Geothermal water in Bulgaria - Real Energy Source

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I. Introduction

Bulgaria has one of Europe's richest renewable energy resource bases. It is endowed with extensive forests. It has one of the world's most developed and intensive agricultural bases. Bulgaria has an important small hydro resource base has been successfully exploited to generate electricity for nearly one hundred years. The country's rich solar resources have been used for thousands of years for crop drying. Traditional Bulgarian architecture has incorporated passive solar designs for hundreds of years. Other renewable resources, including municipal and industrial wastes offer good opportunities for energy utilisation.

Many research matters carried out in Bulgaria show that geothermal energy is one of the most effective renewable resource. Geothermal resources have been used for thousands of years as both a source of energy and for health reasons. These are plentiful and are distributed upon all territory of the country. Modern installations for space heating in buildings and greenhouses date from nearly one hundred years ago. The type and nature of the Bulgarian geothermal resource are low enthalpy. Geothermal waters in Bulgaria have small minerals' content and for main sources it is below 1 gr/l.

II. The Technical and Economic Assessment of Bulgaria's Renewable Sources of Energy.

The Technical and Economic Assessment of Bulgaria's Renewable Sources of Energy was made during last three years. It was designed to set the stage for increasing the contribution of Bulgaria's renewable energy resources (non-large hydro power) to the country's total energy balance to at least 2% by the year 2020. The major objectives of the Assessment were to determine ways and means by which Bulgaria could develop its renewable energy resources to develop more energy independence, to address key environmental concerns, and to promote economic and social development

The terms of reference called for the development of an extensive data and information based on Bulgaria's renewable energy resources, the level of development of those resources, and the current perceptions of renewable energy utilisation in the country. They called for a comprehensive study of the legal and policy framework that affects renewable energy, with the aim of identifying the legal impediments and constraints, and the best means for removing them. The terms of reference also called for a careful examination of the macro- and micro-economic factors that influence Bulgaria's renewable energy sector, with the aim of setting out the economic and financial means by which renewable energy development can be accelerated.

The demonstration projects were also intended to demonstrate the legal, financial, policy and other issues that impede or support renewables in Bulgaria.

Three scenarios were developed to determine what the possibilities for renewable energy development to the year 2020 are. It was decided to examine a basic or business as usual scenario, an energy efficiency scenario and a scenario that sets Bulgaria on a course to join the

European Union by the year 2010.

These scenarios were designed in order to set out a range of benefits that could be achieved under particular policy, legal and economic frameworks.

In this paper we present the main results from Assessment for geothermal energy.

III. Theoretical or Total Resource Potential

Temperature of the water for Bulgarians geothermal resources vary from 22^{o}C to 100^{o}C. The resources important for energy application have temperature between 42^{o}C and 50^{o}C. Bulgaria has about 1000 geothermal sites and a maximal flow rate of the known and investigated sources is 5100 l/s. In the last years this flow decreased due to amortisation of the boreholes and assessment of a flow rate now give about 3200 l/s.

Total or theoretical resource potential is defined as the total amount of the energy source from which energy can be generated. For Bulgaria, where sources are primarily for thermal use, the theoretical or total potential for geothermal energy is the thermal energy contained in the thermal waters. Energy is expressed in Terajoules per annum for comparison purposes with energy balance data. This thermal energy is calculated from the flow rate and the temperature of the thermal waters. The theoretical potential is taken only from known resources. This is

