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Geothermal Resource of Georgia

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ABSTRACT

Georgia has considerable resources of mid and low temperature thermal water (33 – 101 0C). Depth of the geothermal wells varied between 1500-3000 m. At present all geothermal wells have owners and are using for agriculture (mainly in greenhouses) – 50.7%; residential sectors – 29.6%; industry (technology hot water supply) – 17.0%; balneology – 2.7%. Total supply reached more than 22 million m3/a. 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 of the major projects that have already been implemented to assess the potential of geothermal fields using the geothermometers application and numerical modelling approach.

1. INTRODUCTION

Practical utilization of the geothermal resources in Georgia started in 1973 when among others hot water was supplied from the geothermal wells to the residents of Tbilisi. At present the geothermal water is used in Georgia for heating of greenhouses, in spa resorts, public baths, fish farming and for hot water supply (Saburtalo district of Tbilisi). The total supply reached 22 million m3/a, which was used in: Agriculture (mainly in greenhouses) – 50.7%; Residential sectors – 29.6%; Industry (technology hot water supply) – 17.0%; Balneology – 2.7%.

The usage of the geothermal water is regulated by the Resolution No 136 of the Government of Georgia On Approval of the Regulations on the Rules and Conditions of Granting Mineral License dated August 11, 2005. According to which the study of the minerals (including geothermal water) and usage of minerals is allowed only based on the license; the license is issued by auction organized by the National Environment Agency under the Ministry of Environment and Natural Resources Protection of Georgia.

The last geothermal wells were drilled at the beginning of the 1990s, after which their further development was largely stalled due to the political events in Georgia. As a result, geothermal systems were utterly destroyed in Western Georgia, the location of the significant geothermal resources. The situation in Tbilisi was a little better as the geothermal hot water supply system in the Saburtalo region was still functioning, albeit with very low efficiency.

Since independence (1991), geothermal development in Georgia was supported mainly by donors. The Government's contribution is limited to some steps aimed at creation of the legal and regulatory framework; the investments by the private investors are very modest.

Geothermal Association of Georgia (www.gga.ge) in 2009-2010 under the UNDP financing has carried out the study of Tbilisi geothermal reservoir; in 2010-2011 under the USAID financing studied geothermal reservoirs in western Georgia. The total reserves of thermal water for the lowlands of western Georgia were defined as 50,000 m3/day.

Field Surveys showed the pressure drop's trend in the aquifer; if the average expenditure of geothermal water remains at the current level (106 m3/day) in Zugdidi area, the amount of heat will be reduced by 30%. Recommendations have been elaborated following the practices adopted worldwide, in particular, the tendency of drop of pressure and volume of the thermal waters can be stopped only if the re-injection scheme (artificial geothermal circulation system) is introduced.

USAID in 2012 -2013 also financed the creation of the first geothermal circulation system in Georgia, at the "Tsaishi" geothermal deposit, rehabilitation of the heating system of Tsaishi public school. Thermal water from the existing N10 borehole is supplied to the heat exchangers and then is reinjected through the N4 borehole

2. GEOLOGY BACKGROUND, GEOTHERMAL RESOURCES AND POTENTIAL

Geologically, the territory of the Republic of Georgia is located in the central and western parts of the Trans-Caucasus and between the Euro-Asiatic and Afro-Arabian plates, 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. 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. The amount of thermal flow closely related to the geological evolution and 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. Main geothermal fields in western Georgia where the reservoir formations are fractured karstic limestones of the Lower 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 the 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 the Tbilisi region (Buntebarth et al., 2004; Jimsheladze et al., 2008; Bunterbarth et al., 2009). This investigation revealed that the temperature condition of this complex is influenced at depth by a layer of high thermal resistivity upper Eocene rocks as well as their thickness. From the surface of the Volcanic-sediment formation of middle Eocene the temperature of rocks increases to all direction from 200C till 1000^{o}C. To the north-east, the increase in temperature is less than to the other direction because of the nearness of the plate. On the contact of Cretaceous – Eocene temperature has remarkable variation: to the farthest North and East, where Low Cretaceous is raised 500 m we have temperature variation from 100 till 1600^{o}C when to the West, where the Cretaceous extends to 4,000 m depth, we have temperature about 2400^{o}C.

Owing to the high geothermal potential in Georgia, a total confirmed reserve of 90,000 m3/day, corresponding to a heat potential of 500,000 tons of equivalent fuel annually, has been recorded (Tsertsvadze et al., 1998).

