, by using plate heat exchangers, the primary thermal fluid for the heating system, having a temperature of about 85°C. This primary thermal fluid serves to partially cover the heating demand and to completely cover the sanitary hot water preparation.

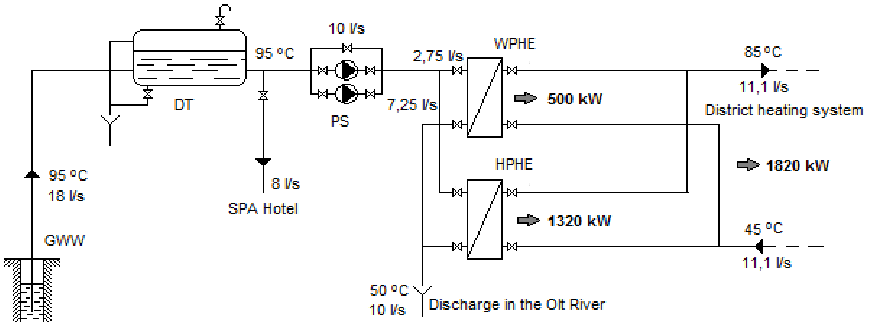

Fig. 2 − The operating scheme of the current geothermal station: GWW – geothermal water well; DT – degassing tank; PS – pumping station; WPHE – plate heat exchanger for domestic hot water; HPHE – plate heat exchanger for heating.

The geothermal heating station with its scheme presented in the Fig. 2, uses a continuous functioning heat exchanger, that completely covers the thermal needs for the sanitary hot water preparation, and another heat exchanger that works only in the cold season, when the heating system is on. Because the temperature of the thermal fluid returned from the both domestic hot water preparation system and heating system is about 45°C, the geothermal water cannot be cooled below 50°C, being discharged in the Olt River at this temperature. In this way, the thermal potential of the geothermal water is not entirely used. Even in these conditions, the use of the geothermal water leads to the complete elimination of the liquid fuel for domestic hot water preparation and to the supply of about 1/3 of the thermal energy needs for heating in the locality of Călimăneşti. In order to cover the peaks and the rest of the thermal energy needs, the oil-fired hot water boilers were maintained. The three district heating plants with oil-fired boilers were transformed in thermal distribution points. The cost of thermal energy produced from geothermal water, is about 0.03 €/kWh, versus 0.1 €/kWh, if the energy is produced in the old oil-fired plants only (ANRSC, 2014).

The primary energy ratio (*PER*) of this combined thermal energy supply system (geothermal and classic) can be determined with the expression:

$$PER = \frac{\dot{Q}_{HWB}}{\dot{Q}_{H}} \cdot \eta_{HWB} \tag{1}$$

where $\dot{Q}$, [kW] is the total estimated thermal power for the heating system (domestic hot water production and heating), $\dot{Q}_H^{HWB}$, [kW] represents the thermal power needs for heating provided only by the oil-fired hot water boilers and η_{HWB} is the efficiency of the hot water boilers, usualy in range of 0.88...0.92 (Bianchi *et al.*, 2011). Considering $\dot{Q}$ = 4000 kW and $\dot{Q}_H^{HWB}$ = 2180 kW, the obtained value is PER = 1.65, which means an improvement of the system efficiency about 83% compared to the previous situation, when the total thermal energy for the heating system was produced only using liquid fuel, in this case the efficiency being $PER = \eta_{HWB} \approx 0.9$.

4. The Recovery of the Combustion Potential of the Gases Using Low Power Cogeneration Units

The simplest solution to utilise this potential consists in the combustion of the gases directly, in the actual oil-fired hot water boilers, completely replacing the liquid fuel. Considering the hot water boilers efficiency of about 90%, the value of the utilisable thermal potential is of about 3.2 MW, the existing heating system having the possibility to work without liquid fuel, taking into account only the burning of combustible gases. However, the best solution is to use the combustible gases to put into action low power cogeneration units such as: gas internal combustion engine units, micro gas turbine units or fuel cell units. The Fig. 3 is presents the schematic diagram of the geothermal station, working together with such a cogeneration unit.

