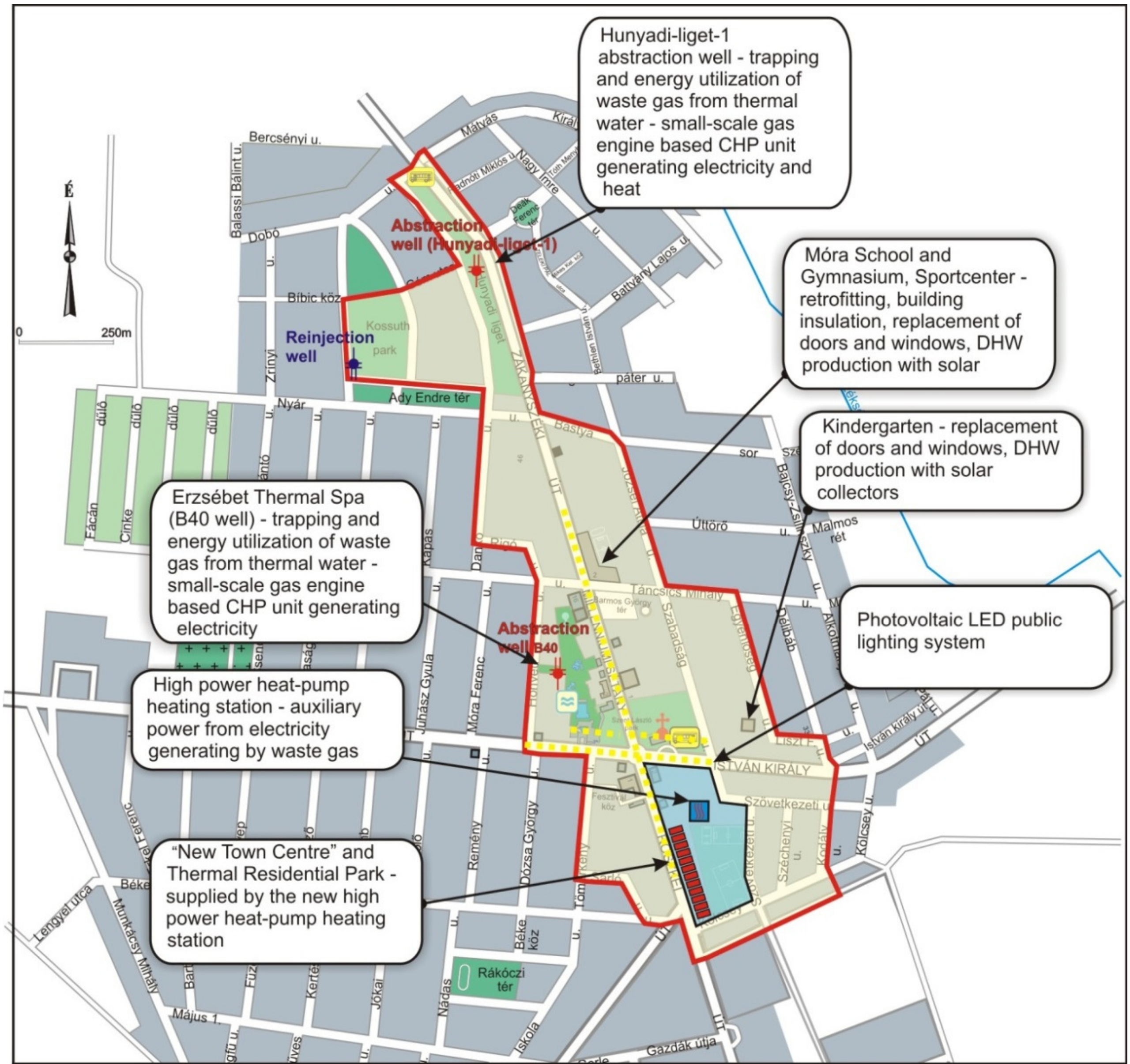
FP7 GEOCOM CONCERTO project implementation in Mórahalom
(subtitle: exploitation of gethermal wells gas emissions)



CONCERTO PROJECT DEVELOPMENT IN MÓRAHALOM
the Concerto Area equals to the operational area of the geothermal cascade system

1. Introduction, history

1.1. Geothermal systems development in Mórahalom.

In the administrative area of Mórahalom works three separated geothermal water-based geothermal systems. The first is the geothermal system of the well-knowed St. Erzsébet spa, the second is the local geothermal cascade system, the last is the Norwegian geothermal district heating system on the edge of town.

As a matter of common knowledge, in the southern region of the Great Hungarian Plain, related in the renewable energies the solar energy and the geothermal energy has the greatest importance because these are available in usable extent.

The geothermal systems in Mórahalom as established in the country other geothermal systems also due to the research of hydrocarbons. During the research finded geothermal water containing reservoirs. The first geothermal well of spa was drilled by the data of researches.

The technology of the well –drilling is similiar like the hydrocarbon drilling procedure but in the structure has more difference. Primarily has difference in the well structure, which means that the geothermal water inflow in to the geothermal wells ensured with Johnson filters. In contrast with the hydrocarbon industry where use the perforation technology and the diameter of the start and the end also has differences.

The first geothermal well was drilled in the year of 1960 with B-13 signal and 660 metre depth for the spa in Mórahalom. The geothermal well ensure with fresh geothermal water for the pools with filler-unloader system up to this day.

In the second place the first well wich really drilled for geothermal energy utilization finished in the year of 2004 with B-40 signal and 1 270,6 metre depth. The B-40 well at the first step ensure building heating for the spa, local health centre and the town hall. At the second step cover the recirculation systems tempering of pools and ensure with fresh geothermal water for the pools with filler-unloader system.

