Country Update from Georgia

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Abstract: Owing to its geological location, Georgia has considerable resources of middle and low temperature thermal water (33 – 108 ºC). Most of the geothermal wells are middle depth and non-operating. On the other hand the economic development of the country relies to a great extent to energy production. Geothermal potential of Georgia exhibits a promising resource that might be available for energy production. This requires an extensive study to re-assess the geothermal potential of the country. Several projects were implemented and some others are underway to achieve this purpose. This paper summarizes the geothermal potential of Georgia based on existing data and outlines one of the major projects that have already been implemented to assess the potential of Tbilisi geothermal field using the hydrodynamic digital modelling approach.

1. INTRODUCTION

Taking into account the world-wide spread energy crisis, search and rational use of cheap and ecologically pollution-free renewable energy sources is extremely important. Among these sources earth depth heat is a noted subject with great potentialities. The renewable sources that are already in use in Georgia for power generation are hydropower plants and to a lesser extent wind plants. The use of geothermal and biomass is limited to heat generation while solar energy is not used at all. Georgia has a high potential of geothermal sources, some have been in use since ancient times. The major areas of utilization are balneology resorts, local heating systems, processing industry and greenhouse. Searching and boring researches carried out in the 70s of the last century and conducted up-to-date, revealed that Georgia abounds in geothermal resources, concentrated in 44 deposits (Tab. #1). According to preliminary estimations, their heat power is 420 megawatts, and elaboration of thermal energy is maximum 2.7 million megawatt/hour/year. However, the most of the existing 50 geothermal wells in Georgia are of medium depth and supply water at temperatures ranging between 40 to 60 °C. It also should be noted that most of these wells are non-operational. By estimation of "Georgian Geothermal Association" the Georgian energy sector uses only 730,000 m^3 per annum of the geothermal water mainly to supply hot water to the Saburtalo district of Tbilisi while other systems are damaged or remain in testing stage. Therefore, a re-assessment of the geothermal potential of Georgia is of major importance from the standpoint of economic development of the country based upon renewable, ecological cleaner energy source [1].

2. GEOLOGY

Geologically, the territory of the Republic of Georgia is located in the Central and Western parts of the Trans-Caucasus and lies between the Euro-Asiatic and Afro-Arabian plates. This area marks the junction of the European and Asiatic branches of the Mediterranean, also known as the Alpine-Himalayan fold belt. The geologic evolution of Georgia is controlled, to a great extent, by the development of the whole Caucasus segment of the Mediterranean belt. The present structure of the ophiolithic rock associations suggests that several oceanic basins were generated and developed during the period between the Precambrian and early Mesozoic as a consequence of the horizontal movements of the ancient East European and African platforms, and some certain litho-stratigraphic plates within the Mediterranean belt [2]. Apart from the Precambrian and Paleozoic formations that cover a smaller area, Mesozoic and Cenozoic rock assemblages mainly build up the geological structure of Georgia. Three major tectonic units can be distinguished according to the geologic evolution of Georgia: 1) Fold system of the Greater Caucasus which represents a marginal sea in the geological past, 2) Trans-Caucasus inter-mountain area which marks the northern part of the Trans-Caucasus island arc, 3) Fold system of the Lesser Caucasus, the southern part of the ancient Trans-Caucasus island arc. Closely related to the geological evolution, Georgia whose about two third of territory is occupied by mountains is characterized by rough topography. The country lies between the Greater Caucasus in the north and the Lesser Caucasus range in the south. The intermountain area that extends between these two mountain ranges is divided by the Likhi ridge into the Kolkheti (riv. Rioni) and Kartly (riv. Kura) lowlands. The Meskheti and Trialeti ridges together with the volcanic highlands in the south make up the major geographic units in Georgia.

