ANALYSIS OF RENEWABLE ENERGY IN ROMANIA'S CENTER DEVELOPMENT REGION

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Abstract
Nowadays various problems and requirements of the society and of the development of cities and regions may be solved by using environmental technologies that provide energy from different renewable sources. Therefore, this study examines the renewable energy potential in one of Romania's development regions that is Center Development Region. The findings of this study reveal that this region has high renewable energy potential, distributed in all its six counties, which makes Center Region an attractive location for people who want to invest in green energy. The study was carried out by combining a wide variety of sources, such as statistics, research reports and articles. The results reported in this study could be used for further research in the area of implementing green energy projects for urban development of the regions.
Keywords: renewable energy, urban management, regional development, Center Development Region, Romania.

1. INTRODUCTION

This study investigates the renewable energy potential in Center Development Region of Romania. Firstly, this study briefly discloses the renewable energy's role in urban development. Secondly, the study discloses an overview of Romania's Center Development Region from a geographical point of view, and also from the point of view of the main resources of the counties included in this region. Thirdly, an analysis of renewable energy potential in Center Development Region is done in this study in order to reveal the areas that have the highest potential of wind energy, solar energy, hydro energy, biomass and geothermal energy.

The research was conducted using a large variety of sources, such as statistics, research reports and articles. The research question was answered by analyzing published sources, evaluating and interpreting evidence.

2. RENEWABLE ENERGY'S ROLE IN URBAN DEVELOPMENT

Various problems and requirements of the society and of the development of cities and regions may be solved by using environmental technologies. The technological development in the urban development of cities may take into account the following prioritized areas: (1) sustainable management of the place

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and use of soil; (2) renewable and alternative energy; (3) sustainable management of water; (4) ecological materials; (5) comfort in the constructed environment; and (6) other resources and processes (Hernandez Moreno, 2009: 126).

Nowadays, a wide variety of technologies provide energy from different renewable sources, such as biomass, wind, solar, hydro, and geothermal sources that have their unique technologies which convert the energy of the resource into a usable form. The elements that differentiate those sources from the conventional ones is their strong spread of the exploitable potential over quite extended areas and the immediate dependence of the season and weather conditions, excepting geothermal power.

The distinctive potentials and contributions of renewable and efficient energy to sustainable and regional development have been recognized, however its widespread implementation was delayed (Ingwe et al., 2009). Nowadays, the European Union's member states are trying to solve this problem by initiating more energy-efficiency investments. For instance, the European Commission is negotiating with member states to include more energy efficiency improvements and renewable energy schemes in housing in all member states (Radulescu and Ioan, 2009: 66).

A higher degree of solar, wind or biomass use as sources for heating, cooling and electricity production could change the buildings' design concept and a series of new standards have to be developed. The architecture of the new or revamped buildings will take into account different new elements (solar panels, photovoltaic walls and roofs, wind generators, etc.) integration in buildings' envelope and resistance structure (Musatescu and Comanescu, 2009: 198).

Urban managements in more prosperous advanced countries are rapidly and seriously transiting from conventional to sustainable energy technologies (Ingwe et al., 2009).

The new environmental technologies applicable to urban sustainable development depend on the degree of the development of the country, its infrastructure, specialized human resources and management of the plans and programs of urban development, in addition to other tools such as methodologies and procedures that help their application. On the other side, regulation, lineaments and rules alike play an important role in the use and advantageous exploitation of these new technologies, as well as the way to apply public policies in the region does (Hernandez Moreno, 2009: 138).

Romania has a significant share of renewable sources, amounting to 12% of gross inland consumption and 29% of electricity production (Eurostat, 2009: 85). The proposed target for 2020 is 24% in final consumption. Although the target is ambitious, there is a significant potential in Romania for wind and biomass as well as for further hydro expansion, particularly smaller-scale hydro.

In terms of theoretical potential, biomass and biogas account for an overwhelming 65% of the total renewable energy sources potential (excluding large hydro) of around 135 TWh/year (cumulating both electric and thermal energy), with wind and solar accounting for 17% and around 13%, respectively. Small hydro (under 10 MW) and geothermal energy register a relatively low share in the total, with 4% and 1%, respectively (Roland Berger Strategy Consultants, 2010; Iluțiu-Varvara et al., 2009).

