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Mini-review

RENEWABLE ENERGY - A CHALLENGE TO AGRICULTURAL FARMS

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ABSTRACT

Studies on biofuels started in Romania over 30 years ago. The present paper presents a Biodiesel Production and Use Integrate System adaptable to agricultural farms in a decentralised manner. Different elements (key actions) of the design system are analysed with respect to energy efficiency and environment protection. The study shows that Romanian agriculture, like many others in Europe, has all the necessary conditions to develop a sustainable biodiesel production and use and the establishment of a network of farms using renewable fuels is a future trend. Finally, protected areas are places where the biodegradable fuels are required. The proposed biofuel integrate system has been experimented successfully in a farm from Cluj county in Romania.

Key words: renewable energy, vegetable oil, integrate system, farm

INTRODUCTION

Energy is the essence of life on Earth and is one of the most basic of human needs, not as an end in itself but as a means to numerous ends[1] The taming of fire was one of humankind's earliest technological achievements. It provided energy for heat and light on demand. But today the environmental impacts of the world's power plants, internal combustion engines and boilers have serious implications for the future health and well being of the planet.

According to the demands of the technological development and the quality of life during the last 50 years, the global consumption of commercial energy has risen more than fourfold, far outpacing the rise in population. All this energy comes from natural resources as fossil fuels, such as coal and oil, living resources, such as timber and biomass, nuclear fuel such as uranium, or renewable resources such as flowing water and wind and the power of the sun.

A generation ago, there was concern that fossil fuels would run out, plunging the world into an energy crisis. Today the fear is that their continued use might be wrecking the global climate by emitting carbon dioxide (CO_2) as we burn carbon-containing fuels (see **Figure 1**). This anxiety is substantially increased in view of the considerable unmet demand for energy in the developing world. It is estimated that since 1751 roughly 283 billion tons of carbon have been released to the atmosphere from the consumption of fossil fuels and cement production. Half of these emissions have occurred since the mid 1970s. In the 2000 global, fossil-fuel CO_2 emission estimate, 6611 million metric tons of carbon, represents a 1.8% increase from 1999. The average annual fossil-fuel release for the decade 1990-1999 was 6.35 billion tons of carbon [1].

Globally, liquid and solid fuels accounted for 76.8% of the emissions from fossil-fuel burning in 2000. Combustion of gas fuels accounted for 19.3% (1277 million metric tons of carbon) of the total emissions from fossil fuels in 2000 and reflects a gradually increasing global utilization of natural gas. Emissions from cement production (226 million metric tons of carbon in 2000) have doubled since the mid 1970s and now represent 3.4% of global CO_2 releases from fossil-fuel burning and cement

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production. Gas flaring, which accounted for roughly 2% of global emissions during the 1970s, now accounts for less than 1% of global fossil-fuel releases [1].

