ANNALS OF THE FACULTY OF ENGINEERING HUNEDOARA
2006, Tome IV, Fascicole 3, (ISSN 1584 – 2673)
FACULTY OF ENGINEERING HUNEDOARA,
5, REVOLUTIEI, 331128, HUNEDOARA

POSSIBLE APPLICATIONS OF GEOTHERMAL ENERGY IN SERBIA

DJAKOVIC D[1]., STRBAC D.[1], DJAKOVIC S.[2], DRAGUTINOVIC G.[1], DIMIC M.[1]

[1]FACULTY OF TECHNICAL SCIENCES, INSTITUTE OF ENERGY, PROCESS AND ENVIRONMENTAL ENGINEERING NOVI SAD, SERBIA
[2]NIS – PETROLEUM INDUSTRY OF SERBIA, NOVI SAD, SERBIA

Summary
In the time of global orientation toward so called alternative forms of energy, people in Serbia started thinking about it also. In this paper are given some of the possibilities of geothermal energy applications, especially those applicable in Serbia, based on recent research on the subject. Discussion was made in the viewpoint of wellhead outlet temperature of known resources. The suggestions given in the paper are based on world-wide experience in the field.

Key words:
geothermal energy, direct use, geothermal resources

1. INTRODUCTION

The first descriptions of geothermal resources in Serbia were given at the end of 19th century by Radovanovic in the book "Ground Water".

Intensive geothermal investigations started during the beginning of the 2nd half of the 20th century and were initiated by the national petroleum company, *NIS* (Serb. *Naftna industrija Srbije*, Eng. *Petroleum Industry of Serbia*). Geothermal energy in Serbia (in last 50 years, approximately) is being utilised mostly for balneological purposes, in greenhouses and for space heating with heat exchangers and heat pumps. This paper is a result of a national study program on geothermal energy led by Institute of Energy, Process and Environmental Engineering and collaborating scientists and engineers of NIS.

2. GEOTHERMAL APPLICATIONS- EXISTING AND POSSIBLE CLASSIFICATIONS

In literature, there are several types of classification of geothermal applications. Obviously it has not been established yet as immutable criterion and that is why the possible variations will be presented and analysed.

One of the classifications is given in [1]. There is stated that direct use of geothermal energy is presented in all cases where there is no electricity generation. There is also a suggestion of differentiation of direct use on a direct use with and without use of heat exchangers (probably as a *natural* type of direct use), which is not often applicable, because of the presence of chemical contaminants in geothermal fluids.

Suggested classification in [1] is based on a temperature of the reservoir (where the temperature gradient should be taken in account in order to get comparable temperature with those specified at the wellhead outlets) and the suggestions of commonly chosen technologies are presented in Table1.

Table 1. Suggested technologies according to reservoir temperature

Reservoir Temperature	Reservoir Fluid	Common Use	Technology commonly chosen
High Temperature >220°C	Water or Steam	- Power Generation - Direct Use	- Flash Steam - Combined (Flash and Binary Cycle) - Direct Fluid Use - Heat Exchangers - Heat Pumps
Intermediate Temperature 100-220°C	Water	- Power Generation - Direct Use	- Binary Cycle - Direct Fluid Use - Heat Exchangers - Heat Pumps
Low Temperature 50-120°C	Water	Direct Use	- Direct Fluid Use - Heat Exchangers - Heat Pumps

There is also a suggestion of distance within 10 km or less between the resource and a user of geothermal energy (practical suggestion for conditions in Vojvodina is up to 1km according to NIS-sources), because geothermal heat is non-transportable (except short distances by fluid pipeline).

As it has been mentioned above, possible geothermal applications are usually determined by the temperature (usually this is a temperature on a wellhead outlet, sometimes this is a temperature of a reservoir, but often it is not clearly emphasized).

According to [1], 3 basic potential types of use are:

- Ground-source heat pumps in temperature interval from 4°C to 38°C,
- Direct use in temperature interval from 38°C to 150°C and
- Electricity generation for temperatures above 150°C

As some kind of an added "category", should be mentioned "cascaded" type of geothermal projects application, i.e. use of the same geothermal resource for multiple purposes, increasing the operation economics, which is usually presented as a combination of different types of applications from these 3 basic types.

