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Geothermal Energy of the Autonomous Republic of Crimea

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1. INTRODUCTION

Today the world community has realized the necessity of transition to a new model of development, which presumes the balance of economic and ecological interests. There are no purely ecological or purely economic problems, but there are common problems in the development of the environment.

The countries of the European Union promote this concept and they actively encourage dynamic development of energy-effective technologies including the technologies that use restorable sources of energy, which are almost inexhaustible and most important, are ecologically clean.

The main factors that define the relevance of this concept are the following:

- provision of energy security;
- reduction of the volume of harmful emissions;
- preservation of local energy resources for future generations.

During the last decades the work of scientists and specialists in many countries has been directed at finding ways to reduce the harmful influence of the energy industry on the environment. It is related first of all to the fact that when the population grows the usage of energy produced by nuclear fuel, coal, oil and gas increases. This is in spite of the introduction of perspective technologies, which reduce harmful emissions. In the traditional energy industry ecological problems do not get resolved. More than that, when energy is produced with the use of organic fuel, nuclear, and thermonuclear energy, besides affecting people it activates the processes of “heat pollution” of the environment. Some scientists think that overheating of the environment to 3.5 degrees is the critical point and it can lead to global changes in climate and atmosphere, which is “the greenhouse effect,” because it will increase the concentration of carbonic acid gas (carbon dioxide) in the atmosphere. [1]

Thus, aiming at achieving highly productive and universal ways of energy consumption, the society finds itself in living conditions that are hard to control and it has to depend on the usage of organic elements.

The world community has defined the following main tendencies in the development of modern energy industry:

- wide usage of restorable sources of energy;
- elaboration and introduction of highly effective energy preserving technologies in traditional power engineering.

2. THE PERSPECTIVES OF IMPLEMENTATION OF THE KYOTO PROTOCOL IN UKRAINE

Considering all that is said above, the articles of the Kioto protocol become the priority. [2] Their implementation will allow us to solve the problems of ecology and effectiveness of energy on the basis of introducing joint projects, attracting investments and passing quotas of emissions in the sphere of technical rearmament of the industry and municipal sector.

Ukraine has ratified the Kioto protocol and by doing this it has not only received opportunities but also has accepted certain responsibilities before the world community.

Our country is facing some difficulties at its present stage of economic development but it sees a real perspective in solving the problems in the energy industry, which will reduce the energy consumption of total resources (gross income) and will bring investments into the country.

Developing a project on arrangements schemes and ways of functioning of the Kioto protocol in Ukraine becomes the priority. It has to be a mobile business infrastructure. It is very important that by 2008 Ukraine creates such a mechanism and works on a world carbon market.

Within the framework of the Kioto protocol in Ukraine, the Autonomous Republic of Crimea is one of the prospective regions. It has a pretty high potential of restorable sources of energy.

The problems of energy engineering, as well as the problems of preserving unique natural curative treasures of the peninsula, are of a major concern to Crimea. In regard to that, restorable sources of energy of the region are considered to be a source of stabilization of energy industry as well as preservation of ecology.

The peninsula has a pretty high potential of wind energy and solar resources. It also has a number of small rivers with fast currents, which can be used as water supply systems if we build economically effective mini-hydroelectric stations on them. There are considerable geothermal waters resources.

The evaluation of recommended volumes of usage of restorable sources of energy was done within the framework of the EU program TACIS. Annual resources constitute around 569.8 thousand tons of c.f. (conditional fuel). [3]

Looking at restorable sources of energy as at a source of stable and ecologically safe development of energy industry, we stand at the beginning of creating a systematic approach to developing and implementing projects on

exploiting restorable sources of energy, including geothermal energy.

3. RESOURCES OF GEOTHERMAL ENERGY IN CRIMEA

Thermal water fields are located in the steppe part of Crimea and they can be effectively used in different areas of the economy – such as thalasso-therapy in resort-recreation complexes, local heat supply in communal settlements and technological complexes that process products of agriculture.

The data in geology exploration has shown that the resources of Crimea that can be exploited constitute 475 thousand cubic meters per day. But these resources cannot be practically used in their full volume because the heat power of geothermal waters cannot be transported further than 3 km. In order to implement economically reasonable geothermal projects we have to consider users located on the territory of the field.