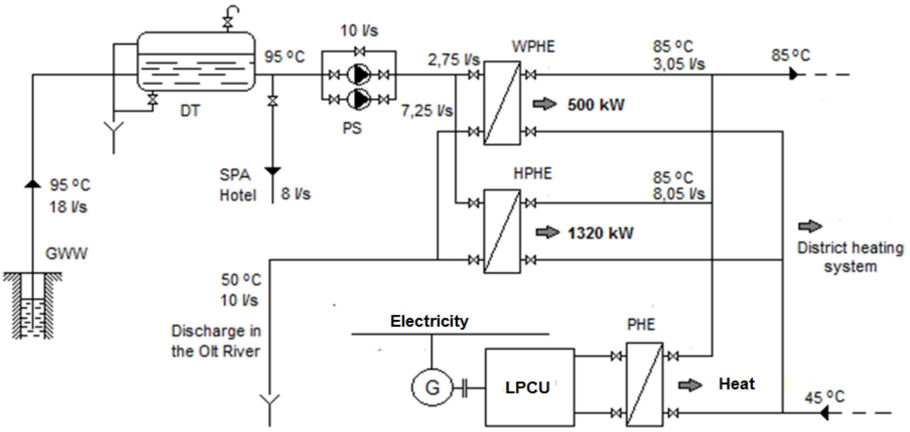

Fig. 3 − The schematic diagram of using a low power cogeneration unit: GWW – geothermal water well; DT – degassing tank; PS – pumping station; WPHE – plate heat exchanger for domestic hot water; HPHE – plate heat exchanger for heating; PHE – plate heat exchanger; LPCU – low power cogeneration unit.

The low power cogeneration unit operates in parallel with the geothermal station, increasing the mass flow of the agent sent into the district heating system. The gas flow obtained from geothermal water allows to put into action the cogeneration unit, an additional amount of heat being delivered into heating system. The electricity obtained in excees can be injected into local public grid.

4.1. The Recovery of the Combustion Potential of the Gases Using Micro Gas Turbine Cogeneration Units

The small gas turbine cogeneration units, using gaseous or liquid fuel, have become commercial and operational around the year 2000. The efficiency of electricity production is about 28…30%, and the global efficiency of the electricity and thermal energy combined production, is about 75…78% (for the exhaust gases temperature of 90°C). Some of the advantages of the gas turbine units are the very low polluting emissions, without chemical treatment or afterburning; one single element in motion - the impeller; air bearings; cooling with air; the possibility to use a great variety of liquid and gaseous fuels, including gases with a high content of hydrogen sulphide (H_2S).

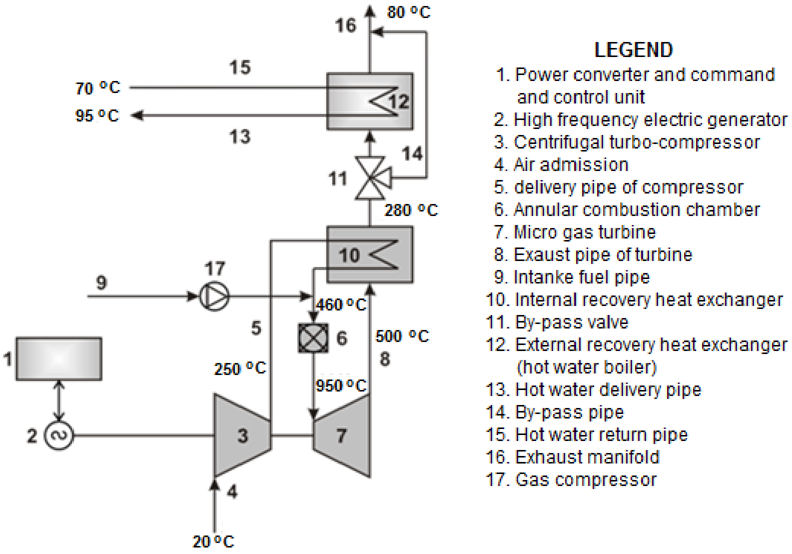

Fig. 4 − Operating scheme of a micro gas turbine cogeneration unit.

It is important to be mentioned also: the optimization for permanent operation at full load (24x7); the ability to track the load variations of the consumer; working unattended and automatic; requirement for less space; maintenance at great intervals of time (about 8000 h) and guaranteed operation over 80000 h; low level of noise (60...70 dBA at distance of 1 m).

The main disadvantages of the use of micro gas turbine cogeneration units are their electric lower efficiency, and their price still high.

