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Strategy of development of the low-enthalpy geothermal energy resources in Macedonia for the period 2000-2010

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ABSTRACT

Main part of the exploitation geothermal energy resources in Macedonia are in use by different (mainly agricultural) projects. The composition of users doesn't enable to reach enough high annual heat loading coefficients and, in that way, possible valuable benefits of this home energy source. On the other hand, there are still a number of geothermal fields in exploitation status for already ten years, without any geothermal project.

Taking into account the weak economy status of the country, the main engagement for development during the period 2000-2010 shall be concentrated to the reconstruction and optimisation of the existing projects by recombining of the users with connection of new ones with different annual heat use characteristics, then by establishment of new projects with convenient characteristics and proven good composition of possible users and, finally, by beginning the development of the projects with aggressive geothermal fluids on disposal, having good composition of possible energy users. Two possible scenarios of the strategy of development are discussed in the paper and necessary conclusions extracted, enabling a good orientation for the influencing factors, necessary preconditions and consequences of the different variants of development.

KEYWORDS

Geothermal energy, development strategy, Macedonia

Introduction - Nature and estimation of the energy resource

Geothermal manifestations in Macedonia, either paleogeothermal or contemporary ones, are mainly connected to the Vardarian (Central) zone. Their stretching in the other geotectonic

units and also in the Serbo-Macedonian mass is significantly weaker. According to the results of the realized studies, the geothermal manifestations are represented as paleogeothermal manifestations from magmatic and volcanic rocks; hydrogeothermal manifestations as paleohydrogeothermal and contemporary, and caustobiogeothermal manifestations.

The hydrogeothermal phenomena are stretched as contemporary and paleohydrogeothermal phenomena in the frames of the Vardarian zone and Serbo-Macedonian Massif. Their presence show intensive hydrogeothermal activity in the past and today in all entire region, particularly in the Vardarian zone. The contemporary hydrogeothermal manifestations are mostly present in the Vardarian zone as a very unstable tectonic unit, and a part of them can be found on the marginal belt between the valley of Vardar and the Serbo-Macedonian Massif. They mainly appear in the lower parts of the explored area.

Presently, 18 localities with contemporary hydrogeothermal manifestations are known in Macedonia, with more than 50 manifestations (figure 1) i.e. wells with thermal or thermomineral water, exploration drillings and exploitation wells.

According to the mineralization, thermal waters are weakly to medium mineralised, with mineralization from 1000 to 3700 mg/l. Only the waters from the Kotchani valley are low mineralised, containing only 0,5 g/l diluted elements,

Of the seven geothermal fields identified in the East and Northeast part of the country, four have been found to be very promising and three of them have been investigated to the stage where practical use is possible. Available flows and temperatures of known geothermal waters in Macedonia can be found in Table 1.Except the springs in Debarska banja and Kosovrasti, which are in the West Bosnian-Serbian-Macedonian geothermal zone, all the others are located in the Central Serbian-Macedonian Geo-thermal Massif (Central and Eastern Macedonia), with the adequate consequences in relation to the chemical composition and other specific characteristics (Kotevski, 1995).

When estimation of the energetic value of the geothermal resource in Macedonia (table 1) is in question, it should be made not only according to the con-temporary technical possibilities but also according to the technical level of the projects in exploitation. Based on the previous experience and technical level of the users, it is realistic to expect that it shall not be possible to reach lower temperatures than 30°C of the effluent water, at least during the next 10 years.

As a consequence of that, the real heat power of presently available geothermal flows is not 283 MWt but about 116 MW. By decreasing the lower limit to 25 °C to the end of the decade, the available power shall increase to about 135 MW. On the previous experience and technical level of the users, it is realistic to expect that it shall not be possible to reach lower temperatures than 30°C of the effluent water, at least during the next 10 years. As a consequence of that, the real heat power of presently available geothermal flows is not 283 MWt but about 116 MW. By decreasing the lower limit to 25 "C to the end of the decade, the available power shall increase to about 135 MW.

It is necessary to underline that these estimations are based to the presently available flows and temperatures of the exploitation wells and sources in Macedonia. Another problem is that it is possible to double the available power with very small investments in explorations and drilling shallow boreholes, in a period of only 5-6 years (Micevski, Kotevski, 1995).

Figure 1: Geothermalfields and projects in Macedonia.