In Crimea, by geological and geothermal conditions, the most prospective are the following regions: Novoselovskaya, Oktyabrskaya, Severo-Sivashskaya territories (table 1). It includes up to 40 wells (including 12 duplets) 1000-2300 m deep with a debit of thermal waters on the point of outpouring -1000-5000 m^3/day (picture 1) and the temperature of stratum water at the mouth – 46-90º C(picture 2). The heat power from such ecologically clean systems constitute 1-6 MWt (picture 3). Mineralization of stratum waters varies between 1.1 and 43 g/l. By their chemical composition the waters are mostly chloride-sodium. Among the micro-components we can single out high contents of iodine (up to 33mg/l) and bromine (up to 143 mg/l).

Practical results of the work on exploiting geothermal energy have shown that the usage of geo-circulation systems (with reverse pumping of used thermal waters into the stratum) is economically and ecologically reasonable. In the past in a number of settlements such systems were built in order to supply the settlements and hothouses with heat.

The data that we have today (table 2) confirms that there is a possibility of social and economical development of the mentioned regions if we use energy potential of thermal waters and hold complex researches on an industrial scale.

4. THE PROJECT OF GEOTHERMAL HEAT SUPPLY OF KRASNOGVARDEYSKIY REGION

Today within the framework of the state program “Ecologically Clean Geothermal Energy Engineering of Ukraine” there exists a number of projects that have potential possibilities for being implemented within the framework of solving social and ecological problems. [4]

The most significant development has been achieved on Oktyabrskaya area thermal waters, where in a number of villages there exist duplets of geothermal wells on the basis of which it is possible to build geo-circular systems.

There are plans to build and start industrial exploitation of the systems of geothermal heat supply of communal and industrial objects in the Krasnogvardeyskiy region including the settlement of Krasnogvardeyskoe, and the villages of Kotelnikovo, Rovnoe, and Pyatihatka, with total capacity (power) of 85 MWt. In the villages Kotelnikovo, Rovnoe and Pyatihatka heat-technical infrastructure, including geothermal wells (table 3) and heat stations for building systems of geothermal heat supply, has been created.

In the Krasnogvardeyskiy settlement, the heat supply is provided from heaters that use natural gas. Geothermal heat stations with the capacity of 70 MWt are planned to be installed. The industrial system of geothermal heat supply of Krasnogvardeysk region, which has major sources of thermal waters, is suggested to be considered. The system will consist of an ecologically clean heat supply complex that will be able to compete with traditional systems working on organic fuel. In our opinion the project is remarkable in its technical structure from the point of view of economy and ecology and it will use natural resources. In order to produce the necessary quantity of thermal water and reverse pumping of cooled water we consider building a geothermal circulation system that will consist of 5 exploitation and 5 pumping wells. The main technical characteristics of the geothermal system of heat supply are offered in table 4.

The capacity of the object is calculated to be round 85 MWt, with annual economy up to 40 thousand tons of the conditional fuel and reduction of harmful emissions of 87.6 tons per year. Expenses constitute up to 24 million US dollars, including drilling of 10 wells 2800 m deep and conducting hydro-geological and geo-physical researches (table 5).

Geothermal system of heat supply in Krasnogvardeysk settlement is based on circulation technology, which will provide:

1. stable extraction of geothermal waters with assigned volume and assigned thermodynamic parameters for at least 25 years;

2. reliable utilization of highly-mineralized natural heat carrier.

In accordance with this technology thermal water goes into heat-exchanger and heats the water in the net, and then is pumped into a pumping well, that is, into the same water carrier horizon of natural geothermal water carrier. That should allow the following:

- restoration of geothermal water resource;

- support of stratum pressure which provides long term period of exploitation of the geo-circulation system.

The technical scheme of the geothermal heat supply system of the Krasnogvardeysk settlement is shown in picture 5.

Expected economic values of the Krasnogvardeysk project on geothermal heat supply is shown in table 6.

The planned project is the first wide scale development in the sphere of geothermal energy engineering of Ukraine in Crimea. In present conditions, considering the lack of stable heat supply, the use of considerable resources of geothermal waters is economically and ecologically reasonable and timely in certain regions.

The practical implementation of the project will allow:

- providing the population and enterprises with reliable long-term and ecologically clean heat supply;

- reducing the usage of organic fuel and reducing the emission of CO^2 and other hothouse gases;

- using the existing exploration wells for producing geothermal heat carrier in order to build systems of geothermal heat supply.

Our calculations have shown that, in general, the production of heat supply in the quantity necessary for covering the assigned heat load of 85 MWt in Krasnogvardeysk, Kotelnikovo, Rovnoe and Pyatihatka constitutes 25470 m^3/day and it can be provided by geo-circulation systems.

