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Geothermal potential of Romania in Renewable Energy Mix

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Abstract: In Europe, there is a growing interest in direct use of geothermal energy across all sectors, specifically balneology (spas, swimming pools).
The 600MW growth in 2013 and the 700MW growth in 2014 as well as the increasing number of new developing projects reflect a secure place in the global energy market for geothermal one. This is why, in this paper we want to present the social, ecological and economic advantages for using geothermal energy and the geothermal potential in Romania.
After Greece and Italy, Romania is considered to be the third in terms of geothermal potential in European Union with 137MW (Megawatts) installed power and recent research estimate an up to 160°C potential in certain regions of Romania in 3km deep wells.

Keywords: Geothermal Energy, Geothermal Potential of Romania, Renewable Energy Mix

1. Introduction

The world's population in 2013 was 7,2 billion and it is estimated to reach 8,7 billion by 2035 and 9,5 billion by 2050. On the other hand, the known deposits of conventional sources used in energy production like oil, coal and natural gas are heading to depletion. This, among other factors like geopolitical tension in the recent years or like economic and technological growth will determine an increase in the demand of energy and will generate growing prices for energy. [5], [6]
The solution to the emerging energy crisis approaching are renewable energies based on energy flows originated by the movement and gravitation of planets, heat stored and released by the earth and energy radiated by the sun.

2. Methods

The ever growing demand for energy in the context of finite character of conventional resources used in energy production and the geopolitical tensions created around the subject as well as the anticipation of the threats caused by climate change generated a growing need to monitor the status and the trends in the vast field of producing and exploiting the energy sources – both conventional and unconventional ones. By the increased access to different studies, statistics and reports we can have an overview of the energy situation – worldwide and by regions. This paper is the result of overviewing Romanian and International studies, reports and legislation about renewable energy.

3. International context for renewable energy

Counting 45.1 billion US dollars in 2004, global new investment in renewable power excluding large hydropower grew to 181.8 billion US dollars in 2008 and to 278.8 billion US dollars in 2011. After two years of decline, global investment in new renewable power in 2014 was 17% higher than in 2013. Although the 270.2 billion USD invested in renewable power in 2014 are 3% below the total record amount invested in 2011, they actually mean more in terms of new installed capacity. Excluding large hydropower, it is estimated a 103GW plus in 2014, compared to 80.5GW built in 2011. China had the most remarkable evolution in the last decade. With a starting point of 3 billion USD invested in 2004, it continuously grew and reached 25.7 billion USD in 2008 and 49.1 billion USD in 2011. With a total of 83.3 billion USD which means 40.2% of the 270.2 billion USD invested in new renewable power in 2014, China is the leader in terms of global new investment in renewable energy excluding large hydropower. Meanwhile, Europe's contribution to the global new investments was 23.6 billion USD in 2004, 81.6 billion USD in 2008 and reached its peak in 2011 with 120.7 billion USD. After 2011 the amounts invested in new projects decreased to 89.6 billion USD in 2012, 57.3 billion USD in 2013 and reached 57.5 billion USD in 2014. [7], [8]
Geothermal energy is renewable and there are proves that its usefulness had been appreciated since roman times. In 1904 the first geothermal power plant had started its activity in Italy and, after a short period of glory, the interest for this type of free energy has paled. Fortunately, it came to our attention once again. According to the Annual U.S. & Global Geothermal Power Production Report published by the Geothermal Energy Association from USA in April 2014 there are about 12000MW in the pipeline and about 30,000 MW of geothermal resources projects under development – in the world. Of the estimated 12000MW about 16% are under construction in 14 countries around the world while about 10% of global projects have drilled injection or production wells and/or are actually in the process of constructing a power plant and another 50% of projects are in the exploration stage meaning the first exploration wells were drilled, project funds have been acquired, and/or