1. Geothermal field Skopje - Katlano – vo Spa; 2. Geothermal field Kumanovo – Kumanovo Spa; **3.** *Geothermalfield Kotchany – Banja Spa;* **4.** *Geothermalfield Kotchany – Integrated geothermal projects Geoterma;* **5.** *Geothermalfield Shtip – Kezovica Spa; 6. Geothermalfield Strumica – Bansko integrated geothermal project; 7. Geothermal field Gevgelia – Negorci Spa; 8. Geothermalfield Gevgelia – Agricultural project Smokvica,* **9.** *Geothermalfield Kotchany – Agricultural project Istibanja; 10. Geothermal field Debar – Kosovrasti and Banjishte Spas.*

1. Geothermal projects in Macedonia

About 15 geothermal projects have been in operation or under development in the Republic of Macedonia from the period of 80-es (table 2). Four of them are of major importance and have a general influence to the development of direct application of geothermal energy in the country. The most important for sure is the Kotchany geothermal district heating scheme, but also the Gevgelija and Vinica agricultural geothermal projects and the integrated project in Bansko are important.

Unfortunately, the process of development is nearly stopped for more than 10 years. Bad economy conditions, strong competition of imported fossil fuels and expensive consequences of the initial mistakes resulted with the desist of this energy source. Except in the Kotchany district heating scheme, where the direct application in paper industry, space heating and sanitary warm water preparation has been introduced, and addition of the heating system for early spring production in the plastic houses in Gevgelia, there were neither development in the other existing geothermal projects nor establishment of new ones. Taking into account that the country suffered of the sanctions of international community against Serbia and the ones of Greece against Macedonia (country was practically cut of Europe for nearly three years, i.e. the main markets for own production) plus the now embargo of Serbia, and the present absence of fresh capital under and still not finished process of the state economy transition, it is difficult to expect any serious change during the coming years.

When having the intention to compose possible development strategy, it is necessary to summarise the state-of-the-art of the existing geothermal projects in the Republic of Macedonia. It can be embraced with the following short list of situations.

Istibanja: The project has been never finished. Wrong connection of the existing installations to the geothermal source doesn't allow proper use of it. Installation is in use only from time to time and a great part of the connection line and connecting installations is rusted.

Bansko: The project is still under development, i.e. not finished. The part of the installations for Hotel "Tsar Samuil" are properly connected to the source and working more-or-less according to the design conditions. Greenhouse installations are connected in a wrong way and disturb proper use of the total system. Heating installations in greenhouses are technologically to much old fashioned and practically out of order. Other two hotels are still not finally connected. Heating installations of plastic houses are of temporal character and using only the effluent water (without real regulation of the inside air temperature).

Table 1: Hydrogeothermal occurrences in Macedonia and their energetic value

	LOCALITY	OCCURENCE	TEMP. (°C)	FLOW (l/s)	HEAT POWER (MWt)
01	Volkovo	GTD-1	25	63	3.4
02		IBSKG1	22	22	0.9
03	Katlanovo	D-1	54.2	10	1.8
04	Spa	B-1, B-2	32	4	0.3
05		Nerv.water	28	2	0.03
06		Potkop	38	2	0.2
07		Fontana	28	0.2	0.03
08		Spring	38	1	0.1
09	Proevci	Borehole	31	2	0.2
10	Strnovec	Borehole	40	17	2.0
11	Podlog	EBMP-1	78	150	41.4
12		P-3	77.8	80	22.0
13		K-1	32	0.5	
14		K-2	40.6	6.9	0.8
15		P-11	50.6	2.6	0.4
16		Ka-1	22.4	6	0.3
17		EB-1	78	350	96.7
18	Istibanja	I-5	66.4	12	2.7
19		I-3	67	5	1.8
20		I-4	56.6	4.2	0.8
21	Trkanie	EB-2	71.3	50	12.4
22		P-9	71.3	85	2.1
23	Banja	B-1	63	8.3	1.8
24		B-2	63.2	55.3	11.8
25		P-1	63	30	6.4
26		P-6	40	1	0.1
27	Bansko	B-1	68	55	12.8
28		Spring	73	6	7.7
29	Negorci	NB-3	47.2	40	5.9
30		NB-4	53.2	40	6.9
31		B-1	32	3	0.3
32	Smokvica	Sied 6	45.1	7.2	1
33		Sied 1	56.7	60	
34		Sied 2	48.1	5.2	
35		Sied 4	56.1	35	6.5
36		Sied 5	64	40	8.7
37		Sied 7	68.5	60	14.2
38	Shtip	Ldzi	59	1	0.2
39		Kezovica	57	7	1.3
40		B-4	32	30	2.5
41	Kozuf	Topli dol	28	0.5	0.03
42		Toplik	22	8	0.5
43		Mrezichko	21	0.2	
44		Gornitchet	23	0.1	
45	Kratovo	Povishica	31	4	0.3
46		Dobrevo	28	5.5	0.4
47	Veles	Sabota voda	21	5	0.2
48	Raklesh	Borehole	26	2	0.1
49	Dojran	Toplec	25	2	0.1
50		Deribash	20.5	10	0.3
	TOTAL			**1396.7**	**283**