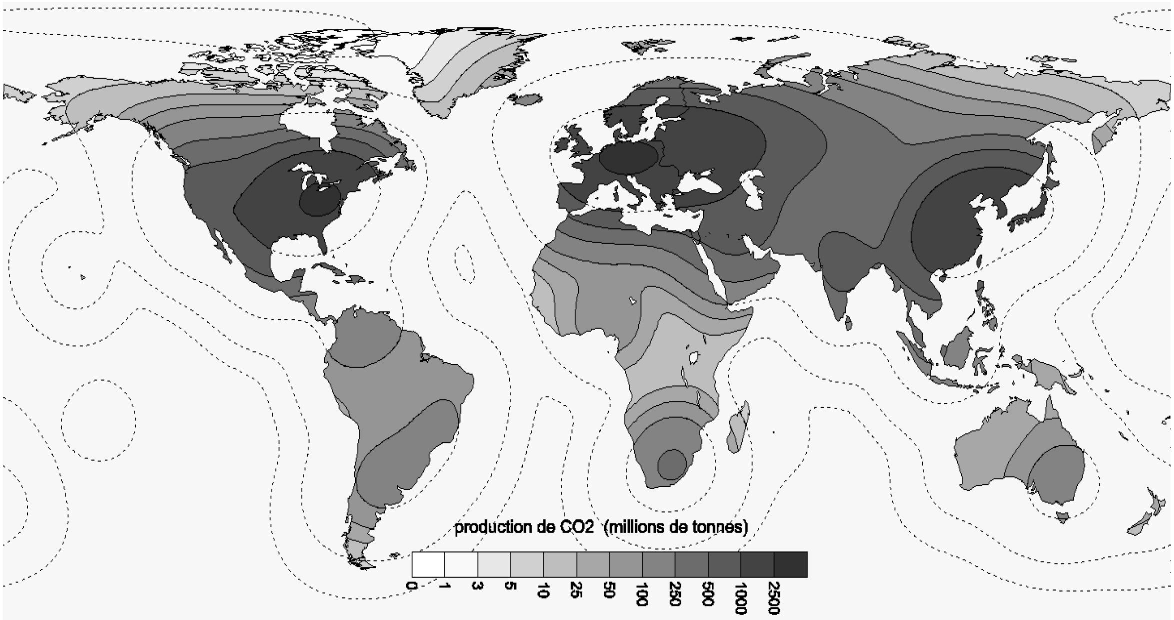

Fig. 1 World CO_2 emission map

Exposure to air pollution is associated with numerous effects on human health, including respiratory problems, hospitalisation for heart or lung diseases, and even premature death. Children are at greater risk because they are generally more active outdoors and their lungs are still developing. The elderly and people with heart or lung diseases are also more sensitive to some types of air pollution. Air pollution can also significantly affect ecosystems. For example, ground-level ozone has been associated with reductions of agricultural and commercial forest yields, and airborne releases of NOx are one of the largest sources of nitrogen pollution in certain water bodies.

In this context the use of “clean” fuels for the internal combustion engines is more than a desire as a necessity. *Rodolfo Diesel*, the father of the compression combustion engines, had foreseen the biofuels use. So, in 1900 he presented at the World Exhibition from Paris an engine working with peanut oil.

By economical considerations the biofuels use was abandoned till the beginning of 1970s when the first major petroleum crisis raised the need for alternative fuels.

Under the pressure of the XXI century environmental demands & concerns (expressed synthetically in the *Kyoto Protocol* that was signed by more than 160 countries) the use of biofuels in the case of diesel engines has been reconsidered [8], especially for the engines working in the most protected areas as communal domains, agriculture, sylviculture and tourist regions (including lakes for nautical sports).

Romania was one of the first industrialised countries that have ratified the Kyoto Protocol and so has assumed responsibilities for pollution reduction. In this direction, biofuel use is an important element.

BIODIESEL INTEGRATE SYSTEM FOR PRODUCING AND USE IN AGRICULTURE

Agriculture is an efficient energy provider, by converting the solar energy during the photosynthesis in biomass energy. Part of the harvest biomass can be used for different biofuels production covering the fuel technological necessities [2].

In the present paper the authors propose an integrate system for biodiesel production and use in the agricultural farms based on the rape crop (**Figure 1**). This system includes eight main levels: crop technology, oil expeller, oil esterification, biodiesel use in internal combustion engines equipping agricultural tractors, oil cake use in animal breeding, bee keeping (melliferous use of rape crop), esterification sub products use and environmental monitoring.

There are about 1700 plants that can offer oil suitable for use as fuel in the internal combustion engines. From these only 72 can present a real commercial interest. According to the natural conditions for agriculture in Romania, the winter rapeseed oil (WRO) and its methyl ester (RME) represents one of the best choices of the alternative fuels