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significant knowledge of the geothermal resource has been attained. Now it is estimated that if all geothermal power plants under construction in the world are completed on schedule the global geothermal industry could reach about 13,450 MW of nameplate capacity by 2017 while the growing interest for shallow geothermal and its benefits generated turns from households projects to district heating and cooling projects. [12]

Energy sector is a strategic one and, despite renewables input, Europe's dependency on imports for different types of fossil fuels is growing. For the last 15 years the import dependency in EU (European Union) has increased. It's maximum value in 2008 was 54.7%. The only country with negative values is Denmark but its imported energy dependency rate decreased from 31.4% in 2003 to 3.4% in 2012. Thermal energy holds the largest share in energy consumption in EU – over 50% and the main fuel used for producing it are hydrocarbons. According to Eurostat, about one third of EU's total crude oil (33.7%) and natural gas (32%) imports in 2012 originated from Russia while the uncertainties over the crisis in Ukraine underlines the implications of energy dependency in Europe. [3], [4], [7]

Since the heat represented 86% of the final energy consumption in households, 76% in trade, services and agriculture, and 55% in industry, while 81% of this energy is produced by burning fossil fuels, renewables for heating and cooling must play an important role in EU's energy security strategy. By Directive 2001/77/EC of the European Parliament and of the Council, Directive 2003/30/EC of the European Parliament and of the Council along with Directives 2009/28/EC and 2012/27/UE, Europe establishes a common frame for the use of energy generated by renewable resources. Beyond the geopolitical reasoning, they are also meant to limit and to decrease greenhouse gas emission and to promote cleaner transport. With a large unexploited potential, geothermal energy could play an important role in the energy mix of the near future. At the end of 2014 the global new investments in Geothermal projects of more than 1MW reached 2.7 billion US dollars – 23% higher than the 2.2 billion US dollars invested in 2013 and 225% higher than the 1.2 billion US dollars invested in 2004. [7], [3], [4]

A good example to follow is Iceland who, during the 20th century, rose up from one of the Europe's poorest countries, dependent on peat and coal import for its energy needs to a country appreciated for the high standards of living where practically all stationary energy are derived from renewable resources and the Geothermal power plants provides more than 26% of its entire electricity production while approximately 87% of all buildings use geothermal heating technology for heating and hot water. The other almost 74% of Iceland electricity is generated by hydro power and only 0.1% is generated by fossil fuels. [14],[15]

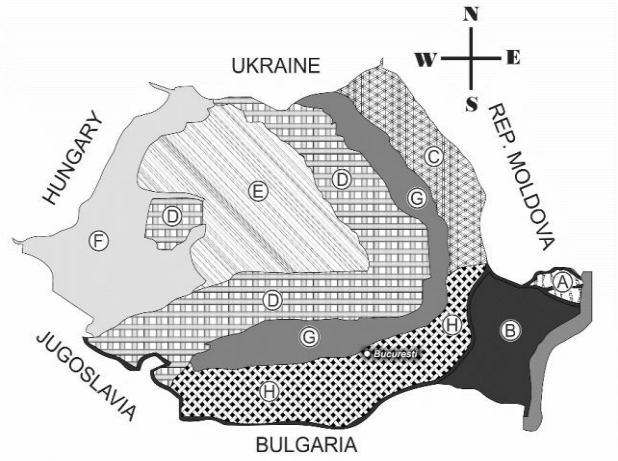
4. Romania

According to the Romania's Energy Strategy for 2007-2020, updated for 2011-2020 and to the draft for 2015-2035 Energy Strategy, Romania's potential for renewables is estimated to have the values presented in Table 1. and the distribution by regions presented in Figure 1. [1]

Table 1. Potential for the renewable sources of energy in Romania [1] (ktoe = thousand tonnes of oil equivalent)