The low power cogeneration unit from scheme of Fig. 4 may be realized with micro gas turbine cogeneration units of MT 250 type (FLEX TURBINE^{TM}, 2014) with nominal electric power of 250 kW. The compression ratio is about 6; the value of internal efficiency of the compressor is about 80…85% and, the temperature of compressed air of about 250°C. The combustion chamber operates with a air excess ratio about 5…6, the exhaust gases having an oxygen content of about 15% and a very low content of polluting emissions. The output temperature from the combustion chamber is about 920…950°C. The rotation speed of the turbine-compressor group is very high: 65000...70000 rpm, the exhaust gas temperature is of about 500°C and the value of the internal turbine efficiency is about 85…90%. After the heat recovery exchanger, the temperature of the exhaust gases is about 280°C and the temperature of the compressed air is about 460°C, the value of the internal recovery rate being 0.7...0.8. The exhaust gases are crossing the hot water boiler, which prepares hot water at 70/95°C. The hot water boiler has on the gases side an electronic controlled pass valve, its thermal load being according to consumer needs. The overall efficiency of the micro gas turbine cogeneration unit is about 45%. The maximum gas flow obtained from water, about 170 m^3_N/h, may produce a thermal output of 725 kW and an electrical output of 435 kW. The primary energy ratio of this thermal energy supply system, coupled with a micro gas turbine cogeneration unit, will be:

$$PER = \frac{\dot{Q} + P_{electrical}}{\left(\dot{Q}_H^{HWB} - \dot{Q}_{cogen}\right)} \cdot \eta_{HWB} \tag{2}$$

where $\dot{Q}_{cogen}$, [kW] is the thermal output and $P_{electrical}$, [kW] is the electrical output of cogeneration unit, the rest of terms having the same semnification as into previous Eq. (1). Considering $\dot{Q}$ = 4000 kW and $\dot{Q}_H^{HWB}$ = 2180 kW as before, the obtained value is PER = 2.7. Peak load of the system is, in this case, only 1/3 of the maximum load to be covered. The obtained electricity exceeds the needs of the circulation pumps and can be locally used. For a better flexibility, it is advantageous to install multiple units of lower power (two units of 250 kW or multiple units of 100 kW each). The cost of gas micro turbine cogeneration units is about to 700...800 EUR/kW of electricity, making investment in this case to recover quickly. The maintenance costs are very low, at 0.5...0.7 EUR/h, and the staff are virtually nil, because operation is completely automatic.

4.2. The Recovery of the Combustion Potential of the Gases Using Gas Engine Cogeneration Units

This kind of cogeneration implies the existence of one or more internal combustion engines, using as fuel the gases separated form geothermal water, connected to an electric generator. The thermal energy is produced by cooling the exhaust gases, lubricating oil and engine jacket.

Some advantages of the gas engine cogeneration are: much simpler systems, less voluminous, cheaper and fully controlled; the possibility of a large range of cogeneration (from some kW to more than 20 MW); a simple operation; a quick start with a short time constant (about 30 s to attain the nominal regime); this kind of cogeneration units can be located in the vicinity of energy consumers, resulting small losses in transport lines.

The main disadvantage of using gas engines is related to their vibrations and noise (about 100-120 dBA); this fact involves the use of silencers on the intake and the delivery lines, as well as a special mounting on heavy supports.

The gas engine cogeneration units can be integrated into a centralized heat supply network, or used – like in this case - for covering the local thermal needs; the generated electrical energy can be used for local needs and/or for the public grid. It is important to mention that the global efficiency of such a system is about 90%, greater than a system using micro gas turbines.

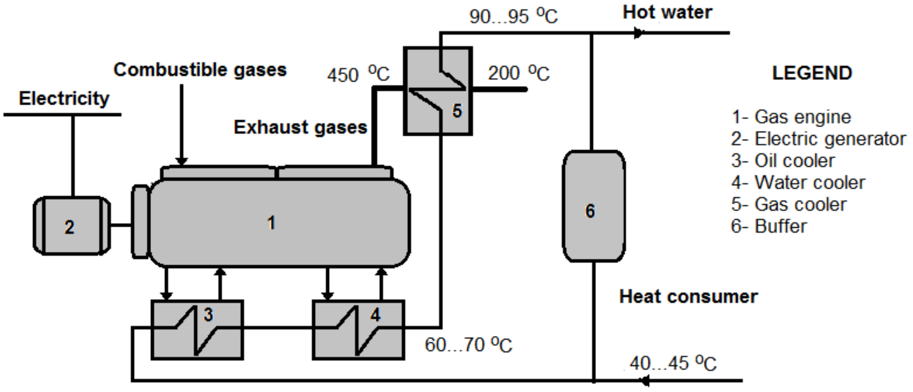

Fig. 5 – Operating scheme of a gas engine cogeneration unit.