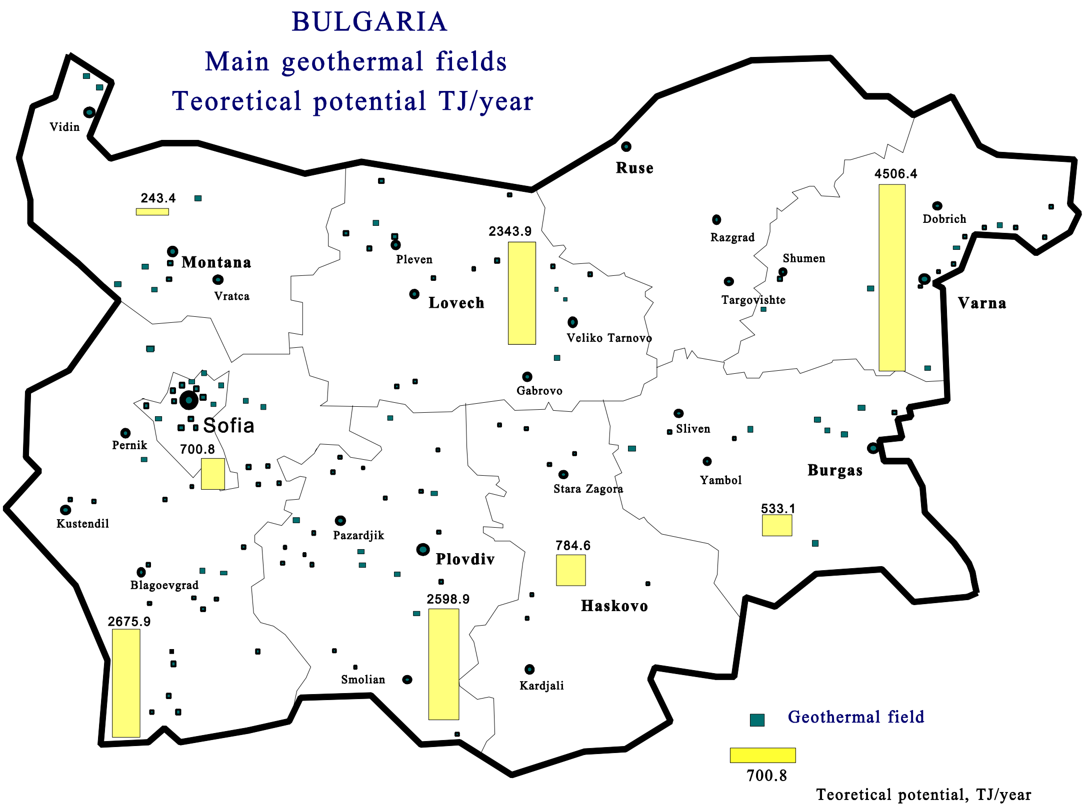

Fig. 1

simplification as estimates of theoretical geothermal energy can be highly technical and include all energy beneath the earth’s surface.

The basis for the resource assessment was data from more than 120 different sites around the country. Fig.1 shows the main sites of geothermal resources and the theoretical potential for geothermal resources in Bulgaria by regions. For Bulgaria, where sources are primarily for thermal use, assessment of the theoretical or total potential for geothermal energy is about 440 MW (14122 TJ/year).

IV. Technical Potential

Geothermal energy is widely available, but not always in circumstances favourable for energy production. We therefore estimate the technical potential: this is the resource that *could* be developed for energy in the absence of any competing use, and without any economic constraint. That resource which remains after technology limitations and non technical barriers are applied to the technical resource. For geothermal energy, the technical potential is equal to the resource if the geothermal site is available to energy use. For Bulgaria, assessment of the technical potential for geothermal energy is about 11195 TJ/year.

V. Geothermal Energy Technologies - Present Status and Installed Capacity

Geothermal energy has been utilised in Bulgaria for heating purposes (in addition to its balneological uses) for thousands of years. Modern installations for space heating in buildings and greenhouses date from nearly one hundred years ago. Considerable technological work was carried out during the 1970s and 1980s. This effectively halted during the late-1980s with the political and economic changes that swept Bulgaria. Table 1 shows the installed capacity of geothermal energy by regions.