Renewable source of energy	Annual energy potential	Energy economic equivalent	Percentage of the total energy	Aplicability
Measurement unit		ktoe	%	
Solar Energy Thermal	60x10^{6}GJ	1 433	9.74	Thermal energy
Solar Energy Photovoltaic	1 200GWh	103	0.70	Electric energy
Eolian Energy	23 000GWh	1 978	13.44	Electric energy
Hidroelectrical Power	40 000GWh	3 440	23.37	Electric energy
Under 10MW Hidroelectrical Power	10 000GWh	516	3.51	Electric energy
Biomass	318 x10^{6}GJ	7 597	51.62	Thermal energy
Solid Biomass	290 x10^{6}GJ	6 917	47.00	Thermal energy
Biomass	15 x10^{6}GJ	353	2.40	Thermal energy
Urban Waste	14 x10^{6}GJ	327	2.22	Thermal energy
Geothermal Energy	7 x10^{6}GJ	167	1.13	Thermal energy
Total Energy		14 718		

Figure 1. Distribution of renewable resources used in energy production in Romania [2]



Legend:			
A.	Danube Delta	-	Solar energy
B.	Dobrogea	-	Solar and eolian energy
C.	Moldova	-	Eolian, micro hidro energy and biomass
D.	Carpathian Mountains	-	Biomass and micro hidro energy
E.	Transilvania Plateau	-	Micro hidro energy
F.	West Field	-	Geothermal energy
G.	The Sub Carpathians	-	Biomass and micro hidro energy
H.	South Field	-	Geothermal, solar energy and biomass

Romania has a wide but limited range of mineral and fossil resources for producing energy like oil, natural gas, coal and uranium so it still depends on imports. The estimated potential of renewable resources, on the other hand, of over 14 700 ktoe exceeds the primary energy imports in 2013 (9 993 ktoe) and the ones in 2014 (10 251 ktoe). Its high potential, along the diversity of renewable resources made Romania an important target for energy investors over the recent years.

As a result, the primary production of renewable energy in 1990-2013 looks as it can be seen in Table 2. while the share of renewable energy in the different energy sectors can be seen in Table 3.

Table 2. Primary production of renewable energy in Romania 1990-2012 (toe=1000 tonne of oil equivalent) [7]

	1990	2000	2010	2011	2012	2013
Wood & other solid biomass	601.7	2 763.2	4 101.4	3 658.4	3 696.7	3 813.8
Hydro power	981.2	1 737	1 709.6	1 266.4	1 037.5	1 286.1
Geothermal energy	0.0	6.7	23.0	23.8	23.3	26.0
Wind power	0.0	0.0	26.3	119.3	227.0	388.7
Solar energy (thermal and photovoltaic)	0.0	0.0	0.1	0.1	0.8	36.3

Table 3. Share of renewable energy in the different energy sectors in Romania [7]

2004	2006	2008	2010	2011	2012	2013
Share of renewable energy in gross final energy consumption						
17.0 %	17.1 %	20.5 %	23.4 %	21.4 %	22.8 %	23.9 %
Share of electricity from renewable sources in gross electricity consumption						
28.4 %	28.1 %	28.1 %	30.4 %	31.1 %	33.6 %	37.5%
Share of renewable energy sources in heating and cooling						
17.4 %	17.6 %	23.2 %	27.2 %	24.3 %	25.7 %	26.2%
Share of renewable energy sources in transport						
0.9 %	0.8 %	2.6 %	3.1 %	2.0 %	4.1 %	4.6%

As it can be seen in Table 2 and Table 3, the investor's interests in renewable resources in Romania met ups and downs over the years and it shifted from solar energy to eolian energy, biomass and micro hydro. The most unexplored and unexploited area of renewables seem to be the one involving heat stored and released by the earth and there is a need for new approaches in this area.

Until now, the heating needs in urban areas were met by local industry. However, most of the national energy sector – including heating – was build during 1960-1970 and it meets the quality and efficiency standards of that period of time. Unfortunately, despite the proper maitainancy of the technology, it does not meet the efficiency of the newer technology and, therefore, this part of the energy sectors is declining since the 1990's. As a result, final thermal energy consumption decreased from 1795.18 thousand tonne of oil equivalent (ktoe) in 2008 to 1415.67ktoe in 2013 while the residential use which consumes 65% of the total, decreased by 25%.