In developing this project we count on the support of international financial organizations and the World Bank and we will lay all our efforts in its effective implementation.

5. CONCLUSION

1. With the present conditions of the development of the fuel-energy complex of the Autonomous Republic of Crimea expending the use of restorable sources of energy, including geothermal energy engineering, has the status of state work, which was reflected in the Program of the work of the Cabinet of Ministers of Ukraine "Consistency. Effectiveness. Responsibility" [5] in 2004.

2. The development of cooperation between the Autonomous Republic of Crimea and international financial organizations in working out a strategy in using geothermal energy in Crimea is one of the directions of state work in creating local ecologically clean base.

3. Implementation of geothermal projects in the area of communal and agricultural-industrial complexes of particular regions of the peninsula will allow us to improve the social and economic situation in Crimea in general.

4. Introduction of new technologies in the sphere of geothermal energy engineering will allow us to create economically beneficial and ecologically clean systems for providing some braches of economy with heat and electric energy.

6. REFERENCES

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3. Elaboration of the plan of developing power engineering in the Autonomous Republic of Crimea, the Final report, Strategy of the development of non-traditional sources of energy, vol.IV-page 23.
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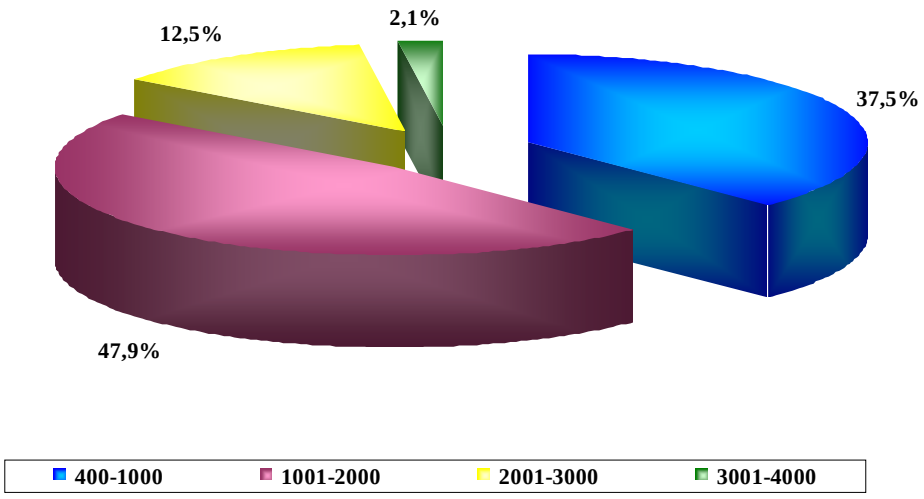
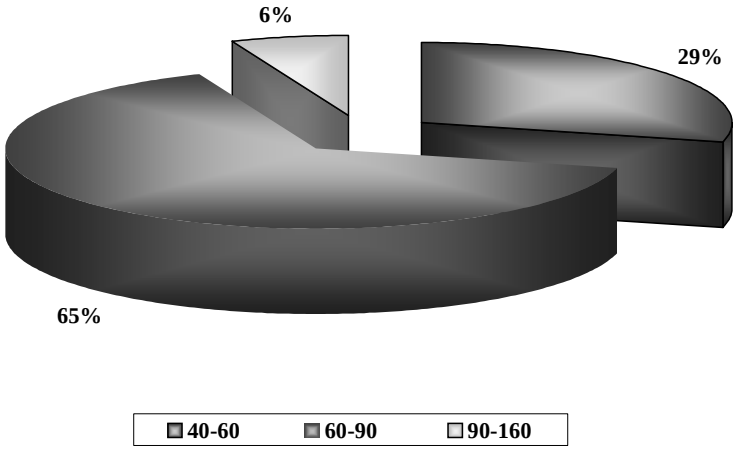
5. The program of the work of the Cabinet of Ministers of Ukraine "Consistence. Effectiveness. Responsibility" – Kiev – 2004 – page 142