The Fig. 5 presents the operating scheme of a gas engine cogeneration unit. The water returned from heating system, takes the heat from the engine lubrication system and cooling system, its temperature rising about to 60...70°C. The exhaust gases, having a temperature of about 450°C, warm up the water to a temperature of 90...95°C. The implementation of such a unit, into the geothermal station operating scheme, corresponds to Fig. 3. The maximum gas flow collected from well #1009 - Călimăneşti, about 170 m^3_N/h, may produce a thermal output of 725 kW and an electrical output of 580 kW. The produced electricity, more much than in case of a microgas turbine unit, also exceeds its own consumption of the plant, and can be injected in local public grid. The primary energy ratio of this thermal energy supply system, coupled with a gas engine cogeneration unit, will be in accordance with Eq. (2) $PER = 2.82$, slightly larger than in the case of a micro gas turbine unit, due to higher electrical efficiency. This solution can be realized modular with small units; it results an economic and flexible system operation in according to thermal need of the consumer.

The cost of the gas engine cogeneration units is nowadays about 600…700 EUR/kW of electricity, which makes the investment to recover also quickly, and determines a low cost for the energy delivered in system. Such solution ensures energy independence, the cost of delivered energy including only the cost of geothermal water (imposed by the drill owner) and the cost for maintenance and operation. Compared with micro gas turbine cogeneration units, maintenance and operation costs are much higher, requiring permanent and qualified staff.

4.3. The Recovery of the Combustion Potential of the Gases Using Molten Carbonate Fuel Cell Cogeneration Units

The stationary power generation with Molten Carbonate Fuel Cell (MCFC) technology offers an efficient alternative to conventional fired power plants. It is considered as an intermediate temperature fuel cell as it operates at a temperature higher than polymer electrolyte fuel cell but lower than traditional solid oxide fuel cells, typically at 650°C. The high operating temperature serves as a big advantage for the MCFC. This leads to higher efficiency, since breaking of carbon bonds occurs much faster at higher temperatures. Other advantages include the flexibility to use more types of fuels and the ability to use inexpensive catalysts. Its ability to work with the different fuel types such as hydrogen, natural gas, light alcohols and its operation without noble metal catalysts, distinguishes it from low temperature fuel cells. A major disadvantage of MCFCs is that high temperatures enhance corrosion and the breakdown of cell components. Over the last five decades the MCFC technology has made impressive progress and a number of MCFC based power generators are currently in operation across the world. With the years of academic and industrial researches and developments in various countries such as USA, Japan, Korea and EU, the MCFC technology is approaching mass commercialization and MCFC is now the leader in terms of the number of installed power generation units among all fuel cell technologies (Kulkarni and Giddey, 2012).

The proposed layout consists in a hybrid scheme that integrates a high temperature MCFC and a gas turbine group. These hybrid systems are particularly suitable to stationary power generation in the field of micro-cogeneration. The layout is presented in Fig. 6, which includes the temperature levels and highlights the electrical and thermal outputs. The mass-flow and energy rates were determined starting from the available methane volume flow rate about of 170 m^3_N/h and the corresponding available energetic potential of 1476 kW, as stated in Table 3.

