EXTENSION OF GEOTHERMAL HOT WATER SUPPLY SYSTEM OF TBILISI (SABURTALO PILOT PROJECT)

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KEY WORDS

Geothermal, supply system, pilot project

ABSTRACT

Since 1973 the centralized geothermal hot water supply system has been putting into practice in Saburtalo district of Tbilisi. The existing system geothermal water supply implies the self-flow of geothermal water from the middle Eocene water-bearing layers through wells to the consumers and is open: well-consumer-sewerage system. As a result of thirty years of such exploitation the debit of wells has monotonously been decreased and the consumption of geothermal water has been reduced.
In 1999-2000 under the financial support of GEF was fulfilled the UNDP/GEF-Georgian Government joint project on feasibility of energy-efficient rehabilitation of municipal heat and hot water supply systems in Tbilisi. Several project ideas have been developed during the feasibility study. The pilot project on “The Use of Geothermal Energy Potential for Hot Water Supply in the Saburtalo Pilot District” was recommended for implementation since 2003. The potential sponsors for the pilot project could be the GEF-2.5 mln USD, Municipality of Tbilisi-1.0 mln USD and Ltd “Geothermia”-0.5 mln USD.

Total investments for the project -4 mln USD;
Construction time -2003-2005;
Installed capacity-22 MW;
Used at the first stage capacity-10.6 MW;

Works planned under the pilot project:

Full reconstruction of existing wells and construction of Geothermal Circulation System (GCS);
Construction of Geothermal Thermal Station (GeoTS);
Construction of accumulator-reservoirs for hot water;
Metering the hot water consumption (installation the hot water meters);

The results of the first stage works:

Cost of heat production- 13 USD/MWh.
Reduction of GHG emission for 20 years of system exploitation- 232,000 t CO_2.

Taking into consideration the geothermal resources estimated in the territory of Tbilisi and the experience gained from the exploitation of pilot GCS it could be planned the construction up to 20 new GCS in Tbilisi.
Preliminary estimations results in total 1100 MW installed capacity with annual production 6-7 mln. MWh/a, which is compatible with the produced in past (1990year) heat by 48 boilers located in Tbilisi. Realization of 20 planned GCS will give possibility to supply the whole city with geothermal hot water and satisfy the 40-50% of demand on heat while replacing up to 1 mln t conventional fuel. Consequently several hundred tones of CO2 and other pollutants will be

reduced annually contributing thus in global processes and improving the ecological conditions in Tbilisi and nearby resorts.

1. INTRODUCTION

The exploitation of old centralized heat and hot water supply systems existed in Georgia became non profitable after the prices of exported fuels (gas, mazut) have grown up to the international prices. As a result all thermal stations and boiler houses ended up operation and have been completely deteriorated during last 10-12 years. The main cause of this was the very low efficiency 50-60% of the systems. Hence the rehabilitation of existing in past centralized systems without the improvement of energy-efficiency is not priority for Georgia. Recognizing above mentioned the use of cheap local energy resource such as geothermal heat is very important.
Hot water supply of Saburtalo district has been taking place since 1973 when the first flow of thermal water with the temperature of 60^0C run out through the well N1-L(isi) with the debit about 2500 m^3/24h. The well N5-T started operation in 1978 and it gave strong flow of geothermal water with the temperature up to 62^0C and debit of water 6000 m^3/h. After the opening of well N5-T the well N1-L stop self-gushing and the system of geothermal hot water supply was switched to the well N5. Thermal water was delivered to the N1 thermal station heat distribution system through which it was supplied to the population of Saburtalo district. Similarly the well N1-Saburtalo was connected to the thermal station N10 and the well N4-T to the thermal station N18. These thermal stations delivered the raw geothermal water to the consumers through special substations. Delivering the non treated geothermal water to the consumers was acceptable because the chemical composition of geothermal water (Table 1:) received from the middle Eocene water-bearing layer in the Tbilisi region coincided with the "drinking water" standards. There were some deviation from standards with regard the gases, but for that time it was ignored.