The evolution of final thermal energy consumption is illustrated in Figure 1.

Table 4. Final thermal energy consumption in Romania [7]

Indicator	2008	2009	2010	2011	2012	2013
	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
Residential	1 206.01	1 182.16	1 134.74	1 120.53	959.52	904.84
Industry	323.49	237.57	282.64	291.39	278.67	258.66
Services	235.17	193.91	214.08	225.14	234.27	223.15
Agriculture	14.18	21.69	18.04	23.98	30.34	6.99
Transportation	16.34	13.69	4.84	1.68	2.25	2.03
Total	**1 795.19**	**1 649.03**	**1 654.34**	**1 662.72**	**1 505.05**	**1 415.67**

In Romania, thermal energy holds the largest share in energy consumption – over 50% - and it has the largest contribution in energy loss while the main fuel used in producing it are hydrocarbons – over 60%, with the largest contribution from coal – over 25%. Unconventional or renewable resources contribution in thermal energy production between the years 2008 and 2013 was below 4% while the estimated potential is over 62% and while the geothermal potential is insufficiently explored and exploited. A national program is currently developing, though, in order to fully understand the status of the geothermal potential. [1], [9], [10]

5. Results and discussions

The international market of geothermal energy is expanding. After Greece and Italy, Romania is considered to be the third in terms of geothermal potential in European Union. The total capacity on existing wells is about 480 MWt of which 148 MWt are currently used mainly for space and district heating but there is a trend in expanding the use of the temperature stored within the earth across different sectors like balneology (spas, swimming pools), agricultural use, fish farming, animal husbandry, biofuels production and many more.

The distribution of hydro-geothermal resources in Romania is illustrated in Figure 2 while the current situation in direct utilization as illustrated in World Energy Council 2013 Report named World Energy Resources, geothermal looks like the one presented in Table 3.

Figure 2. Distribution of hydro-geothermal resources in Romania [10]

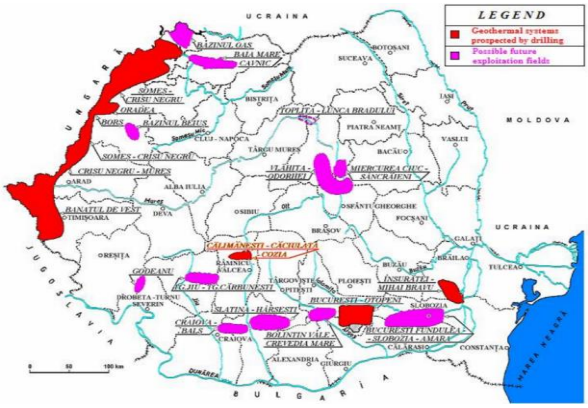


Table 3. Applicability of geothermal resources in Romania [9]

Aplicability for geothermal resources	Measure Unit: MWt	Measure Unit: TJ/year
Individual space heating	13.28 MWt	165.83 TJ/yr
District Heating	58.95 MWt	531.72 TJ/yr
Greenhouses	4.18 MWt	20.78 TJ/yr
Fish farming	4.50 MWt	9.70 TJ/yr
Agricultural drying	1.40 MWt	12.70 TJ/yr
Industrial process heat	0.75 MWt	6.84 TJ/yr
Bathing and swimming	64.68 MWt	489.16 TJ/yr
Geothermal heat pumps	(estimation) 5.5 MWt	29.70 TJ/yr