There are five basic types of direct use [1]:

1. Aquaculture
2. Greenhouses
3. Industrial and agricultural processes
4. Resorts and spas
5. Space and district heating

According to previous reference, possibility for electricity generation exists only for geothermal resources with temperature higher than 150°C. Bearing this fact on mind, and a fact that in Serbia there is no known geothermal resource with the outlet temperature higher than 111°C, it could be implicated that this type of application is not even theoretically possible. This was true before the recent developments of different types of binary fluids cycle electricity generation. Because of that it must be emphasized that previous classification is not as clear as we wish it to be. According to [2] and the previous statement there are 2 subcategories of electricity generation; high enthalpy resources (>150°C) which are suitable for electricity generation with conventional cycles and low enthalpy resources with temperatures lower than

150°C, which are used for direct heat uses and electricity generation by using a binary fluids cycle.

Previously mentioned classifications are probably based more on historical reasons and a spread of particular applications than on strictly differentiated types of use (which is a hard task to do in this interconnected world).

The result of the work [3] was an idea that new classification could be made, mostly because of the fact that in known classifications there are too much overlaps (e.g. between greenhouses and agriculture applications, where greenhouses application is only a subcategory of agriculture use. Similar could be said for aquacultural and agricultural use).

One of suggested ways of categorisation of geothermal energy application could look like this:

- power generation
- direct use

The last could be subdivided into:

- agricultural use (with the subcategories: aquaculture and greenhouses)
- heating (district and space)
- industry application
- spa and resort application

3. GEOTHERMAL POTENTIALS IN SERBIA/VOJVODINA

Up to date there are already several operating facilities in Serbia, i.e. Vojvodina. Currently existing facilities in Vojvodina (according to [4], [5]) are presented in the following Table 2.

Table 2. Currently existing facilities in Vojvodina

Item Nº	Location	Beginning year of use	Flow rate of well [l/s]	Water temperature [°C]	User	Purpose
1	Backo Karadjordjevo	1978	2.2	34	Army	Closed swimming pool
2	Kanjiza (3 wells)	1981 1986 1998	5.0 14.0 20.0	41 65 72	The “Kanjiza” spa	Heating, healing
3	Kula	1981	9.5	50	Sports and recreation center	Open swimming pool
4	Prigrevica spa	1983	20.8	54	The “Junakovic” spa	Heating, healing
5	Srbobran	1984	11.67	63	Agricultural complex “Elan”	Greenhouse heating
6	Kikinda Sumice	1984	6.17	50	“6th October”	Space heating
7	Mokrin	1984	10.5	51	“Mokrin”	Farm heating
8	Kula	1984	8.33	53	Leather factory “Eterna”	Technical needs
9	Subotica	1984	4.83	35	Sports and recreation center	Open swimming pool
10	Palic lake	1985	12.17	48	“Akumulacija”	Open swimming pool
11	Melenci	1985	10.33	33	The “Rusanda” spa	Healing
12	Kula	1985	8.5	51	Textile factory “Sloboda”	Technical needs

13	Kikinda	1985	15.17	51	Pig farm "Jedinstvo"	Farm heating
14	Vrbas (2 wells)	1986 1986	3.5 4.33	39 51	Sports center	Closed swimming pool
15	Becej spa	-	1.16	-	Iodine spa	Healing
16	Devojacki bunar	1986	10.0	25	Hotel	Open swimming pool
17	Temerin	1987	20.0	41	Local municipality	Open swimming pool
18	Backi Petrovac	1987	7.83	45	Agricultural Institute	Heating
19	Ban. Veliko Selo	1987	10.0	43	Pig farm "Kozara"	Farm heating
20	Palic lake	1987	5.0	45	Hotel "Jezero"	Hotel heating
21	Becej	1988	19.4	65	Sports center "Mladost"	Heating
22	Ban. Veliko Selo	1990	6.67	45	Agricultural complex	Space heating
23	Celarevo	1996	5.0	31	Textile factory "Dunav"	Close swim. pool in Motel "Dunav"

In this table the existing facilities are presented, but not all of them are currently in use, mostly in last few years. According to [6] and because of the existing temperature level, primary way of use of geothermal energy in Serbia is direct use with installed capacity of 80MW and annual output of 660GWh. According to these data Serbia is ranked 16th in Europe by the installed capacity (including both EU and non EU countries), and 8th by the annual output. The data given in this resource are from 1999. In the following figures (Fig.1, Fig.2), the data [3] about the drills and springs of Central and South Serbia and never used drills of Vojvodina are given graphically as diagram flow-temperature.