Taking into account the significant potential of renewable energy sources in Romania, it is reasonable to use it in order to develop Romanian cities and regions. There are some current technologies that may be applied to urban sustainable development, such as new-generation photovoltaic panels, systems of passive heating of water, wind energy, geothermal energy, mini-hydraulic energy, etc. (Hernandez Moreno, 2009: 135). These technologies may be applied at the households, places of work, offices and any building so as to ensure an efficient energy management in cities and regions.

3. OVERVIEW OF ROMANIA'S CENTER DEVELOPMENT REGION

Center Development Region is situated in the central part of Romania (figure1 and figure 2), at the interior of the Carpathian Mountains, on the course of Mures and Olt rivers.

FIGURE 1 - GEOGRAPHIC POSITIONING OF THE CENTER DEVELOPMENT REGION IN EUROPEAN UNION AND ROMANIA
Source: Center Regional Development Agency, n.d.

The region includes 6 counties, namely: Alba, Brasov, Covasna, Harghita, Mures and Sibiu (figure 3).

Covering 34.100 square kilometres, approximately 14.3 % of Romania, Center Region is the fifth largest

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of the eight Romanian regions. Its geographical position connects it to six of the other seven regions, the distances between its central area and the country borders being almost equal (see figure 2).

FIGURE 2 - ROMANIA'S CENTER DEVELOPMENT REGION

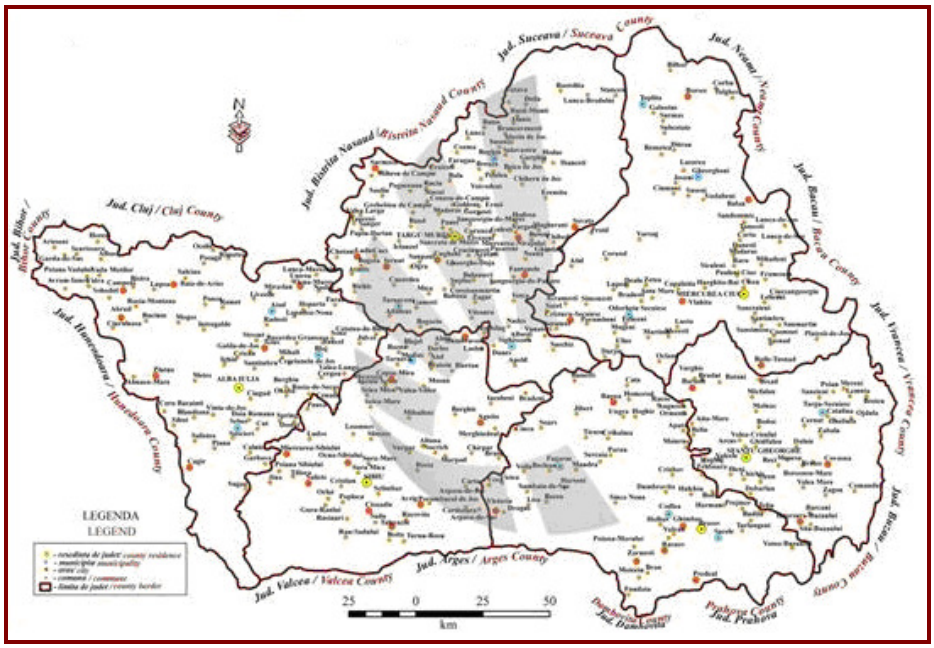

FIGURE 3 - ADMINISTRATIVE UNITS OF THE CENTER DEVELOPMENT REGION
Source: Center Regional Development Agency, n.d.

Alba County is situated at the intersection of Transylvania Plateau with Apuseni Mountains and Southern Carpathians. County area is 6231 square kilometres, which represents 2.6% of Romania's territory, occupying 16th place in size (Consiliul Județean Alba, 2010). There are important natural resources: ferrous ores (gold, silver, copper in Baia de Aries, Rosia Montana, Almasu Mare, Zlatna, Abrud, etc.); mercury (Izvorul Ampoiului); salt (Ocna Mures); gas (Cetatea de Balta); chlorine water (Ocna Mures); limestone; and building stone (Fundația Națională a Tinerilor Manageri, 2007).

Nevertheless there are large areas of forests, pastures and meadows, highlighting the economic potential of this county.

