IDENTIFICATION OF RENEWABLE ENERGY RESOURCES FOR SUSTAINABLE DEVELOPMENT OF AGRICULTURE

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Abstract

The research carried out by the authors of this paper is focused on identifying those areas of Romania with the potential to obtain energy from unconventional sources, sources that do not affect the surrounding environment and that are consistent with sustainable development. This issue is all the more important because the leaders of the European Union set a target in 2009 that, by 2020, 20% of the total energy consumption of EU countries will come from renewable energy, and, in 2018, it was agreed that this type of consumption will increase by 32% by 2030.

In this context, the authors have tried to identify in Romania the location of renewable energy sources (RES) from which our country can produce energy. In order to reach this goal, the main objectives have been: identification of areas with solar energy sources, identification of areas with wind energy sources, identification of areas with hydroelectricity sources, identification of areas with geothermal energy sources, and identification of the energy potential of biomass in Romania. The study is based on research, data collection from official documents, literature, and official websites, followed by data processing and interpretation.

Key words: energy, renewable energy sources, potential, sustainable

INTRODUCTION

Agriculture as an ecological system integrates all biological, geochemical, and geomorphological processes into a unitary whole, which supports the vital activity of a community of organisms. The agricultural system is open because it changes matter with the environment in the form of energy and substance (Chiriță et al., 1967).

Compliance with environmental criteria in agriculture is part of the general issue of environmental protection and pollution control. In this respect, as Berca (2000) reported, agro-ecodevelopment is part of the "biosphere management, a key issue of the 21st century", which requires strategies and actions to preserve and improve the agricultural landscape.

Răuţă (1997) showed that the implementation of the concept of sustainable agriculture must be carried out according to the specific conditions of our country. In Romania, the implementation of sustainable agriculture on family farms based on private ownership requires extensive

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research, restructuring and, last but not least, massive investments in line with specific policies for the integration of the agricultural sector related to the other sectors of the Romanian economy (Mateoc, Mănescu, 2012). Here are some of these extremely important principles: the legal regulation of the resource base of agriculture, especially high-quality land; promotion of the integration of plant production with animal production and other related activities; protection and restoration of the natural resource base through landscape reconstruction actions and the development of agriculture in harmony with nature. (Florea et al., 2014).

Our existence, the existence of life in general on Earth depends on the health of the planet and it is already severely affected. One cannot know to what extent this process of continuous, severe degradation of the environment as a whole can be stopped, let alone if the phenomenon is reversible, but it is certain that, without urgent global measures, the scenario is apocalyptic and imminent. (Otiman et al., 2006).

For the first time, environmental health was called into question worldwide in 1972 at the Stockholm Conference, when the "Final Declaration on the Environment" was signed, which noted the interdependence between economic and social development and the environment. This first step was followed, in 1992, by the "Millennium Declaration" in Rio de Janeiro. The 1992 United Nations Framework Convention on Climate Change aimed at limiting the rise in global temperature but, since 1995, it has been found that this was not the right strategy. As a result, the nations of the world have initiated further negotiations aimed at strengthening the unified global response to climate change. The Kyoto Protocol, which provides for the legal obligation of all developed countries, was, thus, adopted in 1997 to reduce emissions (from their 1990 level) by a minimum of 18% by 2020. The Protocol was amended in 2012 in Doha, and a second commitment period was introduced – from 2013 to 2020. Globally, the effort has continued and, on 12 December 2015, a new global agreement was signed in Paris that provided for climate change, for an action plan starting in 2020 and that aimed at limiting global warming as much as possible (below 2°C to a limit of 1.5°C). The Paris Agreement entered into force on 4 November 2016, with the ratification conditions of around 55 countries which, globally, account for at least 55% of total greenhouse gas (GHG) emissions.

At national level, the "Romanian Parliament's Declaration No.1/2016 for the implementation of the 2030 Agenda for 15 years" was adopted containing the "Sustainable Development Goals", with the National Strategy for Sustainable Development – Horizons 2013-2020-2030 to be modified in this respect.