In third place completed in the year of 2008 the second 1260 metre depth geothermal well, which also drilled for geothermal energy utilization. This well currently working as producer well for the geothermal cascade system of Mórahalom. However in pursuance of the laws and the relevant KEOP-4.1.0-2007 calling for tender needed to drill an injection well too, wich completed at the year of 2009 with 900 metre depth. The whole geothermal heating system finished at Spetember of 2010. With this installation started the second geothermal system in Mórahalom. However this system almost made for heating in contrast with the system of spa.

The third local geothermal district heating system completed at the year of 2010 with signal K-43 and 1255 metre depth production well and the K-44 signed and 940 metre depth injection well. The system also contain the connected overground technology and the pipes which connecting the wells.

However since then at the year of 2011 drilled another well with B-49 signal and 660 metre depth for the spa in order to reseerve the B-13 signed well, but this only provide fresh geothermal water for the pools with filler-unloader system. Therefore this is just for balneology utilization without energy utilization.

Well name, sign	Well localization, topographic number	Well depth	Water production liter/min	Wellhead temperature	Solution Gas-Water Ratio	Well drilling year
B-13 geothermal well	Thermal pansion, topographic number. 2/5	660,0 m	340	38,0 ^{0}C	362liter/m^3	1960
B-40 geothermal well	Thermal Spa, topographic number 2/1	1.270,6 m	475	68,0 ^{0}C	544liter/m^3	2004
B-45 geothermal well	Hunyadi liget, topographic number 399	1.260,0 m	1.000	63,4 ^{0}C	524liter/m^3	2008
B-46 injection well	Ady sguare, topographic number 401	900 m	650	48,2 ^{0}C		2009
B-49 geothermal well	Tömörkény street 3, topographic number 1415	660,0 m	700	38,4 ^{0}C	89liter/m^3	2011
K-43 geothermal well	Szent János area, topographic number 0406/164	1.255,0 m	1.000	64,9 ^{0}C	238liter/m^3	2010
K-44 injection well	Szent János area, topographic number 0406/171	940,0 m	750	45,8 ^{0}C		2010

1.2. Accompanied gas of geothermal water: Data which getting from the geothermal systems drilling and operation in Mórahalom

The significant part of the explored geothermal resources in the area of Great Plain the accompanied gas also surface with the produced geothermal water. These contain methane in usable extent too. Similiar high methane content geothermal water and accompanied gas sources has in the region of Mórahalom and Hajdúszoboszló. The both towns started these utilization. The difference between the two settlement is the rate of recovery and the way of the utilization only the volume of associated gas and the ratio of the geothermal water and associated gas.

During the examination the B-40 well and during the operation acquired data has been detected to Mórahalom have enough usable extent and usable quality sources of associated gas.

In this way at the year of 2008 started the detailed studies for the way of utilization and the financing. However then these efforts was not been succesfully.

In the next years started the first only energetic purpose geothermal energy utilization local system, the Geothermal Cascade System of Mórahalom implementation. During the implementation the B-45 well gave as expected significant degree of high quaility and high amount of associated gas.

Therefore started the measuring the technological and economical opportunities regarding both well to utilization the associated gas. In this way we came in contact with the **„FP7-ENERGY-2008-TREN-1 ENERGY.2008.8.4.1.: CONCERTO communities: the way to the future”** programme to join and in order to represent Hungary as pilotsite in the **Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures** project.

1.3. ***FP7-ENERGY-2008-TREN-1 ENERGY.2008.8.4.1.: CONCERTO communities: the way to the future*** *programme* ***Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures****: Development site in Mórahalom.*

We pledge the following innovative activities fullfilment in the project of **TREN/FP7EN/239515/GEOCOM MUNMOR, „Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures"**, as implementation site in the geothermal energy utilization

A. Intergration the solar collector systems in the available geothermal heating and DHW produce system

B. Building energy modernization on the geothermal heated buildings (heat insulation and change the doors and windows)

C. Waste heat of geothermal water utilization with heat – pump

D. Installation an energy saving (LED) public lighting system in combination with solar collector system

1.4 Research and Technological Innovation Fund calling for tender: Co-financing opportunities to the project of ***TREN/FP7EN/239515/GEOCOM***

The project of ***TREN/FP7EN/239515/GEOCOM MUNMOR*** **- „Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures"** aid intensity is 50% of the net expenditures. Therefore the own contribution is the net expenditures 50%, the VAT, and the currency risk is also the Local Government's expenses. Based on the above we submitted an application to the *EU_BONUS_12* calling for tender of Research and Technological Innovation Fund.

The application was succesfully, therefore we signed the Subsidy Contract in 27th March 2013. The aid intensity is grown about gross 50% with the winner tender.