Table 2. Projects with geothermal energy use in Macedonia

Geothermal location	Geothermal field	Application	Heat power Total kW	Geotherm. kW	Heating system
Istibanja	Kotchany	Greenhouse heating (6,0 ha)	17.500	2.350	Aerial steel pipes (reconstruction of existing installation with heavy oil boiler)
Bansko (integrated geothermal project)	Strumica	Greenhouse heating (2,9 ha) Greenhouse heating (600 m^2)	9.000 150	9.000 150	Aerial steel pipes and on soil surface steel pipes. Corrugated PP pipes on soil surface + fan-jet air heating
		Plastichouses heating (3,0 ha)	3.000	13.000	Soil heating
		Space heating	1.560	1.560	Al radiators
		Sanitary warm water preparation	700	700	Plate heat exchangers + warm water accumulation
		Swimming pool heating Balneology	350	350	Plate heat exchanger
Podlog	Kotchany	Greenhouse heating (6,0 ha)	17.500	17.500	Aerial steel pipes
Kotchany (district heating)	Kotchany	Greenhouse heating (12 ha)	40.700	20.500	Aerial steel pipes
		Rice drying	1.600	1.600	Square finned pipes heat exchanger (w/a)
		Paper industry	3.200	3.200	Plate heat exchanger
		Space heating	650	650	Al and iron radiators
Smokvica	Gevgelija	Greenhouse heating (22,5 ha) Pl.h.heat. (10ha)	65.500 10.000	11.750 10.000	Aerial steel pipes + corrugated PP pipes on soil surface
Negorci	Gevgelija	Space heating	250	250	Steel radiators
		Balneology			
Katlanovo	Skopje	Balneology			
Kumanovo	Kumanovo	Balneology			
Banja	Kotchany	Balneology			
Kezovica	Shtip	Balneology			
Kosovrasti	Debar	Balneology			
Banjishte	Debar	Balneology			
TOTAL			**171.660**	**82.560**	

Existing installations in Macedonia:

- Space heating (5 units)
- Paper industry (1 complete)
- Sanitary warm water preparation (2 units)
- Rice drying (1 unit)
- Swimming pool heating (1 unit)
- Balneology (8 spas)
- Greenhouses (62.46 ha).

Podlog: Connection part and installations designed about 15 years ago and, therefore, not optimal for the intensive growing of vegetables and flowers. However, good maintenance and proper exploitation result with a good technical state of installations.

Kotchany: District heating scheme in development for already 10-12 years and, there-fore, consisting installations of different technical state. Greenhouse heating installations are also designed 15 years ago and are not accommodated for an intensive protected crop cultivation. Maintenance is rather weak but, still, the installations are in working condition and in regular use. Rice drying unit is out of working condition. The installations for paper industry, space heating and sanitary warm water preparation are in a normal working condition, like are also the new connected central heating of dwellings.

Gevgelia: Initially designed in a very wrong way, the system suffers of corrosion, weak possibilities for proper heat supply in heated greenhouses and old fashioned heating technology which is not convenient for modern intensive growing technologies. Trials with introduction of new solutions for anti-corrosion protection and new types of heating installations cannot be estimated as successful because have not been neither designed nor completed properly.

Negorci: Very primitive "self-made" central heating of the spa building. Presently out of operation.

Taking into account that technical feasibility for proper completion of geothermal projects (from the mechanical engineering point of view) is out of question nowadays, main problem for optiinisation of the present state of application of geothermal projects in Macedonia is connected to the collected experiences in exploitation, the economic feasibility in connection to the technical solutions applied and results of realized studies. Several important statements (influencing the choice of development strategies) can be made, such as:

- Geothermal systems with only one type of heat consumer cannot be economically feasible for any optimisation, particularly when greenhouses are in question. Rather mild climate results with very low annual heat loading factor (0,12-0,17) which doesn't allow any significant investment in reconstruction and optimisation of the systems. As the examples of the integrated project Bansko and district heating scheme Kotchany show, orientation towards combinations of heat users and cascades is necessary.

