BIOMASS AND BIOLOGICAL FUELS

***Ch. POPESCU*[1], *D. BUCUR*[2*]**
[1]*Gh. Asachi Technical University of Iasi*
[2]*University of Agricultural Sciences and Veterinary Medicine of Iaşi*

ABSTRACT *- The analysis of results obtained at national and international level on the utilization of renewable energy sources pointed out the opportunity of over-passing the energy crisis by the orientation of world economy to produce energy by the help of biomass. The high plant mass volume present in the world could compensate the relatively low output of light energy conversion through photosynthesis. The climatic conditions from Romania favourable to plant growing with high capacity of biomass multiplication, as well as farming by-product, animal dejections, domestic garbage, can ensure the biogas necessary to cover a great percentage of the energy necessary for animal breeding farms or heating dwellings.*

Key words: biomass, biological fuel, alternative energy

INTRODUCTION

The opportunity of putting into practice of an energetic strategy for the revaluation of the potential of renewable energy sources is found in the framework of long-term Romanian energy development and offers the adequate frame for adopting some decisions concerning the energy alternatives. The revaluation of the potential of energy renewable sources offers the real premises for achieving some strategic objectives on increasing the safety of energy supply by diversification of sources and diminution in the weight of energy resources importation and sustainable development of the energetic field and environment protection. The energy renewable sources can contribute to satisfy the usual needs for heating in some disfavoured areas (rural areas) (e.g. biomass). For the revaluation of the economic potential of energy renewable sources, under conditions of competition energy market it is necessary to adopt specific policies, instruments and resources (Carlea, 2003).

* E-mail: dbucur@univagro-iasi.ro

MATERIALS AND METHODS

The present study is the result of an approach on investigating the concerns at national and international level of the utilization of renewable energy sources. The comparative analysis of present achievements has allowed the identification of opportunities to give alternative energy solutions, in the future for human communities from rural areas, which are in deficit from the economic point of view and/ or lack the conventional energy sources.

RESULTS AND DISCUSSION

The energy necessary has increased during the last 7-8 decades at an unusual rate. If in 1925, the energy consumption in the entire world was of about 1.5 billion tones coal equivalent, in 1960 it increased at 2.8 billion tones, in 1970 at 7 billion tones, in 1983 at almost 11 billion tones, and in 2000, it exceeded 25 billion tones. To this high increase in the energy consumption, a great contribution was brought by the continuous increase in car number, which was of about 50 millions, at the end of the second world war, and reached about 400 millions in 1986 (*Table 1*).

Table 1

Density of cars during 1970-1986 and the number of cars in 1986, on zones (according to Coman *et al.,* 1996)

Zone or country	Density (People/car) 1970	1980	1986	Number of cars in 1986 (million cars)
SUA	2.0	1.9	1.8	135
Western Europe	5.2	3.3	2.8	125
Oceania	4.0	3.3	2.8	8
Canada	3.0	2.6	2.3	11
Japan	12.0	4.9	4.2	29
Eastern Europe	36	12	11	17
Latin America	38	18	15	26
ex Soviet Union	147	32	24	12
Asia [1]	196	95	62	12
Africa [2]	191	111	110	5
India	901	713	554	1.4
China	27.707	18.673	1.374	0.8
World level	18	14	12	386

[1] Except Japan, China and India
[2] Except South Africa

For diminishing fuel consumption, the Japanese created the electric car Eliica (Electric Lithium-Ion Battery Car) with 8 wheels, able to reach

370 km/hour. Estimations on the fossil energy resources of the world have shown that oil stocks would finish in 50-60 years, coal stock, in 100-150 years, etc, while the discovery of new energy sources and the modification of present technologies might last for a few decades. Large and complex studies were carried out on a better revaluation of nuclear, sun, wind, geothermic and hydraulic energy, as well as getting synthetic fuels from coal, bituminous schist, tarring sands, etc.

In this search for new energy resources, Calvin (1976), who has won the Nobel Prize for the works on photosynthesis, has shown that this energy crisis could be solved by the orientation of the world economy to produce energy by the help of biomass. Light energy conversion through photosynthesis rate was relatively low, 1 m^2 of green leaf accumulating in one hour only a gram of dry matter. The area occupied by plants being very high, the weight of flora on Earth was estimated at 2625 billion tones, more abundant in the equatorial area (70,000 t/km^2) and poorer at poles. Every year, the amount of organic matter increases on Earth by 173 billion tones (Mohan *et al.,* 1989). Almost 2/3 of this vegetal source is represented by forests and 1/3 by grasses, although the surface covered by forests is only 4,113 billion ha from 13 billion ha of land. For the formation of world biomass, two plant categories play an important role. Wooden plants (wooden-cellulose), that is, fast growth forest species (5-10 years), like mountainous plants (*Acer pseudoplatanus*), poplar (*Populus* sp.), pine (*Pinus* sp.), etc. have a production of 8-12 t DM / ha /year.