2. Introduction the developments and the systems

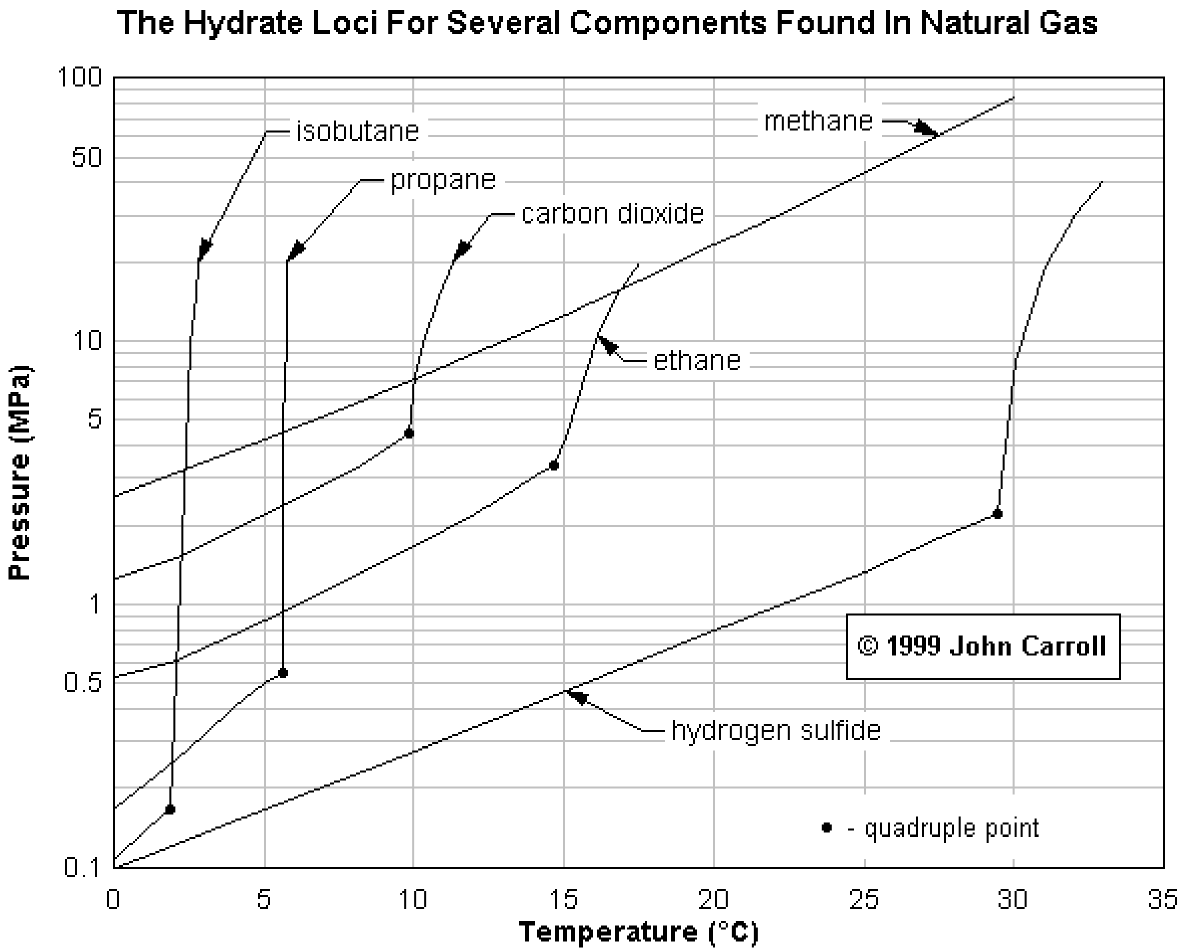
2.1. Geothermal wells associated gas utilization systems:

As previously mentioned, the significant part of the explored geothermal resources in the area of Great Plain the accompanied gas also surface with the produced geothermal water. These contain methane in usable extent too. Similiar high methane content geothermal water and accompanied gas sources has in the region of Mórahalom and Hajdúszoboszló. The both towns started these utilization. However in the utilization have difference between the two town.

Firstly in Hajdúszoboszló the geothermal water contain high value of gas, so there we can talk about gas wells with geothermal water. The amount of associated gas is significantly higher than the geothermal water amount. The gas – water ratio > 1000 liter/m^3. The geothermal wells is far from the utilization site, from the spa so the produced and separated gas need to prepare to suitable level to transit in the pipes.

The gas with water – dust and waterdrop may stoppage the pipeline at some temperature and pressure conditions. This must be aviod when transporting the gas in all circumstances. Additionally the utilization technology does not allow to include water in the gas. Consequently the gas have to cool and dry with gas drier compressor installation. After the drying the gas without water need to stop at the separator (similarly as the gas industry and oil industry). Other chance if no opportunities to drying with the above mentioned system is use of the glycol drier. However is not appropriate solution at utilization in the spa and it is not the best choice in the environment and economical aspect.

What are gas hydrates? Gas hydrates are naturally ocurring, crystalline, ice-like substances composed of gas molecules (methane, ethane, propane, etc.) held in a cage-like ice structure. (clathrate). Hydrates are a concentrated form of natural gas compared with compressed gas, wich is flammable but less concentrated than liquefied natural gas. The following diagram shows that what kind of pressure and temperature need to come up gas hydrate in some cases.



The prepared gas need to compress to transit to the utilization site. However at the aspect of the geothermal wells in Mórahalom has no opportunities for this process for two reasons.

Firstly the associated gas amount is significantly lower so in this case we can talk about geothermal water with gas. In additional the amount of producted associated gas with geothermal water is also lower than in Hajduszoboszló.

Secondly the production wells is nearly to the utilization site, so there is no need to transport the gas to long distance. The associated gas utilization equipment instruments not require the same preparation process. At the utilization technology selection is also taken into account the assciated gas benefits keeping and the end of the energy utilization process have to be positive.

Namely the amount of invested energy in the process should be much smaller than the produced energy by the process.

What this really means? If we used the gas in other place, and if we produce the gas similarly than

Hajduszoboszló, the necessary energy could reach or exceed the energy which got during the produce. In this way the all of benefit would lost, which obtain from the energy utilization.

From our geothermal wells the geothermal water have to pumping because the water level is lower than the ground level. We use for this a submersible pump. During the produce the gas in the well partly secede from the geothermal water, so one of the part of the gas we produce from the pipeline, the other part of gas we produce from the geothermal water. The type of LVS degasser was not suit for this which is installated at drilling because it not let to leave the gas in closed system from the geothermal water. Therefore we had to buid a new gas separation tecnology between the well and the storage tank but for safety margin the LVS degasser also in work due to the geothermal applications. In regard to the geothermal water containing iron and manganese compounds, and the LVS degasser mix the geothermal water with oxygen so the iron and the mananese is oxidize, which secede as wet from the water and this we can separate in zeolite filled tanks. After this process the geothermal water will appropriate for the spa.