3. GEOTHERMAL RESOURCES AND POTENTIAL

Owing to the high geothermal potential in the South Caucasus and particularly in Georgia, a confirmed total reserves of 90,000 m^3/day, corresponding to a heat potential of 500,000 tonnes of equivalent fuel annually, has been recorded [3]. The amount of thermal flow for the main parts of Georgia can be listed as follows:

1) The south flank of Caucasus Mountains
   100 mWm^{-2}
2) Plate of Georgia;
   a) for the west zone 40 mWm^{-2}
   b) for the east zone 30 mWm^{-2}
3) Adjara-Trialeti folded system
   a) Central part 90 mWm^{-2}
   b) the east zone 50 mWm^{-2}
4) Artvin- Bolnisi platform 60 mWm^{-2}.

Figure 1 shows the main geothermal fields in western Georgia where the reservoir formations are fractured karstic limestone's of the Upper Cretaceous in the sedimentary trough and at the southeast where the reservoir formations are volcanic and sandstones of Paleocene-Middle Eocene in the fold system. Thus we see the following pattern in the distribution of heat flow: the maximum heat flow is observed for the central zone of folded part of Georgia and the minimum for the plate.

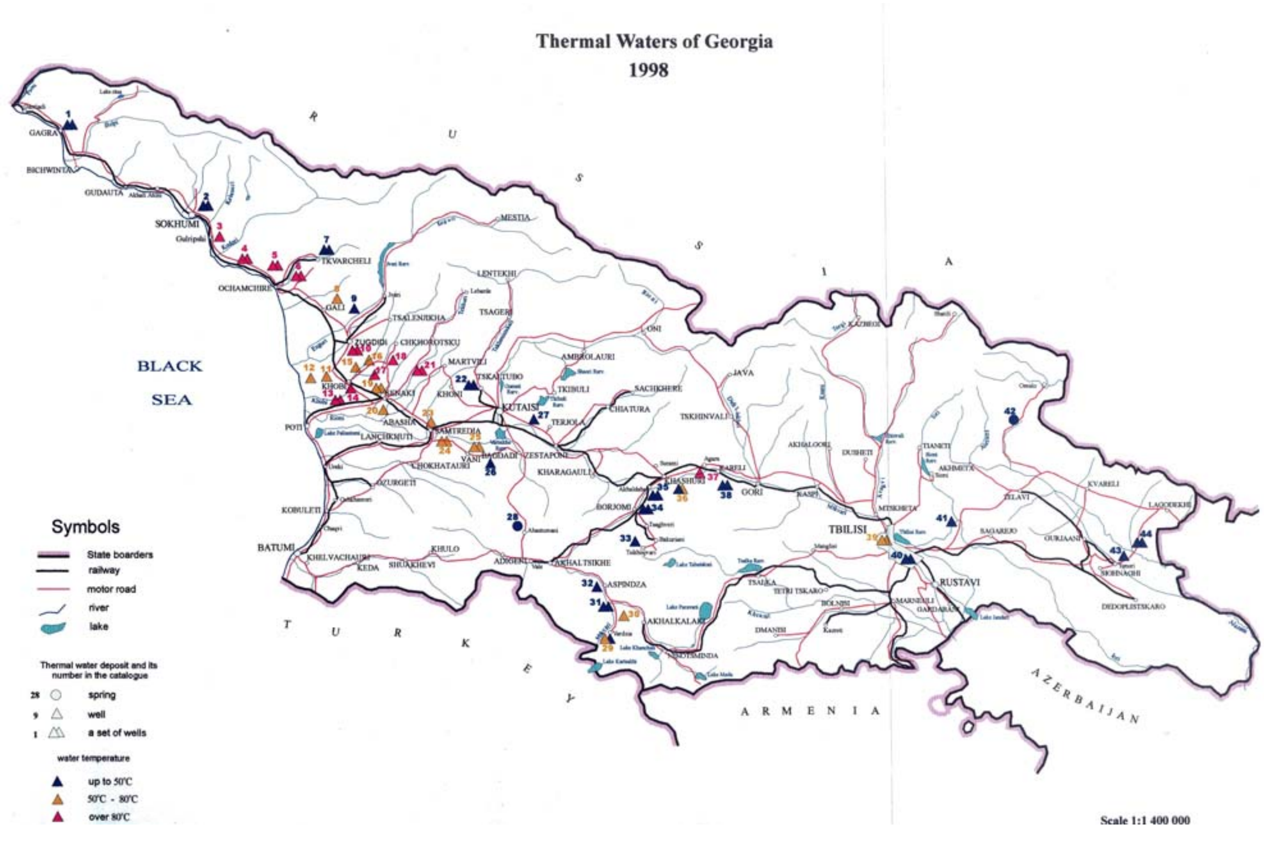

Figure 1. Main geothermal fields in Georgia

As to heat flow for Adjara-Trialeti folded system, is characterized by the middle range. The temperature condition of Paleocene- middle Eocene thermal water bearing complex is better investigated for Tbilisi region [4,5]. This investigation revealed that temperature condition of this complex is influenced by depth of layer of high thermal resistivity upper Eocene rocks as well as their thickness. From the surface of Volcanic-sediment formation of middle Eocene the temperature of rocks increases to all direction from 20 ^{0} C till 100^{0}C. To the north-east the increase of temperature is less then to other direction because of nearness of the plate. On the contact of Cretaceous – Eocene temperature has remarkable variation: to the farthest North and East, where upper Cretaceous is raised till 500 m. we have temperature variation from 100 till 160 ^{0}C, when to the West, where the Cretaceous deeps till 4000 m we have temperature about 240 ^{0}C.

Complete development of this energy will allow to save up to 500 000 tonnes of conventional fuel (TCF) per year and reduce CO_2 emission level in the atmosphere by 1.22 million tonnes.