3. GEOTHERMAL UTILIZATION

The most promising geothermal resources in Tbilisi, Zugdidi-Tsaishi, Kvaloni and others are already under the private ownerships (licenses are issued). However, they are not utilized in an effective way. According to estimates of Georgian Geothermal Association only about 27% of the energy potential (212 MW) is used at present in Georgia (15% of available geothermal water – 23,838 out of 160,000 m3/day). For examples:

Utilization of geothermal water in Saburtalo district of Tbilisi

The State-owned company Thermal Waters owns a license for boreholes 1 and 4 (Saburtalo section of Tbilisi geothermal reservoir); 1, 5, 7, and 9 (Lisi section); and 6 (Vashlijvari section). Geothermal water from the boreholes 4 and 5 are used for hot water supply (natural flow, no re-injection) to the residents of the Saburtalo I, Saburtalo II districts and also of end section of the Alexander Kazbegi avenue (about 10,000 residents in total). The used water after the utilization flows into the sewage system. The metering system is installed only in part of apartments; out of 3.81 MW capacity only 12% (0.46 MW) is metered. Due to this reason the population does not have incentives for efficient use of the hot water. The existing billing system is mostly based on a number of residents, and thus the water is spent uncontrollably for both hot water and heating. Such inefficient use of the resource has resulted in pressure drop and deficit for consumers on the upper floors of the multistore buildings. There are also great losses in the distribution network.

Utilization of geothermal water in Samegrelo Region

Out of license holders the most of valuable activities have been implemented by LLC "Agro Group Four season", who owns a license for Zugdidi-Tsaishi (in western Georgia) boreholes (1, 2, 12, 17 and 18) out of which only two, No.1 (temperature 850C; daily flow 2,700 m3) and No.17 (940C; daily flow 1,200 m3) are in operation. Hot water through the heat exchanger is supplied to the greenhouses; after that the thermal water is wasted. The temperatures of the water downstream greenhouses are 450C (No.1), and 480C (No.17), i.e. only about 50% of the potential of geothermal water is used.

These taxes are paid based on the flow meter records (but not less than the whole amount of water fixed in the license). Therefore, the licenses holders are paying extra taxes in case of low utilization factor. For instance, LLC "Agro Group Four season" is paying for 9,000 m^3 daily while it uses only 3,900 m^3 in the heating season and practically no use is non-heating season. Nevertheless, the amount of taxes paid by the company for the geothermal water (GEL 237,600 annually) is far below of costs of alternative fuels (wood – by 3.3 times; coal – 1.7 times; diesel fuel – 20 times; natural gas 7 times)

Other companies in western Georgia (Khobi, Kvaloni), are utilizing geothermal water for the same purposes with much lower efficiency. In western Georgia, there are boreholes, which have licensees but no activities are implemented and also boreholes, for utilization of which the licenses are not issued yet.

Today the amount of confirmed reserves does not correspond to the 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 reassess their reserves.

Reasons for insufficient utilization of the geothermal potential in Georgia

Several reasons for the insufficient level of utilization of the geothermal potential in Georgia and among them:

- At all geothermal fields, except one, the resource is mostly wasted; the geothermal circulation systems are not arranged.
- Most of the technologies for the operation of geothermal systems are obsolete and inefficient.
- Entrepreneurs, with few exceptions, use the outdated and inefficient technologies in greenhouses and farms; Actually, only a small part (20-25%) of resource is used, while the rest is spilled.
- There are not existing practices of seasonal regulation of operated boreholes/closing of not operating boreholes.
- Requirements for long-term operation of the boreholes are not outlined in the license conditions and are not controlled by the State.
- No incentives are offered to the investors in the geothermal energy.

From our point of view, the main reason is the absence of the strategic approach for the wide development of the geothermal sector.

DISCUSSION

The overall challenge is to accelerate the development and commercialization of geothermal energy technologies in Georgia. This can be achieved, as mentioned above, by the developing of the corresponding Strategy/Action Plan/Road Map. Among others may include practical guidance for achieving of; (i) assessment of the technically available potential; (ii) based on the international experience identification of the most suitable geothermal energy technologies (for residential heating and hot water supply – highest priority; greenhouses – high priority; power generation – lower priority); (iii) development of the business model on the basis of the feasibility study and implementation of small-scale pilot project(s) on the identified technology; (iv) identification of the strategic targets and outlines of the corresponding policy instruments to achieve the targets; (v) based on the monitoring & evaluation of the pilot project, re-assessment of the feasibility of the geothermal investment projects and determination of short-term measures for ensuring the feasibility (financial, technical, environmental) of the geothermal project types and corresponding actions/ways for their implementation. The outcome of these activities will be the developed pipeline of the geothermal investment projects and created financing mechanism.

The development of the geothermal sector will: improve the energy security and energy independence, reduce GHG reductions, improve the integrated resource planning; make more realistic renewable energy targets and INDC (under the UNFCCC); reduce the air- and surface water pollution, etc.

FUTURE DEVELOPMENT AND INSTALLATIONS

There is current preparation for a proposal for feasibility study of available resources of Zugdidi geothermal reservoir for use in small scale geothermal electricity production.