A. Utilization the geothermal wells associated gas.

On the basis of detailed examination regarding the content of gas, which made in the year of 2008 at the St. Erzsébet spa B-40 geothermal well, the accompanying gas content is the following:

B-40 productive geothermal well
Well depth: 1270m
Water production: 30 m^3/h wit submersible pump
Wellhead temperature: 69 °C
Gas content (composition, constitution): Methane 83,8%, Carbon dioxide 9,3%, Nitrogen dioxide 6,9%
Submersible pump frekvency: 48,7 Hz
Separator fluid output /gas free/ water flow: 25 m^3/h, 417, - liter/min
Separator gas output, separated gas flow:
9,73 Nm^3/h, hydrocarbon containing 7,63 Nm^3/h
Casing gas output flow: 3,87 Nm^3/h, hydrocarbon containing 3,63 Nm^3/h
Total gas output: 13,6 Nm^3/h, hydrocarbon containing 11,26 Nm^3/h
GVV: 544 liter/Nm^3, CHVV: 450,4 liter/m^3

The following results gave the laboratory in connenction with the above measurement:

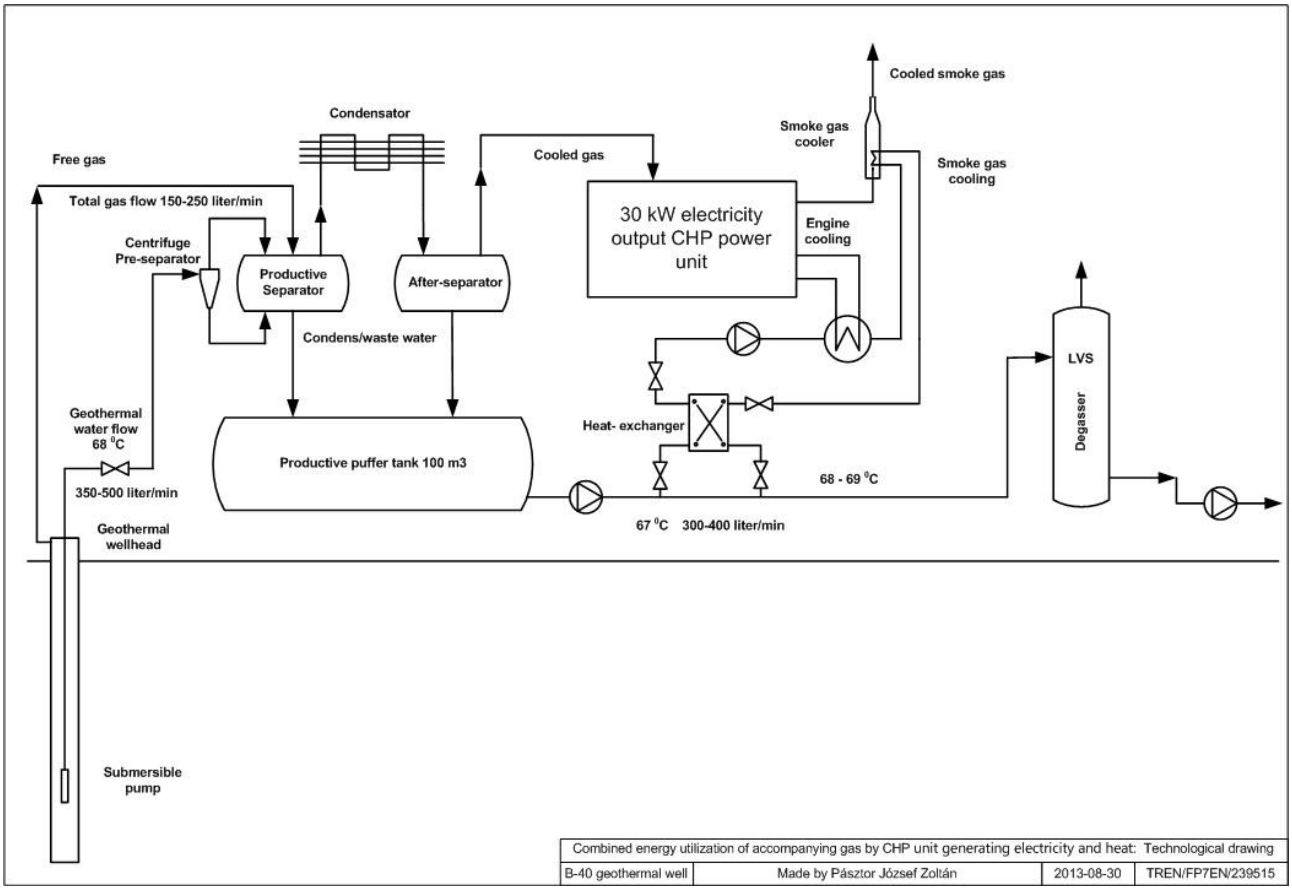
	a) Separated gas	**b) Casing gas**
C1:	76,117 mol%	91,140 mol%
C2:	1,944	2,304
C3:	0,238	0,273
I - C4:	0,024	0,020
N – C4:	0,029	0,018
I – C5:	0,009	0,002
N – C5:	0,008	0,002
C6:	0,009	0,003
C7:	0,013	0,007
C8+:	0,009	0,007
CO_2:	7,785	2,084
N_2:	13,815	4,140
Total:	100,000	100,000
Heat-value:	27,417 MJ/Nm^3	32,178 MJ/Nm^3

The mixed gas heat-value:
(9,73 : 13,6) x 27,417 + (3,87 : 13,6) x 32,178 = **28,772 MJ/Nm^3**

The currently unfettered gas performance: 8 kWh / Nm^3 x 13,6 Nm^3/h = **108,8 kW**
The gas motor with 40% and the generator with 90% effect 36% efficiency regarding the electrical performance. This result is **108,8 x 0,36 = 39,168 kW.** In this way the maximum available power is 40 kW, which means that electrical energy can be made from the gas utilization which prvided by B-40 signed well. However in practice the reccomendation is to installation just 30 kW electrical performance

unit.