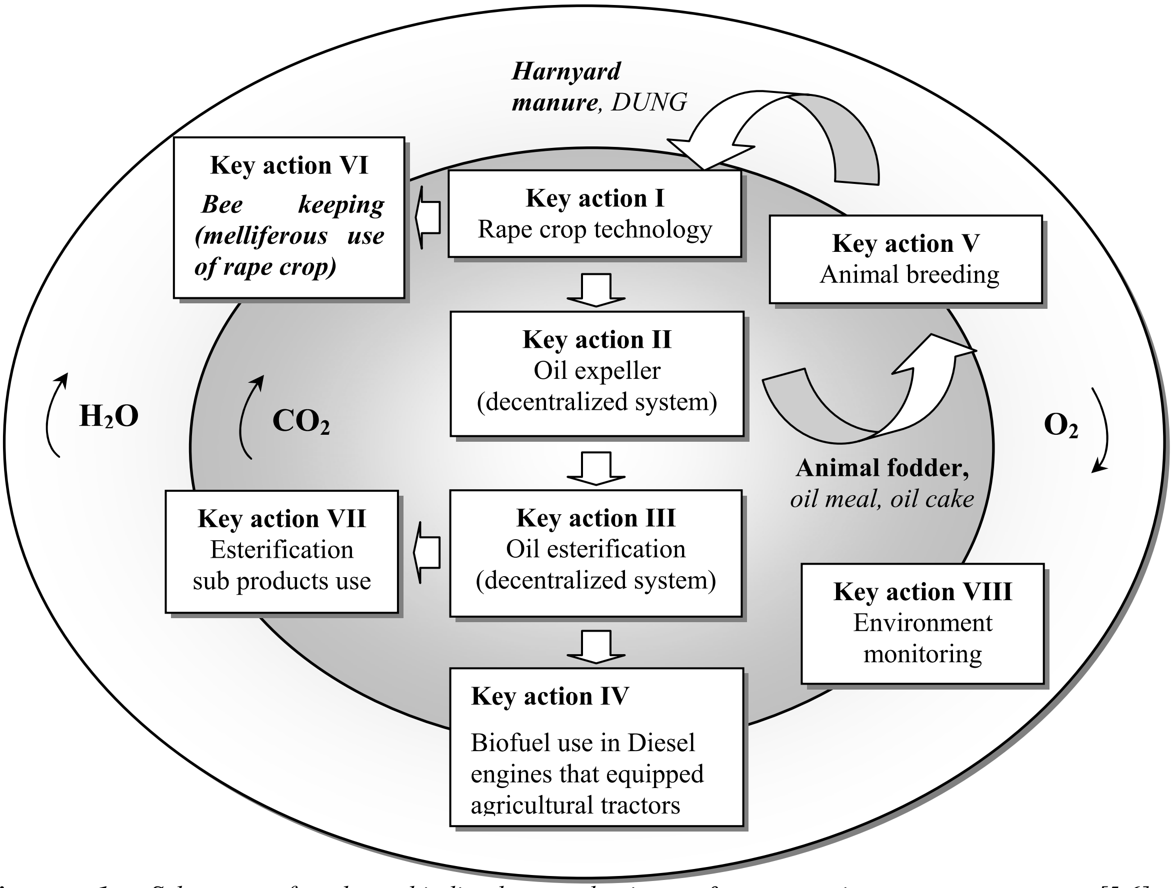

Figure 1 *Scheme of the biodiesel production & use integrate system, [5,6]*

Crop technology

The rape crop requires a precise technology that includes high-level seedbed preparation, low/medium level of chemical treatments and high quality harvesting combines. The crop yield varies between a low level 3,2 t/ha and a high level of 5,4 t/ha.