Oceans and seas of the Earth adsorb annually an energy amount from sun of over 1000 times greater than the mankind total consumption, and the total amount of phytoplankton is of $65 \cdot 10^6$ tones DM /year, of which $5 \cdot 10^8$ tones come from the sweet waters of the earth (Groşanu, 1986). Algae and some superior plants belong to this aquatic plant category, able to treat biologically the wasted waters. Unicellular alga *Botrycoccus braunii* contains hydrocarbons at an amount of 15-75% from its dry weight (Mohan, Avram, 1989). This sweet water alga has two forms of pigmentation: green and red. The green one contains lineal hydrocarbons with impair number of carbon atoms and the red one contains hydrocarbons with pair number of carbon atoms and many double links. The hydrocarbons from this alga can be used directly as energy source or raw material in the oil-chemical industry.

This huge vegetal mass or biomass includes great amounts of energy, which was partially used by man from the ancient times. For thousands of years, man has used as food fruits, seeds and other parts of plants; for heating, he has burnt their stems. The biomass was not revaluated under the best conditions, because almost 50% of wood from forests was used for heating in undeveloped countries. The lack of cooking machines and heating systems makes that only 55% of the energy contained by this fuel could be used, while, by wood gasification, this valuable energy resource could be used almost entirely.

During the last decades, some plant species were found in the group of biological fuels or energetic crops, such as few species of the *Euphorbia* genus, as castor-oil plant, savage cotton, cactus, maize, etc. The rate of dry matter accumulation was investigated in these crops. Investigations have shown that in some areas of the world, grasses originating from warm areas (maize, sorghum, sugar cane, etc.) have a mean rate of daily growth higher than other species (Boardman, 1980) (*Table 2*). Under climatic conditions of Romania, a rapid growth rate was found in grain or silage maize, potato, pea, alfalfa, beet, etc.

Table 2

The average rate of daily growth of a few plant species (according to N.K. Boardman, 1980)

Species	Place of cultivation	Growth period (days)	Average growth rate ($g/m^2/day$)
Maize	Colorado	117	23
Sugar cane	Hawai, USA	365	18
Millet	Australia	112	19
Fodder sorghum	Australia	83	17
	California, USA	120	23
Sugar beet	California, SUA	240	14
Alfalfa	California, SUA	365	8
Soybean	Japan	130	7

In warm climate areas, the following bush species proved to be valuable from this point of view: *Euphorbia lathyris* and *Euphorbia tirucalli,* which sap contains an emulsion of hydrocarbons in water resembling to those from oil. From the biomass of these plants, 25-40 barrels of hydrocarbons could be extracted each year/ha, at a price of 10 dollars/barrel (Constantinescu, 1981). In the last decades, in Brazil, sugar cane was considered as an energetic plant and in 1985, 10.7 billion litres of ethylic alcohol were produced, mixed at a rate of 10-20% with oil and forming the so-called "gasohol", thus diminishing the fuel importation. In 2005, in USA, 1280 million litres of "hydro-diesel" fuel, made of soybean oil and gas-oil were used for 200 buses. For 2006, the estimate is three times more. In the tropical area of Africa, good results were obtained with manioc, a perennial wooden plant that accumulated in roots high amounts of starch, proper for obtaining alcohol. In France, there was an attempt of replacing about 20 million tones of oil by "carburol", a mixture made of oil, methanol and alcohol obtained by the fermentation of kohlrabi, sugar beet, maize stalk, etc. Using the mixture of oil and plant fuels (ethanol, methanol and vegetal oils), named *diesters* for internal combustion engines, the air pollution caused by carbon dioxide and other toxic gases was greatly reduced (*Table 3*).

For diminishing the land occupied by energetic crops, in the latest years, gigantic sea plants were grown on certain areas of the ocean, the biomass obtained being used for fuel production by fermentation. Algae, having a rapid growth, form great amounts of raw material for fuels.