Today the amount of confirmed reserves does not correspond to reality for, under the current conditions of exploitation, well pressure and discharge rates are dropping. This will make it necessary for us to examine the current situation at the existing thermal water deposits and to re-assess their reserves.

4. GEOTHERMAL UTILIZATION

As it is evident from the tables, that only small part of recourses is used, when it could remarkably improve the economic condition of country.

Among thermal water deposits available on the territory of Georgia two main thermal aquifers – Tbilisi and Zugdidi-Tsaishi, are distinguished for their wide regional expansion, considerable thickness, high collecting and filtration properties, water abundance and high water temperature. Exactly these two thermal aquifers can partially solve the existing energy problem in Georgia. Urban centre Tbilisi is of a particular importance with its multilateral and dimensioned consumer existence, thermal waters resources, unlimited perspective of development and 1.5 million populations. Tbilisi thermal waters' deposit as a result of historical and research works' chronology, conditionally has been divided into 3 exploitation sections: central or balneology resort and baths section, Lisi and Saburtalo section which is related to the same Middle Eocene thermal water horizon.

Currently the low mineralization water tapped in the central area is used by the Tbilisi Balneological Health Resort and the hygienic bath houses (45-50^{0}C). The high-temperature water (57-74^{0}C) tapped in the Lisi (wells № 5-t, 7-t, 8-t) and the Saburtalo (№ 1, 4-t, 6-t) areas with total discharge of 4000 m^3/day is used for hot-water supply and heating the population and offices. Furthermore, in development is farming and the complex under construction at Lisi Lake. Negotiations are conducted with LLC "Lisi Lake" for supply of large healing-recreational and residential complex around the lake, with geothermal heating completely. It is worth noting that the thermal waters in the three areas are of the same composition. They are of low T.D.S. content (0, 19-0, 26 g/L), with alkaline reaction. It is of sulphate-chloride-sodic type with the content of hydrogen sulphide.

The 25-year exploitation of the Lisi area showed that utilization of thermal waters under such a regime (well-consumer-sewage) causes a gradual reduction of water discharge in production wells as the amount of the produced water exceeds the rate of natural recharge of the underground reservoir.