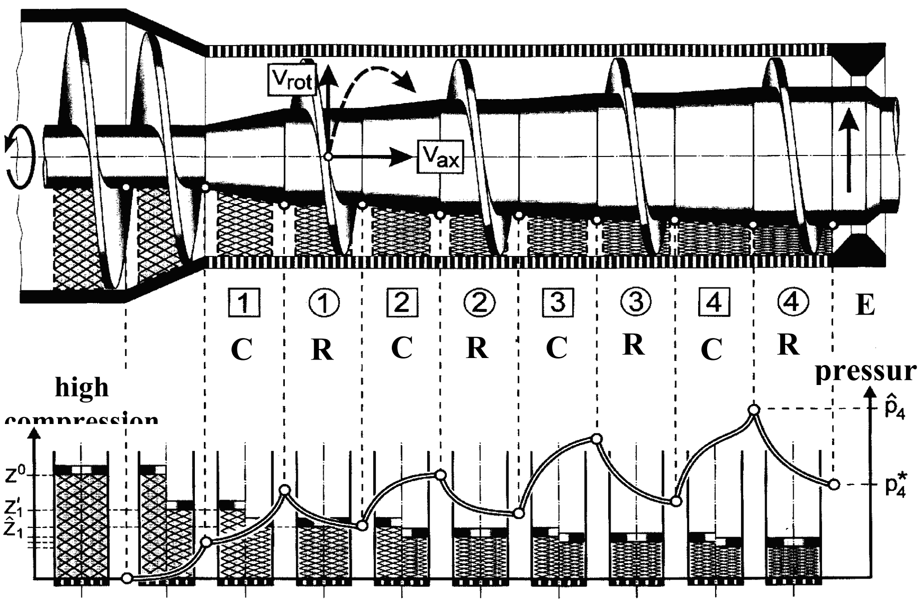

Figure 2 *Working of the screw press for oil expulsion. (C – compression; R – relaxing time; E – exit)*

The actual gross energy consumption for rape cultivation including fertilizers and pesticides corresponds to the general average in farming, excluding fertilizers and pesticides. An increase in the rape production area will therefore not increase the total gross energy consumption in agriculture.

Oil expeller & esterification

Unlike ethanol, which is an alcohol, biodiesel is an ester (similar to vinegar) that can be made from several types of oils such as soybean, rapeseed, and vegetable or animal fats. Through a process called transesterification, organically derived oils are combined with alcohol (ethanol or methanol) and chemically altered to form fatty esters such as ethyl or methyl ester. The biomass-derived ethyl or methyl esters can be blended with conventional diesel fuel or used as a neat fuel (100% biodiesel).