Table 1 Characteristics of geo-circulation systems in Crimea

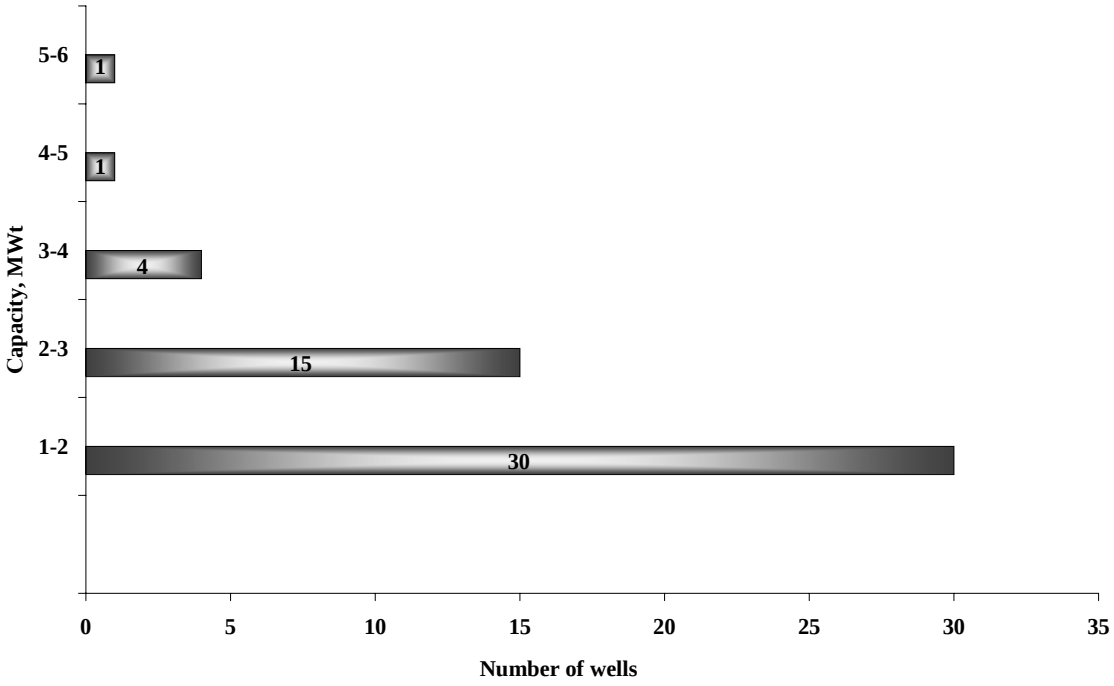
№ п/п	Area, settlement	Depth of the well, m	Debit of the well, m³/day	Temperature of the water at the mouth, °C	Mineralization, g/l	Power of the Collector, m	Power, MWt	Objects of heat supply	Annual economy of fuel, Tons of c.f.
1	2	3	4	5	6	7	8	9	10
				Novoselovskaya area					
1.	Il'inka	1200	1730	59	11,0	100	1,0	residential settlement	500
2.	Sizovka	1400	1730	63	18,0	93	1,0	residential settlement	500
3.	Trudovoe	1160	2300	54	8,0	110	1,0	hothouses, hot water supply	700
4.	Zernovoe	1100	1730	51	5,0	110	1,0	hothouses, hot water supply	500
				Oktyabrskaya area					
5.	Kotelnikovo	1500	1600	66	6,4	100	2,0	residential settlement	1 000
6.	Yantarnoe	2300	1490	87	43,0	200	5,0	residential settlement	5 000
7.	Novoalexeevka	1360	4950	58	1,5	200	3,0	dairy farm, residential settlement	-
8.	Rovnoe	1360	3345	65	9,0	150	3,0	residential settlement	1 500
9.	Pyatihatka	1300	4000	57	1,1	80	1,0	hot water supply	2 500
10.	Krasnogvardeyskoe	project 2800	2200	96	≈ 20,0	200	70,0	city districts	30 000
				Severo-Sivash area					
11.	Medvedevka	1750	670	67	26,0	80	1,0	residential settlement	1 000



Picture 1. Allocation of wells in Crimea by debits (m³/day)



Picture 2. Allocation of wells in Crimea by temperature ºC.