Table 1: Complete water chemical analyses

Source name:	Well № 5 – T				mg./l	mg./Eq.	
Type of water:	Thermal			Hardness:		0,02	
Place:	Lisi			Fr. Alkalinity :		0,07	
Debit m^3/d: 2000				Free. CO_2:	0,00		
Color:	0			Diss. O_2:	14,00		
Odour:	2			General N:	–		
Taste:	2			Organic C:	0,00		
Turbidity:	0			Summary SiO_2:	26,75		
pH:	10,00			H_2S	0,0000		
Temperature:	62			Residual. Cl:	0,000		
Conductivity:	-						
Dry residues:	224						
Ions	mg./l	mg./Eq.	Mg./Eq.%	Ions	mg./l	mg./Eq.	Mg./Eq.%
Cations				Anions			
NH_4	0,000	0,0000	0,0	F	0,999	0,0526	1,6
Ca	0,400	0,0200	0,7	Cl	35,500	1,0000	30,4
Mg	0,019	0,0016	0,1	Br	0,000	0,0000	0,0
Na	69,600	3,0261	98,4	J	0,000	0,000	0,0
K	0,770	0,0197	0,6	HCO_3	16,720	0,2741	8,3
Li	0,025	0,0036	0,1	CO_3	16,554	0,5518	16,8
Sr	0,000	0,0000	0,0	SO_4	67,622	1,4088	42,9
Co	0,000	0,0000	0,0	SO_4	67,622	1,4088	42,9
Fe	0,090	0,0048	0,2	NO_2	0,018	0,0004	0,0
Sum	70 905	3,0758	100 %	Sum	137,414	3,2877	1000 %

Mineralization: 235,0688 mg./l

After the destroy of the above mentioned thermal stations in Saburtalo district of Tbilisi the independent small geothermal centralized hot water supply systems have been established with the wells N5-T; N1-Saburtalo and N4. They are still operating in the initial regime well-consumer-sewerage. As a result of thirty years exploitation the debit of wells has monotonously been decreasing and the consumption of geothermal water has been reducing.
Stabilization of water debit while intensifying the extract of thermal water could be reached in two ways:

1. Constructing the GCS using the existing wells with open middle Eocene layers and compulsory intensification of water extraction using the hanging pumps.
2. Drilling of new wells aimed at creation of second circulation contour at the level of upper non Cretaceous formation. Anticipate temperature of geothermal water extracted from this horizon is $100 \div 170^0$ C.

The second option is related with the new drillings and needs very high initial investments. Therefore the second option could be considered only in perspective.

2. Geothermal Circulation System (GCS)

In 1999-2000 was carried out the UNDP/GEF-Georgian Government joint project dealing with the feasibility study for "Removing the Barriers to the Energy Efficiency in Municipal Heat and Hot Water Supply Systems in Georgia". The several alternatives of pilot project have been developed in the framework of the feasibility study. The following options for maximum use of geothermal heat in Saburtalo district have been elaborated:

SB'- geothermal heat consumption only for hot water supply

SB1- Centralized geothermal heat and hot water supply of No.32 and No.47 ThS operation areas, geothermal only hot water supply of operation area of ThS No.1 from GeoTS installed in No.47 ThS building. Centralized heat supply to the rest part of the pilot area (No.1 ThS area) by the installation of block boiler in the yard of residential building consisted of 130 flats located at Vazha-Pshavela I block.

` SB2- Centralized geothermal heat supply to No.32 and No.47 ThS operation areas, geothermal hot water supply to operating area of No.1ThS from GeoTS installed in No.47 ThS building. Heat supply to the rest part of the pilot area (No.1 ThS area) by autonomous boilers.

SB3- Centralized geothermal heat supply of No.32 and No.47 ThS operation areas, geothermal hot water supply of operating area of No.1ThS from GeoTS installed in No.47 ThS building. Heat supply of the rest part of the pilot area (No.1 ThS area) by group boilers.

SB4-Centralized geothermal heat supply of No.32 and No.47 ThS operation areas, geothermal hot water supply of operating area of No.1ThS from GeoTS installed in No.47 ThS building. Heat supply of the rest part of the pilot area (No.1 ThS area) by individual heaters.

As it is clear from description of alternatives all of them imply the centralized system of geothermal hot water supply and variations of heat supply. Results of economic analyses of all alternatives are presented in Table 2. As it was revealed the Alternative SB', geothermal heat consumption only for hot water supply, has the least cost per MWh thermal energy.