B. *B-40 gasengine CHP House-scale Small Powerplant*
NRG MINI P30 SP NG type CHP unit
CHP unit Technical /specifications:
CHP type: NRG MINI P30 SP NG
Motor type: NRG 30 G4LTi (Perkins 1004 G)
4 cycle, lined 4 cylinder motor
Electric output: 30,3 kW,
Thermic output: 60,61 kW,
Total energy output: 90,91 kW
Generator: Mecc-Alte Eco 32-3S/4 0,4 kV, 50Hz
Elecric efficiency: 30,3%,
Thermic efficiency: 60,61%,
Total efficiency: 90,91%
Gas need: 10,5 Nm^3/h, 25-50mbar
Emission: N_2O 490mg/Nm^3, CO_2 640mg/Nm^3, CH 140mg/Nm^3
Cooling water temperature: 70/90°C
Smoke gas noise level (1m, spectralical): 75dB(A)
Engine noise level (1m, spectralical): 75dB(A)



A NRG 30 G4L gas engine technical datas:

Builded datas:		
Oparation method	4 cycle, sparkle ignition motor, without turbo, suction-motor	
Rotation angle from the fly-wheel angle seeing	inverse clock hand action angle	
Cylinder arrange		lined
Cylinder number		4
Borehole	mm	100
Stroke	mm	127
Total stroke volume	l	3,99
Mechanical capacity	kW	35
Compression rate	Epsi-lon	12

Normal reference terms/conditions:

Air pressure	mbar	1000*)
Air temperature	°C	25
Relative vapour capacity	%	30

*) or rather above the avarage sea level 100 m

Operational datas:

Engine nominal speed/rotate	rotate/min	1500
The plungers avarage speed with the engine normal speed/rotate	m/s	6,35
Lubricating oil operational pressure	bar	3 – 4
Lubricating oil minimal pressure[1)]	bar	2
Cooling water output temperature with the engine total loading	°C	90
Lubricating oil consumption (avarage value with the engine total loading)	g/kWh	0,2
[1)] The lubricating oil minimum pressure which depends on the motor oil temperature and the motor temperature and it is between 2 and 4 bar.		

Gas consumption
The basic fuel is the natural gas with 98% methane and with the following parameters:

Minimal methane number	80
Heat-value	34MJ/m^3
Minimal gas pressure	2kPa
Pressure alteration	< 10%

The quantity of gas consumption is estimate with billing:

Gas temperature	15 ^{0}C
Absolute gas pressure	101,325 kPa

The data regarding the gas comsumption the valid tolerances is ± 5% at 100% performance and the tolerance is ± 8% at75% or at 50% performance.

Dangerous substances emission
The cogeneration unit are same with the following emission values:

NO_X	500mg/Nm^3
CO	650mg/Nm^3
other hydrocarbons without mathane C_xH_y	150mg/Nm^3

The emission without methane C_xH_y value is relevant if the current consumption is higher than 3kg/hour.

C. The detailed examination for the accompanying gas content wich made on the B-45 signed well at the year of 2011 on the Geothermal Cascade System of Mórahalom is gave the following results:

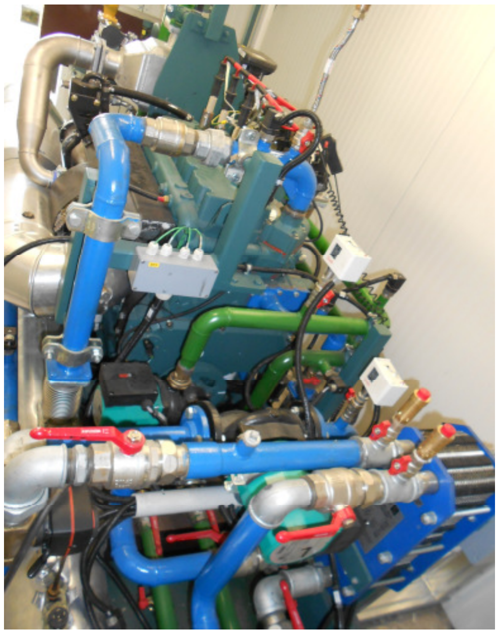
B-45 (T-1) productive geothermal well:
Hunyadi Liget grove TT-1 production well
Depth: 1260m
Total fluid capacity: 1500 liter/min

Geothermal water capacity: 55,2 m^3/h with diving pump (920 liter/min), 132 m^3/h with compressor
Wellhead temperature: 62,1 ^oC
Solution dissolved gas-water ratio: 664,7 liter/m^3
Solution free gas-water ratio:
Total gas capacity: 608 liter/min
Gas content (composition, constitution): Methane 83,8%, Carbon dioxide 9,3%, Nitrogen dioxide 6,9%
Water demand: winter 60 m3/h, summer 15 m3/h

The Geo-Log Ltd. measuring group made a gas compound examination on the basis of KHVM. (Ministry of Transportation, Telecommunication and Water) 12/1997. (VIII.29.) regulation and communiaceted the following results:

