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STATUS OF GEOTHERMAL ENERGY IN BULGARIA

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ABSTRACT

Geothermal research and development in Bulgaria has progressed at a slow pace in the last five years. Government has withdrawn their support and the private industry has been generally involved only in bottling of potable water and soft drinks. Only two small demonstration projects for space heating and hot tap water, entirely financed by the PHARE Program have been completed at two geothermal cites. A small geothermal installation for school heating was partially funded by the State. The paper gives an updated summary of utilization for balneology, space heating, greenhouses, aquaculture, swimming pools and bottling of potable water.
At that point (mid 1999) the total installed capacity for geothermal energy in the country is 95.35 MWt. Compared to 1995 about 2.5 MWt of direct schemes dropped out due to wear and new 0.85 MWt were built. The use of geothermal energy resulted in fuel savings amounting up to 33,030 TOE/year (46,988 tons of coal equivalent/year). The presented status of geothermal energy is based on the resource reassessment that was completed in 1998 by the Geological Institute at the Bulgarian Academy of Sciences.

1. THE TRENDS OF ENERGY SUPPLY IN BULGARIA

The trend of energy flows for the last 11 year period is shown on Fig. 1. After 1989 the social changes and economic crisis in the country caused a sharp decrease in domestic use of primary energy and consequently in fossil fuel imports. In the period 1989-1992 there is also a decrease in the local production (mainly low quality coal and hydroenergy), as well as in the export of electricity from the nuclear power station.

Annually published energy balances for the country show an insignificant change of the primary energy supply (from domestic and imported sources) for the last five years. The primary energy from domestic sources (Fig. 2) is mainly based on nuclear and hydropower (50.8%) and coal (44.7%), (National Statistical Institute, 1999). Renewable energy sources are only 0.8% of the total. According to the new Draft Energy Law an increase in the use of natural gas is envisaged, while the renewable energy resources share is anticipated to reach 2 % by the year 2010.

Good management and exploitation of geothermal reservoirs using cascade systems will considerably decrease the use of imported fossil fuels and the environmental pollution associated with them. This is of vital significance for the numerous spas in Bulgaria. The fossil fuels saved due to the utilization of geothermal energy are estimated at up to 33,030 TOE/year (46,988 tons of coal equivalent).

2. BASIC DATA

2.1 Heat flow

The country is rich in low enthalpy geothermal energy. Conductive heat flow data vary within the interval 30-80 mW/m^2, while in the hydrothermal zones it reaches 140 mW/m^2 (Sofia depression) and 200 mW/m^2 in the Erma reka region (Petrov and Bojadgieva,1993).

2.2 Geological background

The geological structure of Northern and Southern Bulgaria is variegated and contrasting. The hydrothermal systems were formed mainly during the Alpine tectonic activity in the Balkan region.

Natural thermal springs are not found in the region of Northern Bulgaria. Two artesian basins are located in it - the Moesian and Varna basin. Thermal water was discovered only in deep wells. The southern part of the country has abundant springs which provide drainage of nonstratified mountain systems. The springs are developed mainly in granite and granitoid intrusions and ancient siliceous and metamorphic complexes.

2.3 Sources

The hydrothermal data comes from prospecting carried out in hundreds of exploratory and production wells, springs, ore pits and tunnels. In the ex-socialist countries, geological exploration had extensive budgets enabling the identification of geothermal reservoirs, proven by wells.

The depth of the hydrothermal exploratory wells ranges from 100 to 5000 m in Northern Bulgaria and from 100 to 1500 m in Southern Bulgaria.

2.4 Basic thermal characteristics

The basic characteristics of geothermal water on the territory of the country have been reassessed and updated in the period 1994 -1998 by extensive study carried out by the specialists from the Geological Institute of the Bulgarian Academy of Sciences. The project was funded by the Ministry of Environment and Waters. The basis for resource reassessment was data from about 160 fields all over the country, of which 103 are protected by the State.

- The water temperature of the discovered reservoirs ranges between 20°C - 100°C.
- The total flow rate of subthermal and thermal waters run up to 4600 l/s (Petrov et.al,1998), of which 3000 l/s

is the flow rate of the discovered thermal waters (T>20°C). These data are very close to the published ones in Bojadgieva et al,1995. The flow rate decrease is a result of bad technical conditions for most of the wells and for some of the installations of direct schemes. About 33 % of the total discovered flow rate is of temperature between 20°C-30°C, and 43% - between 40°C-60 °C, Fig. 3. According to Petrov et al,1998 about 2300 l/s of recoverable resources could be discovered by additional drilling.

