# Issues of geothermal and biomass energy efficiency in agriculture, industry, transports and domestic consumption

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***Abstract:*** *Increasing energy efficiency should be a concern for both the firm managers and any leader at any level, given that energy efficiency significantly reduce production costs. An important aspect of this is the use of renewable energy sources, in different types of activities, depending on the possibilities to produce it on favorable terms, to supply at relatively low costs and to efficiently consume it both in the producing units and the households. A skilful and powerful leader will seek and support, through its influence, all the means that determine the reduction of the production costs and obtain a profit as high as possible. Wider use of renewable energy promotes concern for the environment through clean energy, for reducing pollution and for facilitate, in some cases, even the increase of the production with the same costs or lower costs. In agriculture, industry, transports and household consumption, a high importance presents the geothermal energy and the biomass as source of energy.*

***Keywords:*** energy efficiency, geothermal energy, biomass, bio-fuel, energy production, energy, biological agriculture

**JEL Classification:** D21, D24, L26, L94, M11, M14, Q42, Q47

## 1. Introduction

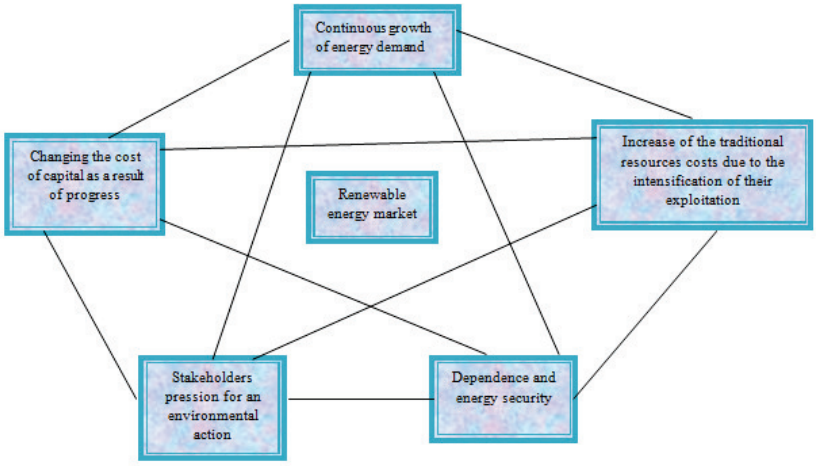
Increasing energy efficiency is a very important objective of the sustainable development, is a prerequisite for reducing the negative impacts on the environment of the energy production and consumption. Achieving energy efficiency implies, in all the countries, to produce a bigger amount of clean energy and to increase the number of transactions with such energy, thus reducing carbon dioxide emissions.

As outlined in the "Energy Strategy of Romania during 2007-2020 updated for 2011-2020", "The overall objective of the energy sector is satisfying the energy needs both now and in the medium and long term at prices as low as possible, suitable for a modern market economy and a decent standard of living, in terms of quality, food safety, respecting the principles of sustainable development. " The same document stresses as targets for increasing energy efficiency in agriculture: "increase of the efficiency and use of biofuels on agricultural machines; development of the energy crops in order to produce biofuels such as for the production of electricity and heat; increasing energy efficiency of the irrigations. ... .. Biomass fuel is the main rural fuel and it is used mainly for space heating, for water heating and for cooking. Biomass covers about 7% of primary energy demand and 50% of Romania's renewable resource potential. For the geothermal energy that can be used for space heating and water heating, the main potential for use is in the rural areas - houses, greenhouses, aquaculture, milk pasteurization – in locations located at distances up to 35 km from the place of extraction".

To define the energy efficiency, it starts from the concept of energy intensity, which represents at the level of each country, the ratio of energy consumption to GDP. Energy efficiency expresses the ability of the new technologies to reduce the energy intensity. The importance of this challenge is illustrated by the global world investment made for renewable energy, which, for example in 2012, there were 244 bln. dollars, the highest increases corresponding to countries like China, South Africa, Morocco, Mexico, Chile and Kenya.