Brasov County is situated in the south-eastern part of Transylvania and covers 5363 square kilometres, i.e. approximately 2.2% of Romania (Consiliul Județean Braşov, 2008). Within this county, the Metropolitan Area of Brasov plays a significant role for the development of Center region. According to The Metropolitan Agency for Sustainable Development Brasov (2010: 3) the Metropolitan area of Brasov is a compact geographical space, which ensures a coherent and coordinated framework for the development of the town area of Brasov, starting from the idea that it represents, together with the surrounding localities, a coherent functional system, structured as a result of a long historical process. The Metropolitan Area is built around Brasov (including other 13 localities surrounding it), which is the only national growing pole from the Center Development Region. Brasov is one of the most developed industrial centres in Romania and geographically is situated on the most important development axis that is Bucharest-Ploiesti-Iasi axis, which may be more important in the future, both from economic and logistic points of view (Popescu and Corbos, 2010). Brasov has the greatest urbanization degree within the Center Region (74.7%) and takes the first place in terms of GDP/inhabitant and work productivity (The Metropolitan Agency for Sustainable Development Brasov, 2010: 6).

Covasna County is located in the Carpathian curve and stretches over 3710 square kilometres, i.e. 1.6% of Romania, being one of the smaller counties in Romania (SC Computer Club SRL, 2000). This county is the least inhabited in Romania, having a population of 231,170 people both in towns and villages. It consists of a capital city (Sfantu-Gheorghe), four towns and over 150 small villages. Covasna soil and sub-soil are very rich: hundreds of table and medicinal mineral water springs, only a very small part of them being exploited – Biborteni, Malnas, Bodoc, Valcele, Covasna, and Poiana. The lignite ores of Baraolt are also exploited, and about 47% of the county area is covered with forests, leading to a high tourism potential and development of the wood industry.

Covasna is one of the counties in Romania which has a great number of mountain resorts, such as: Covasna, Balvanyos, Valcele, Bodoc, Biborteni and Sugas. These resorts harmoniously combine themselves to the natural landscape such as Mestecanisul Nature Reserve at Reci, Varghis Quays and the Saint Ana and Moacsa Lakes as well.

Harghita County lies in a depression surrounded by the Eastern Carpathians, being split in the middle by the Gurghiu Mountains and Harghita, the sacred mountain of the Szeklers, which is also the youngest member of the volcanic mountain range of the Eastern Carpathians. Harghita County's territory is of 6639 square kilometres and is covered by forests (mostly pine), which gives an evergreen

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aspect to the place. The mountain ranges of the county have volcanic origins, and hence there are treasure wonders like the lake of Saint Ana, the pit bog of Mohoş, the numerous mineral water springs, the Red lake, with its peculiar landscape and legend, that offer the blessings of future tourism investments. The effort to create real values is gaining ground on both side of the Harghita County, and in spite of the scientific and technological achievements and challenges of our age, still the ace in the sleeve for this county is represented by timber, construction material, clay, and salt (Harghita County Council, 2010).

Mures County is following the course of Mures River and has a relief that gradually descends from the mountain tops of the Eastern Carpathians to the Transylvanian Plain and the Tirnave Plateau. The plateau and the hills cover half of the county's area, the other half belonging to the sub-Carpathians hills and the volcanic mountains of Calimani and Gurghiu. The surface of Mures County includes 6696 square kilometres, i.e. almost 3% of the present surface of Romania, and Tirgu Mures is the county town. Natural gas, rocks used as building materials, mineral water springs, and forests are the main natural resources of the county. The economy is represented by natural gas drilling, electric and thermal energy production, chemical, woodworking, building materials and food industries. There are factories of furniture, carved furniture in particular, glass and broad glass, ceramics at Tirnaveni, Tirgu Mures and Sighisoara, of textiles and garments at Tirgu Mures and Sighisoara, of leather items at Tirgu Mures and Reghin. Mures County is the only producer of carbide (Tirnaveni) and musical instruments (Reghin) from Romania (Mures County Council, 2010).