- Established chemical water content (TDS) varies from 0.1g/l to 50g/l - 100g/l. The prevailing thermal waters in Southern Bulgaria region are of nitrogen gas composition and are less than 1 g/l TDS. The highest percentage of low alkaline waters pH (7.2 - 8.5) is about 55% of the total flow rate.

- The total geothermal potential is defined as the thermal energy contained in the discovered thermal waters and it amounts to 14,122 TJ/year or about 440 MWt (Phare Project, 1997). This is a simplification as estimates of theoretical geothermal energy can be highly technical and include all energy beneath the earth's surface.

The distribution of the geothermal sites within the different regions is presented on Fig 4.

3. DIRECT HEAT USES IN BULGARIA

3.1 Types of application

The basic types of thermal water and geothermal energy application in Bulgaria are shown on Fig.5. The major application of thermal water in the country is in balneology (healing and recreation), space heating and air-conditioning, provision of domestic hot water, greenhouses and aquaculture, and swimming pools and bottling. There is also some processing of flax and hemp fibers. A small enterprise for extraction of iodine, bromine, boron, strontium, etc. from the thermal water is in operation near Varna city (Northern Black sea coast).

Balneology

The tradition of utilizing thermal waters for medical treatment has existed since ancient times. At present, 42 balneological centers, combining treatment, rehabilitation and prevention are in operation year round. Due to the various chemical content of the waters, a wide range of diseases are treated by water procedures (drinking the water, physiotherapy, etc).

Space heating

The duration of the heating season in Bulgaria is about 160 - 180 days. Along the Northern Black sea coast and in one site in SW Bulgaria (Sandanski town) geothermal energy is being used in public buildings throughout the year for heating (during the winter) and for air-conditioning and ventilation (during the summer). The thermal water in these sites is utilized also for recreation and swimming pools.

The total installed capacity in the country is 95.35 MWt (Fig.4), which includes simple and technological schemes of installations. The energy produced is 1,382 TJ/year (at 0.46 average load factor).

The rather low temperatures of the majority of reservoirs determine the utilization of the technical schemes used for heat carriers of 50°C/40°C and 60°C/40°C parameters (Hristov and Nikolova,1993). The latter are suitable for low temperature underfloor heating and convector systems. Only a few of the reservoirs are suitable to use a heat carriers of 90°C/70°C parameters, (Fig 3). Modern installations employ mainly plate heat exchangers of stainless steel and heat pumps. Some systems have fossil fuel back-up boilers to provide for the periods of peak loading. In addition, indirect systems provide ventilation and air - conditioning. The majority of direct (simple) geothermal systems currently operating have low performance and are technically and morally worn out. The present production is below the potential allowed by the resource assessment. There is no injection of the waste water into the source reservoir and no pressure maintenance. The concept of a doublet has no application in the country.

When high temperature reservoirs were used for medical purposes the thermal waters were often left in open tanks to cool down to the desired temperature or mixed with expensive cold mains water. At the same time buildings were heated using conventional fossil fuel boilers usually coal or oil. This gives a situation of reduced efficiency of medical applications, wasted energy, and locally polluted environment. This is the situation of most of the sites of SW Bulgaria. The building up of cascade geothermal systems will considerably improve the efficiency.

Greenhouses

The areas covered by greenhouses (glass and plastic) heated with geothermal energy amount to about 22 ha, Fig. 6. A variety of flowers and vegetables are grown. The largest ones do not exceed 3 ha. Most of the greenhouses are old, with expired term of exploitation and in poor technical condition. The geothermal water enters directly into the installations. Intensive scaling and low heating efficiency are typical for most of them. There is a real possibility for new greenhouses of total area 30-35 ha to be built on the discovered fields. They would be located mainly in SW Bulgaria and be small in size due to the comparatively low heat potential of the existing sources. The recent social and economic changes in Eastern Europe reflected unfavorably on the development of greenhouses in the country. Most of them decreased their production considerably, thus, existing foreign markets were lost. The new stage of greenhouse development in Bulgaria has already started. Up-to-date technologies will reduce energy consumption and some of the existing systems will be adopted to operate by low temperature geothermal fluids.