Table 2: Economic estimation of the alternatives for Saburtalo pilot district

Alternatives	Installed capacity, MW	Initial investment, 10^3 USD	Generated energy, 10^3 GWh/yr	Consumed energy, 10^3 GWh/yr	Cost of 1 MWh of thermal energy USD
SA	CENTRALIZED HEAT SUPPLY				
SA1	49.4	6560	91	85	19.08
SA2	59.60	10569	97	92	20.88
GEOTHERMAL HEAT CONSUMPTION ONLY FOR HOT WATER SUPPLY					
SB’	10.6	3937	46	44	13.04
GEOTHERMAL HEAT SUPPLY WITHOUT OTHER ALTERNATIVES					
SB	42.92	9858	93	87	18.59
SB	MAXIMUM CONSUMPTION OF GEOTHERMAL ENERGY FOR HEAT AND HOT WATER SUPPLY				
SB1	58.92	11592	110	102	19.64
SB2	58.32	12056	110	102	20.21
SB3	56.29	11410	109	102	19.18
SB4	56.29	11261	109	102	18.85
SC1	DECENTRALIZED HEAT SUPPLY (BY GROUP BOILERS)				
SC11	49.9	7495	91	85	19.64
SC12	60.5	11505	97	92	22.37
SC2	AUTONOMOUS HEAT SUPPLY				
SC21	49.22	5570	85	85	16.24
SC22	51.4	9448	94	92	20.12
SD	INDIVIDUAL HEAT SUPPLY				
SD1		7394	85	85	18.79
SD2	51.4	7816	94	92	16.67

Pilot project implies the construction of GCS using the existing 4 wells (Fig. 1). Productive wells in this system are: No.5-T* and No.7-T and No.1-Lisi and No.9-T wells are used for re-injection. The principle scheme of GCS presented on Fig.1 considers the thermal water pumping up by hanging pumps from wells N5 and 7 (Diameter of wells are accordingly well N5-T 16” up to 38m and 11” up to 1168m; well N7-T 16” up to 30m and 12” up to 1433m). Their technical condition is rather better than other wells and correspondingly they don’t need the significant rehabilitation works. At present these wells are conserved and thus, the national experts cannot exactly determine the necessary works in advance. Thermal water pumped up at the earth surface passes through the natural degasification sink, installed directly near the wells and then the main stream of thermal water from the wells No.5-T and No.7-T by self-flow is delivered to the Geothermal Station (GeoTS). The GeoTS will be located in the building of former N47 boiler house.

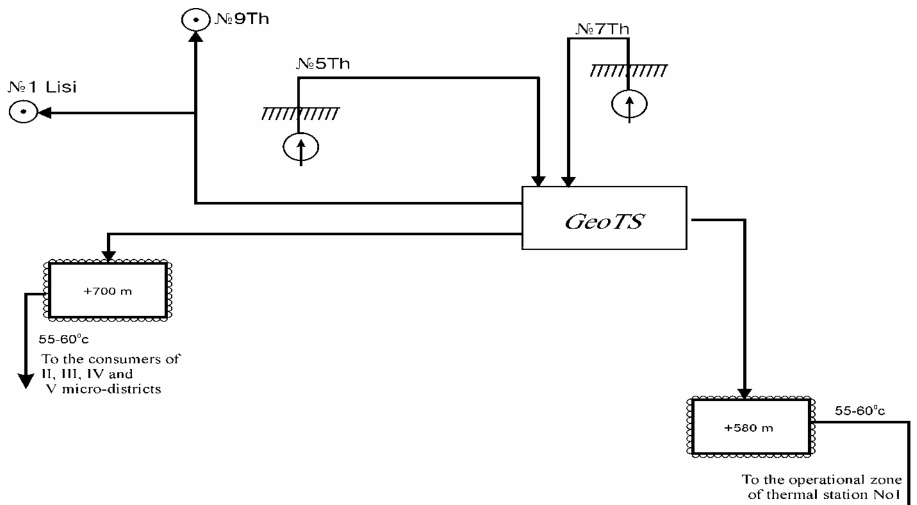

Fig. 1. The principal scheme of Tbilisi Pilot GCS

* The index “T” in wells identification indicates that it was initially drilled for thermal water. Wells with all other indexes are drilled for oil prospecting and are used as geothermal after the end of searching.

The principal technological scheme of GeoTS is shown on Fig. 2. According this scheme raw geothermal water extracted from both wells is delivered to the tank-accumulator 1, which also has the function of degasificator. The vacuum pump 2 connected to the accumulator is producing the necessary vacuum for boiling the geothermal water. The full degasification of geothermal water is resulting of boiling. Evaporated steam is pumped by the vacuum pump 2.

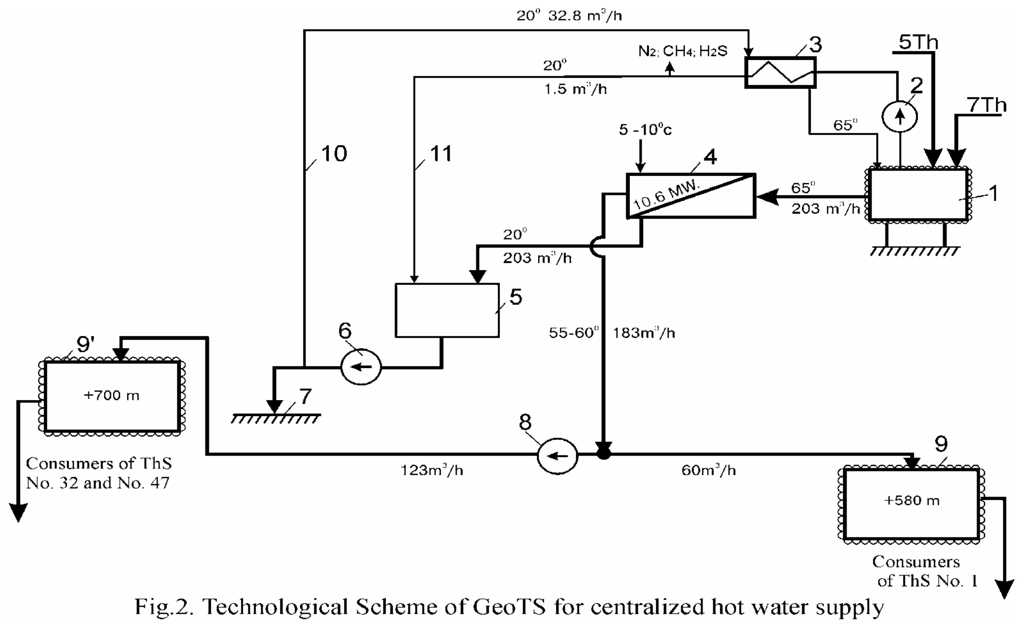

Fig.2. Technological Scheme of GeoTS for centralized hot water supply

1. Collecting degasator of geothermal water; 2. Vacuum pump; 3. Vapour cooler ; 4. Plate heat exchanger; 5. Reservoir of waste thermal water; 6. Re-injection pump; 7. Re-injection well; 8. Hot water transfer pump; 9 and 9' Hot water accumulator reservoir; 10. Re-circulating line of thermal water; 11. Line of condensate flow.

The main flow of degasified thermal water will pass the plate heat exchanger (4), where it will heat up network water. The used thermal water cooled down to about 20^0C is collected in the reservoir (5), from where it is delivered to the re-injection wells N1-L and 9-T (7) by the re-injection pump (6).
Heated up to 55^0C network water runs into the hot water tank-accumulator 9 under the network pressure, and is pumped to the tank-accumulator 9' by the pump 8. The accumulators are located at the different marks thus supplying the consumers with hot water by self-flow.
The initial investments were tentatively estimated based on the existing prices of constructive materials, equipment and salary for employees. The prices of import –oriented materials and equipment are in conformity with the international (European) prices. In the Table 3 are presented the investment components.

Table 3: Initial investments for realization of Saburtalo pilot project

N	Investment components	Investments in thous. USD
1	Preparation of Lisi deposit territory	606,9
2	Rehabilitation of the boiler house N47 building and construction of GeoTS	445,1
3	Construction of hot water reservoir-accumulators on the marks of +580 and +700 m	359,0
4	Installation of the single pipe network in IV and V m/districts of Nutsubidze Plateau	373,0
5	Installation of single-pipe network in II and III m/districts of Nutsubidze Plateau	552,0
6	Installation of single-pipe network in the zone of thermal station N1	351,0
7	Installation of substations	605,3
8	Rehabilitation of internal systems and installation of hot water meters	644,7
	Total	**3937**

The reduction of CO_2 emission in Saburtalo district was calculated considering only hot water supply of this district by geothermal heat and business as usual heat supply. The results of modeling the heat consumption trends and relevant CO_2 emissions for Saburtalo pilot district according the described scenario are presented in Table 4.

Table 4: Fuel consumption and CO_2 emissions for the pilot project in Saburtalo

Year	Annual energy production, GWh	Annual Consumption		Annual CO_2 emissions, thousand tons		
		Natural Gas, million m^3	Electricity, MWh	Natural Gas	Electricity	Total
2001	18.016	1.360	3600	2.666	0.993	6.610[1]
2002	17.920	1.817	26	3.561	0.155	3.734
2003	35.841	3.633	53	7.121	0.309	7.475
2004	36.992	3.750	54	7.350	0.310	7.710
2005	37.979	3.850	56	7.546	0.321	7.919
2006	39.130	3.967	58	7.775	0.333	8.161
2007	40.116	4.067	59	7.971	0.338	8.364
2008	41.267	4.183	61	8.199	0.350	8.606
2009	42.253	4.283	62	8.395	0.355	8.809
2010	43.404	4.400	64	8.624	0.367	9.051
2011	44.555	4.517	66	8.853	0.378	9.293
2012	47.186	4.783	70	9.375	0.401	9.842
2013	48.500	4.917	71	9.637	0.407	10.110
2014	49.816	5.050	73	9.898	0.419	10.385
2015	51.131	5.183	75	10.159	0.430	10.659
2016	52.446	5.317	77	10.421	0.441	10.934
2017	53.762	5.450	79	10.682	0.453	11.209
2018	55.241	5.600	81	10.976	0.464	11.516
2019	55.241	5.600	81	10.976	0.464	11.516
2020	55.241	5.600	81	10.976	0.464	11.516
Total in 2001 - 2020	866.035	87.327	4847	171.161	9.306	182.265
		Baseline Emissions				513.890
		Emission Reduction				331.625

The results of financial and economic estimations of Saburtalo pilot project are presented in tables 5 and 6.

Table 5: Economic estimation (in thousand $)

Disc. rate=10 % Price=30 $/MWh Benefit=17,986,000 $ Cost=12,061,000 $ NPV=5,925,000 $ Rbc=1.491 EIRR=18,3 %

Yr	Consu-mption, MWh	Income	Costs												Cash flow	Accum. cash flow
			VAT	Invest-ment	Fuel	Electri-city	Mainte-nance	Wages	Other	Tax on property	Road tax	Water	Tax on profite	Total		
1	0	0	0	3937	0	0	0	0	0	0	0	0	0	3937	-3937	-3937
2	12248	367	0	1540	22	15	31	18	9	0	0	6	0	1642	-1275	-5212
3	35942	1078	0	816	87	40	77	45	23	0	0	13	0	1100	-22	-5234

[1] In baseline besides natural gas and electricity, there are used also kerosene, liquid gas and firewood

4	48270	1448	0	885	140	49	95	54	27	0	0	13	0	1264	184	-5050
5	59521	1786	0	428	188	58	104	57	29	0	0	13	0	877	908	-4142
6	71019	2131	0	718	252	64	118	63	32	0	0	14	0	1260	870	-3272
7	75628	2269	0	278	276	67	124	66	33	0	0	14	0	858	1410	-1862
8	77888	2337	0	0	284	69	124	66	33	0	0	14	0	591	1746	-117
9	79120	2374	0	0	289	70	124	66	33	0	0	15	0	597	1777	1660
10	80416	2412	0	0	294	71	124	66	33	0	0	15	0	603	1809	3469
11	81775	2453	0	0	298	72	124	66	33	0	0	16	0	609	1843	5312
12	83204	2496	0	0	304	74	124	66	33	0	0	16	0	616	1879	7192
13	84711	2541	0	0	309	75	124	66	33	0	0	17	0	624	1917	9109
14	86296	2589	0	0	315	76	124	66	33	0	0	17	0	631	1957	11066
15	87965	2639	0	0	321	78	124	66	33	0	0	17	0	639	1999	13065
16	89725	2692	0	0	328	79	124	66	33	0	0	18	0	648	2043	15108
17	91570	2747	0	0	334	81	124	66	33	0	0	18	0	657	2090	17198
18	91936	2758	0	0	336	81	124	66	33	0	0	19	0	659	2099	19297
19	91936	2758	0	0	336	81	124	66	33	0	0	19	0	659	2098	21395
20	91936	2758	0	0	336	81	124	66	33	0	0	20	0	660	2098	23493
21	91936	2758	0	0	336	81	124	66	33	0	0	20	0	660	2097	25591
22	91936	2758	0	0	336	81	124	66	33	0	0	21	0	661	2097	27688
23	91936	2758	0	0	336	81	124	66	33	0	0	21	0	661	2096	29784
24	91936	2758	0	0	336	81	124	66	33	0	0	22	0	662	2096	31880
25	91936	2758	0	0	336	81	124	66	33	0	0	22	0	662	2095	33975
Sum	1880785	56424	0	8602	6739	1689	2781	1492	746	0	0	400	0	22448	33975	
PV	599520	17986	0	7571	2084	551	951	515	258	0	0	130	0	12061	5925	
$/MWh			0	12,63	3,48	0,92	1,59	0,86	0,43	0	0	0,22	0	20,12		

Table 6: Financial estimation (in thousand $)

Disc. rate=10 % Price=30 $/MWh Benefit=17,819,000 $ Cost=17,465,000 $
NPV= 354,000 $ Rbc=1.020 FIRR=10,5 %

Yr	Consumption, MWh	Income	**Costs**												Cash flow	Accum. cash flow
			VAT	Investment	Fuel	Electricity	Maintenance	Wages	Other	Tax on property	Road tax	Water	Tax on profite	Total		
1	0	0	0	3937	0	0	0	0	0	0	0	0	0	3937	-3937	-3937
2	12248	184	61	1540	22	15	31	18	9	55	4	6	0	1761	-1578	-5515
3	35942	1078	180	816	87	40	77	45	23	63	11	13	0	1354	-276	-5791
4	48270	1448	242	885	140	49	95	54	27	72	14	13	0	1592	-144	-5936
5	59521	1786	298	428	188	58	104	57	29	76	18	13	103	1372	413	-5523
6	71019	2131	356	718	252	64	118	63	32	83	21	14	82	1803	328	-5195
7	75628	2269	379	278	276	67	124	66	33	86	23	14	185	1530	738	-4457
8	77888	2337	390	0	284	69	124	66	33	86	23	14	249	1339	997	-3460
9	79120	2374	396	0	289	70	124	66	33	86	24	15	254	1357	1016	-2444
10	80416	2412	403	0	294	71	124	66	33	86	24	15	259	1375	1037	-1407
11	81775	2453	410	0	298	72	124	66	33	86	25	16	265	1394	1058	-349
12	83204	2496	417	0	304	74	124	66	33	86	25	16	270	1414	1081	732
13	84711	2541	424	0	309	75	124	66	33	86	25	17	276	1436	1105	1837
14	86296	2589	432	0	315	76	124	66	33	86	26	17	283	1458	1130	2968
15	87965	2639	441	0	321	78	124	66	33	86	26	17	289	1482	1157	4124
16	89725	2692	450	0	328	79	124	66	33	86	27	18	296	1506	1185	5309
17	91570	2747	459	0	334	81	124	66	33	86	27	18	304	1532	1214	6523
18	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	7743
19	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	8963

20	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	10182
21	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	11402
22	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	12622
23	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	13841
24	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	15061
25	91936	2758	461	0	336	81	124	66	33	86	28	19	305	1538	1220	16281
Sum	1880785	56240	9423	8602	6739	1689	2781	1492	746	1983	564	387	5554	39959	16281	
PV	599520	**17819**	3004	7571	2084	551	951	515	258	706	180	129	1516	**17465**	**354**	
$/MWh			5,01	12,63	3,48	0,92	1,59	0,86	0,43	1,18	0,3	0,21	2,53	**29,13**		

4. CONCLUSIONS

The feasibility study of heat and hot water supply systems rehabilitation was carried out in Georgia under the assist of GEF (Global Environmental Facility) in 1999-2000. The above-mentioned project, differing from the previous projects, pays the special attention to energy efficiency increase in the sector and limitation of GHG emissions from the sector. Ensuing from the mentioned these two aspects were paid the keen attention while selecting and elaborating the pilot project, which is one of the main results of this work.

On the basis of analysis of sector’s current conditions and the conclusions of previous studies, Saburtalo district was selected for the implementation of pilot project in Tbilisi. The existence of geothermal water deposit, which supplies to some districts of Saburtalo administrative region the geothermal hot water, caused the selection of Saburtalo district. All the possible alternatives of thermal energy supply were examined for pilot district. In particular, centralized, group, autonomous and individual systems.

Unreliability or absence of the statistic data, non-conformity of still acting sanitary norms with the current climatic conditions in Georgia are reasons of the particular difficulties while the implementation of the works. New parameters determined in the process of work are recommended in the project for heat and hot water supply systems, though calculation of heat loading for the buildings and districts was performed according to still active old norms. The list of the main measures was elaborated implementation of which, according to thermal energy experts` estimations energy efficiency will increase to a minimum 30%. Installation of meters for hot water supply and heat regulators for space heating is important for the considered pilot project. As for energy efficiency increase among the consumers, by improvement of the heat insulation of entrances, flats, walls and windows was not considered at this stage due to high investment necessary for its implementation.

Feasibility study of the pilot project envisages installation of GCS (Geothermal Circulation Station) on the existing 4 wells: No5, No 7, No 1-Lisi and No 9. After the rehabilitation of No5 and No 7 wells minimum 65^0C geothermal water will be pumped up. 20^0C waste water will be re-injected in No1-Lisi and No9 wells. Geothermal station (GeoTS) will be installed in the building of No47 boiler. Warming of drinking water by geothermal water using heat exchangers is the main principle of GeoTS. Later the warm drinking water will be supplied to the population. Thus the debit of the wells will be preserved and restored and pipes will not be damaged by sulphur. 65^0C geothermal water with 200 m^3/h rate from two wells give 10.6 MW of capacity. All the existing networks should be replaced. 14 km of the existing channels should be opened and preinsulated pipes will be placed in it. Hot water meters will be installed in the consumers’ apartments.

Two versions had been considered during the assessment of geothermal resource usage in heat and hot water supply of Saburtalo pilot district. We’d like to distinguish two of them:

1. Total centralized geothermal hot water supply to 27 825 residents of Saburtalo pilot district (operational area of No1, No32 and No47 thermal stations) and heat supply by various options: the centralized, autonomous, group boilers or individual heaters;
2. Geothermal hot water supply to the whole pilot district and geothermal centralized heating only zones of No32 and No47 boilers. Zones of No32 and No47 boilers consist of 119 many-storied buildings with 976 290 m^2 of heated area and 18 618 of residents. As it was discussed in the alternatives, the zone of No1 thermal station which is included in the pilot district (70 buildings (5-8 storied), total heated area – 152 260 m^2, population – 9 207) will be supplied by using various options.