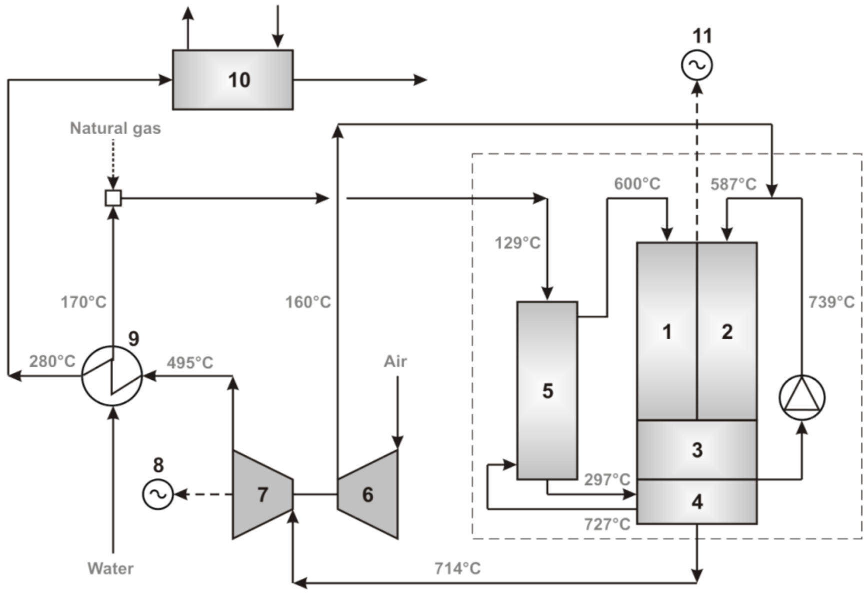

Fig. 6 − Molten carbonate fuel cell – gas turbine cogeneration system
1-anode; 2-cathode; 3-catalytic burner; 4-reformer; 5-regenerative heat exchanger;
6-air compressor; 7-gas turbine; 8-electric generator; 9-gas-water heat exchanger;
10-cogeneration heat exchanger; 11-electrical energy from fuel cell.

The cogeneration system will provide 716 kW electrical power from the MCFC stack, 94 kW electrical power from the GT bottoming cycle and 306 kW thermal power (at the cogeneration heat exchanger). We considered a bottoming cycle efficiency of 12.4% (Fermeglia *et al.*, 2005), using the expression (De Simon *et al.*, 2003):

$$\eta_{bc} = \frac{P_{turbine} - P_{compressor}}{P_{chemical} - P_{stack}} \tag{3}$$

The low value of the bottoming cycle (GT) efficiency is due to the fact that the operating pressure of 3.5 bar and the inlet turbine gas temperature, less than 700°C, are optimised for fuel cells stack and not for bottoming gas turbine cycle. The electrical efficiency can be expressed by formula:

$$\eta_{el} = \frac{P_{electrical}}{P_{chemical}} = \frac{P_{turbine} + P_{stack}}{P_{chemical}} \tag{4}$$

and the cogeneration efficiency by formula:

$$\eta_{cogen} = \frac{P_{electrical} + \dot{Q}_{cogen}}{P_{chemical}} \tag{5}$$

The chemical energy rate introduced with input methane based on lower heating value of the gas-flow rate is about 1476 kW, which leads to the values of the electrical efficiency about 55% and the cogeneration efficiency about 76%. The primary energy ratio of this thermal energy supply system, coupled with a MCFC, will be in accordance with Eq. (2): *PER* = 2.86, slightly larger than in the case of a gas engine unit, respectively micro gas turbine unit, due to very high electrical efficiency. The cost of MCFC cogeneration units is still high, about 2000 EUR/kW, up to three times higher than gas engine or micro gas turbine cogeneration units of same power. Manufacturers believe that the entry price where fuel cells could compete successfully with other small power generators would have to be roughly half of the current price (EPA, 2013).

5. Conclusions

The gases contained in geothermal water have an important thermal potential, which actually is not used. It is very difficult to find permanent local consumers due the fluctuating flow, caused by geothermal water use. The problem can be solved by using a low power cogeneration unit; in this way it is possible to obtain, in same time, additional thermal energy, and electricity which covers the entire electricity demand of the heating system. It was analyzed the using of three types of cogeneration plants functioning with the gases separated from geothermal water: micro gas turbine cogeneration unit, reciprocating gas engine unit and molten carbonate fuel cell unit. In none of these cases, the amount of gas was not sufficient to cover the total load of the heating system with additional thermal energy produced: as a result, in peak situations, it is necessary to use oil-fired boilers. Even in these conditions, it is highlighted a significant increase in effectiveness of the heating system: from *PER* = 1.65 when only geothermal energy is used, at *PER* = 2.7...2.9 in case of recovery the thermal potential of gases with a low power cogeneration plant.

Table 4

The Average Costs for Low Power Cogeneration Units in EUR/kW-Electrical Power

Cogeneration unit type	Equipment	Installation	Engineering/ contingency	Total
Reciprocating Gas Engine	810	365	390	1565
Micro Gas Turbine	1090	695	380	2165
Fuel Cell	4940	1430	130	6500

Current average costs for equipment, installation, design, engineering and management are shown in Table 4 (Santech, Inc., 2010).

Spark ignited gas engines are available in a wide range of sizes and offer low first cost, easy start-up, proven reliability when properly maintained, and good load-following characteristics. Gas engines have dramatically improved their performance and emissions profile in recent years. But maintenance and operation costs are higher, requiring permanent and qualified personnel.