Well location, sign: Mórahalom, Hunyadi Liget grove, B-45 productive geothermal well
Drilling year: 2008
Well depth: 1260,0 m; Filteration depth: betwwen 1079,5 and 1232,5 m
Feeld test date: 21th july 2011
Location of the sepatartor connection: on the submersible pump pressure line
Separation way, duration: electric circuit, flowing, 2 hours, the secede gas also is connection to the separator
Test hole: behind the separator
Working number of Laboratory: **34489**
Water production with submersible pump
Gas separtion:
Water production: 790 [l/min], Gas production: 444 [l/min]
Water temperature: 63,0 [°C]; Gas temperature: 47,7 [°C]; Air pressure: 1003 [hPa]
Separated gas-water ratio: 508 liter/m^3
Separated methane-water ratio: 446 liter/m^3
Dissolved gas-water ratio: 15,6 liter/m^3
Dissolved methane-water ratio: 9,4 liter/m^3
Total gas-water ratio: 524 liter/m^3
Total methane-water ratio: 455 liter/m^3

Basis on the 12/1997. (VIII.29.) KHVM regulation the water with this methane content is in the **"C"** scale**. The methane output is 359,4 liter/min with 790 liter/min water flow:**



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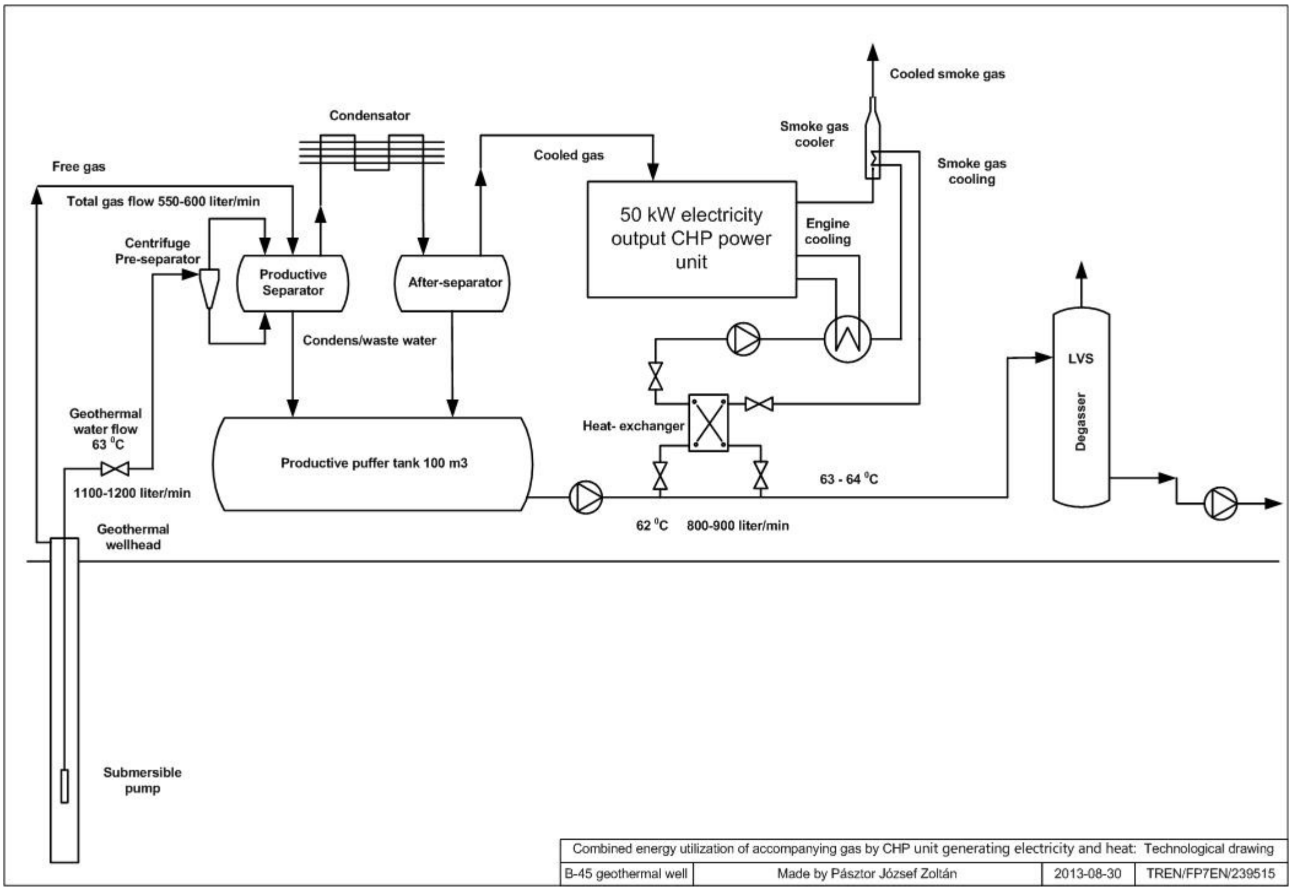
Electric output: 50 kW,
Thermic output: 66 kW,
Total energy output: 116kW
Generator: Mecc-Alte Eco 32-1L/4 0,4 kV, 50Hz
Elecric efficiency: 34%,
Thermic efficiency: 50%,

Total efficiency: 84%
Gas need: 13,9 Nm^3/h, 25-50mbar
Emission: N_2O 490mg/Nm^3, CO_2 640mg/Nm^3, CH 140mg/Nm^3
Cooling water temperature: 70/90°C
Smoke gas noise level (1m, spectralical): 75dB(A)
Engine noise level (1m, spectralical): 75dB(A)
Energy need: 132 kW