Table 1

Bulgaria Geothermal Installed Capacity (1993, at 0.46 load factor)

Region	MWh	TJ/year	toe/year
Montana	0.5	7.3	247.5
Lovetch	12.0	174.0	5,940.1
Varna	35.0	507.6	17,325.4
Burgas	3.0	43.5	1,485.0
Haskovo	5.0	72.5	2,475.1
Plovdiv	18.0	261.1	8,910.2
Sofia	17.0	247.0	8,415.0
Sofia City	4.0	58.0	1980.0
Total	**94.5**	**1,371.0**	**46,778.3**

Bulgarian geothermal technology is currently in a moderate condition. Plate heat exchangers are manufactured under license from the French company Vicarb and there are companies manufacturing pressure housings and pipework, all this principally for food and process industries but clearly with application to geothermal energy production.

The long tradition of geothermal exploitation in the country has ensured that there have always been some manufacturing capabilities although this is based upon the process industry requirements. Much of the latest equipment is manufactured under license or directly by a foreign company with a Bulgarian facility. Some original domestic equipment is now obsolete, such as heat pumps using banned Freon based refrigerants(CFCs). Some pipelines are available made of glass fibre but these are extremely expensive and poor quality.

For low enthalpy geothermal systems the applied technology is generally drawn from the food and process industries. There is a minimal amount of specialised equipment, even the borehole requirements are normally met from the water industry or at the extreme the oil and gas business. This generally means that there are no specific technical stimuli which would be particularly effective for the geothermal industry. It also means that as far as technology goes there is no specific government support. Import taxes and preferential tax treatment on the technology would also benefit other industries and as such will be to wide ranging and expensive for the Government.

VI. Geothermal Energy Economic, Pricing, Financing and Social Assessment

The economic assessments purely concerned with the capital and operating costs of the technologies (that is, a micro-economic assessment). A broader assessment of economic, environmental and social viability could be made from a macro-economic perspective. This would cover the overall effects on the Bulgarian economy such as changes in balances of payments (through import reductions), employment creation and changes in GDP.

Installed costs for geothermal heating systems are also site specific. A range of ECU 150 to ECU 1,200 per kW is possible. Load factors can also range from 25% to 70% making it difficult to generalise. The bases for these costs are:

- As most geothermal technology is based on oil/gas and process industry equipment it is probable that there will be an increase of about 20% in costs in alignment with predictions of these industries.
- Load factors and availability is 50% (80% winter +20% summer)
- For heat pump schemes the Coefficient of Performance (COP) - min. 3.5
-There are no water charges
-Capital costs are geothermal plant costs only and do not include site heating installations. Capital costs included are: Boreholes, Borehole Pumps, Heat Exchangers, Heat pumps, Geo piping, Control systems, Water storage.

The capital costs for geothermal installations vary widely in Bulgaria and are highly site specific.

Direct Schemes

The type and nature of the Bulgarian geothermal resource is low enthalpy. Therefore all means of exploitation use water directly or through heat pumps to increase the temperature. A direct scheme is simple to implement but requires temperatures above 40^{o}C assuming the method of heating is via convective radiators and there is no opportunity to install underfloor heating.

Indirect schemes

Resources below 40^{o}C will require heat pumps. Modern heat pumps are usually specified with a conservative COP of around 4. However, this represents the best possible performance at optimum load and input/output water temperatures. A more representative figure would be the performance over the year which takes into account seasonal variations and lower efficiencies. High system load factors (plant utilisation) will be required to achieve reasonable unit costs. At a COP of 3.8 heat unit costs are not so sensitive to the electricity costs (electrically powered heat pumps) but as the COP reduces the sensitivity increases. Adding a fossil fuelled auxiliary boiler adds to capital costs but may increase the COP by allowing more optimal sizing of heat pumps to operate at maximum load.

Analysing for a range of 12 heat pump assisted schemes with various realistic storage/borehole requirements shows a range of costs between 0.015 and 0.036 Ecu/kWh. These schemes have a range of water inlet temperatures from 22^{o}C to 40^{o}C and a range of power outputs from 50kW to 1,380 kW. Load factors and equipment utilisation is 50%.