Micro turbine systems are capable of producing power at around 25-33 percent efficiency by employing a heat exchanger that transfers exhaust heat back into the incoming air stream. The systems are air cooled and some designs use air bearings, thereby eliminating both water and oil systems used by reciprocating engines. Low emission combustion systems are being demonstrated and the potential for reduced maintenance and high reliability and durability are the basic advantages of these units.

Fuel cells produce power electrochemically and are generally more efficient than using fuel to drive a heat engine to produce electricity. Fuel cell efficiencies is upwards of 60% for MCFC. Fuel cells are inherently quiet and have extremely low emissions levels as only a small part of the fuel is combusted. The equipment and installations costs are still high, but the producers promise that by 2030 these costs become competitive with those of micro-turbines and gas engines. In these conditions, MCFC is a particularly cogeneration system, both in terms of efficiency and in terms of environmental impact.

The thermal potential of gases from geothermal water of the well #1009 can provide the functioning of cogeneration plant in the power range of 200...300 kW. The choosing a solution or the other depends on energy policy, market conditions and environmental policy in the moment of implementation decision.

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SOLUŢII MODERNE PENTRU VALORIFICAREA POTENŢIALULUI ENERGETIC AL GAZELOR COMBUSTIBILE DIN APELE GEOTERMALE PRIN COGENERARE DE MICĂ PUTERE

(Rezumat)

Lucrarea are ca obiectiv analizarea posibilităţilor de valorificare a potenţialului termic al gazelor combustibile separate din apa geotermală furnizată de forajele aflate în exploatare pe valea Oltului, în perimetrul Călimăneşti – Căciulata – Cozia, concentrându-se pe staţia geotermală care furnizează energie termică sistemului de încălzire centrală al oraşului Călimăneşti. Utilizând un debit maxim de 10 l/s de apă geotermală furnizată de sonda nr. 1009 situată în vecinătate, staţia geotermală acoperă complet necesarul de energie termică pentru prepararea apei calde de consum şi cca 1/3 din sarcina maximă a sistemului centralizat de încălzire, restul fiind asigurat din surse clasice – cazane cu combustibil lichid. Debitul total al sondei fiind de 18 l/s, rezultă un debit maxim de gaze combustibile de cca. 170 m^3_N/h, reprezentând un potenţial termic brut de cca. 1,5 MW.

Lucrarea propune pentru utilizarea acestui potenţial o soluţie modernă, utilizând unităţi de cogenerare de mică putere, în domeniul de putere electrică 200...300 kW. S-au avut în vedere trei tipuri de astfel de unităţi, comercializate în mod curent: cu micro turbine cu gaze, cu motoare cu argere internă cu gaz şi cu pile de combustie cu carbonaţi topiţi. S-au trecut în revistă cele trei tipuri de unităţi de cogenerare, punându-se în evidenţă avantajele şi dezavantajele fiecăruia şi s-au stabilit performanţele sistemului actual, în ipoteza cuplării cu o astfel de unitate de cogenerare, utilizând drept combustibil gazele separate din apa geotermală. Se scoate în evidenţă faptul că pe lângă mărirea fluxului de căldură, introdus în sistemul centralizat de încălzire din surse regenerabile, se obţine şi acoperirea totală a necesarului de energie electrică pentru funcţionarea acestuia.

Analizând costurile actuale pentru echipamente, instalare şi M&O în fiecare din cazurile analizate se constată că la ora actuală soluţiile competititive sunt microturbinele cu gaze şi motoarele termice cu gaze. Pila de combustie este o soluţie deosebită atât din punct de vedere energetic cât şi din punct de vedere al impactului asupra mediului, dar costurile echipamentelor sunt încă deosebit de ridicate. Pila de combustie rămâne o soluţie preferată pentru viitor, producătorii promiţînd o importantă reducere a costurilor în următorii ani.

Autorii recomandă în final cuplarea sistemului actual de încălzire, bazat pe energie geotermală, cu cogenerare de mică putere realizată cu unităţi cu microturbine cu gaze sau motoare termice cu gaz, acestea putând funcţiona în condiţii de sarcină variabilă, obţinându-se o creştere a eficacităţii sistemului (PER) de cca 70%. Se estimează că investiţia poate fi recuperată într-o perioadă de cca 5-7 ani, ceea ce face ca această soluţie să fie interesantă.