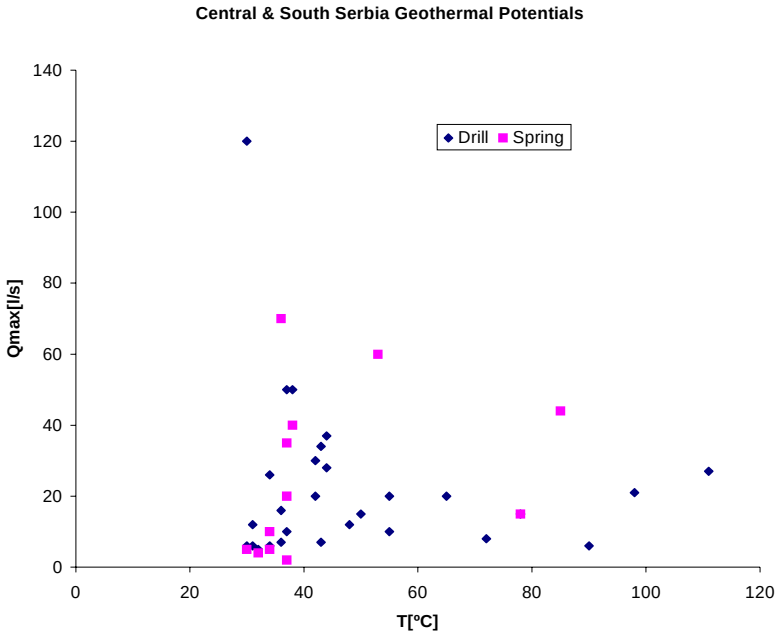


Fig.1 Central and South Serbia Geothermal Drills and Springs

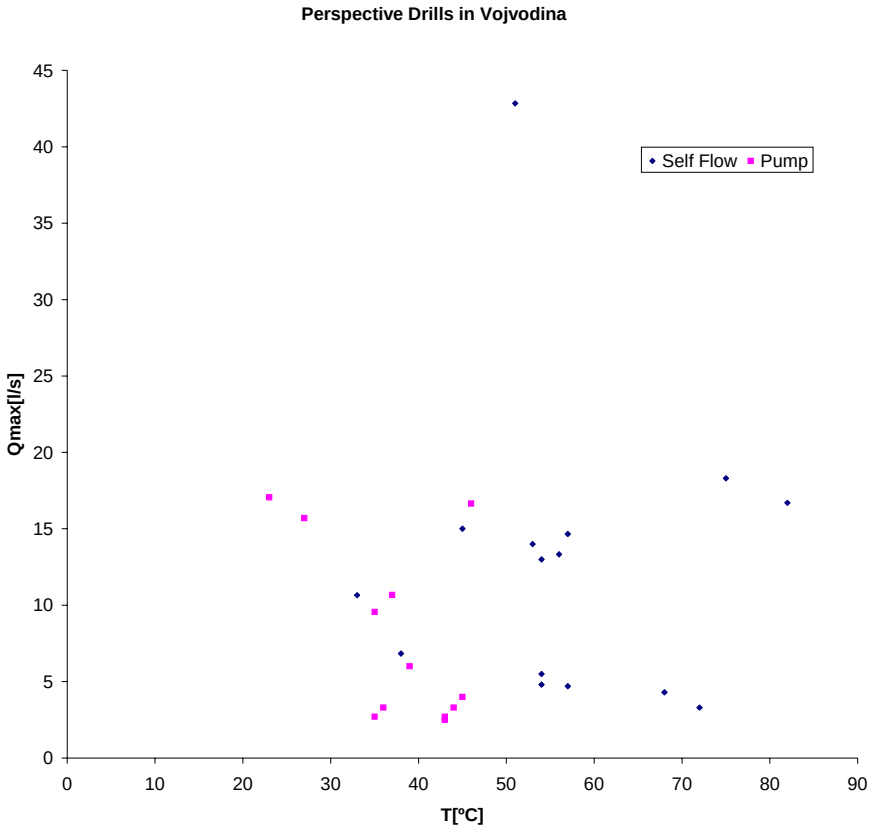


Fig.2 Drills in Vojvodina which had never been exploited, but which have the potential for the geothermal energy applications

4. CURRENT AND POSSIBLE APPLICATIONS

After all these data and diagrams and before any further discussion, so called *Lindal diagram*, named after Baldur Lindal (1918-1997), one of pionirs of direct geothermal use, should be mentioned (Fig.3).