This may result in stopping water flow in the borehles. To prevent this, it is necessary to install a Geothermal Circulation Systems (GCS) in the Lisi area. To do this, favourable conditions exist especially in this area. In particular, there are production wells № 5-t, 7-t and 8-t and № 1-Lisi and 9-t wells (with depth 2556-3702 m) with the negative level for reinjection. The above mentioned wells have intersected the Middle Eocene thermal confined aquifer, thus the reinjected water will circulate only in this aquifer. Consequently, the World Bank (WEF) and UNDP financed aquifer-testing and have created hydro geological model of a GCS system for the Lisi area [6,7]. As a result of implementing such technology, it will be possible to gradually transfer the whole capital to the geothermal heat supply. In addition to the large economic profit, it will give us a significant ecological effect, for the population in the Saburtalo region (120,000) will substitute by geothermal energy, than 30.6 thousand tons of equivalent fuel (EF) will be released.

Second, it is Zugdidi-Tsaishi region. In 1992 year 24 wells were drilled. From the depth of 1272-2820 m water with temperature 83^0-98^{0}C Q=25,000 m^3/day [8]; than 42,5 thousand tonnes of equivalent fuel EF (the annual production 250,000 megawatt/hour).

In the frame project "Re-Assessment of Existing Condition of the Geothermal Resources (West Georgia) Establishment of the Rational Exploitation Regime of Thermal Water Deposits Rehabilitation of Khobi Hospital Heat Supply System Using Geothermal Energy" which was financed by USAID foundation, Georgian scientists did hydro geologic – geothermic testing works and hydrogeodynamic 3D model of region [9]. Now it is time to plan new modern enterprise using unique conditions-existence of the deep boreholes with high temperature steam-water mixture. Disposition of this boreholes make possible to construct three independent GCS.

5. DISCUSSION

Launching the rational regime of deposits exploitation recommended in this proposal may considerably increase these parameters. To connect the cheap and ecologically clean geothermal energy to the country's common heat and cold supply system, it is necessary to calculate geothermal resources, the thickness and the potentialities of individual deposits, to introduce up-to-date progressive technologies and to chart rational schemes.

REFERENCES

1. SEEC (South East Europe Consultants) 2007. Georgia: Strategic Environmental Assessment of Power Sector Development, Final Report.

2. Moores, E. M., Fairbridge, R.W., 1997. Encyclopedia of European and Asian Regional Geology, Springer Publ. p 804.

3. Lund J W., and Freeston D H., 2001 World-wide direct uses of geothermal energy 2000 Geothermics Volume 30, Issue 1, 29-68

4. G. Buntebarth, T. Chelidze, G. Melikadze-Hydrodynamic and microtemperature monitoring in seismic areas. Georgian Engineering News, # 3, 12-132, 2004.

5. Jimsheladze T, Kapanadze N, Melikadze G. “Microtemperature observation in Tbilisi seismoactiv region”, Journal of Georgian Geophysical Association, №12, 2008.

6. A Correia, J. Carneiro, G. Buntebarth, T Chelidze, G. Melikadze, Numerical simulation of groundwater flow and heat transport in the Tbilisi hydrothermal reservoir. printed by M. NODIA INSTITUTE OF GEOPHYSICS, GEORGIAN. ACADEMY OF SCIENCES, EUROPIAN CENTER "GEODYNAMICAL HAZARDS OF HIGHDAMS" OF OPEN PARTIAL AGRREEMENT ON MAJOR DISASTERS, COUNCIL OF EUROPE. Editors: G. Buntebarth, T. Chelidze Tbilisi 2005.

7. Tamaz L. Chelidze, Tamar J. Jimsheladze, George I. Melikadze , "Induced seismicity due to the oil production in Tbilisi region, Georgia”, Journal of Georgian Geophysical Association, №12, 2008.

8. N. Tsertsvadze, O. Vardigoreli, B.Vashakidze, V.Barnov, N.Kotrikadze - Generalization of the Projects of Production Testing Exploitation of Georgian Thermal Waters for Working out a Scheme of Their Rational Utilization. – Tbilisi, 1990. The "Sakburggeothermy" Funds. (In Russian).