The importance and the role of the renewable energy are illustrated in the particularly suggestive scheme of C. Sesto:

*Chart 1. C. Sesto scheme regarding the renewable energy market*




*Source: D. de Vincenzo, P. Morelli, G. Spinelli, L. Scarpelli – Geografia economica, McGraw Hill Companies Inc., Milano, 2010*

**2. Literature Review**

The authors H. Gupta, S. Roy, emphasizes in the book „Geothermal Energy: An Alternative Resource for the 21st Century" (2007), which is an interdisciplinary approach between geology, geophysics and engineering, all the aspects regarding the geothermal energy resources, their exploitation and their development. The authors are presenting some geothermal resource models and exploration and production technology. The book describes, also the importance of bringing potable water to high-demand areas such as the tropical regions.

„Geothermal Energy: Renewable Energy and the Environment" by W. Glassley describes the geothermal energy uses in the history and highlights that a restriction arising from the fact that it can be exploited only in areas where there are adequate natural conditions. The modern technologies allow the use of more resources directly, especially for applications such as modular power generation and home heating. The author explores the reserves and resources of geothermal energy, the technological modalities to explore them and to use them in the production and consumption and also the possible improvements for the future. There are also presented the consequences on the environment and the economic aspects. These ideas show that this resource of energy can be very important and can replace a big quantity of fossil fuels.

Ernst Huenges, the author of „Geothermal Energy Systems: Exploration, Development, and Utilization" presents the restrictions for the economic and environmental utilization of geothermal technology. Because of this, the book is important both for the scientists and managers, from the research field and the political field regarding the instruments that an enterprise or a state can use in order to optimize the use of the geothermal energy.

„Biodiesel: Growing A New Energy Economy„ by Greg Pahl presents the background of the Biodiesel story and its use and benefits in the energy production. The book has four sections - "Biodiesel Basics", "Biodiesel around the World", "Biodiesel in the United States", and "Biodiesel in the Future". "Biodiesel Basics" is a history of the first diesel engine and of the different uses of the biomass. The various types of crops that can be used to produce biodiesel are rapeseed, sunflowers and soy beans. The following parts, "Biodiesel around the Word", "Biodiesel in the United States" and "Biodiesel in the future" refers to the history and the development of the bio-fuel development in the world and in U.S.A. and to the forecasts regarding the use of bio-fuels in the future.

The "Action Plan for bio-energy / biomass of Central Region 2014 - 2020", the Agency for the Center Regional Development, underlines the importance of biomass energy and its role in the economic activities. The European Commission Directive for bio-fuels for transports are provided "setting national targets for the market share of bio-fuels; obligation to use bio-fuels; implement a system to certify compliance with the standards of bio-fuels. In order to stimulate the supply of raw materials, it is important to reforming the Common Agricultural Policy (CAP), which introduces an" aid for energy crops." It will be fund also an information campaign on the priorities for energy crops and prospects for exploiting them. As currently about one third of the annual growth

of E.U. forests remains unused, it is considered that the wood can become very important, and the EU will review the impact of the energy use of wood and forest residues. The European Commission also points out that a number of animal sub-products that do not serve at the human consumption are increasingly used for biomass energy production. The European Commission will "also give special attention to the adoption of European standards for solid biomass fuels in order to facilitate the trade, to develop the markets and to increase the consumer's confidence. The European Commission encourages the development of the action plans at national and regional level to assess the biomass. In the same document are presented the most important economic subjects that should contribute to the development and implementation of the action plan for bio-energy / biomass. These have almost the same importance and weights in the total: county councils, local authorities, universities and research institutes, regional development agencies, followed by local energy agencies, Prefectures, decentralized institutions of central government, education and training providers, industrial enterprises and forests owners. They also defined the main obstacles in the development of biomass use: lack of funding sources (28%), insufficient subsidies (10%), insufficient quantity of available biomass (7%), lack or inaccessibility of appropriate technologies for obtaining biomass (24%), reluctance of the population and the industrial consumers towards this type of resource (10%), law (7%), other (14%).

### 3. Geothermal energy

Geothermal energy is a renewable and alternative energy form that can be used in combination with one of the other traditional forms of energy. This sector has developed especially after the oil crisis of 1973. Today it represents about 1% of the world's energy production and it represents, as average, about 15-20% of the total energy production of the countries that produce it. This field is in a continuous growth, increasing by an average annual rate of 3 - 7%.

Geothermal energy relies on the use of natural heat emitted from Earth. This heat comes mainly from the natural decomposition of chemical elements such as uranium, thorium, potassium, sulfur, mercury, arsenic. It can also come from volcanic and tectonic energy.

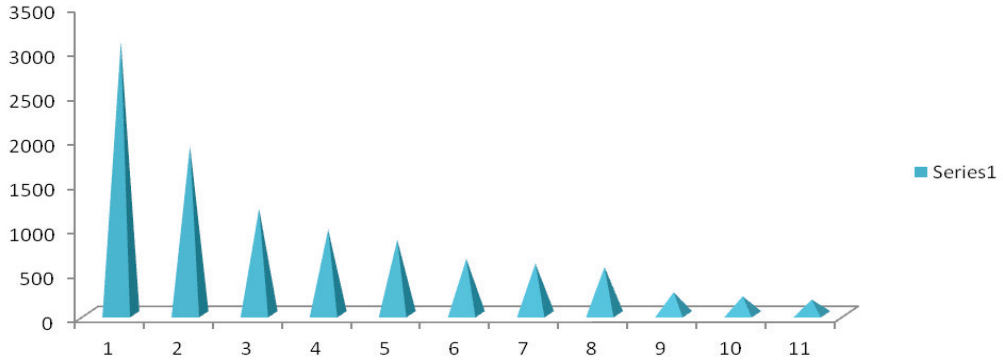
The heat from these processes can be used in two different ways: either to use the heat directly for heating or to use it in the electricity production. The oldest method of use it for heating dates from 2.300 years ago and it is the first hot pool (in China). The first industrial use of the geothermal energy was when it was used to extract boric acid from mud volcanoes in 1827 in Italy, in Larderello (Tuscany). The first use of the geothermal energy for the electricity production was in 1904, also in Larderello (Tuscany, Italy). Subsequently, many countries have switched to the exploitation of geothermal energy, on the first places in the world being the U.S.A., Iceland and France. Nowadays, the largest geothermal complex in the world is still in Italy, at Monte Amiata, with a power of 1.400MW. In Europe, the largest exploitation place of geothermal energy is the Eastern Hungarian Plain.

Using geothermal energy to electrical purposes relates primarily to heat buildings and industrial objectives with pumps and power plants. In this area, on the first places

in Europe in 2009 were Sweden, Germany, Finland, France and Austria.

In 2010, there were, worldwide, geothermal plants in 24 countries, and compared with 2005 the global production capacity increased by 20%. The countries with the largest installed capacity in MW, in 2010 were: U.S.A. (3086), Philippines (1904), Indonesia (1197), Mexico (958), Italy (843), New Zealand (628), Iceland (575), Japan (536), Iran (250), El Salvador (204) Kenya (167). These countries have also the highest share in the world production of geothermal energy. It is believed that, globally, in this field, for the near future, particularly high potential have the countries in East Africa (Eritrea, Ethiopia, Djibouti, Kenya, Uganda and Zambia).

*Chart 2. Installed capacity in MW*

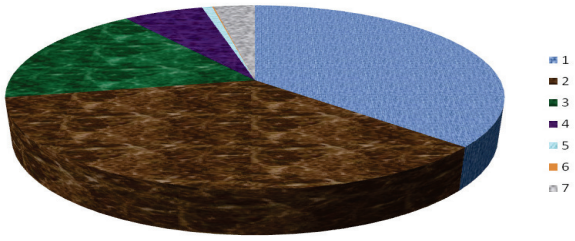



*1 =United States of America, 2 = Philippines, 3 = Indonesia, 4 = Mexico, 5 = Italy, 6 = New Zealand, 7 = Iceland, 8 = Japan, 9 =Iran, 10 = El Salvador, 11= Kenya*

*Source: Processed by author*

In 2010, it was considered that, depending on the installed power, geothermal potential for non-electrical uses, as the average in Europe is: 36.5% for heating and cooling ambient, 35.5% for balneology, 17.7% for greenhouses, 6.2% for aquaculture, 0.8% for industry, 0.1% for dehydration of agricultural products and 3.2% for other uses.

*Chart 3. European averages of geothermal potential for non-electrical uses*




*1 = heating and cooling ambient, 2 = balneology, 3 = greenhouses, 4 = aquaculture, 5 = industry, 6 = dehydration of agricultural products, 7 = other uses*

*Source: Processed by author*

Romania is considered to be the third country in Europe with geothermal potential, after Greece and Italy. The areas with the highest potential in our country are considered to be Banat and West Apuseni Mountains, where the exploitation is performed on the increasingly wider scale. Since the temperatures of the thermal waters are not very high, even in the areas with high potential, the geothermal energy cannot replace all the other forms of energy, but can complement them. A very good example is the town Beius, where local leaders have seen fit to try a new and bold project – the full heating of the houses using the geothermal energy. Although the project which started in the years 1995 - 1996 had some interruptions and produced many noise and visual pollution, especially until the conclusion of the works, and its total value was 20 million, now it is considered a success and a good example to follow. Geothermal resources are widely used in Bihor County, particularly in the area of residence Oradea and in Timis County. In Oradea there is the Transgex, the first company in Romania that uses the geothermal energy to produce electricity, from Electrica Transilvania Nord.

Geothermal energy can be used, besides heating, primarily in the agriculture but also in the industry, with many uses that an informed and courageous leader can successfully exploit: heating greenhouses where vegetables and flowers are grown, drying crops, heating water from fish farms, industrial milk pasteurizing, providing domestic hot water.

In agriculture, the main use of the geothermal energy is for heating greenhouses where vegetables and flowers are grown. The advantage is that these greenhouses have a much lower consumption than those heated with gas. The hot water is pumped by pumps to the greenhouses. This procedure significantly reduces the carbon dioxide emissions. These emissions can be reduced up to 10% of the amount of those that results from the other forms of heating, thus achieving at a biological agriculture that protects nature. Although them require some significantly higher investments than the greenhouses which are heated with gas, their efficiency is 3 times higher. In addition to its principal use for heating, geothermal energy may also be used to control the humidity of the greenhouse's air and to achieve an optimum speed of the air movement. An important element in increasing the efficiency is the greenhouses wall insulation. The glass walls, allow the penetration of a larger amount of light, but they have not so high insulating properties as the plastic walls. Building plastic walls can greatly reduce the energy consumption, which is very important because these costs can reach up to 35% of the total costs of the greenhouses that grow vegetables and flowers.

Also in agriculture, an important use of the geothermal energy is in the process of breeding. A good and informed leader knows that he can improve the long breeding process by creating temperatures which can be controlled. To heat a farm for growing animals the energy consumption is lower than for a greenhouse, about a half of it. At the same time, it improves the health conditions of the animals, the hot water being used for washing, sterilizing and dehumidification and for cleaning the waste. In the pools where fish are bred, is even more evident the importance of maintaining optimal temperatures, thereby allowing the production cycle

intensification and the growth of exotic species of fish. Some countries consider very important the growth of the microalgae such as Spirulina, which are used in the pharmaceutical industry.

Other possible uses of geothermal energy are: in industry - water supply, in balneology, for heating the soil, for the mushroom cultivation, for thawing frozen fish, for drying the organic matters - greens, hay and wool -, for drying agricultural products and for preserving food, fish and timber, for the evaporation in the sugar refining process, for the sugar crystallization, for the alumina production, for the paper production, for pools heating.

The main advantages a leader who promotes the use of renewable energy needs to know are: it is a form of clean energy, it is environmentally friendly; it is not polluting; the wastes can be recycled; it is safe; it is always available without interruption in supply, independently of day-night cycles and weather conditions; the maintenance costs are much lower than for other types of power plants.

The main disadvantages includes: it can be used only in limited areas which are the areas where there is water with a very high temperature; the exploitation reduces the altitude of the soil; commissioning of a geothermal plant requires high costs; the geothermal plants produce a pretty nasty odor vapor and noise, creating a noise pollution and also a visually pollution through the form of the tubes network of considerable size; the studies to determine drill sites and drilling itself are also quite costly as working with high temperature water and steam; the distribution network construction, the acquisition and the installation of monitoring and control systems also implies high costs; after a few months of starting their operation, cool rocks can become ineffective; the thermal waters, after they are used, are discharged into rivers, polluting them because of the high temperatures and increased salt content; the possibilities to conserve this form of energy are reduced as the conservation requires repumping which, in turn, requires a relatively high consumption of energy from other sources.

**4. Energy from biomass**

The biomass energy is a renewable and alternative energy form that uses biological materials as raw materials derived from plants or animal materials, household waste etc. It can be used either directly by combustion or can be converted into biodiesel and bio-ethanol. The production of bio-fuels can be done by thermal, chemical or biochemical methods, sometimes requiring mixing biomass with petroleum or diesel. Bio-fuels can be used for heating or transports. The biogas methanol is used directly to produce energy. The conversion of biomass to fuel means the conversion to liquid, solid or gaseous fuels that can be used for producing electricity or as auto fuel. The transformation is done by mechanical, thermal or biological methods. Mechanical processes are advantageous because it keeps the nature of biomass - producing bales, pellets, chopping, pressing. Combustion and gasification processes presumed thermal heat production and can have the aim to produce liquid or gaseous fuels. The biological methods include fermentation and digestion, based on the microbes and enzymes, and resulting solid or gaseous fuels.

The most important source of biomass energy production is the wood, the residues resulted from its processing being called

the "black liquor". Forestry waste is generally used for the thermal energy production. Besides wood, other sources of biomass energy are: plants from agriculture (wheat, barley, rye, oats, corn, sunflower, peas, beans, rapeseed, soybean, tobacco, fruit trees and vines), fish or aquaculture. Biomass may also result from household waste. Of them, whether they are collected in urban or rural areas, it is estimated that nearly half can be used as biomass. Currently biomass energy accounts for about 15% of primary energy sources worldwide. In developing countries, biomass energy use is more common and larger, biomass is available in larger quantities than other energy sources, thereby providing up to 38% of total energy consumption of these countries. Biomass energy sector is becoming increasingly important in developed countries. For example, given the significant resources that benefit U.S.A. - wood and ethanol from corn - it is expected that biomass energy will be the largest source of non-hydro energy by 2020. Another country on first places in the world is Brazil, which produces energy based on sugar cane and one of the European countries with tradition in this area is Finland. World leader in the production of biodiesel is Germany.

It is expected that by 2020 biomass energy will be two times more expensive than natural gas, a little more expensive than nuclear and cheaper than photovoltaic solar energy, which must be very important information for the leaders that want to use the possibility of exploitation of the biomass energy sector.

Romania's potential in terms of energy from biomass is considered to be quite high. So far, there were been spent in this area about 70 million euro. Romita Green Energy Company wants to invest 41 million euro in the near future in biomass power plants with the capacity of 10 MW electricity power and of 19 MW thermal power. In Cluj County, the Austrian Schweighofer Holzindustrie already operated a 22 MW plant along with other plants in Sebes, Radauti, Siret and Comanesti. Another firm that invests in biomass energy is BioElectrica Transylvania. From the records available at Transelectrica results that from the total of the energy used for lighting, 35 MW are produced from biomass, agricultural waste and forestry. KDF Energy Company from Bucharest has proposed to allocate 11 million euro to build a biomass power plant of 413 MW in Valcea County, at Horezu.

*Table 1. Energy productivity of the main varieties of plants*

| Dry materials production (tons/hectare) | Cultures | Equivalent production of oil (liters/hectare) |
|---|---|---|
| 30 | sorghum, reed, mischantus | 12.000 |
| 20 | peas, sunflower, hemp, grain, rush, willow, poplar, eucalyptus | 8.000 |
| 10 | rape, buckwheat, acacia | 1.000 |

*Source: Energy Management Agency of Maramures*

In our country, woody biomass has been used since ancient times for heating and preparing food. Use it as firewood is not very efficient because it has very low yields (about 20%) and, in addition, pollute the environment. The use of some more efficient boilers, with yields of at least 75%, it would greatly reduce the negative effects. For this, however, would need state support, through national and regional programs. The state's role covers both producers and consumers. Regarding the consumers, it is important to mention the role of the state (art. 5, Consumer Code). "The state aims at: the protection of consumers against the risk of purchasing a product or a service are likely to prejudice the life, health or safety or affect their rights and interests; promotion and protection of economic interests of consumers; consumer access to comprehensive, accurate and precise on the essential characteristics of products and services, so the decision to be taken in connection therewith to better meet their needs; consumer education; effective consumer compensation; helping consumers or other groups or organizations representative to organize, to make their views in decision-making processes concerning them; to promote international cooperation in the field of consumer protection and participation in the rapid exchange of information; prevent and combat by all means, unfair trade practices and service delivery, including financial that may affect the economic interests of consumers." (A. N. Gheorghe, C. Spasici, D.S. Arjoca, "Consumption Law", Hamangiu Publishing House, Bucharest 2012).

Another element that demonstrates the importance of the state involvement in this area is the launch and the operation of the National Program "Green House" in 2010 and 2011 which illustrated the preference and the interests of domestic consumers to switch to new energy technologies, including biomass, to produce heat and hot water. The operation of the program was short, the main causes being the reduced fund financing and the bureaucracy in the assessing applications process. Another brake on expanding the use of biomass energy in Romania is the too high prices charged by most manufacturers of biomass, especially of pellets and briquettes. The excessively high level of the prices is explained by the fact that the manufacturers, even if they fail to sell their products on the domestic internal market, know that they have the sales ensured by the exports on the foreign markets. This is due to the fact that the energy produced from biomass - mainly pellets - is the only alternative in our country for the traditional energy based on strategic resource exploitation, primarily to the natural gas. The differences between the prices of natural gas are very high. In Romania the gas is twice cheaper than in other European developed countries as Germany, Austria and Italy.

It provides that in Romania, until 2015, the biomass power plants will provide 210 MW of the total energy production. The development of this area is slower than wind energy and solar energy, even if our country has great potential due to the large agricultural areas and those occupied by forests for biomass and biogas, to the industrial and municipal waste. Biomass energy production is now rewarded with two green certificates and the production that uses the resulting gases is rewarded with 1 green certificate. For those using energy crops or forestry waste is added another green certificate.