Having 66 hydro-geothermal resources discovered in more than 250 exploration wells, most of Romania's low-enthalpy geothermal potential lies in south-central part of the country and along the western border, namely in Pannonian Plain (Timis County and Arad County with 143 exploration wells and 49 hydro-geothermal sources), North-Western area (Bihor County and Satu Mare County with 44 exploration wells), Getic Depression (Valcea County with 3 hydro-geothermal sources) and Moesian Plate (Ilfov County with 14 hydro-geothermal sources). Measurements of temperatures in exploration wells allowed mapping geothermal resources and their categorisation by its exploitation potential: the ones with temperatures between 60^0C and 120^0C on 3km

exploration depth and therefore suitable for thermal use who are represented mainly along Western and North-Western border and the ones above 140^0C at the same depth – represented mainly in Oriental Carpathians area. The areas with temperatures higher than 140^0C are considered to be suitable for installing power plants. Until now, there is no use of geothermal resources in Romania for electricity generation but the 20 MW_e potential encourages further research into the possible use of binary plants. The technical estimated potential in producing electricity is 9 000 TJ or 215 ktoe per year and the economic potential is 7 000 TJ or 167 ktoe per year. [9], [10]

The main concern in exploiting geothermal energy is the high cost of the exploration and the high cost drilling wells but there are research programs looking to eliminate that objection and it is expected that newer technology will accomplish that pretty soon. Exploiting geothermal resources in Romania, though, may bring a wide range of benefits: from reducing greenhouse gas emission to diversity in energy mix and to security in import dependency as well as predictability for energy price. In terms of national economy, we also have to mention the taxes, the dues and the new created jobs. All these and many more could be observed as a result of the geothermal heating project in Beius town from Bihor County that started as a result of a drilling made back in 1995-1996 at a depth of 2 576 m and after a testing period made in 1999. This first well provided heat for the main administrative buildings in Beius and for apartment buildings. The raising demand of thermal energy determined the exploration and exploitation of another well. This second project was made by European grant support programme and, therefore, the money "problem" was eliminated. [9], [10], [11]

1. Conclusions

The international market of geothermal energy is expanding. Concerned about the consequences of climate change and about the geopolitical implications of import dependency on fossil fuels for producing energy, many countries ranging from small island nations to large, developed economies like China, Canada or the United States of America choose the renewable resources that the Earth and the Sun so generously provides. A good example comes from Iceland who, during the 20th century, rose up from one of the Europe's poorest countries, dependent on peat and coal import for its energy needs to a country appreciated for the high standards of living where practically all stationary energy are derived from renewable resources and the Geothermal power provides more than 25% of its entire electricity production while approximately 87% of all buildings use geothermal heating technology for heating and hot water.

In Romania, thermal energy holds the largest share in energy consumption – over 50% - and it has the largest contribution in energy loss while the main fuel used in producing it are hydrocarbons – over 60%, with the largest contribution from coal – over 25%. For now, Romania has a wide but limited range of mineral and fossil resources for producing energy like oil, natural gas, coal and uranium so it still depends on imports. The estimated potential of renewable resources, on the other hand, of over 14 700 ktoe exceeds the primary energy imports in 2013 (9 993 ktoe) and the ones in 2014 (10 251 ktoe). Unconventional or renewable resources contribution in thermal energy production between the years 2008 and 2013 was below 4% while the estimated potential is over 62% and while the geothermal potential is insufficiently explored and exploited. In terms of geothermal potential Romania is considered to be the third in European Union The most recent research estimate an up to 160°C potential in certain regions of Romania in 3km deep wells which makes it possible to develop projects for district heating and cooling. Due to newer high performance technology, shallow geothermal energy use could bring an up to 70% economy compared to the technology based on conventional energy producing resources. It has to be sustained, though, by a proper, long term law environment and energy strategy. In order to do that, Romania also needs a strategy and a set of measures set to increase the energy efficiency and to lower the energy loss in heating and cooling of buildings.

Exploiting geothermal resources in Romania, despite the high initial investments, may bring a wide range of benefits: from fire free risks technology and chemical combustion free technology, to reducing greenhouse gas emission, to diversity in energy mix, security in import dependency, predictability for energy price, new jobs, new incomes to the local economy by specific taxes, and low price maintenance.

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