MATERIAL AND METHOD

The methods of research and analysis used in this study are analytical and synthetic methods, mathematical calculation, data collection, interpretation and processing, and interpretation of graphs. Research has been the basis for finding the most important sources of renewable energy to develop the relaunch of agriculture, a particularly important branch in the development of Romanian rural economy.

RESULTS AND DISCUSSION

There is no longer any doubt that, in order to adequately protect and conserve renewable natural resources (namely air, soil, water and biodiversity), and also for the natural resources in agriculture to be given sustainable use, it is imperative to implement wise policies that consistently aim to mitigate climate change as far as possible. (Mănescu et al., 2014).

The sustainability of an agricultural system depends, to a large extent, on social justice and not on ensuring an immediate and momentary income; sustainability must enable constant and lasting financial support to avoid land degradation and producer poverty; ultimately, it leads to the development and consolidation of rural areas (Mănescu et al., 2014). To these can be added other criteria such as the possibility of regenerating renewable natural resources, reducing pollution as much as possible, observing biodiversity conservation and avoiding the irreversibility of economic and biological processes where they occur.

Agriculture in its evolution, especially in the last 20-30 years, has marked increases in production, in some very spectacular countries, but also increases in energy consumption (Mateoc et. al.,2012). For example, the shift from hypo traction to tractor has led to a 2.4-fold increase in the amount of fuel used for the various works of the agricultural technological flow. Moreover, as specialists suggested, the nature of the energy consumed has changed: from horse oats to diesel tractors and other machinery, imported on hard currency (Hornacek, 1979). Of course, compared to the national economy in general or with industry, energy consumption in agriculture is low. Thus, in France, agriculture consumes only 2-3% of the country's total energy. And there is another aspect: agricultural production receives so much free unconventional energy, in various forms, from the sun and from the soil, that it can continuously reduce conventional energy consumption in certain agroecosystems.

Intensive agriculture involves direct energy consumption (fuels, electricity) and indirect energy consumption (fertilizers and machinery), which is a matter of utmost importance. Reducing energy consumption requires an optimal ratio between direct and indirect energy, as well as reducing energy consumption. In France, the share of the two energy components represents 44% and 56% of total consumption, respectively. In Sweden, fuels account for 43% and fertilisers for 37% of total consumption. The industrialisation of agriculture has led to an increase in the inputs of some material resources. The estimates made by the F.A.O. admit that 2 kg of fossil fuel is required for the manufacture, distribution and soil application of 1 kg of nitrogen, 0.2 kg for 1 kg of phosphorus, and 0.18 kg for 1 kg of potassium. For the manufacture and use of 1 kg of pesticides, a consumption of 2.2 kg of conventional fuel has been evaluated. A consumption of 100-200 l/ha of fuel of irrigated land and 3-4 t of fuel per year per tractor has also been calculated.

Super intensive ecosystems are 3-6 times more productive compared to traditional ones, but their energy consumption is 10-20 times higher. (Sabău, 2008). Some of them (animal husbandry) are strongly entropic, the amount of intensive cultural energy is 2-20 times greater than the energy found in the form of food. In intensive agricultural ecosystems, the ratio between energy used and pollution produced is geometric: pollution increases by the square of energy spent. This is a catastrophic situation on which people should reflect responsibly. Another example of consumption in intensive agricultural ecosystems is enlightening. Thus, in autumn potato, an important place in the energy consumption structure is that of fertilization (50.74%), biological material for planting (24.45%) and mechanical work (22.85%). As the level of mechanisation is very high, the living workforce represents only 0.12%, and disease and pest control (1.84%). The energy balance results in the following values: energy spent – 26.665 kwh/ha, energy produced – 24.366 kwh/ha, net energy – 7.700 kwh/ha, ultimately resulting in an energy ratio of 1.45 (Tucuman, 1982).

Nowadays, humanity is turning to new sources of energy. The most used alternative energy sources are:

Solar energy that is captured from the sun by solar panels. However, it is known that 80-90% is lost when converting solar energy into electricity or heat. Another drawback of the capture of sunlight is that it can only be achieved during the day, which is why the energy must be stored for use at night.