The main advantages that a good leader needs to know in order to promote the use

of biomass energy are: the materials that are used are biodegradable; it is reducing the time for the waste storage, thus decreasing the storage costs; the biomass burning produces less carbon dioxide than the combustion of coal or gas; the biomass energy production plants can be placed in the proximity of the biomass energy consumers, in which case the shipping costs are very low; because biomass power plants works like thermal power plants, they can provide electricity; they produce economic benefits, but also social benefits; unlike other forms of renewable energy, biomass-based energy can be stored easily as it involves actually fuel storage; production may be changed, it may be reduced or increased according to the needs and desires of the manufacturer; because it requires less sophisticated technology, these plants are cheaper; investments recovery period is not very long, being between 5 and 12 years; the energy efficiency is higher than for other energy sources; currently, there are some possibilities to reduce significantly the negative side effects by the introduction in the production of new and more efficient technologies, especially in the combustion process.

The main disadvantages faced by those that are using the biomass energy are: in the process of burning plants emit into the atmosphere an amount of carbon dioxide approximately equal to that they absorb during their growth, which contribute to the greenhouse effect; the power plants based on biomass emit, during the combustion, nitrogen oxide and sulfur; large areas are needed for starting material cultures as the energy density is relatively low; there are voices saying that there are used such big areas of land to power machines and equipment instead to provide food for people; logistics problems may arise in the supply of the needed raw materials because the production requires large amounts of raw materials; the fuel storage needs large spaces; when the biomass plants are not placed in the proximity of the consumption places, transporting them becomes very expensive because the bio-fuels require large transport means; the crops that are the base for the biomass are using chemical fertilizers which are produced by consuming energy based on strategic resources (oil and gas); the fuel conversion requires a relatively high energy, which makes the production of this field efficient rather on a large scale; on the other hand, however, large-scale production has negative effects on the environment, determines some risks associated with the existing technologies and therefore appear the public health risks; waste recycling requires the use of large amounts of water; even if the production in a year is not dependent on the variation of the natural conditions or on the day-night cycles as is the case of solar energy, however, the production cannot be considered constant from an year to another because it depends on the annual agricultural production, which is depending in turn on the weather conditions and on other economic and non-economic elements; a negative collateral consequence is that the rise of the demand for agricultural products used in the biomass energy production, determined an increase of the prices for the agricultural products, mainly in the less developed countries; another side effect is the loss of biodiversity and the increase of the soil erosion; the visual pollution occurs by affecting aesthetics especially in rural areas; the production of the biomass energy faces in many countries with the shortages legal regulations, who do not sufficiently promote

the use of this energy source; the immaturity of the management system that is not open to this new possibility.

### 6. Conclusions

In presenting the advantages and disadvantages of renewable geothermal and biomass based energy results several important conclusions for all the leaders at all levels, given the fact that our country have to reduce the energy consumption per unit of GDP achieved, which means the increase of the energy efficiency. Romania must rely more than ever on the renewable energy, which will increase the food safety, will be more environmentally friendly by being a clean form of energy and will reduce the country's dependence on energy imports. In "The Romanian Energy Strategy for 2007-2020 updated for 2011-2020" is underlined the important role of the use of bio-fuels in the transports and in agriculture, to power the agricultural machinery, and the importance of developing energy crops. The focus is also on energy consumption efficiency in the agricultural works, such as irrigations. Biomass fuel, being the main fuel in the rural areas covers about 7% of the primary energy demand and about a half of Romania's renewable resource potential.

The rural environment is very important also for the geothermal energy, mainly used for space and water heating because of the localization. The main potential for use is in the rural areas. Both forms of

energy, geothermal and biomass, have both advantages and disadvantages. A good manager and a good leader should know them and should decide to use one of these forms only where they are efficient, where this can be done with low costs and without affect too much the environment, aiming to reduce at minimum the economic, social or any other kind negative side effects.

A further analysis of this topic, it might consider concrete case studies conducted primarily in rural areas but also in urban areas, from economic subjects who have the conditions for the possibility of using geothermal energy and biomass-based energy, the state intervention analysis including some legislative measures and the measures which aim to stimulate the scientific research in order to improve the technologies which are used in the production, the forecasts of the energy consumption per unit of GDP, the study of the international energy prices evolution, the possibility of reducing the country's dependence on the imports in this sector.

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