Sibiu County is located in the south-east of Transylvania, and has an area of 5432 square kilometres, representing 2.3% of the country's area (Eurostat, 2004). The rich natural wealth of the county is enhanced by six natural reservations of great scientific and public value: the Bottomless Lake at the Sibiu Salt Mine, the calcium deposits of Cisnadioara and Turnu Rosu, the reserve in the Sarba Valley, Balea Lake and Balea Waterfall, and the Cindrel Mountain Lakes reserve (Rest Romania SRL, 2009). The natural resources are represented by forests, pastures, hays, agricultural lands, rich flora and fauna; concerning the sub-soil resources, the most important is the methane gas, with a purity of 99% (the cleanest methane gas in the world) as well as slat deposits and sodium chloride mineral waters (Eurostat, 2004). Sibiu County has some of the most dynamic economies in Romania, being one of the counties with the highest level of foreign investment. The predominant industries in the county are machine and automotive components, food industry, textile industry and wood industry. The restructuring and modernization that took place in the last decade led the industry to the first position in the county's economy, accounting for approximately 39% of GDP, followed by agriculture, construction, trade and services.

4. ANALYSIS OF RENEWABLE ENERGY POTENTIAL IN CENTER DEVELOPMENT REGION

As mentioned before, Center Development Region has many energy resources, such as methane gas, coal, mineral waters, forests, etc.

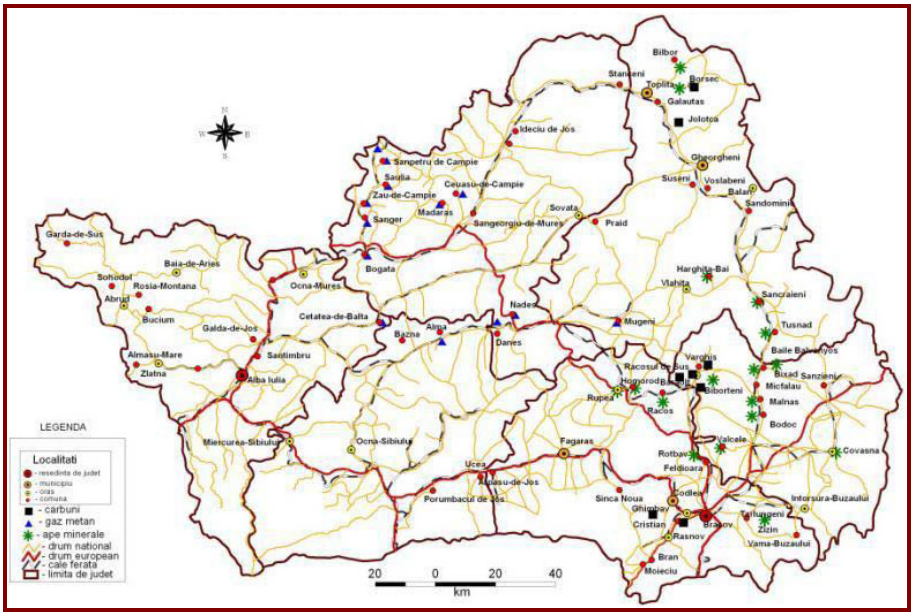

FIGURE 4 - GEOGRAPHICAL DISTRIBUTION OF ENERGY RESOURCES WITHIN CENTER DEVELOPMENT REGION
Source: Center Regional Development Agency, 2009: 33

Figure 4 shows the geographical distribution of energy resources within the region. However, Center Region's fossil resources may be exhausted in less than one hundred years. Therefore, the renewable energy sources may be the solution for the development of this region in terms of the economic activity and of the life quality.

The analysis of the renewable energy sources potential in Center Development Region may be based on the particularities of the natural frame and the interpretation of the spatial modelling maps. The main reason is that the renewable sources potential depends on the characteristics of the relief, climate, hydrography, soil and vegetation.

The **wind energy potential** (figure 5) is influenced by the altitude of the relief and the dominant direction of air masses. Almost half of the territory of Center Development Region is composed mainly by the branches of the Carpathians, plus the hilly and depresionery areas of the Transylvanian Plateau.

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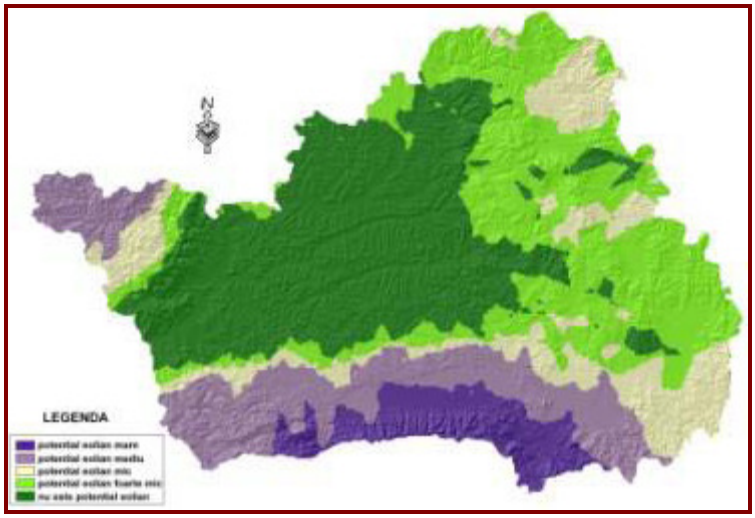

FIGURE 5 - MAP OF WIND POTENTIAL WITHIN CENTER DEVELOPMENT REGION
Source: Center Regional Development Agency, 2010: 10

As figure 5 reveals, there are some favourable areas for the exploitation of wind energy, such as: Apuseni Mountains' areas, with permanent winds caused by climatic influences from the West and Fagaras Mountains' areas (over 2500m), Cindrel, Calimani, Gurghiu and Harghita Mountains, with high altitudes (Center Regional Development Agency, 2009: 17). These areas have high wind energy potential. However, there are some areas with low energy potential. In the depression areas and most of the Transylvanian Plateau the wind energy potential is very low or cannot be exploited.

The **solar energy potential** can be capitalized in all Center Region's relief units (figure 6), the highest potential being that of the Transylvanian Plateau. In the mountain area the solar energy potential can be exploited on the slopes facing south (Center Regional Development Agency, 2009: 24).

The **hydro energy potential** is defined by the constant high debits and the pronounced longitudinal incline of the rivers. Center Region's hydrography is represented by important surfaces of Mures and Olt Rivers basins. Mures and Olt Rivers offer high hydro energy potential which can be capitalized in the areas that have pronounced inclines (more than 7 degrees) and debits of 60-70 mc/s. The most important affluents of Mures River are Tirnava, Secas, Sebes, Aries and Ampoi. From the point of view of debits the most important affluent is Aries River, with 23.5 mc/s debit (Center Regional Development Agency, 2009: 29). The map of hydro energy resources within Center Development Region is illustrated in figure 7. Harghita County is suitable for micro hydro power plants investment projects.

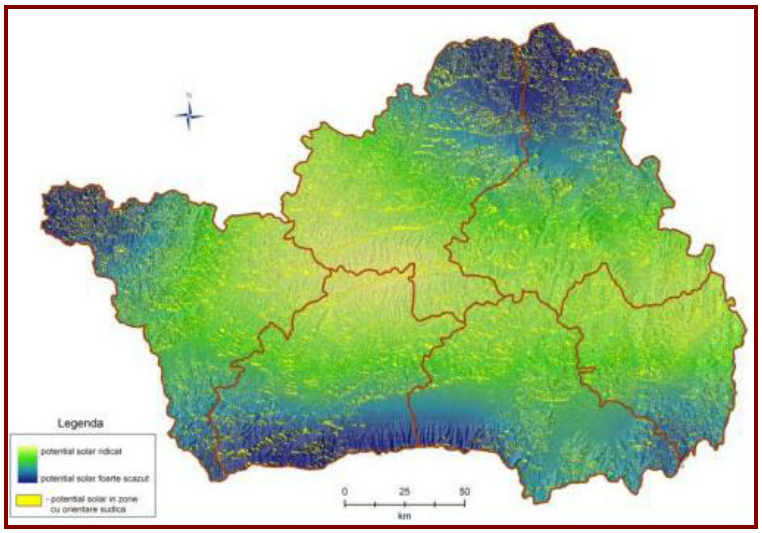

FIGURE 6 - MAP OF SOLAR POTENTIAL WITHIN CENTER DEVELOPMENT REGION
(Source: Center Regional Development Agency, 2010: 9)