Water energy. This type of energy has been used since ancient times. The capture is done by the construction of hydropower plants that convert the force of water into large amounts of energy.

Wind or *air current energy*. It has been estimated that the wind produces an energy that exceeds 200 times the world’s needs. However, very large and quite expensive aeolian generators are needed to capture wind.

Nuclear energy is used on a fairly large scale worldwide because of its productivity. It is produced in two ways: through fission and fusion. However, atomic power plants, against all advanced security technologies, have a high degree of risk because of the devastating environmental consequences that any accident can cause in such an energy generation unit. There have been nuclear accidents around the world with disastrous effects on those areas.

Geothermal energy is also known and used in many areas of the planet.

In the field of agriculture, unconventional energy comprises the sources of solar, wind, geothermal, and recoverable energy from industrial processes, the treatment of organic, vegetable or animal residues in animal husbandry. This energy is clean and, therefore, environmentally-friendly, with a direct impact on agricultural production and on the health of consumers.

Renewable energy, together with improved energy efficiency, are key elements in the development of eco-energy, both in industry and in agriculture.

It is essential to look at unconventional energy sources in the context of a country's climate resources, bioconversion processes, and photosynthesis, which have huge, sometimes unimaginable possibilities to make different accessible forms of energy available to agriculture. Research and applications carried out, some on a large scale, have demonstrated the high efficiency of unconventional energy, even in temperate climates. Based on all this, one can speak of the ability of agriculture to also produce energy, not only food.

Solar energy is the cheapest form of energy. The farmer holds an instrument of action on the crop with an impressive force, solar energy, which he must capture by finding the right solutions. Solar energy is at the origin of all forms of energy and power. Solar energy that falls on Earth is estimated at about 120 billion MW, which equates to 100 million large nuclear power plants. For photosynthesis, a process by which green plants synthesize organic substances from carbon dioxide and water in the presence of light, which ultimately leads, in the case of agricultural plants, to crops, a small part of energy is used. This is the energy introduced into the free, biologically-founded ecosystem that actually conditions life on earth, namely human nutrition. (Șerban, Dragotă 2013).

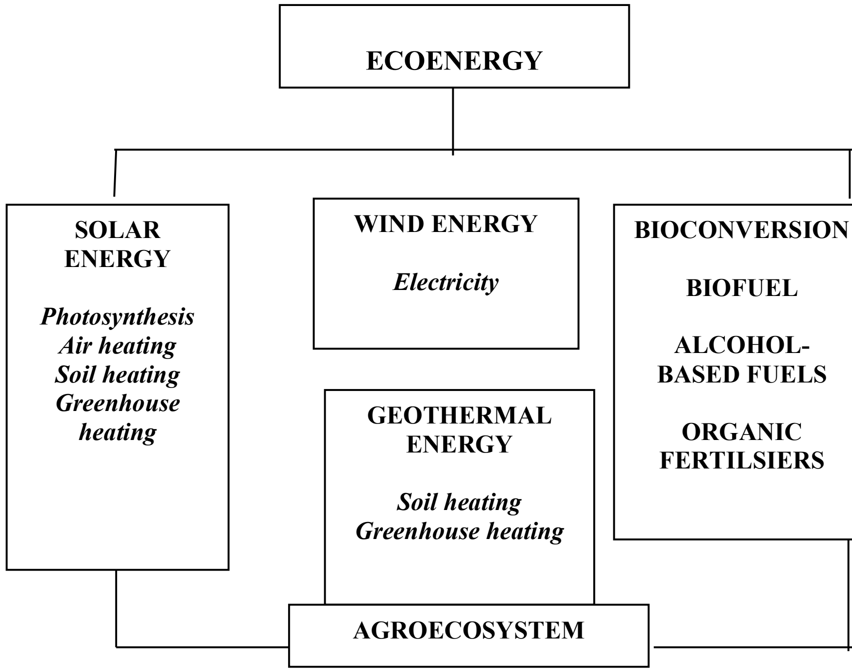
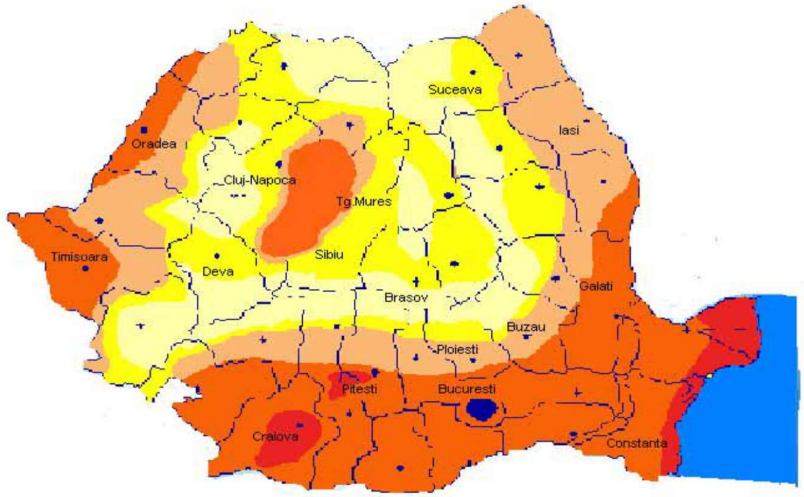


