Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Country Update from Georgia

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Keywords: energy, hydrodynamic digital model, geothermal resources, Geothermal Circulation System.

ABSTRACT

Owing to its geological location, Georgia has considerable resources of middle and low temperature thermal water (33 ºC – 108ºC) that are presently for heat supply only. 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 on energy production. The Geothermal potential of Georgia may be a promising resource that could 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 has 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, the searching out and rational use of cheap and ecologically pollution-free renewable energy sources is extremely important. Among these sources deep earth heat is a noted subject with great potential. 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 of which have been in use since ancient times. The major areas of utilization are balneologic resorts, local heating systems, the processing industry and greenhouses. Exploration and drilling research carried out in the 70s of the last century and sampled until the present date reveal that Georgia abounds in geothermal resources, concentrated in 44 deposits (Tabel. 9). According to preliminary estimations, their heat power is 420 megawatts, and the exploitation of thermal energy is maximum 2.7 million megawatt/hour/year. However, most of the existing 50 geothermal wells in Georgia are of medium depth and supply water at temperatures ranging between 40°C to 60°C. It also should be noted that most of these wells are non-operational. In spite of being concerned with developing and opening up of natural resources, Ministry of Environmental Protection and Natural Resources has not issued many licenses until 2010. None of the wells are used for power generation. By estimation of LTD “Geotherm” and “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 the 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.

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 make 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 in which about two thirds of the 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 30mWm^{-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. As to heat flow for Adjara-Trialeti folded system, is characterized by the middle range. The temperature condition of the Paleocene- middle Eocene thermal water bearing complex is better investigated for Tbilisi region. This investigation revealed that temperature condition of this complex is influenced by the depth of the 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 in all directions from 20^0C till 100^0C. To the north-east the increase of temperature is less than in other directions because of the proximity of the plate. At the contact of Cretaceous – Eocene temperature has remarkable variation: to the farthest west, where upper Cretaceous is raised up to 500m we have temperature variation from 100^0C - 160^0C, when to the North and East, where the Cretaceous sinks to 600m we have temperature about 240^0C.

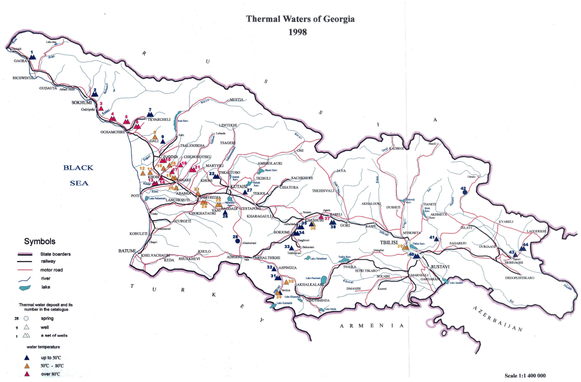

Figure 1. Main geothermal fields in Georgia.

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

Today the amount of confirmed reserves does not correspond to reality because, 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, only small parts of resources are used, even 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 by their wide regional expansion, considerable thickness, high collecting and filtration properties, water abundance and high water temperature. It is exactly these two thermal aquifers which 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 water resources, unlimited perspective of development and population of 1.5 million. As a result of historical and research work and chronology the Tbilisi thermal waters deposit have conditionally 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 water low in minerals tapped in the central area is used by the Tbilisi Balneological Health Resort and the hygienic bath houses (45^0C - 50^0C). The high-temperature water (57^0C - 74^0C) 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, there is farming and other 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 complete geothermal heating. 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 well. To prevent this, it is necessary to install a Geothermal Circulation Systems (GCS) in the Lisi area. Favourable conditions exist to do this 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 suitable 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. 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 have a significant ecological effect, for the population in the Saburtalo region (120,000) will substitute by geothermal energy instead of using 30.6 thousand tons of equivalent fuel (EF).

Second, is the Zugdidi-Tsaishi region. In 1992, 24 wells were drilled. From depths of 1272-2820 m water with temperature 83^0C - 98^0C Q=25,000 m^3/day was found; enough to offset 42,5 thousand tonnes of equivalent fuel EF (the annual production 250,000 megawatt/hour).