Aquaculture

In the Rupite region (SW Bulgaria, 42° North latitude) a center for open mass cultivation and processing of microalgae was set up in the sixties, Fig.7. The existence of a hydrothermal source (temperature 74 °C) which releases free CO_2 in the atmosphere proved to be a significant factor for economic efficiency of microalgal cultivation (Furnadzieva et al,1993). The installations have a total area of 2690 m^2 and produce about 5-6 tonnes/year of dry product. Due to their varied and rich chemical composition, microalgae are used in food, pharmaceutical and cosmetic industries in Bulgaria.

Swimming pools

There are about 31 public outdoor swimming pools built on 29 geothermal sites across the country. They are in use mainly for recreation only during the summer time. The geothermal water directly enter the installations. Most of the pools are very old and need renovation. Several up-to-date indoor swimming pools have been built in some spas and sea resorts. They are in use throughout the year. Two installations employing small heat pumps extract heat from waste geothermal waters after balneological treatment to heat the swimming pools. The total volume of the existing swimming pools amounts to 35,300 m^3.

Bottling

The share of bottling of portable water and soft drinks increased during the last 5 years. About 30 private enterprises have obtained licenses for performing this activity. The greatest part of the production meets the local market demand.

4. GEOTHERMAL ENERGY DEVELOPMENT POLICY IN BULGARIA

4.1. Demonstration projects

The geothermal sites built in Bulgaria in recent years are rather modest. At this point in time there are two small demonstration projects entirely financed by the PHARE Program. These projects were intended to demonstrate the legal, financial, policy and other issues that impede or support renewables in Bulgaria.

From 1994 to1996 CSM Associates Ltd. (Penryn,UK), ESD (Bath, UK) and Ecothermengineering (Sofia, Bulgaria) conducted a study into the renewable energy potential in Bulgaria (Phare Project,1997) Five energy sources were considered - Biomass, Wind, Solar, Hydro and Geothermal. A demonstration project was conducted for each of the technologies and detailed costing produced regarding the effectiveness of each project. The geothermal project was implemented in a large balneological center in SW Bulgaria (Sapareva banja town). The cost of the project was EUR 25 000. Equipment for heating and providing hot tap water for a building of the balneological complex was installed. The system has a capacity of 0.250 MWt. Permanent monitoring of its parameters is performed.

The other demonstration project was executed by COWI (Denmark) and Energyproject (Bulgaria) in connection with a program concerned with energy efficiency in a large region of Southern Bulgaria (Haskovo region). An installation costing EUR 20,000 for heating of the Municipality of the town of Haskovo and a kindergarten was constructed. The installed capacity is 0.200 MWt. Another installation of 0.400 MWt for school heating in the town of Velingrad (SW Bulgaria) has been completed recently.

The next step for the development of the geothermal energy should be the modernization and extension of the existing systems to achieve higher technical and economic parameters.

5. FINANCING AND LEGISLATION

The basic consumers of geothermal water and geothermal energy in Bulgaria are the balneological centers. According to the Health Law they are entitled to all of the required mineral water completely free of charge.

Until 1990 the geothermal systems were entirely financed by the state. Private investments now are directed mainly to the bottling industry. At the moment, foreign investments are used only for small demonstration projects.

New methods for assessing the price of mineral water and the geothermal energy will be introduced. Installed costs for the constructed geothermal heating systems are site specific and a range of EUR 150 to EUR 900 per kW is possible (Phare Project, 1997). The prime cost of the produced thermal energy from existing geothermal stations ranges from 3.5 US$/GJ to 8.5 US$/GJ.

Until recently the mineral water application was controlled by the Ministry of Health. Later on some of the mineral water sources passed on to local Municipalities' control. The first law of cold and thermal water in Bulgaria was published in 1891. Currently, there are several laws treating issues related to waters. The Water Law, Concession Law, and Energy Law are the important laws, while the others play only a coordination role. The fact that these new laws are untested means a great deal of uncertainty still exists with regard to policy support for the industry and development of regulations.

ACKNOWLEDGMENTS

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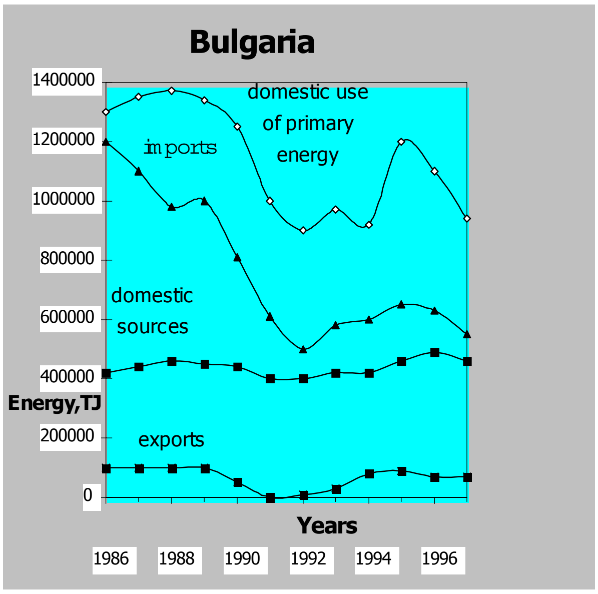