Picture 3. Allocation of wells in Crimea by their capacity

Table 2: Potential characteristics of geothermal wells

№№	Number of wells, Residential settlement	Debit of self outpouring, m³/day	Temperature at the mouth/ In stratum conditions, ºC	Quantity of produced heat, Gcal/day	Heat capacity, MWt/hour
Krasnogvardeyskiy region (Oktyabrskaya area)					
1	Well 32, Kotelnikovo	1600	66 / 69	57,6 / 41,6	2,8 / 2.0
2	Well 33, Rovnoe	3345	65 / 68	117,0 / 83,6	5,6 / 4.0
3	Well 35, Novoalexeevka	4925	58 / 60	137,9 / 88,7	6,6 / 4,3
4	Well 36, Yantarnoe	1490	87 / 92	84,9 / 70,0	4,1 / 3,4
5	Well 38, Pyatihatka	4000	57 / 60	108,0 / 68,0	5,2 / 3,3
Saki region(Novoselovskaya area)					
6	Well 14, Trudovoe	2300	54 / -	55,2 / 32,2	2,6 / 1,6
7	Well 14, Trudovoe	1730	59 / 62	50,2 / 32,9	2,4 / 1,6
8	Well 21, Sizovka	1730	63 / 67	57,0 / 39,8	2,7 / 1,9
9	**Well 28, Zernovoe .**	1730	51 / -	36,3 / 19,0	1,7 / 0,9
10	**Well 41, Frunze**	1740	62 / 64	55,6 / 38,2	2,7 / 1,8
Djankoy region (Severo-Sivash)					
11	Well 39, Medvedevka	670	68 / 74	25,5 / 18,7	1,2 /. 0,9
12	**Well 1, Predmostnoe**	1894	67 / 69	90,0 / 60,0	4,3 / 2,9

Note: heat potential and capacity of the geo-circulation system were calculated while measuring the temperature in a heat-exchanger up to 30 and 40ºC respectively.

Table 3 Information on wells drilled in Krasnogvardeysk area

Parameter		Number of the well			
		2 – Krasnogvardeyskaya	**32 – Kotelnikovo**	**33 – Rovnoe**	**38 – Pyatihatka**
1.	the year when the well was drilled	1970	1990	1990	1990
2.	the depth of the well	2693	1509	1963	1186
3.	the age of water carrier horizon	Lower nel, neocom			
4.	Litological composition of waterholding rocks	Sandstone, alevrolite	sandstone	sandstone	sandstone
5.	interval of the locations of water carrier horizon, m	2520-2601	1355-1509	1185-1360	975-1186
6.	Capacity of water carrier horizon, m	81	144	175	211
7.	Stratum temperature, ºC	≈ 100	66	65	57
8.	Static level of thermal waters regarding earth surface, m	≈ (+180,0)	+180,5	+187,9	+189,6
9.	Debit of selfoutpouring, m³/day	Hasn't been tested	1600	3345	4000
10.	Temperature of thermal water at the mouth of the well, ºC	≈96	64	62	55
11.	Mineralization, g/l	21,5	6,35	9,0	1,1
12.	Specific components, mg/liter	J-is not defined Br – 25.9 B – is not defined NH – 32.4	J-2,6 Br – 12,5 B – 10,8 NH – 9,0	J – 5,5-1,8 Br –19,6-28,5 B – not defined NH – not defined	J – none Br – none B – not defined NH – not defined
13.	pH value	7,2	7,3	7,1	7,5
14.	echnical condition of the well	satisfactory	satisfactory	satisfactory	satisfactory

Table 4 Technical data of the system of geothermal heat supply of Krasnogvardeysk settlement