- Existing low-intensive production technologies in Macedonian greenhouses does not allow any serious financial investment in them. It is necessary to improve the economy of the production before thinking for optimisation of geothermal heating installations.
- Taking into account that necessary reconstructions and optimisation are mainly concentrated to the geothermal water distribution part and heating systems, necessary investment costs allow rather short pay-back periods, i.e. they are (according to the realised studies) always economically feasible.

2. Identification of possible new consumers during the period 2000-2010

Precise identification of possible new consumers is practically impossible due to the fact that there was no investigation made for this purpose and that there is no real possibility to plan any serious one under the influencing state economy conditions and absence of state development strategies for a list of economy sectors.

According to the last checking of the situation (Popovski, Lund, 1998), it can be estimated that during the period 2000-2010 only recompletion and modernisation of existing systems can be made, plus some new industrial and residential projects in the Kotchany geothermal system, connection of the central heating of the other hotels in Bansko and probably completion of the "water" centre in Negorci and medical centre in Katlanovska Spa. There are some possibilities for beginning the geothermal energy application development in Kratovo but it shall depend very much on the destiny of the Industrial complex "Sileks".

There are not enough data and information for prediction of possible development of some other (new) geothermal systems. That shall depend on the general change of the economy status of the country and the volume and results of new explorations and investigations during the period in question.

3. Possible development strategies

Taking into account the complete change of the economy system of the country in flow and, as consequence of it, interruption of all continual processes of development plus absence of development strategies for the main economy sectors, there is no possibility to use any of classical inethodologies for geothermal development strategy definition. Therefore, only accommodation to the on site collected data can be applied.

Depending on the official predictions for finalisation of the privatisation process in agriculture and energy, two strategies have been accepted

- The optimistic one, based on full success of the privatisation process according to the plan of the government.
- The pessimistic one, based on the experience with previous governmental predictions.

According to the first one the process shall be finished in a period of two years, and according to the second one in 4-5 years.

4. Geothermal development strategies for 2000-2010

The optimistic strategy predicts realisation of necessary reconstructions during the period 2000-2005 and beginning of completion of new geothermal projects during the period 2004-2010 (Table 3).

The pessimistic strategy predicts the reconstructions during the period 2002-2008 and establishment of new projects in 2007-2010 (figure 2).

During the period after it (2010-2020) more significant arise can be expected. For that period, it is very realistic to predict at least 50-100% arise of the heat consumption, i.e. 150-200,000MWh/y annual geothermal heat consumption.

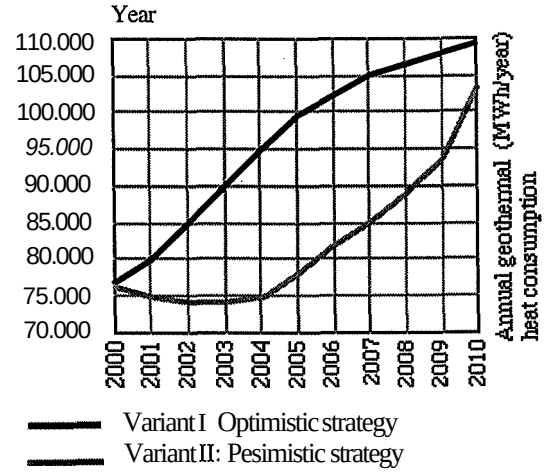

Figure 2: Prediction of geothermal energy consumption development during the period 2000-2010.

5. Consequences

Consequences of two different strategies are immediately recognisable, i.e. when the optimistic one is in question geothermal energy should take its previous importance very early (in 2002), and when the pessimistic one is in question, not before 2007. Not the energetic but the other factors shall determine which one is realistic. Before all, stabilisation of the political situation around the country and, in that way, opening the traditional markets for Macedonian out-of-season agricultural production which should enable financing

of necessary technological and geothermal reconstructions. Then, development of closer economic relations with the EC countries which should intensify the process of foreign investments in the country. At last but not least, normalisation of the energy consumption at all in the country (i.e. putting the "dead" production capacities in work) should show again how important is to use the home energetic resources, offering cheap and environmentally benign energy production.

At the end, it is necessary to underline that the main constraint for geothermal energy application development in other countries, i.e. its economical feasibility, doesn't exist in Macedonia. It is a proven in practice resource, and existing and new consumers are "hungry" for improvement of possibilities for its use. That's excellent base for future intensive development.

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