Figure 1: Trend of energy flows

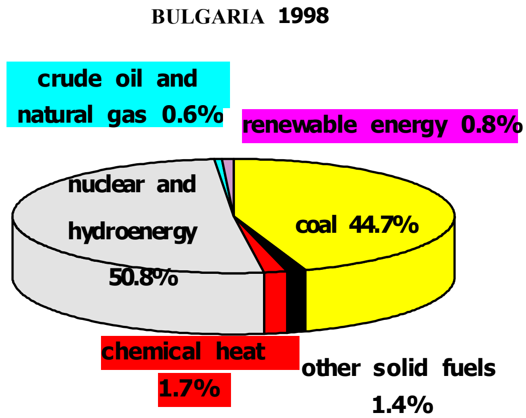

Figure 2. Production of primary energy (domestic sources)

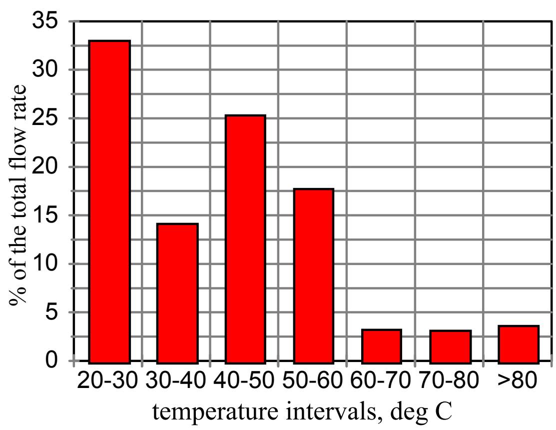

Figure 3: Flow rate distribution (in %) for temperature intervals

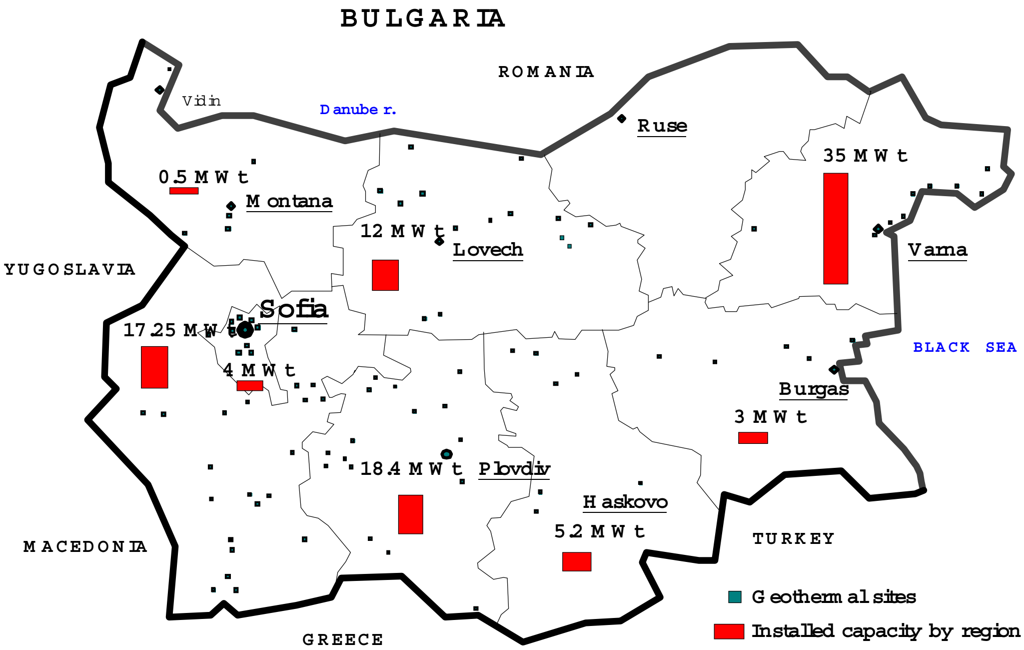

Figure 4: Geothermal sites distribution and installed capacity by administrative regions (1998)