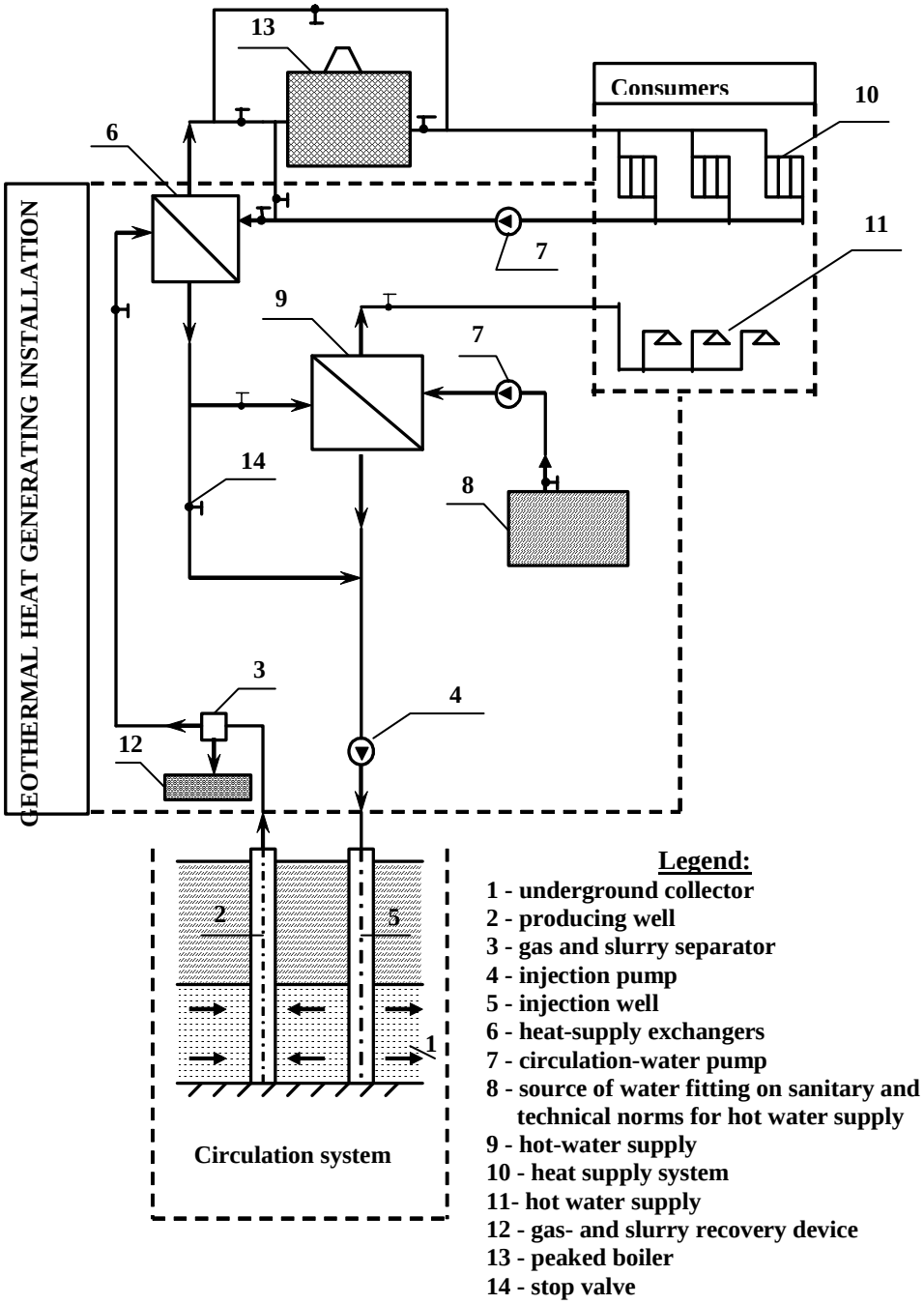
№	data	value
1.	Temperature of geothermal water	96ºC
2.	Static pressure at the mouth of the well	12 athm.
3.	Mineralization of thermal water	15…20 g/l
4.	Number of exploitation wells	5
5.	Number of consuming wells	5
6.	Debit of the exploitation wells	4400m³/day
7.	Debit of consuming wells	4400m³/day
8.	Prognosis of exploitation resources of thermalwater-intake working in the conditions of pumping used heat carrier	22000m³/day
9.	Heat workload of the users including: - heat supply system - hot water supply system	69.6 MWt 61.3 MWt 8.3 MWt

Table 5 Volume of financing

The source	**Thousand US dollars**
The World Bank (preparing the project)	1 500
A Foreign bank credit	16 500
Local investments	6 000
Total:	24 000

Table 6 Expected economic data of Krasnogvardeysk project on geothermal heat supply (heat capacity – 85 MWt)

data	value
1. Major (capital) expenses, thousand US dollars	
1.1. Geothermal stations	14000
1.2. Wells (5 producing ones and 5 pumping ones)	10000
Total	**24000**
2. Exploitation expenses, thousand US dollars	
2.1. Cost of materials, spare parts, electricity, others	750,4
2.2. Salaries for the personnel (10 people)	143,2
2.3. Other expenses (non-budget funds, local taxes, overhead costs, maintenance of the premises and such)	77,0
2.4. Unexpected expenses	31,8
Total	**1002,4**
2.5. Amortization (10%)	**2400**
3. Economic data	
3.1. Annual production of heat, MWt/hour	258560
3.2. Specific capital investments, US dollars/kW-hour	282,4
3.3. Prime cost of the heat production, US dollars/MWt-hour	3,88
3.4. Annual economy of the conditional fuel, tons of c.f.	40000
3.5. Reductions of CO emission, tons	87600
3.6. Time period of cover of expenditure of the capital investments, years (income tax – 30%)	
- with the price of 15.5 US dollars for 1 MWt/hour	8
- with the price of 20 US dollars for 1 MWt/hour	6
- with the price of 27 US dollars for 1 MWt/hour	4,5
- with the price of 37 US dollars for 1 MWt/hour	3,3



Picture 5. Technological scheme of a geo-circulation system