Table 3

Air pollution caused by different fuels (according to P. Dobre *et al.,* 2004)

Polluting agents (g/Kwh)	Fuels	
	Gas-oil	Diesters
Carbon dioxide	1060	170
Sulphur dioxide	1,5	0,3
Hydrocarbons	2,6	2,5
Ash	6,9	0,5
Nitrogen dioxide	19	20

In Romania, investigations on selecting, testing and adapting a few species with rapid growth in water medium have shown that *Pistia stratiotis,* Family *Araceae* and *Eichhornia crassipes,* Family *Pontederiaceae* obtained good results (*Figure 1*).

a b

Figure *1* – Water plants with great capacity of biomass multiplication
a. *Pistia stratiotis:* b. *Eichhornia crassipes*

The climatic conditions from Romania are favourable for these plants growth only 150 days/year, with a green mass production, which could reach 5-8 t/ha/day (Codreanu, 1986). These species grow well in wasted waters with pH = 6.5 – 8.0, total suspensions 90-600 ml/l, NH_4 = 0.7-40 mg/l, PO_4 = 0.01-17 mg/l, etc. Laboratory analyses have shown that *Pistia stratiotis* and *Euphoria crazies* had a relatively high content of protean substances, glucide, mineral salts and many amino acids. They could be used as biological fuels and for feeding some species of animals. Tests conducted on animal species have proved that the biomass of these plants was proper for feeding fish, nutria, hens, ducks and gooses.

For the transformation of different vegetal products, of biomass into food or fuels, a special role was played by microorganisms, which under anaerobe conditions, change cellulose by the help of some inferior fungi bacteria into hydrogen, methane, alcohols, organic acids and other intermediary compounds. From one tone of cellulose residues, about 255 l of ethylic alcohol could be obtained. Most of microorganisms, which produced liquid or gaseous fuels by fermentation had a lengthen body. By their drying, the microbial protein with high nutritive value was obtained.

Hydrogen, the ideal fuel, which forms water by its burning, is obtained biologically by photosynthesis – made bacteria, by water photolysis or by fermentation of different complex organic substances. Berill (1977) has shown that *Rhizobium* bacteria that lived in symbiosis with legumes, released hydrogen. Besides bacteria, green algae are able to produce hydrogen by bio-photolysis.

In the last 10-25 years, systems were arranged for the biogas use and production of biogas, proceeding from anaerobe fermentation of crop residues (straw, chaff) and dejections from different animal species, domestic garbage, sewage sludge from wasted water treatment or other organic residues. Systems with fermentation units of 10 m^3 (*Figure 2*) consume 150 kg/day of residual products, with 8-10% dry matter and produce 1-4.5 m^3 /day biogas, according to temperature (at temperatures close to 35-44° C the fermentation is more intense).

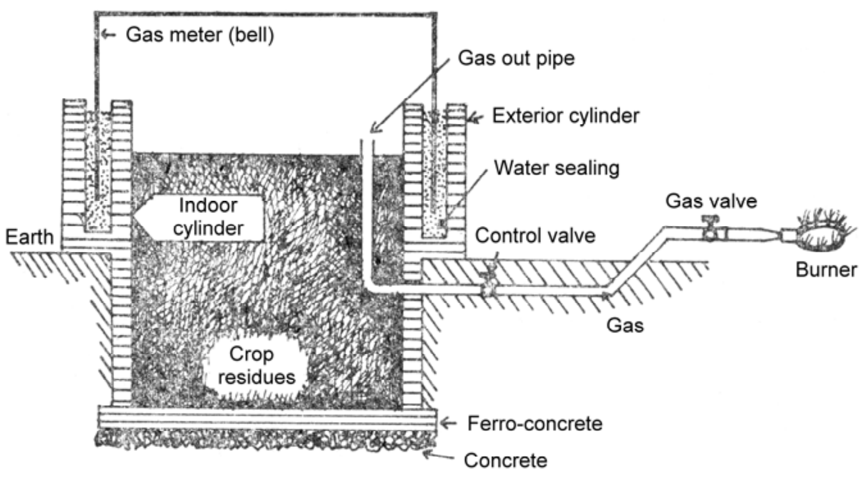

Figure 2 - Simple biogas system

Biogas or fermentation gas, found by Volta since 1778, when it emanated from marshes, is a mixture of methane 65-70%, carbon dioxide 25-30%, carbon oxide 2-45 %, nitrogen 1-2%, etc., and has a heating power of 5000-5500 kcal/m^3. Energy produced by 28 m^3 biogas equalizes the one produced by 16.8 m^3 natural gases or 20.8 l oil. Sludge, which remained after fermentation, was a good organic fertilizer.