9. George Melikadze, Nino Kapanadze, Genadi Kobzev & Tamar Jimsheladze, Assessment of the geothermal potential of west Georgia, Springer 2012, in print

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Table 1: Parameters of main geothermal deposit of Georgia

##	Deposit's name	Number of boreholes	Tempera-ture t °C	Flow rate m^3/day	Thermal capa-city (MWth) Δt=t-25°C	conventional fuel (TCF) Thousand tonne per year
1	Gagra	3	38-43	920	0,8	1,14
2	Besleti	2	39-41	370	0,25	0,34
3	Dranda	1	93	1500	4,8	7,0
4	Kindgi	11	75-108	26600	95	141,2
5	Moqva	8	100-105	13470	48,9	73,5
6	Oxurei	2	104	3500	12,8	19,1
7	Tkvarcheli	2	35-38	690	0,35	0,53
8	Rechkhi	1	77	1080	2,6	4,5
9	Saberio	1	34	1230	0,5	0,8
10	Zugdidi-Tcaishi	15	78-98	24564	69,8	103,8
11	Torsa	1	63	108	0,2	0,3
12	Oqros satsmisi	1	63	104	0,2	0,3
13	Qvaloni	2	78-98	4300	11,6	17,2
14	Khobi	1	82	450	1,1	1,7
15	Bia	1	65	2600	4,8	7,2
16	Gafshakari	1	64	120	0,2	0,3
17	Zeni	1	80	372	0,9	1,4
18	Zana	1	101	400	1,4	2,1
19	Mengi	3	57-65	5750	9,2	13,6
20	Isula	1	75	370	0,9	1,3
21	Noqalaqevi	2	80-82	700	1,8	2,6
22	Tskaltubo	75+4sp.	31-35	20000	7,7	11,5
23	Samtredia	1	61	3000	4,9	7,2
24	Vanis raioni	3	52-60	2152	3,2	4,8
25	Vani	2	60	2780	4,5	6,8
26	Amagleba	1	41	346	0,3	0,5
27	SimoneTi	1	42	520	0,4	0,6
28	Abastumani	3 sp.	48	1040	1,1	1,7
29	Vardzia	3	45-58	1330	1,75	2,7
30	Tmogvi	1	62	520	0,9	1,3
31	Naqalaqevi	3	34-58	795	0,64	1,05
32	Aspindza	1	42	864	0,7	1,0
33	Tsixisjvari	1	32	1000	0,34	0,5
34	Borjomi	25	30-41	537	0,4	0,6
35	Axaldaba	4	33-42	500	0,26	0,43
36	Tsromi	5	39-55	732	1,03	1,64
37	Agara	1	82	260	0,7	1,1
38	Khvedureti	2	45-49	140	0,15	0,2
39	Tbilisi I	7	56-70	3760	6,5	9,9
40	Tbilisi II	5	38-48	1111	0,82	1,16
41	Ujarma	1	42	50	0,04	0,06
42	Torgvas-abano	1 sp	35	800	0,4	0,6
43	Tsnori	1	37	864	0,5	0,75
44	Heretiskari	2	34-37	3300	1,65	2,6
Sum		206 bor. 8 spring		135599	307,1	458,4

Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012	-		2473	6163		
Under construction end of 2012	-			1900		
Total projected by 2015	-			8000		

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH Plants		Geothermal heat in agriculture and industry		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2012	1.3	4.745	2.8	10.22	0.7	2.555
Under construction end of 2012	4.3	15.695	31.4	114.61	2.2	8.03
Total projected by 2015	5.6	20.44	34.2	124.83	2.9	10.59

Table D: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Tbilisi	Tbilisi		12.2		12.2	12.2	44.53	
Central Georgia	Agara		3.05		3.05	3.05	11.13	
West Georgia	Zugdidi		27.45		27.45	27.45	100.2	
total			**42.7**		**42.7**	**42.7**	**155.86**	

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012						
Projected by 2015						

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses	0.15	12	0.6	50
Shallow geothermal				
total				

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D		0.15	
Financial Incentives – Investment			
Financial Incentives – Operation/Production			
Information activities – promotion for the public			
Information activities – geological information			
Education/Training – Academic			
Education/Training – Vocational			

Key for financial incentives:

DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota