Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Technological Schemes to Utilize West Georgian Geothermal Resources

O. Vardigoreli, M. Shvangiradze, N. Tsertsvadze, L. Tsertsvadze, and G. Buachidze

30 Bakhtrioni str. apt.35, 0194 Tbilisi, Georgia

E-mail address: irakli@lycos.com

Keywords: Geothermal circulation system, Argo complex, Geothermal power station

ABSTRACT

Over 80 percent of geothermal resources of the Republic of Georgia are in Western Georgia. Of them, of special importance is the Zugdidi-Tsaishi deposit due its vast resources and thermal potential. Apart from this, it is better studied. The thermal aquifer at the deposit has been fractured by the regional fault of 1000-1500 amplitude.

In the upper (upthrown) block, water of about 1.0 g/l mineralization at 82ºC -87ºC is circulating. While the lower (downthrown) block contains water of the 2.5 g/l mineralization at 98ºC-102ºC [1].

In 1997-98 the geothermal wells at the deposit were tested together with American experts. The tests showed that the two tectonic blocks of the producing horizon might be regarded as two independent aquifers, actually as two deposits for there had been no hydraulic links (contacts) established. That is why (proceeding from the above mentioned) it will be possible to regularly produce 30,000 m^3/day of high-temperature geothermal water from the two blocks by building the geothermal circulation system (GCS) and using the waste thermal water reinjection.

In accordance with the location of wells and distribution of users, the deposit has been conventionally divided into three areas. Three GCSs are to be established there. One of them will be used for heating the Zugdidi municipal sector (18-20 MW); the other for heating the big agro complex in Tsaishi (34-36 MW); while in the higher-temperature area (the downthrown block) a binary geothermal power plant (BGPP) will be built [2].

It is possible to generate thermal heat for Georgia's main port of Poti from the Kvaloni and Menji geothermal water deposits. The 20-MW geothermal power plant (GPP) to be built in the village of Kvaloni will be 20-22km from Poti. By connecting it to the Poti central fuel oil boiler, it will be possible to supply geothermal heating to Poti and the neighboring villages.

The balneological resort Tskhaltubo is well known in the world. The temperature of water used in the resort's baths reaches 30-31ºC while the total flow rate amounts to 20,000 m^3/day. This quantity of thermal water is gathered in a special collector that crosses the resort's center and flows down to the river. Transforming the geothermal water's low-temperature heat by thermocompressors, it will be possible to produce the required 24-MW thermal energy that will be sufficient for central heating of the numerous sanatoriums and rest homes in Tskhaltubo. Then there will be no need in the inefficient fuel oil boilers used there currently.

INTRODUCTION

Presently there are about 250 natural and artificial thermal water manifestations at 30º-110ºC. Their total discharge amounts to 160 m^3/day while their estimated resources amount to 250 million m^3/year. The manifestations have been grouped into 44 deposits (Fig.1, Tab.1). Of them, the wells with water at 85ºC and higher have been located in the area covering 3500 km^2. It has been estimated that in those deposits the geothermal energy resource amounts to annual 330 TW.

By the end of the last century the large-scale explorations had been carried out throughout Georgia. They were financed mainly by the USSR Ministries of Geology and of Gas Industry. Now the cost of such work amounts to $150 million. Due to this, the volume of explorations for thermal water greatly increased and in 1998 the volume of its realization amounted to annual 22 million m^3. The structure of utilization of this quantity of water is as follows:

- agriculture (mainly for greenhouses) – 50.7%;
- the municipal sector –29.6%;
- industry (technological hot water supply) – 17%; and
- Balneology – 2.7%.

NEW PROJECTS

a) The Zugdidi-Tsaishi deposit. Over 80% of geothermal deposits are located in western Georgia. Consequently the better part of them (almost 90%) was used there. Unfortunately now we have quite a different picture. During the civil war the geothermal industry in western Georgia had fully fallen into decay. Now it should be rehabilitated anew. The process of rehabilitation should begin with the rehabilitation of the Zugdidi-Tsaishi deposit.

Presently nine productive (Fig. 2 and 3, Tab.2), seven reinjection and three observation wells can be used for the exploitation in the Zugdidi-Tsaishvi geothermal field.

In 1997-1998 the hydrogeological and geothermal tests at the deposit were performed jointly with American experts. It has been established [3] that the deposit consisted of two separate (independent) tectonic blocks or the thermal aquifers at which it is possible to produce regularly through reinjection 30,000 m^3 of thermal water daily. The presence of the two separate (independent) blocks has been the result of (local) regional fracture within the deposit's Lower Cretaceous horizon. It has been established that there had been no hydraulic connection (link) between the upper (upthrown) and lower (downthrown) blocks.

According to the location of wells and distribution of users, the Zugdidi-Tsaishi deposit had been conventionally divided into three areas (zones) in which three separate (independent) geothermal circulation systems (GCS) are to be established. One of them will be used for thermal heating of Zugdidi. In this system wells № 2-t and 3-Zugdidi will be used as production wells. Wells №31-t and 34-t will be used for reinjection. The second system will be used for supplying geothermal heat to the Tsaishi big agro complex. Here wells №1-t, 1key, 8-t, 12-t, and 14-t will be used as production ones while wells №9-t, 11-t, and 22-t as reinjection. Wells №3-t, 4-t, and 5-t will be used as the observation wells. The third GCS is to be established in the downthrown (high-temperature) block where wells № 10-t and 18-t will be used as production wells while well №17-t for reinjection. In this system it is planned to build the binary cycle geothermal power plant (BCGP) (T_{ave} = 95ºC).

There have been project proposals worked out for the first and second systems in cooperation with American firms. The projects provide for the renovation (modernization) of the whole geothermal industry. To establish the system of geothermal energy generation (GCS and the system of thermal water transportation and reinjection) the required estimated investments amount to $2,851 million; for the heat distribution system - $2,717 million; and for the heat utilization system - $2,816 million.

The technological scheme of thermal heating of Zugdidi (the municipal sector) is shown in Fig.4. It operates as follows: the thermal water at 870C is pumped from well №2-t (1) to the vacuum deaerator’s (3) gasification head (4) where it is subjected to the intensive degasification. Then it is sent to the deaerator’s storage tank. From which it is delivered by the transfer pump (2) to Zugdidi. From the deaerator the flash steam is sent by the vacuum pump (4) to the heat exchanger (5) in which the network water is heated due to the flash steam condensation. By the circulating pump (9) the water is sent to the poultry farm (10) heating system. The condensate and gas mixture produced in the heat exchanger is carried to the storage tank from which by means of the reinjection pump (8) it is injected into well №13-t.

Similar process of geothermal water degasification is used in the deaerator (31) available near №3-Zugdidi well. The deaerated water from wells № 2-t and 3-t is sent to the storage tank. Then the whole quantity is delivered by the transfer pump (13) to the Zugdidi heating system (14) central heat exchangers (5') and (5"). Of them the former is the hot water heat exchanger while the latter is the heating heat exchanger. In the heat exchangers the thermal water is cooled to 200C then through pipe-lines (15) and (16) it is sent to the waste water storage tank (18). From there by the reinjection pump (19) it is injected into wells № 31-t and 34-t.

In the second area (the village of Tsaishi) presently there are actually no heat users. There are only the fragments of the Zugdidi poultry farm that are in rather poor condition. That is why the question of building a big agro complex there has been raised. Its final result is shown in Table 3.

The technologhical scheme of thermal energy supply to the Tsaishi agro complex and waste water reinjection is shown in Fig. 5. Here, proceeding from the well location two independent deaerators (1) and (11) are used. From them the deaerated geothermal water is gathered in the mixing chamber (9) and then it is sent to the main heat exchanger (10). Here the geothermal water is cooled to 20ºC and then injected by the reinjection pump (6 1) into proper wells. In the main heat exchanger the network water is heated up to 70º C. It is supplied to the agro complex heating system by the main circulating pump (11). There is one more heat-exchanger (4) (Fig.5) which is designed to cool (by 10ºC) the reinjected geothermal water delivered from the third GCS. In the flash-steam cooler (3) the drinkable (potable) water warmed to 60ºC-65ºC is sent by pump (8) to the hot water supply system.

The technological scheme of heating the agro complex component installations is shown in Fig.6. Here the four-pipe system has been used increasing the initial investments. The four-pipe system allows to maximally equalize the distribution of the annual heat utilization (Fig.7).

The estimated investments required for establishing the geothermal energy generating system are $4,465 million while establishing the heat distribution system needs $3,564 million.

The many years of experience in geothermal facilities exploitation showed that the heat producer and heat user should be within one and the same infrastructure. In the Georgian conditions, such geothermal installations are characterized by the best technical and economic indices.

In Tables 4 and 5 the final result of the engineering-economic analysis are given.

When estimating the dynamic cost of all kinds of expenses of the twenty-year exploitation of the heating system, the 12% interest rate had been taken into account. The natural gas boilers have been considered as an alternative to the geothermal heating.

When comparing the dynamic costs of the thermal heat generation and gas boilers, it becomes clear that the geothermal system is highly efficient. For example, the cost of the geothermal heat component of the agro complex output will be 40% less than the heat component generated by natural gas. This factor is favorable for the competitive ability of its output price and attractive argument for the agro complex’s investors.

b). The Kvaloni deposit. The technological scheme of thermal heat generation and supply to the Poti geothermal heating is given in Fig 8. It is worth noting that in the scheme the network water is used from the artesian wells (7). After being used, the network water is sent to the utilization system. The system is open and the waste network water flows into the sewage system.

c) The Tskhaltubo deposit. Tskhaltubo is the world known popular balneological resort. Until 1991 there functioned 18 sanatoriums, two rest homes and the out-patient center serving 700 patents daily. There is also the hotel "Intourist", a lot of administrative buildings and the multistorey dwelling houses in Tskhaltubo. Presently all of them are not heated, as the old fuel oil boilers had been destroyed. Our project provides for rehabilitation of the Tskhaltubo heating system by using the residual heat of the geothermal water used in balneology by means of a thermocompressor. Through heat transformation of the whole waste water flow rate, it is possible to produce 24 MWt of thermal energy of required parameters that will be sufficient for heating the resort in winter and cooling in summer. This will allow to essentially protect the airspace from pollution.

The geothermal resources available in western Georgia give the opportunity to supply central heating to the regional centers as follows: Khobi – 5.9MW; Senaki – 9.2 MW ; Samtredia – 4.9 MW ; and Vani – 7.7 MW.

REFERENCES:

1. Gzirishvili T. (Project manager) at/al. Removing Barriers to Energy Efficiency Municipal Heat and Hot Water Supply in Georgia. UNDP/GEF-Georgian Government, Project GEO/98/GA32, 2000
2. L. Tallbacka and O.Vardigoreli: Geothermal Power Generation Through Application of Low Temperature Turbine (LTT) Power Generation Technology. International Geothermal Workshop, Russia, Sochi. October 2003
3. Sanyal S.K., et al. Results of a Comprehensive Well Test Programme to Assess the Zugdidi-Tsaishi Geothermal Field, Republic of Georgia. World Geothermal Congress 2000, Kyushu-Tohoku, Japan, 2000

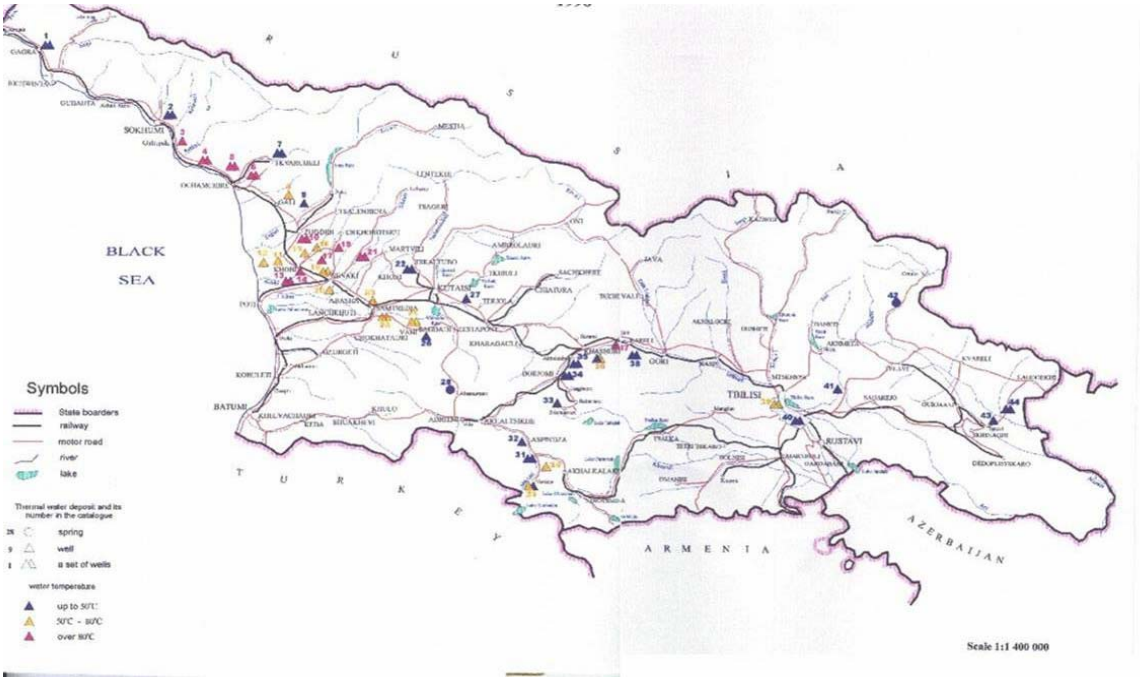

Figure 1: Thermal waters of Georgia, 1998.

Table 1: Basic indexes of thermal water deposits of Georgia.

Deposit No	Name of the deposit	Well No	Tempera-ture t °C	Dis-charge m^3/day	Thermal capacity Δt=t-25°C	The amount of saved equivalent fuel thousand t/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	Mokvi	8	100-105	13470	48,9	73,5
6	Okhurei	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-Tsaishi	15	78-98	24564	69,8	103,8
11	Torsa	1	63	108	0,2	0,3
12	Okros Satsmisi	1	63	104	0,2	0,3
13	Kvaloni	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	Japshakari	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	Menji	3	57-65	5750	9,2	13,6
20	Isula	1	75	370	0,9	1,3
21	Nokalakevi	2	80-82	700	1,8	2,6
22	Tskaltubo	75+4spr.	31-35	20000	7,7	11,5
23	Samtredia	1	61	3000	4,9	7,2
24	Vani region	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 spr.	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	Nakalakevi	3	34-58	795	0,64	1,05
32	Aspindza	1	42	864	0,7	1,0
33	Tsikhisjvari	1	32	1000	0,34	0,5
34	Borjomi	25	30-41	537	0,4	0,6
35	Akhaldaba	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 spr.	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
all		206 wells 8 springs		135599	307,1	458,4

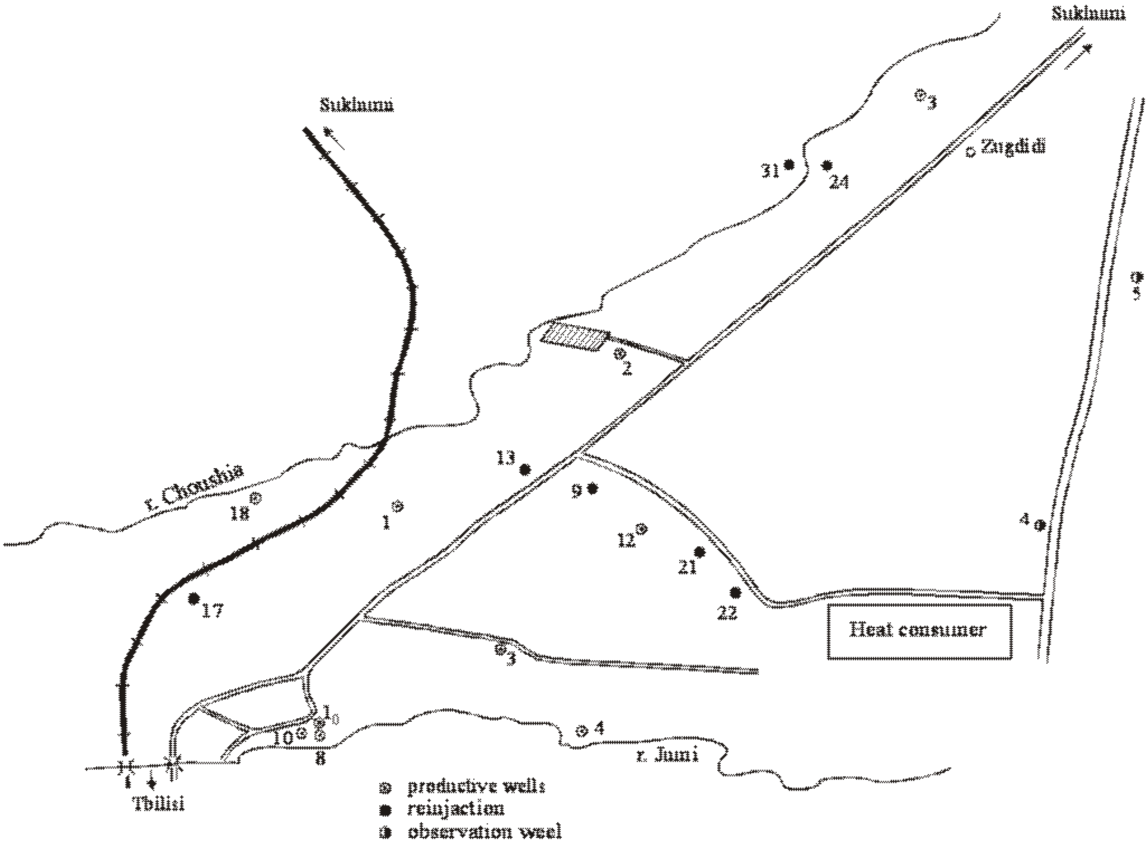

Figure 2: Well locations in Zugdidi-Tsaishi deposit.

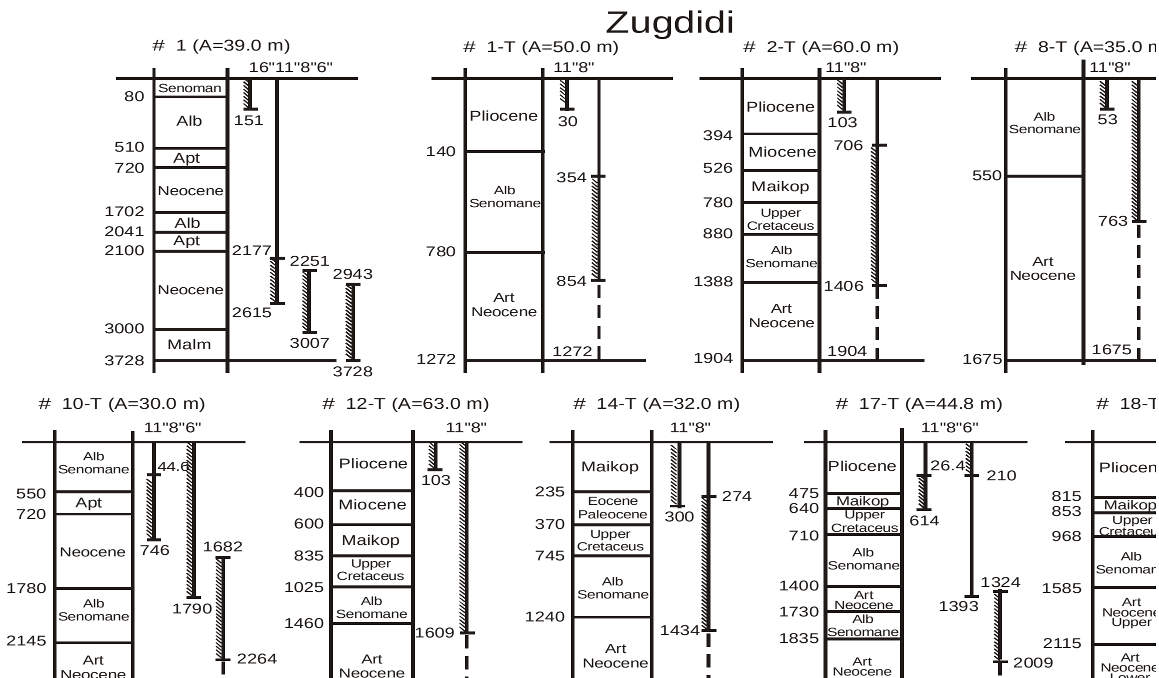

Figure 3: Construction scheme of Zugdidi-Tsaishi deposit productive wells.

Table 2. Main features of Zugdidi-Tsaishi deposit productive wells

##	Well number	Year of lead-in	Bench mark, m	Aquifer interval	Index	Depth, m	Pressure atm	Discharge m^3/day	T °C	Chemical composition
1	1-on	1963	34.3	731-1,790	K_1	3,728	3.0	1,600	82	$M_{1.47}\frac{SO_4 64 Cl 26 HCO_3 10}{Ca 58 Na 19 Mg 19 K 4}$
2	1-T	1980	53.0	780-1,272	K_1	1,272	3.0	3,800	86	$M_{1.18}\frac{SO_4 61 Cl 25 HCO_3 14}{Ca 58 Na 21 Mg 18 K 3}$
3	2-T	1980	58.65	1,388-1,904	K_1	1,904	3.5	2,800	87	$M_{1.24}\frac{SO_4 63 Cl 22 HCO_3 15}{Ca 55 Na 21 g 20 K 4}$
4	8-T	1983	28.9	730-1,675	K_1	1,675	-	6,000	84	$M_{1.54}\frac{SO_4 63 Cl 27 HCO_3 10}{Ca 56 Na 22 Mg 18 K 4}$
5	10-T	1985	35.81	2,450-2,800	K_1	2,803	5.2	3,000	102	$M_{2.4}\frac{Cl 50 SO_4 43 HCO_3 7}{Ca 45 Na 39 Mg 12 K 4}$
6	12-T	1986	69.69	1,460-2,410	K_1	2,410	-	3,000	90	$M_{1.59}\frac{SO_4 64 Cl 28 HCO_3 8}{Ca 55 Na 21 Mg 204}$
7	14-T	1986	32.0	1,240-2,000	K_1	2,000	-	2,500	84	$M_{1.42}\frac{SO_4 70 Cl 20 HCO_3 10}{Ca 67 Mg 19 Na 14}$
8	17-T	1987	44.8	2,350-2,749	K_1	2,749	-	3,000	94	$M_{1.19}\frac{SO_4 70 Cl 16 HCO_3 14}{Ca 55 Mg 23 Na 18 K 4}$
9	3-Zug	1966	93.7	1,525-2,400	K_1	2,401	0.17	3,000	84	$M_{0.87}\frac{SO_4 61 Cl 21 HCO_3 18}{Ca 54 Na 25 Mg 21}$
10	18-T	1987	+40.0	1,584-2,820	K_1	2,820	-	2,500	93	________

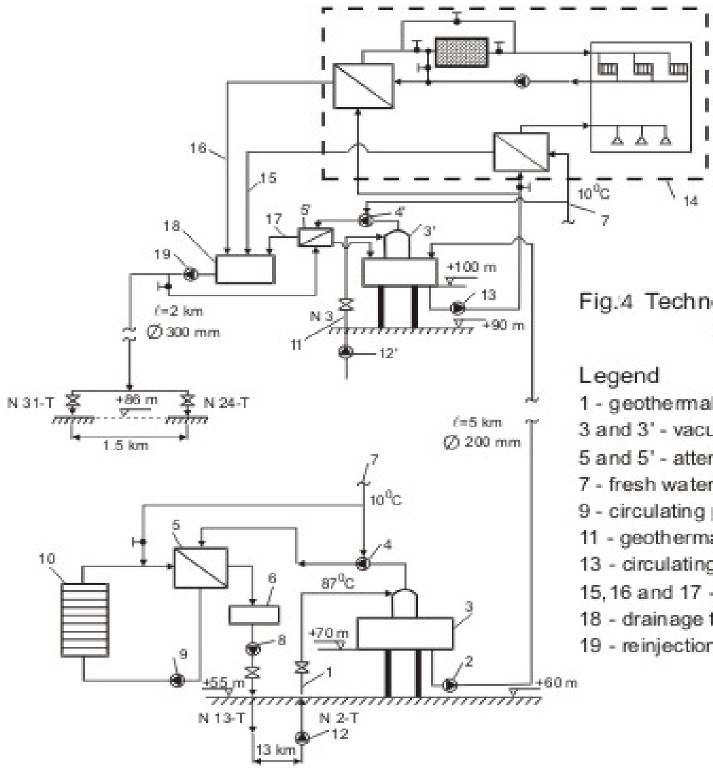

Fig.4 Technological scheme of geothermal heating of Zugdidi

Legend

1 - geothermal well No 2-T; 2 - transfer pumps;
3 and 3' - vacuum deaeration; 4 and 4' - vacuum pump;
5 and 5' - attemperator; 6 - condensat basin;
7 - fresh water pipeline; 8 - reinjection pump;
9 - circulating pump; 10 - paultry farm;
11 - geothermal well No 3; 12 and 12' - submecible pumps;
13 - circulating pump; 14 - heathing system of Zugdidi;
15, 16 and 17 - pipeline system;
18 - drainage thermal insulation basin;
19 - reinjection pump.

Table 3. Estimated amount of investments required for building the Tsaishi agro complex

№	Investment components	Sum of investments $million
1.	Full rehabilitation and putting into operation the integrated poultry farm; annual capacity 600 tons	3,3-3,6
2.	Building and putting into exploitation the greenhouse integrated farm; annual capacity 1800 tons	4,2-4,5
3.	Building and putting into exploitation fish industry; annual capacity - 320 tons	3,0-3,4
4.	Outdoor fishing pond with warm water - 120 ton/year.	1,2-1,5
5.	Building and exploiting of the vegetable storehouse (refrigerator). Capacity - 200 ton.	1,5-1,8
6.	Building and putting into operation the tea-leaf and fruit drier. Annual capacity - 1500 ton	1,5-1,8
7.	Building the mushroom-growing farm with heating and cooling systems. Its exploitation. Annual capacity -1500 ton	4,9-5,2
8.	Outdoor market garden with heated soil. Annual capacity -1500 tons of vegetable	2,0-2,3
	TOTAL	21,6-24,1

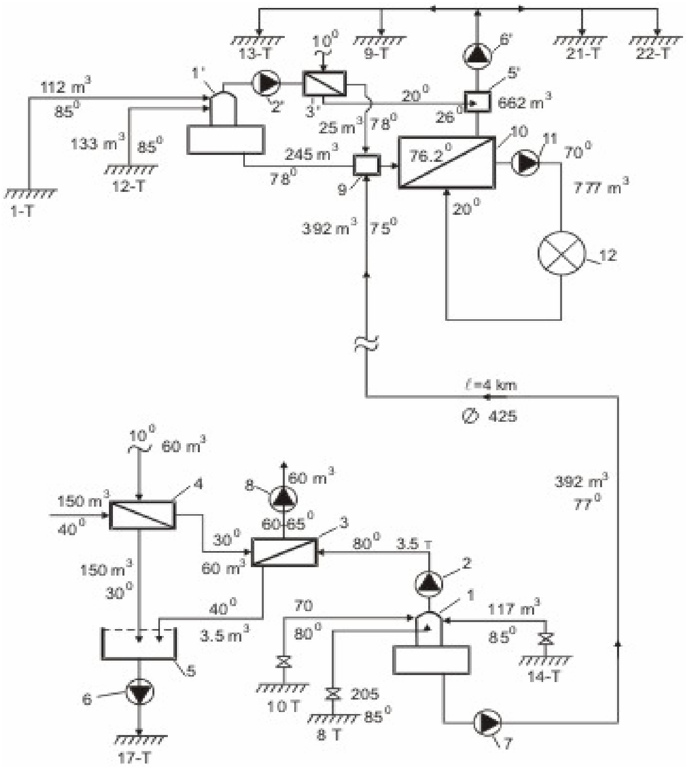

Fig. 5 Technological scheme of geothermal heating of the Tbilisi region a big agrocomplex

Legend

1 and 1' - vacuum deaerations;
2 and 2' - vacuum pumps;
3 and 3' - attemperators;
4 - exchanger;
5 and 5' - drainage thermal insulation basins;
6 and 6' - reinection pumps;
7 - thermal water transfer pump;
8 - heat water transfer pump;
9 - mixing camera;
10 - major exchanger;
11 - circulating pump;
12 - agrocomplex.

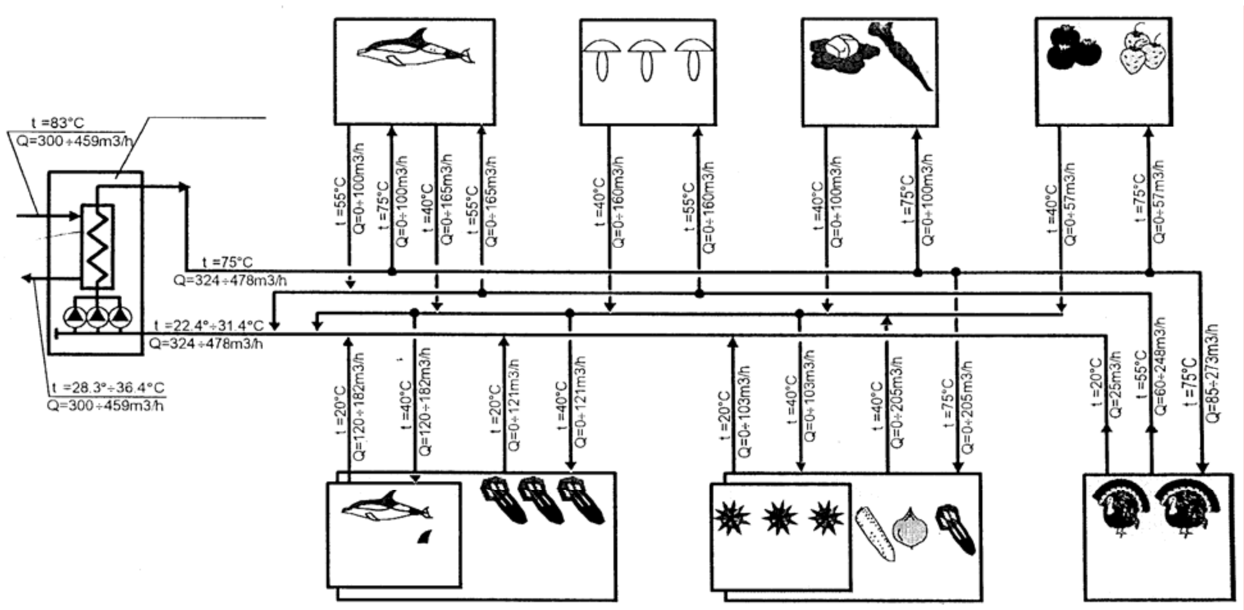

Fig. 6. The principal scheme of geothermally powered Agrocomplex.

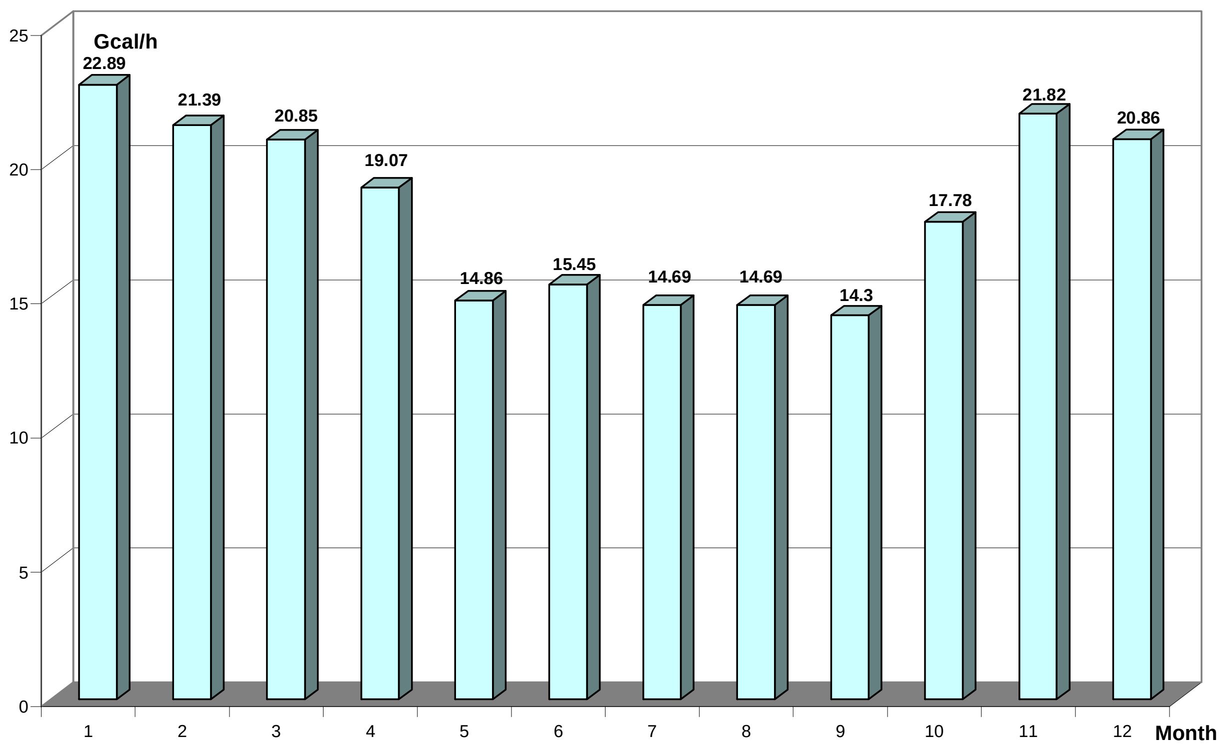

Fig. 7. Heat load diagram for Agro complex

Table 4. Dynamic cost of thermal energy generated by the Zugdidi heating system

Expenses USD/MWhr						
Investment components	Capital investments	Electric power purchase costs	Technical maintenance costs	Payment costs	Total, geothermal energy	Total costs per gas boiler
Heat generation	6,4	2,5	0,9	0,7	10,5	16,9
Heat Distribution	6,1	0,6	0,8	0,3	7,8	4,8
Heat utilization	6,3	-	0,9	0,9	7,8	8,6
Total	18,8	3,1	2,6	1,6	26,1	30,3

Table 5. The dynamic cost of the thermal energy generated for the Tsaishi agro complex

Expenses USD/MWhr						
Investment components	Capital investments	Electric Power purchase costs	Technical maintenance costs	Payment costs	Total per geothermal energy	Total costs per gas boiler
Heat generation	3,3	1,8	0,5	0,3	5,9	16,9
Heat distribution	2,7	-	0,4	0,1	3,2	4,8
TOTAL	6,0	1,8	0,9	0,4	9,1	8,6