Fig. 1. Unconventional energy sources

Solar-powered heating also plays a role in agriculture. It is widespread in the householding sector, heating homes and water preparation in countries with an excessive solar regime, with high year-round sunstroke, such as Israel, Greece, Japan, and Australia. It is economic in areas with long clear days, which makes installations accessible and cost-effective to the population, both for domestic use and for different sectors of agriculture – greenhouses, nurseries, workshops, and small industries.

In greenhouses, heat accumulates as a result of the penetration of solar radiation through the transparent glass or plastic roof. On clear days, with strong heat, in winter or summer, large amounts of heat can accumulate. Solar radiation entering the greenhouse reduces heat loss, which can be seen from the overall balance sheet. Large inflows of solar radiation in greenhouses, in the spring- summer period (March-June) and autumn (September-October) allow the growing of a wide range of early vegetables without conventional energy consumption, with high yields and a superior recovery of the land and the leaf system. For southern areas, these amounts of solar energy entering the greenhouse are double and even triple, which is to the farmer's advantage. Moreover, nowadays, all vegetable cultivation in plastic greenhouses is based on the accumulation of solar energy. The greatest possibilities are, of course, for growers in areas with a large number of hours of sunlight in all seasons of the year. But, even in temperate areas, solar energy can take over some of the energy effort, thus becoming a conventional fuel replacement resource.



ZONA DE RADIATIE SOLARA	INTENSITATEA RADIATIEI SOLARE (kWh/m^2/an
I	>1350
II	1300-1350
III	1250-1300
IV	1200-1250
V	<1200

Fig. 2 Solar map of Romania

The most important areas of interest for electro-energy applications of solar energy in our country are: *The first area*, including the areas with the highest potential and covering Dobrogea and much of the Romanian Plain. *The second area*, with good potential, includes the north of the Romanian Plain, the Getic Plateau, the Oltenia and Muntenia Sub-Carpathians, a good part of the Danube Meadow, the southern and central of the Moldovan Plateau and the Western Hills and the western Transylvanian Plateau; and *the third area*, with moderate potential, with less than 1,300 MJ/m^2 covering most of the Transylvanian Plateau, the northern Moldovan Plateau, and the sub-Carpathian area.

Wind energy, produced by the movement of air masses, also generated by differences in temperature and pressure between different areas of a territory or on a planetary scale, is a formidable source, valued at

38,372 · 10^{14} kWh. Wind power could meet 20% of the world's energy needs. It was calculated that an average wind speed of 5.5 m/s corresponds to an energy flow of 200 W/m^2. Wind energy is considered complementary to electricity-generating installations and energy storage systems, which, during certain periods, contribute to the reduction of fuel consumption. Thus, the savings achieved daily by the operation of a Savonius wind power plant amount to 100 l Diesel, compared to motor pumps or 230 l compared to electro-pumps (Gănescu, 1982; Risoud, 1999).