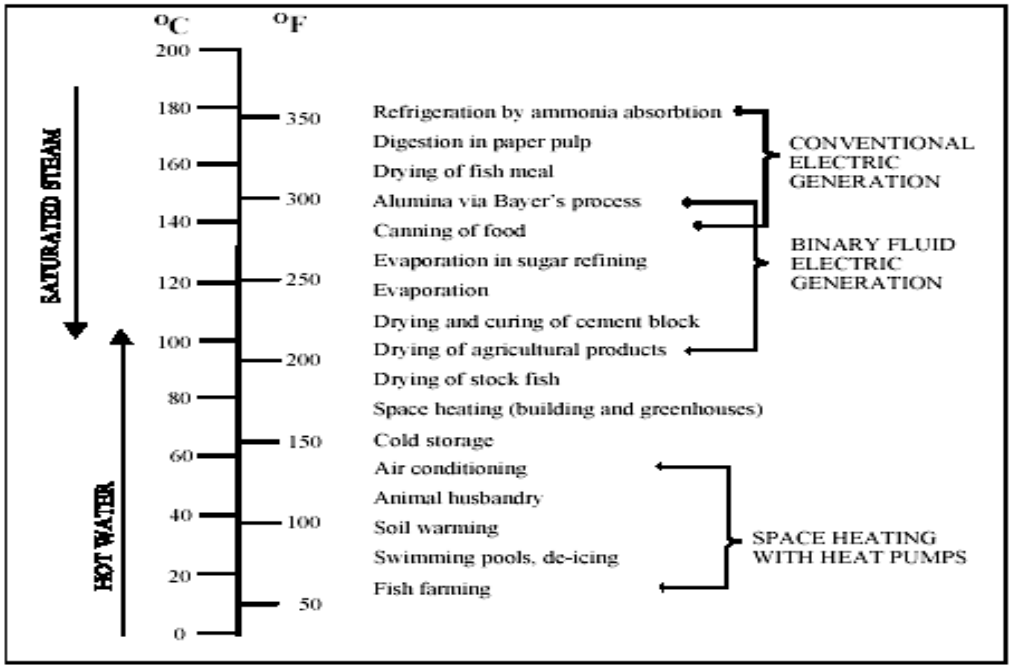


Fig.3 Lindal diagram

Direct use, whether it is in one of agricultural subtypes or industrial application or heating or healing, should be, obviously, the main form of geothermal energy application in Serbia.

Direct systems are typically composed of three components:

1. A production facility – usually a well, to bring the hot water to the surface

2. A mechanical system – piping, heat exchanger, controls, to deliver the heat to the space or process

3. A disposal system – injection well or storage pond, to receive the cooled geothermal fluid

Depending on concrete case there are differences on a suggested equipment and flow sheet. There are many manufacturers of different types of equipment which are used (among many other applications) during the exploitation of geothermal resources, but only a few of them are specialized strictly in geothermal. When we say this, we keep in mind the fact that geothermal fluid could make the problems during the working hours. These problems are mostly corrosion in the pipes and heat exchangers and different types of incrustation. The "quality", i.e. the content of different chemicals in concrete cases is the main reason of these problems and before any attempt of geothermal fluids' exploitation, exact composition should be defined in order to avoid these problems.