On the request of Georgian Government a Iceland consulting group "Virkir-Orkint" evaluated Geothermal Resources of this region. On this basis the American company "Berns and Ro-ue" together with Georgian scientists did hydrogeologic – geothermic testing. Now it is time to plan a new modern enterprise using unique conditions- existence of the deep holes with high temperature steam-water mixture. The position of these boreholes make it possible to construct three independent GCS.

5. DISCUSSION

Launching the rational regime of deposits exploitation recommended in this proposal may considerably increase these parameters. If we take into account that Georgia has no domestic fuel resources of its own and after the political collisions of the 90s, the country's heat supply system has been completely destroyed, it will be clear how important it is to develop local renewable resources. 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 current progressive technologies, and to chart rational schemes.

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Table 1. Present and planned production of electricity.

	Geothermal		Fossil fuel		Hydro		Nuclear		Other renewable (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2009			1718	1698	2473	6163			105	287		8088
Under constraction in December 2009				2300						510		2810
Funds commited, but not yet under construction in December 2009			1	6000		1900				700		8600
Total projected use by 2015				10000		8000				1500		25000

Table 3. Utilization of geothermal energy for direct heat as of 31 December 2009 (other than heat pumps).

Locality	Type $^{1)}$	Maximum Utilization					Capacity $^{3)}$ (MWt)	Annual utilization		
		Flow Rate (kg/s)	Temperature (^{0}C)		Enthalpy$^{2)}$ (kJ/kg)			Ave. Flow (kg/s)	Energy$^{4)}$ (TJ/yr)	Capacity Factor$^{5)}$
			Inlet	Outlet	Inlet	Outlet				
Tbilisi	B,G,H, D	46.4	65	10			8.74	40.4	239.79	0.87
Zugdidi	G,H	77.22	87	45			13.57	65	360.09	0.84
Agara	G	10.5	81	31			2.20	9	59.36	0.86
TOTAL		134.12					24.51		659.24	0.86

I = Industrial process heat
H = Individual space heating (other than heat pumps)

C = Air conditioning (cooling)
D = District heating (other than heat pumps)

A = Agricultural drying (grain, fruit, vegetables)
B = Bathing and swimming (including balneology)

F = Fish farming
G = Greenhouse and soil heating

K = Animal farming
O = Other (please specify by footnote)

S = Snow melting

Note: please report all numbers to three significant figures

Table 5. Summary table of geothermal direct heat uses as of 31 December 2009.

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]	13.57	360.09	0.84
District Heating [4)]	8.74	239.79	0.87
Air Conditioning (Cooling)			
Greenhouse Heating	2.20	59.36	0.86
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]			
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps			
TOTAL	24.51	659.24	0.86

Table 7. Allocation of Professional personel to geothermal

Activities: (Restricted to personnel with University degrees)

(1) Government (4) Paid Foreign Consultants

(2) Public Utilities (5) Contributed Through Foreign Aid Programs

(3) Universities (6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	2	2	11	2	2	
2006	2	2	11	2	2	
2007	3	2	12	3	3	14
2008	3	2	12	4	4	14
2009	4	2	15	4	4	15
Total	14	10	61	15	15	43

Table 8. Total investments in geothermal in 2009 (US$).

Period	Research and Development incl. Surface Explor. And Exploration Drilling Million US$	Field Development Including Production Drilling & Surface Equipment Million US$	Utilization		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %
1995-1999						
2000-2004	0.17		0.17			100
2005-2009	0.35					100

Table 9. Parameters of main geothermal deposit of Georgia.

	Deposit's name	**Quantity of bore holes**	**Temperature t °C**	**Flow rate m^3/dR**	**Thermal capacity (MWt) $\Delta t=t-25°C$**	**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	64	4300	11,6	17,2
14	Khobi	1	78-98	450	1,1	1,7
15	Bia	1	82	2600	4,8	7,2
16	Gafshakari	1	65	120	0,2	0,3
17	Zeni	1	64	372	0,9	1,4
18	Zana	1	80	400	1,4	2,1
19	Mengi	3	101	5750	9,2	13,6
20	Isula	1	57-65	370	0,9	1,3
21	Noqalaqevi	2	75	700	1,8	2,6
22	Tskaltubo	75 + 4 sp.	80-82	20000	7,7	11,5

	Deposit's name	**Quantity of bore holes**	**Temperature t °C**	**Flow rate m^3/dR**	**Thermal capacity (MWt) $\Delta t=t-25°C$**	**Conventional fuel (TCF) Thousand tonne per year**
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