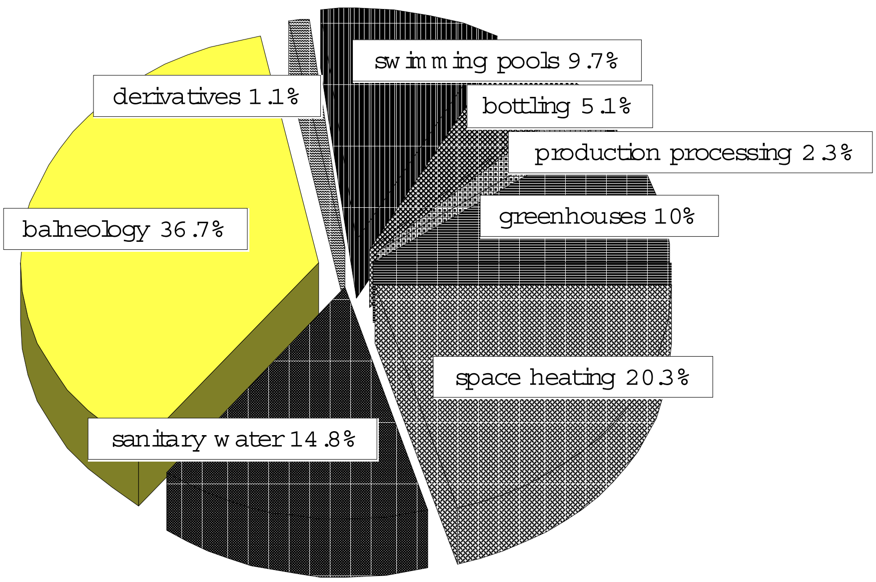

Figure 5: Direct uses of thermal water (in % of the total used flow rate)

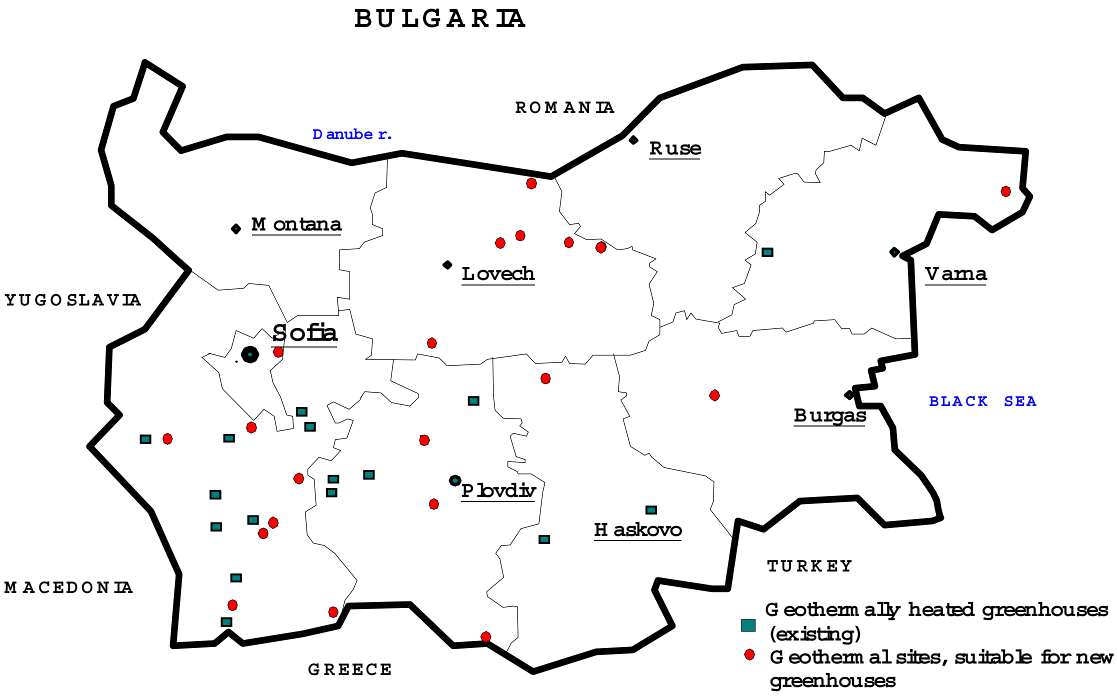

Figure 6. Distribution of greenhouses heated with geothermal energy

Figure 7. Open mass cultivation of microalgae in Rupite region (SW Bulgaria, 42° Northern latitude)