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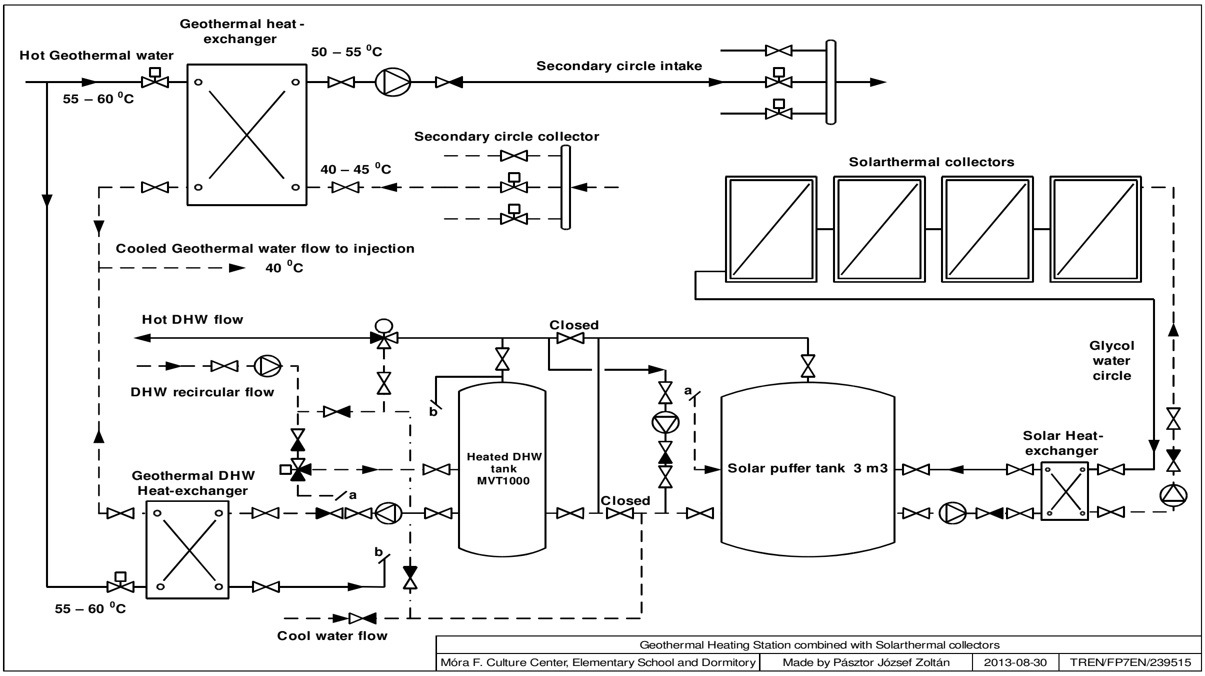
other hydrocarbons without mathane C_xH_y	150mg/Nm^3

The emission without methane C_xH_y value is relevant if the current consumption is higher than 3kg/hour.

2.2. Intergration the solar collector systems in to the available geothermal heating and produce system

After the set in operation the Geothermal Cascade System of Mórahalom we wanted to reduce the neccessity of natural gas for water heating. The building of school and kindergaten needed natural gas service provide in the all of the year. In the kitchens need 50-55 C heat water but the geothermal water temperature is not appropriate for this so the system is able to preheating. Therefore the necessary tempreture still require natural gas provide. These reasons take necessary the solar collectors integration in the system. Primarily the solar collector system provide the hot water needs after the heating season. Early and the end of the heating season (April and May) the solar system cooperate with the geothermal system and this way provide the hot water needs in both location.

In the other months just preheat the water for the geothermal system and with this help to ensure the hot water.



The above picture show the operation of the combined system with solar collectors for heat water providing in one of the implementation location.


little tikes

2.3. Building energy modernization on the geothermal heated buildings (heat insulation and change the doors and windows)

When the Geothermal Cascade System of Mórahalom was in planning and implementing period we know to the system will not comply for the criteria of the modern energy saver systems because the KEOP – 4.1.0-2007 calling for tenders is not allow to the building engineering modernization. Therefore we started to collate our ideas for the future developments and we are planned with building energy saving techology also in the implementation places. We didn't want to waste the energy in this sense. With help of own contribution we changed the radiators which orient to the geothermal energy technology. We also changed the obsolete doors and windows and give heat insulation too. In this way reduced the buildings demand of heat, the geothermal energy able to heating on extended range of temperature with lower geothermal water amount from the system.

2.4. Waste heat of geothermal water utilization with heat – pump

As we saw in the previous paragraph we have to manage also with the renewable energy in order to the systems would be more energy saving and increase the utilization range.