For each alternative of Saburtalo pilot district (14 alternatives in total and 10 out of them by using geothermal heat) were performed economic (without considering various types of taxes) calculations: initial investments, annual incomes and expenses were estimated and prime cost of 1 MW of thermal energy was established. The analysis of the obtained results ascertained that the lowest economic prime cost has the alternative that provides population only with geothermal hot water. In this case the prime cost of 1 MWh of thermal energy is 13.04 US$. As heating should have also been considered in the pilot project selection happened from the alternatives in which population is supplied by heat and hot water. Among them the lowest prime cost – 16.24 US$/1MWh has autonomous heat supply. The system has other merits as well. It's more flexible in the sense of consumed heat repayment that is very important in difficult social conditions existing in Georgia when solvency is very low. Though it's natural that considering limitation of GHG emissions and other environmental aspects the geothermal source usage in heat and hot water supply is more effective than this system.
Thus as a result of estimation of economic and social aspects and GHGs emissions reduction the alternative that envisages supply to the pilot district population with hot water using geothermal heat and heating by autonomous boilers burning natural gas was selected as a pilot project of Saburtalo district. Economic prime cost for this alternative equals to 20.12 US$/1MWh. It is obvious that the combination of geothermal hot water supply with heat supply by autonomous boilers (pilot project) makes the prime cost by 4 dollars expensive. It caused by the inefficiency (25 US$/1MWh) of using autonomous boilers only for heat supply.
This alternative is very important for limitation of GHGs. In particular, CO_2 emission factor equals to 0.125 tonnes on 1 MWh of generated thermal energy for this pilot alternative and 0.233 tonnes – for the autonomous heat supply. As for individual heating (at present population use various types of heating) that is examined as a baseline for this project, CO_2 emission factor equals to 0.261 tonnes for 1MWh thermal energy in case if all consumers use natural gas. But when population use various kinds of fuel this factor is equal to 0.6 tonnes. The most profiTable alternative from the emission reduction standpoint supplies the whole pilot district with geothermal hot water and operational zones of No32 and No47 with geothermal space heating and only one district (No1 boiler) is supplied by the autonomous gas boilers. For this alternative emission factor is equal to 0.105 tonnes of CO_2 on 1MWh of generated thermal energy. But regulation of consumed heat repayment and cutting the non-solvent buildings from the system would be very difficult in this case.
All financial estimations were made for the selected pilot project which foresees hot water supply to the whole pilot district and heat supply to the buildings on the base of previously signed contract according to its solvency.
The main financial parameters of the mentioned pilot alternatives are: initial investment – 9. 448 mln. US$, average annual net profit - 1 200 US$ while 1MWh thermal energy is sold for 30$ (after full operation of the system that according to prognosis will start 5 years later). 3. 937 mln. US$ of investment for geothermal hot water supply will be used the first year and autonomous boilers will be installed step by step during the next 6 years and investment is correspondingly distributed. From the estimation it is clear that Internal Return Rate (FIRR) of the project equals to 10.5% when 1 MWh of thermal energy is sold for 30$. It's very low for the conditions of Georgia and requires privilegable investment or assistance by grant. Net Present Value (NPV) of the project is 354 000 US$ 25 years later. GEF grant is considered during the estimation and it`s supposed that it will make one-third of initial investment of the project. If we take 2. 581 mln. US$ grant, FIRR of the project will increase up to 15.8%.
According to the survey made within the project, at present population of Tbilisi consumes 10% of the necessary norm. At present 1MWh of thermal energy generation using electricity costs 10 tetri in Georgia, using natural gas – 2.5 tetri and according to our pilot project it will cost 6 tetri. Thus, if a capita consumes 30 litre of hot water per day (according to our project 1.6 kWh of thermal energy is necessary for the generation of 30 litre of hot water) it will cost 9.6 tetri (0.096 GEL). Correspondingly monthly expenses for hot water will make 2.88 GEL. As for heating of $1m^2$ of area it will cost minimum 35 kWh* 6 tetri = 2.10 GEL per month (119 kWh*6 = 7.14 GEL – maximum use of heat) and if 18 m^2 room is heated on the average it will cost minimum 37.8 GEL. If we suppose that heating season is five months, annual price will equal to minimum 189 GEL. If we divide the mentioned sum on five months, heating of $18m^2$ room will cost 15.75 GEL which with the price of hot water makes 18.63 GEL. At this stage due to low solvency of population the risk concerning the payback of the price is high. That is why only hot water supply may be examined at the first stage, 1MWh of which may be sold for 20 US$ or cheaper.

That will significantly reduce per month cost on hot water. In particular, per month cost on 30 litre of consumed hot water will be 1.92 GEL instead of 2.88 GEL in case if 1 MWh is sold for 20 US$.

Company “Geothermia” is responsible for installation and maintenance of the system examined in the project and for payback. The company possesses the license on geothermal well and it is setting up the new structure. All relevant agencies connected with geothermal activities in Georgia will join in the structure. Company “Geothermia” is going to establish joint venture together with the foreign and local investors. Municipal enterprise of Tbilisi “Tbomeurneoba” should be considered as the local partner. At present on the balance of the above-mentioned enterprise are all the existing heating infrastructures (boiler plants, thermal stations, networks). Company “Geothermia” will be also responsible for operation and maintenance of the autonomous boilers. Payment agreement will be concluded with the proxy of each building or sometimes with the families. National Agency on Climate Change takes responsibility for the monitoring on project implementation and GHGs emissions reduction.