The distribution in Romania of the average wind speed highlights as the *main area with wind energy potential* mountain peaks where the wind speed can exceed 8 m/s. The *second area* with cost-effective wind potential covers the Black Sea Coast, the Danube Delta, and northern Dobrogea where the average annual wind speed is around 6 m/s. The *third area* with considerable potential is the Bârlad Plateau, where the average wind speed is about 4-5 m/s. Favourable wind speeds are also reported in other smaller areas in the west of the country, in Banat and on the western slopes of the Western Hills. To note that the two basic technical indicators, which must be identified before assessing economically a possible investment in a wind energy production unit, are the *frequency and intensity of the wind* relative to time unit for each location, monitoring them for a period of at least one year.

Geothermal energy is the type of renewable, clean energy obtained from the capture of geothermal waters inside the Earth. Hot water and steam resulting from volcanic and tectonic activity are, thus, used for heating buildings, for electricity generation, in industry, in agriculture, or in tourism. Geothermal systems can operate permanently, without taking into account climate or meteorological conditions (Lazăr, 2009; Pătrașcu, 2015).

In the world, countries whose geothermal resources have been appreciated since ancient times are Iceland, France, Italy, Belgium, Greece, U.S.A., New Zealand, Japan, Indonesia, Hungary, etc.

Along with other European countries with a tradition of geothermal waters, Romania also has such important resources. In Romania, geothermal waters, extremely valuable resources, have not been exploited enough, and this sector has always been poorly developed. The heating of buildings, premises or greenhouses for the production of plants with geothermal water does not require transport costs, since energy capture is carried out in the same place where the consumer is located. At the same time, specialists in the field believe that geothermal waters have a major potential for electricity production, with an estimated geothermal energy technology by 2050 to produce around 10-20% of electricity demand in Europe. In this respect, the production of geothermal energy requires a number of actions to conserve and evaluate resources, substantial investments in drilling and pipeline networks, heat pumps, water treatment and wastewater disposal technologies, etc. (David, 2017; Lazăr, 2009; Pătrașcu, 2015).

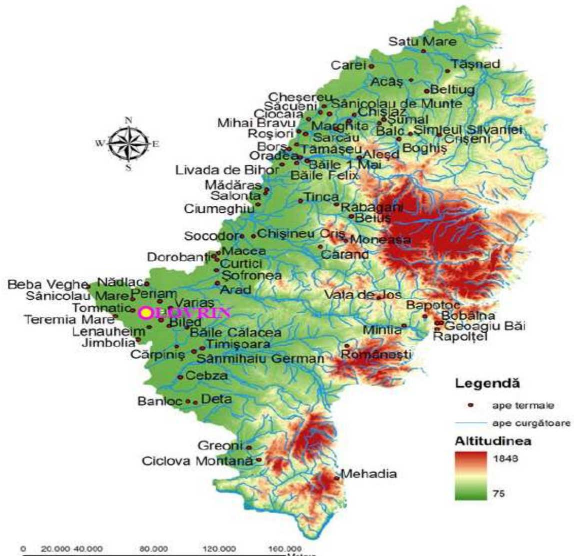


Fig. 3. Locations with geothermal waters in western Romania
Sursa:Prelucrare după datele http://blog.zonaeconomica.ro

The western part of Romania is an area rich in geothermal waters, with very favourable conditions for the production of geothermal energy, as well as for the development of various forms of tourism that exploit these thermal waters. Geothermal aquifers on the Romanian side of the Pannonia Depression are the best known in the country. Thus, counties such as Bihor, Satu Mare, Arad or Timiş sit on real natural treasures that must be exploited. The average temperatures at a depth of about 2,000 m are around 120°C and, at a depth of about 3,000 m, they can reach up to 150°C, representing the highest temperatures of geothermal waters in Romania.

Another area of our country rich in geothermal water resources is that of the Romanian Plain, located between the Dâmbovița Valley and the Olt Valley, where temperatures of geothermal waters can reach between 100-120°C, at a depth of 3,000 m. Also, geothermal resources can be found in the central area of Dobrogea, south of the Hârșova – Medgidia – Constanța alignment, where geothermal waters can reach temperatures very similar to those of the Romanian Plain.

Biomass energy. Biomass is a promising renewable energy source for Romania. Bioconversion is an undeniable technology of the present and the future, of great perspectives. It is an area where the huge potential of bacteria, microbial action like fermentations transform organic matter into different finished products. Bioconversion has been shown (through anaerobic fermentation of vegetable residues and manure from animal husbandry, household garbage and even some plants) to provide an energy resource for agriculture: gas fuel (biogas). In this respect, there are many advantages: the ease, simplicity and economy of processing, the extraction of biogas in considerable amounts, the production of an organic fertilizer rich in nutrients, the efficient destruction of pathogens from garbage and, at the same time, a clean technology. By bioconversion nothing is lost, everything is transformed, everything is recovered.

Bioconversion could, in time, lead to a new type of agriculture, in which the principle of agro-energy finds a wide range of applications. It seems to be one of the basic technologies of energy production for the needs of agriculture in certain sectors. The results achieved so far at home and abroad are encouraging, some even very optimistic. It depends very much on the equipment in which bioconversion is carried out with high efficiency and costs as low as possible. It is also important to have a system for collecting, with great economic efficiency, organic materials that lend themselves to bioconversion.

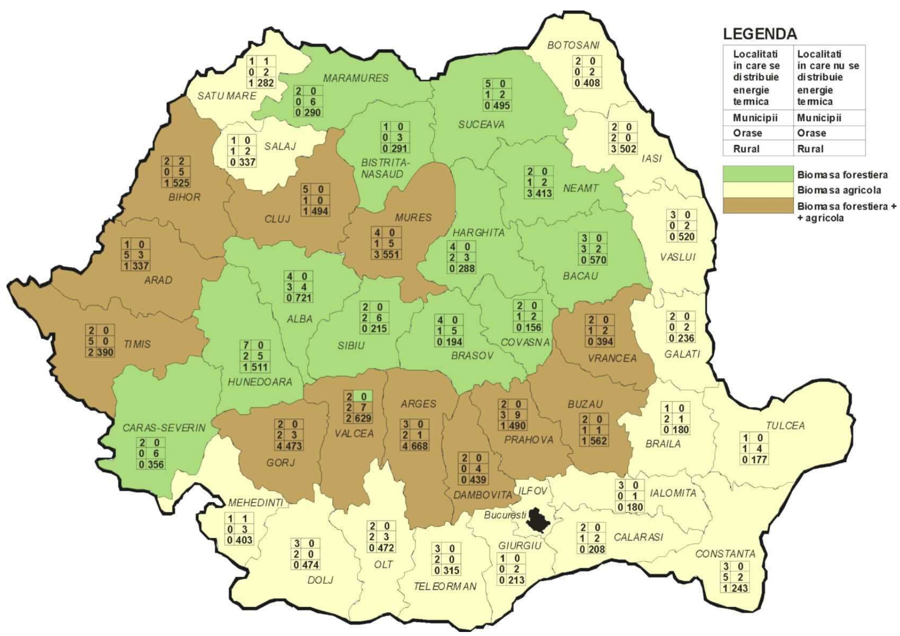


Fig.4. Romanian localities with central heating

Biogas from manure is the fuel made from the manure of animal husbandry farms, especially pig farms, since pollution control is the only way out of this situation, using the method of aerobic and anaerobic biological cleansing, controlling odour by disinfectants, masking or biological deodorizers. This last process is being experienced in France and it consists in continuous anaerobic fermentation of liquid manure in a specially constructed plant. From 1 kg of treated dry matter, at 35°C in containers, an amount of 0.35 m^3 biogas containing 40% methane is produced by fermentation within ten days. The fertilizing substances resulting from the fermentation process are kept intact, even without any loss of nitrogen. It is partly mineralized into ammonia. Larger amounts of ammonia are lost during storage and the reaction of the residue is slightly basic. The plant becomes cost-effective at more than 1,000 pig heads in order to compete with oil.