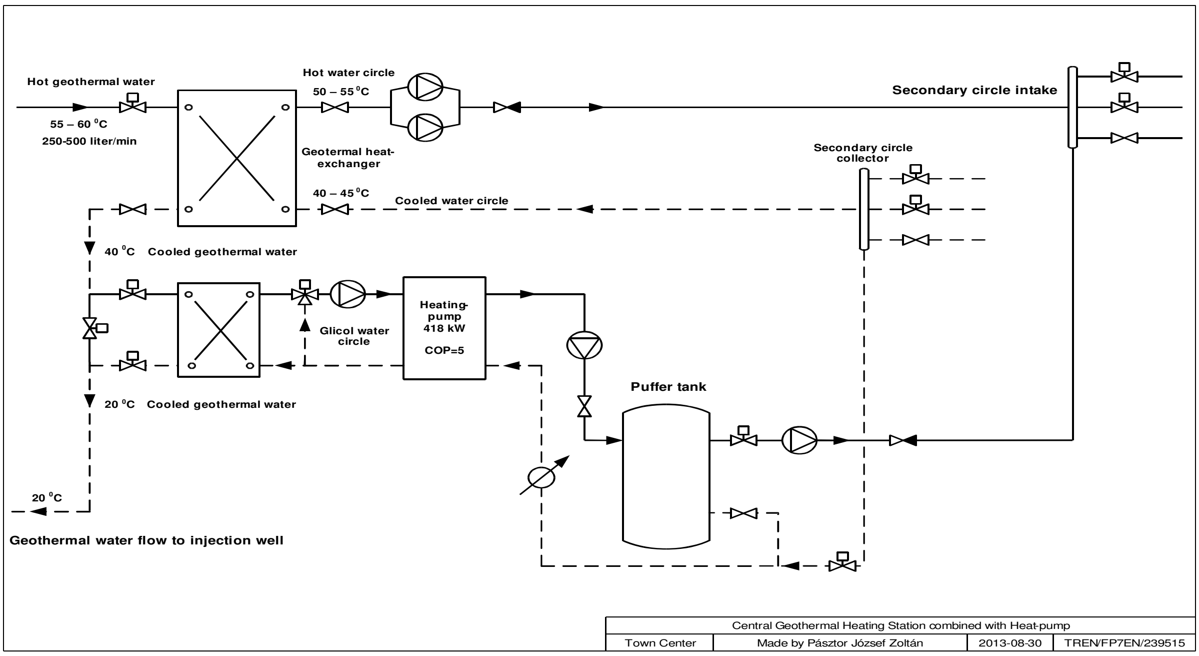
This means that the incoming heat from the thermal water should utilize in the system as far as possible. The lower degrees of heat have to let go out in the injection system.

For this option has more technical opportunities:

In the buildings have to set up systems with low heat demand (floor, ceiling, wall heating) or in the end of the system have to utilize the remaining heat in a vegetation heating system.

On the one part the obsolete heating systems restructuring at the available buildings is too expensive and time-consuming work. Secondly this work in not supported in the KEOP financial resources. Futhermore in the maintenance period at the KEOP projects not possible to use vegetation heating system.

The second opportunity is the waste heat utilization in the system of heat pump at the last heat center. With the above the useful heat may convert to heating water with electrical energy addition.



The above picture shows the operating principles of the waste heat of gethermal water utilization with heat pump combinated system.

2.5.Energy save (LED type) public lightning system combinated with photovoltaic system

Local Government of Mórahalom have been looking for the opportunities since years to modernization the public lightning system of the town and to provide public lighting systems with energy saving lamps on the areas where previously handn't it with help of project funds.

However for the energy save public lightning system implementation we didn't find appropriate KEOP project funds so it's realized in the frame of **TREN/FP7EN/239515/GEOCOM** project as innovative development.

Technical details:

A. Photovoltaic House-scale Power Plant:

Photovoltaic solar cells installing on the roof-timbers of the New Town Center: 40Yingli Solar 240 W polycrystalline solar panel on the top of the New Town Market Hall, 1 pc of Fronius IG Plus 12 V-3 (10000W) inverter **Total photovoltaic capacity: 10kW**

B. LED public lightning system:

Photovoltaic LED public lightning system installing in the town centre: 50 LED lamps with 35 lampposts, 4 autonomic solar power LED public lighting lampposts **Total electric input: 2,95kW**

Installation area: Town Center (traffic round, Szegedi road), Szentharomsag square, Tömbbelső road and car parking, Szövetkezeti street, Bus and Coach Station roof-timbers, 4 busstop

Results, comparison:

The type of HMKE solar collector produced 11.249 kWh electric energy in the year of 2014. This value is 386 628 forints. The LEDs electric energy consumption was 12.021 kWh in the year of 2014, which value is 460 044 forints. Basis on the above the solar collector system produced 93,58 % of the LED type public lightning system energy demand. In the sense of financial that means the solar collectors system produced 84,04% value of the LED type public lightning systems demand.

Payback periods of systems and projects

Payback period of Geothermal Cascade System

Simple payback period:

Thanks to the yearly 442 300 cubic metre natural gas substitution we achieved yearly net 65 415 000 forints savings so far, simultaneously with the 12 000 000 forints operating cost. We realized gross 67 837 700 forints total savings.

Basis on the above the payback period is 8,015 years if we doesn't count with amortization costs.

Payback period with amortization:

The amortization yearly cost is 10 875 620 forints. Taking into account with this, the real gross savings is 56 961 380 forints. In this sense the payback period is 9,5465 years.

The payback period of FP7-ENERGY-2008-TREN-1 ENERGY.2008.8.4.1.: CONCERTO communities: the way to the future program **Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures**:

Simple payback period:

Based on current data we realized net 24 073 224 forints savings so far, simultaneously with yearly net 1.887.840 forints operating cost. We realized gross 22 185 384 forints total savings.

Basis on the above the payback period is 10,881 years, if we doesn't count with amortization costs.

Payback period with amortization:

The amortization yearly cost is 3 665 893 forints. Taking into account with this, the real gross savings is 18 519 491 forints. In this sense the payback period is 13,035 years.

The payback period of the call of tender of Research and Technological Innovation Fund **EU BONUS 12** co-financed with the project of **TREN/FP7EN/239515/GEOCOM MUNMOR - „Geothermal Communities – demonstrating the cascading use of geothermal energy for district heating with small scale RES integration and retrofitting measures"**

Simple payback period:

Based on the previously data we realized net 24 073 224 forints savings so far, simultaneously with yearly net 1.887.840 forints operating cost. We realized gross 22 185 384 forints total savings

Therefore the payback period is change to 8,16 years if we doesn't count with amortization costs.

Payback period with amortization:

The amortization yearly cost is 3 665 893 forints. Taking into account with this, the real gross savings is 18 519 491 forints.

In this sense the payback period is change to 9,776 years.

13th july 2015, Mórahalom

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Municipality of Mórahalom

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