Starting drilling several boreholes to install a heat pump for heating/culling system in the Kutaisi international airport

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STANDARDS TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (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 2019			1445.13	12485.9	1051.7	9087.43			484.71	4187.86	2,982	25,761
Under construction in December 2019					520	4,493			20	173	540	4,666
Funds committed, but not yet under construction in December 2019												
Estimated total projected use by 2020			1445.13	12485.9	1,572	13,580			505	4,361	3,522	30,427

TABLE 3 UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2019

Location	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Akhaldaba	B	1.76	42	18			0.18	1.76	5.56	0.98
Tmogvi	B	1.69	62	39			0.16	1.69	5.12	1.01
Agara	G	1.16	82	58			0.12	1.16	3.66	0.97
Isula	G	3.47	75	50			0.36	3.47	11.45	1.01
Torsa	G	1.16	63	40			0.11	1.16	3.51	1.01
Tbilisi II	B	16.78	48	24			1.68	16.78	53.11	1.00
Zeni	G	4.30	80	55			0.45	4.3	14.19	1.00
Tsromi	G	4.00	55	30			0.42	4	13.18	1.00
Qvaloni	G	15.04	98	75			1.45	15.04	45.63	1.00
Sakharbedio	B	10.00	57	32			1.05	10	32.96	1.00
Zana	G	4.63	101	78			0.45	4.63	14.04	0.99
Samtredia	G	31.99	61	36			3.35	31.99	105.49	1.00
Abastumani	B	9.49	48	23			0.99	9.49	31.28	1.00
Bia	G	30.08	65	42			2.89	30.08	91.26	1.00
Tsaishi	G	79.83	98	73			8.35	79.83	263.25	1.00
Noqalaqevi	G	8.10	82	59			0.78	8.1	24.57	1.00
Menji	G	3.26	65	40			0.34	3.26	10.76	1.00
Aspindza	B	2.31	42	18			0.23	2.31	7.33	1.01
Tbilisi I	B	34.71	70	46			3.49	34.71	109.88	1.00
Tsroni	F	0.35	55	31			0.03	0.35	1.1	1.16
Tskaltubo	B	219.83	35	10			22.99	219.83	724.89	1.00
Zugdidi-Tsaishi	G	11.57	98	73			1.21	11.57	38.15	1.00
Tsaishi-2	G	4.43	75	55			1.16	4.4	47.25	1.29
Akhalsofeli	G	1.30	90	68			0.2	1.2	4.62	0.73
Bataria	G	1.11	85	63			0.13	1.1	4.09	1.00
Amagleba	B	3.95	41	20			0.35	3.95	10.94	1.00
Simoneti	B	6.01	42	20			0.55	6.01	17.44	1.00
Khorga	G	2.26	98	70			0.63	2.26	16.36	0.82
Khobi	G	5.21	82	50			0.70	5.21	21.98	1.00
Vani	G	32.18	60	40			2.69	32.18	84.88	1.00
Akhaldaba	B	5.79	42	20			0.53	5.79	16.79	1.00
Agara	G	3.01	82	55			0.34	3.01	10.72	1.00
Khvedureti	G	1.62	49	35			0.09	1.62	2.99	1.00
Tbilisi I	G	43.52	70	40			5.46	43.52	172.20	1.00
Vardzia	B	15.39	58	40			1.16	15.39	36.55	1.00
Ujarrna	B	0.58	42	20			0.05	0.58	1.68	1.00
Torvas-Abano	B	9.26	35	20			0.58	9.26	18.32	1.00
Heretiskari	B	10.00	37	20			0.71	10.00	22.42	1.00
Tmogvi	B	6.02	62	35			0.68	6.02	21.43	1.00
Nakhalakevi	B	9.20	58	40			0.69	9.20	21.85	1.00
Tsikhijvari	B	11.57	32	15			0.82	11.57	25.95	1.00
Borjomi	B	6.22	41	20			0.55	6.22	17.22	1.00
TOTAL		674.13					69.17	673.99	2186.06	

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2019

Locality	Ground or Water Temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used[5)] (TJ/yr)	Cooling Energy[6)] (TJ/yr)
Kutaisi airport	15	one unit 150	5	W		8752.99	0.82	
TOTAL								

TABLE 5 SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2019

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
0			
	8.11	261.04	1.02
District Heating [4)]	5.46	172.20	1.00
Air Conditioning (Cooling)			
Greenhouse Heating	18.12	571	0.99
Fish Farming	0.03	1.1	0.95
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]	37.45	1180.72	1.00
Other Uses (specify)			
Subtotal	69.17	2186.06	1.00
Geothermal Heat Pumps	0.03	0.16	0.95
TOTAL	69.2	2186.22	0.95

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2015 TO DECEMBER 31, 2019 (EXCLUDING HEAT PUMP WELLS)

Purpose	Wellhead Temperature	Number of Wells Drilled: Electric Power	Direct Use	Combined	Other (specify)	Total Depth (km)
Exploration[1)]	(all)					
Production	>150° C					
	150-100° C					
	<100° C					
Injection	(all)					
Total						

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (RESTRICTED TO PERSONNEL WITH UNIVERSITY DEGREES)

Year	Professional Person-Years of Effort (1)	(2)	(3)	(4)	(5)	(6)
2015	5	3	10			100
2016	5	3	10			100
2017	4	2	5			150
2018	5		10			150
2019	3		10			200
Total	22	8	45			700

TABLE 8 TOTAL INVESTMENTS IN GEOTHERMAL IN (2019) US$

Period	Research & Development Incl.	Field Development Including	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0.1		0.1			100
2000-2004	0.17		0.17			100
2005-2009	0.35		0.35			100
2010-2014	0.2		0.2			100
2015-2019	0.1		0.1			100