Biogas obtained from plants can be obtained from the various biomass sources of agriculture and turns into biological heat. It is claimed that plants with high productivity energy potential are an important source of energy (biofuel). Biomass can only be studied and used if recovery is not too costly, if it ensures as positive and favourable an energy balance as possible and as much efficiency as possible of the conversion process. In order to ensure the efficiency of "energy crops", production techniques, plant species and varieties should be carefully chosen, in order to obtain a maximum efficiency of the dry matter and an energy balance as favourable as possible. Important sources of plant biomass, to which specialists turn their attention, are aquatic plants. Algae such as *Hydrodiction reticulatum* and *Cladophora glomerata* provide yields of 10 t/ha of dry matter. *Eichornia crassispes* has an extraordinary growth rate, multiplying every 8-20 days in warm and nutrient-rich waters.

In the experiments made by the Institute of Biological Research in Bucharest in the 1980s and at the Water Treatment Plant in Pitesti, *Pystia stratyotes*, another water plant, produced 90 t/ha, being used for the production of biogas with very good results.

Biofuel, another source of biological heat from the manure of cattle and horses, has a high energy value, being used in nurseries for the production of vegetable seedlings between January and March. At a temperature of +50...+70°C, it is, for vegetable farms, almost the only energy resource for heating, but also cheaper, compared to oil products. (Zagoni et al., 2012). After use, with the end of fermentation, this organic material decomposes and, in the following spring, it becomes a very valuable fertilizer for vegetable and flower crops. An example of triple conversion: manure → heat → fertilizer of great energy value.

Agriculture as a system has great possibilities to renew some of the energy needed for its normal functioning (Table 1).

Table 1

Energy consumption in major agricultural crops

Crop	Yield (kg/ha)	Energy obtained (Gcal/ha)	Energy consumed (Gcal/ha)	Energy balance (Gcal/ha)	Energy yield
Irrigated wheat	5.500	20.76	6.24	14.52	3.32
Non-irrigated wheat	4.000	15.10	4.57	10.53	3.30
Irrigated maize	9.000	35.29	6.75	28.54	5.23
Non-irrigated maize	4.500	17.65	4.89	12.76	3.60
Irrigated sunflower	3.000	16.98	3.68	13.30	4.61
Non-irrigated sunflower	2.500	14.15	2.20	11.95	6.45
Irrigated sugar beat	40.000	39.22	12.51	26.71	3.13
Non-irrigated sugar beat	27.160	26.63	5.79	20.84	4.59
Irrigated potato	30.000	22.19	10.82	11.37	2.05
Irrigated soy	3.190	15.86	3.04	12.82	5.21
Non-irrigated soy	1.800	8.95	2.16	6.79	4.13

Sursa: I. Teşu şi V. Baghinschi, 1984

It is interesting to note that agricultural production in Romania consumes 7% of total energy production and 5% of fuels, heat and electricity. in relation to industry, Romanian agriculture consumes 14-15 times less energy, a trend that will continue in the coming years. For the main agricultural crops, the energy consumption is shown in table no. 1

CONCLUSIONS

Humanity is at a crossroads: the main resources, which make man's life on earth possible, are about to run out quickly. oxygen in the air, drinking water, fuels and food are already insufficient for the population of the blue planet. The path humans have chosen to follow will be the one that will not allow survival.

Undoubtedly, agriculture will exist as long as humanity exists. humanity needs a clean and healthy environment, drinking water, food and energy: all this is necessary, the rest is useful but not imperiously necessary.

Exploitation of renewable energy resources is also becoming mandatory in Romania, where the E.U. has established that by 2030 energy produced from renewable sources will reach 32% of total energy consumption.

In order to establish a coherent energy policy in a given region, it is necessary to inventory renewable energy sources according to their type. For each resource it is useful to indicate:

- theoretical potential;
- technical development potential (depending on existing technologies);
- economic potential (benefit producer taking into account investment, production costs, financing schemes and state support, as well as the state of land, infrastructure, utility networks and electricity transmission networks by regimes and voltage levels).

It is absolutely necessary that, when an entrepreneur decides to make an investment in the field of renewable energy production, he carries out pre-feasibility and feasibility studies for which he takes the financing assumptions into account in order to choose the optimal source of financing.

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