Economic assessment compares the discounted unit costs of heat or electricity with the fossil fuel equivalent. At present fossil fuel prices are at low levels historically. There is a general consensus amongst international agencies such as the IEA (International Energy Agency) and the European Commission that oil prices will rise in the future. In this study it is assumed that oil will rise to $32/barrel by 2020. This will increase heating costs from their present level of $25/Gcal to $44/Gcal.

Bulgaria's industrial sector is energy-intensive and, given historically very low energy prices, very energy-inefficient. This high energy inefficiency characterises the domestic /household, agriculture and commercial sectors, and is currently a major structural problem in Bulgaria's transformation to a modern internationally-linked economy.

VII. Geothermal Energy Futures to the Year 2020

Three scenarios for potential energy futures for Bulgaria was developed in order to examine a range of benefits that could be gained from the development of, and investment in, renewable energy in Bulgaria. These, in turn, provide a range of costs associated with each scenario, and the policy and legislative implications of each.

The first scenario is the Basic Scenario. This projects slow economic and energy growth between the present and the year 2005. The economy then begins to pick up quickly by 2005, and grows rapidly by the year 2020. Growth is strongest in the transport, commercial and industrial sectors, with energy growing at a similar rate. Renewable energy grows very fast under this scenario, but its relative share as a proportion of overall energy supply remains constant because all other energy demand also increases rapidly.

The Energy Efficiency scenario was developed to examine the impact on energy growth, and renewable energy development specifically, in a future in which Bulgaria places high emphasis on energy efficiency and demand side management. Under this scenario, economic growth is also slow until 2005, where it starts to pick up, although at a much slower rate than the Basic Scenario. However, because of the strong policy and economic focus on energy efficiency, while energy demand does not grow as much as the Basic Scenario, renewable energy demand increases more rapidly. Renewables achieve a higher share of overall energy supplies because of more favourable electricity prices for renewable energy and other supports.

The European Convergence Scenario was developed to see what the effects membership in the European Union would have on renewable energy in Bulgaria. Under this scenario, energy markets liberalise and open very widely by 2010 to the same extent as the European Union. Growth rates are similar to the Energy Efficiency Scenario, but renewable energy penetration grows faster because of renewable energy policies that are in place in other European countries.

Special computer model for assessing the first order impacts that new energy technologies was used. The development of the model was funded by the European Commission - Directorate General XII, Science, Research and Development under the Joule II programme. The model provides decision makers with a set of tools that can be used to examine and assess the impact of different energy technologies against a background of different economic policies and instruments.

VIII. Projections by Scenario

Using the energy demands, resources and technical potentials as a starting point for economic analyses, we predict by the computer model the market potential of the renewable technologies with the competing conventional alternatives. These calculations are repeated every year taking into account changes caused by the scenario variables eg energy demand may go up, capital costs of renewable technologies may come down and fossil fuel prices may increase.

Fig. 2 shows result for geothermal market penetration by years up to 2020. This results show that geothermal is a viable technology for thermal use. Bulgarian resources are not suitable for electricity generation. The constraints in the EU case are the number of suitable sources available and the demand for its use. Penetration is lower in the BS and EE cases due to higher costs and less favourable economic framework.

Growth in renewable energy is low between 1997 and 2000. This reflects the present policies which do not encourage renewable energy. Around 2000 the policies in the EE and EU scenarios start to have an effect. Prices are reduced for renewable technologies and there is a favourable enabling environment of loans and capital. The price reductions are not so marked in the EE scenario and growth stays at the same rate. Once 2010 is reached the EE scenario starts to level off.

The basic scenario is not favourable to renewables, there is a greater increase in demand in this scenario than EE and EU and although renewables do increase slightly in absolute terms,

there is a gradual decrease in the percentage of renewables of primary energy after 2000 as more conventional energy is imported to keep up with increases in demand.

IX. Conclusion

The Assessment shows that Bulgaria's rich geothermal energy resource base can be tapped extensively and sustainably to achieve real contribution in energy sector. This is a viable technology for thermal use and this would provide important environmental benefits through the reduction of carbon dioxide emissions.

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