Biomass is an important source of energy. On the average, in Romania, about 20,637,000 t/year by-products, wastes and residues result only from crops (*Table 4*).

Table 4

Products obtained in Romania from by-products (thousands of tones)

Crop	2001	2002	2003	Average
Wheat- rye, straw	5590.0	3464.0	1947.2	3667.1
Barley - two-row barley, straw	1374.6	1009.5	470.4	951.5
Oats, straw	422.0	343.8	339.3	368.4
Rice, straw	1.0	0.4	0.2	0.5
Maize, stalk	9921.7	9139.1	10420	9826.9
Maize, cobs	2425.7	2234.4	2547.5	2402.5
Grain pea, stalk	14.3	15.1	17.3	15.6
Beans, stalk	24.7	24.6	26.9	25.4
Soybean, stalk	47.3	97.8	146.2	97.1
Sunflower, heads	626.1	680.0	1015.3	773.8
Sunflower, stems	752.7	916.6	1377.1	1015.5
Sunflower, shells	232.6	283.3	425.6	313.8
Oil linseed, stems	3.0	2.7	2.3	2.7
Grain sorghum, stems	7.1	3.3	6.3	5.6
Sugar beet, leaves, stem base	220.6	240.6	192.7	218.0
Total	**21663.4**	**18455.2**	**18934.3**	**19684.3**

From one tone of wheat straw or chaff, 900 m^3 biogas could be obtained, and in case of maize, 1/2 or 2/3 of crop was made of stalks and by-products, which contained high amounts of energy. Gathering at harvest all crop residues, fields might lack the organic matter necessary to maintain and improve fertility. It was necessary that sludge, which remained after the biogas extraction should be applied as fertilizer in field.

After the fermentation of 100 kg of food residues, 12 m^3 of biogas could be obtained. In Bucharest, about 1200 tones of garbage are collected each day, approximately 200 kg domestic residues/tone (Sălăgeanu, Constantin, 1984). In Romania, biogas could cover, at a rate of 70-80%, the energy necessary for animal breeding farms, and could be used for heating houses. Methanol and rapeseed oil, with the characteristics mentioned in *Table 5*, could ensure, with other fuels, the running of internal combustion engines.

Chinese people have been using biogas for over 100 years for heating rural dwellings, for food preparation, etc. In the latest years, biogas was used even in the industrialized countries. In the autumn of the year 2005, in Sweden, the train from Linkoeping-Vaestervik to Vastervink cities , found at a distance of 80 km from each other, has used biogas. This train carries 54 passengers with a speed of

130 km/h and uses the biogas obtained by the decomposition of organic residues, saving fuel and diminishing air pollution. Sweden has already 779 biogas-based buses and hundreds of cars running with a mixture made of oil and biogas or natural gas. The biogas train was built by Svensk Biogas and its price was of 1.08 million euros.

Table 5

Characteristics of some engine fuels
(P. Dobre et al., 2004)

Specification	Methanol (CH_3OH)	Ethanol (CH_3CH_2OH)	Gasoline	Diesel fuel	Rapeseed oil
Density ($g \cdot cm^{-3}$)	0.7924	0.7893	0.74	0.84	0.885
Heating value ($kj \cdot kg^{-1}$)	19975	30730	43940	42100	37700
Freezing point (°C)	-98	-114	-50	-5	5
Octane number	110	106	97	20	-
Cetane number	-	5	10	49	55
Air/fuel ratio ($kg \cdot kg^{-1}$)	6/1	9/1	15/1	14/1	14/1
Flash point (°C)	64.7	78.3	30-180	180-360	160-240
Viscosity ($mm^2 \cdot s^{-1}$)	0.6	1.2	0.42.	3.32	4.68

Nature is superior to man in this field of energy accumulation in biogas and its transfer, without causing environment pollution.

CONCLUSIONS

Estimates on the exhausting of oil world stock in the next 60 years, and of coal in 150 years have resulted in complex studies on a better revaluation of renewable energy sources, by the orientation of world economy to energy production through biomass.

The climatic conditions of Romania, favourable to growing plants with high capacity of biomass multiplication, as well as farming by-products, animal dejections, domestic garbage, etc. can offer alternative energetic solutions in the future.

Biogas, proceeding from anaerobe fermentation of crop residues and dejections from different animal species, domestic garbage and sewage sludge can cover the energy necessary for animal breeding farms at a rate of 70-80%.

Efficient utilization of the potential of energy renewable sources is done by means of policies, tools and resources adequate to this purpose.

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