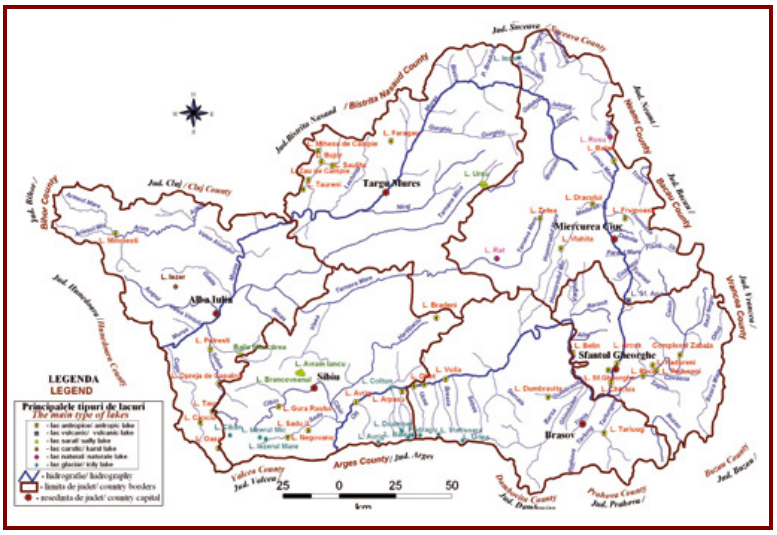

FIGURE 7 - MAP OF HYDRO ENERGY RESOURCES WITHIN CENTER DEVELOPMENT REGION
(Source: Center Regional Development Agency, 2010: 11)

The **biomass potential** of Center Development Region is very high (figure 8), because the altitude of the relief determines a vertical levelling of the vegetation, with three levels of forestry vegetation. The development of the vegetation with high potential for the capitalization of biomass depends on the soils quality. The cereals and technical plants have the highest potential for biomass and biofuels production, but they need fertile soils rich in humus. These types of soils (chernozems and leached chernozems) are specific for the plain areas and the areas with altitudes of maximum 400 m. The Transylvanian Plateau is characterized by fertile soils that are appropriate for cultures of cereals and technical plants (Center Regional Development Agency, 2009: 31).

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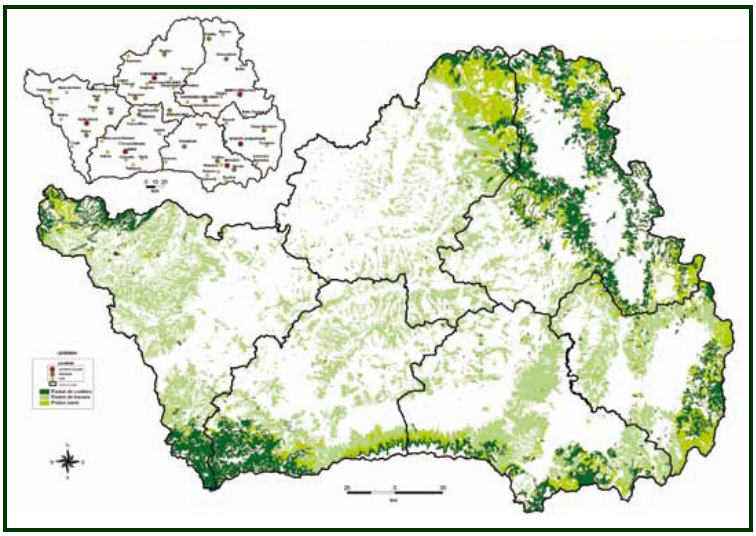

FIGURE 8 - MAP OF BIOMASS POTENTIAL WITHIN CENTER DEVELOPMENT REGION
(Source: Center Regional Development Agency, 2010: 8)

The forestry fund within Center Development Region is rich and diversified, favourable for the development of wood processing industry and this represents the premises for the capitalization of wood waste and biomass (Center Regional Development Agency, 2009: 32). The most resourceful county with available energy potential of the vegetal biomass in Center Development Region is Harghita (Roland Berger Strategy Consultants, 2010).

The **geothermal potential** is low in Center Development Region, but there are two favourable areas (Toplita and Miercurea Ciuc-Jigodin) with geothermic heating pumps.

5. CONCLUSIONS

This study has revealed that Center Development Region from Romania has high renewable energy potential, distributed in all its six counties, which makes it an attractive location for people who want to invest in green energy. This conclusion is based on the following premises: (1) there is great potential of biomass in Center Development Region because the regional relief and soils are well suited for energetic cultures and most of the region's surface is covered by a rich forestry fund; (2) this region has significant potential of solar energy in all its relief units whose characteristics and parameters are favouring the exploitation of solar energy; (3) the hydro potential is not fully exploited, and there are important sectors of Mures River and Olt River and their affluents where micro hydro power plants may be constructed; and (4) the wind energy potential and the geothermal energy potential may be exploited in small areas of the region.

The results reported in this study could be used for further research in the area of implementing green energy projects for sustainable urban development of the regions.

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