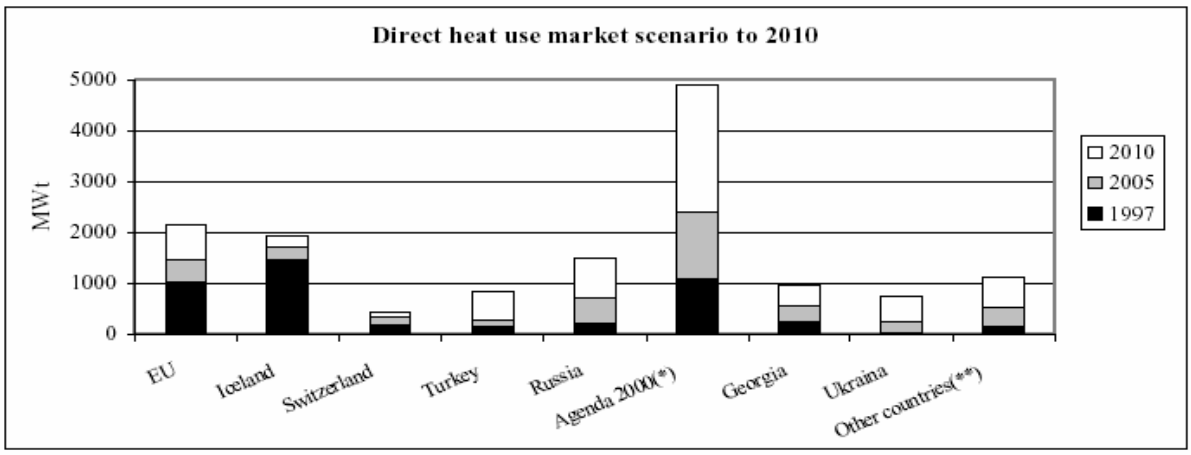
Beside equipment issues, different types of direct use depend on composition in the bigger or less amount. Geothermal application in aquaculture (different fish kinds growth in Serbia, mostly, although there is a opportunity for algae growth because of big protein value)

Different factors regulatie fish growth and depend on temperature (higher than 40°C) and water composition, cascading systems could be arranged based on purity and water temperature demands.

The healing use in Serbia has long tradition, since the ancient Roman times and in spas (especially in Vojvodina) use of geothermal energy is not limited on balneological use only, but the whole range of geothermal use, including rooms and pools heating is already applied. There are plenty room for improvements in this field, too, particularly in the restoration of existing equipment.

Geothermal application in greenhouses heating is not as popular as spas' application, but it has a growing trend.

Speaking of direct heat use, it is interesting to have a look at the scenario to 2010 for European countries (Fig.4) [2].



(*) Bulgaria, Hungary, Poland, Romania, Slovakia, Slovenia
(**) Macedonia and Yugoslavia

Fig.4 Direct heat use market scenario to 2010

Power generation based on geothermal energy has not been started in Serbia because of many reasons.

There are, according to temperature, only 2 locations in south of Serbia, for making a small geothermal plant operated by Kalina or maybe some other binary cycle, but it still has been a questionable issue because of temperature values closer to the down limit of known plant technologies on a world-wide level and the questions are raised about economic validity of such application taking in account on site equipment energy demands. It is a complex problem based on thermodynamical, geological, economical and even political evaluation and it will be a subject of investigation in the following years, too.

5. CONCLUSION

Some of the geothermal capacities are already in use, but there are still many possibilities for application of this type of energy. Direct types of use, with the added heat pumps should be improved and increased by a quantity, and investigations on less known types should be deepened in order to prepare this type of *alternative energy* to take a bigger part of energy market. Here should be stated, that with the government's regulations and political help, especially in the early stages of development, this process could be dramatically accelerated.

REFERENCES

[1.] http://www.worldbank.org/html/fpd/energy/geothermal/technology.htm, last accesed on May 2nd, 2004
[2.] http://www.agores.org/Publications/bbgtes.pdf, last accessed on Jun 10th, 2004
[3.] Study of geothermal energy potentials and the possibility of electricity generation and heat energy production, led by Dj. Basic, Institute of Energy, Process and Environmental Engineering, Novi Sad, Serbia and Montenegro, 2004
[4.] Vidovic S., Varga P., Djuric S., Utilisation of geothermal waters and geothermal energy in Vojvodina, European Geothermal Conference EGC 2003, Szeged, Hungary, 2003
[5.] Dimic M., Vidovic S., Alternative Energetics Potentials, Research, Applications, Workshop on Contemporary Problems in Power Engineering, Thessaloniki, Greece, 1995
[6.] http://www.worldenergy.org/wec-geis/publications/reports/ser/geo/geo.asp, last accessed on Jun 15th, 2004