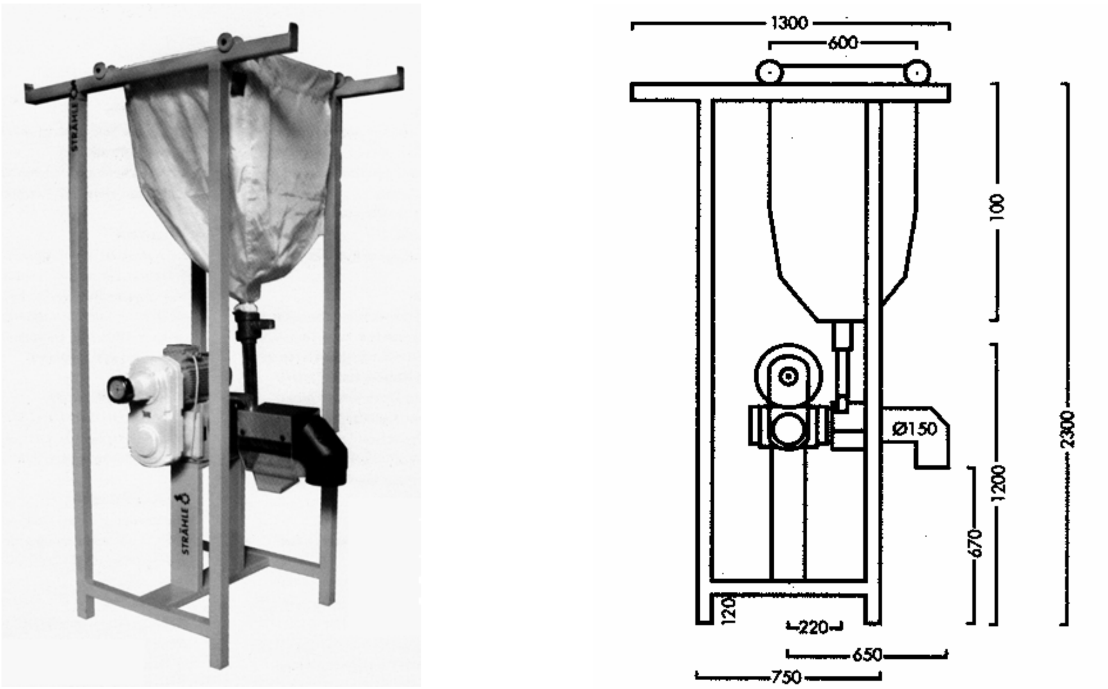

Figure 3 *SK 60/1 unit for rape oil extraction in the farms (working capacity 120 l/day; electric engine 3 kW, 360 V, 50 Hz)*

The cold pressed rapeseed oil presents the energetically and environmentally best alternative to fossil diesel with a strongly positive energy and CO_2 balance. The use of rapeseed oil for transport can substitute, after a minor modification of the engine, the agricultural sector's own fuel consumption. The oil presents no fire and health hazards, and it is non-polluting [2]. The oil is pressed in an inexpensive plant with low energy consumption, and the whole production can take place at the individual farm, so the fodder cakes can be used on site or be sold locally.

Biodiesel can substitute fossil diesel right away [3, 4]. However, biodiesel presents health and fire hazards in itself, and it is polluting. The pressing and the following esterification phase comprises an industrial process with a high energy consumption which requires an expensive, decentralised or decentralised production plant [7]. The transformation process of rapeseed oil in order to obtain biodiesel fuel is based on the transesterification reaction of triglycerides, components of vegetable oils, by means of short chain aliphatic alcohols (C1-C4) resulting in the release of monoesters of fatty acids and glycerol.

It is estimated that oil production of 580,000 tons corresponds to 604 million litres of rapeseed oil equalling 580 million litres of diesel (this amounts to approximately 32 TJ).

The physical and chemical characteristics of biodiesel obtained from rapeseed oil are presented on **Table 1**.

Animal fodder

A fodder cake production of 560,000 tons equals 623 million fodder units (FU), 20% of the total consumption of protein fodder of 3131 million FU, [7].

We can estimate that by cultivation of winter rape, the total fuel consumption of the Romanian agricultural sector could be covered on a good 18 % of the arable area along with covering 25 % of the protein fodder consumption and about 80 % of agriculture's total gross energy consumption.

Table 1*Experimental values of basic fuel properties in comparison with the standard ones*

Property	Units	Value	
		Experimental	***Standard DIN 51606***
Density at 20°C	g/cm3	0.880	0.860-0.900
Kinematic viscosity at 20°C	mm2/s	6.30	3.50-5.00
Flash point Pensky-Martens	°C	184	≥100
Water content	%	0.02	<0.03
Methanol content	%	0.20	<0.30
Free glycerine content	%	0.02	<0.02
Ash content	%	<0.01	<0.01
Sulphur content	%	<0.01	<0.02
Cetane index	-	51	≥51
Lower calorific capacity	kcal/kg	9000	-

Table 2 *Fodder value of the rape cakes*

Fodder value in fodder units (FU) of rape cakes, cold pressing of rape seed oil		
FU/kg solids	% solids	FU/kg rape cake
1.25	89	1.1125

Table 3 *Energy content of the rape cakes components*

Energy content in rape cakes, cold pressing of rape seed oil			**Energy [MJ/kg rape cake]**
Kind	***% of solids***	***Energy, [MJ/kg]***	
Protein	33.7	23.9	8.05
Fat	14.6	39.8	5.81
Hydrocarbons	44.6	17.6	7.85
Total solids	92.9		21.71
Total at 89% solids			19.32

Table 4. *Energy efficiency of the integrate system for biodiesel producing and use in agriculture (at a minim yield of 3,2 t/ha)*

System stage	**Crude oil**		**Esterificated oil**	
	Agricultural Production			
- agricultural production	3,2 t/ha	3,2 t/ha	3,2 t/ha	3,2 t/ha
- energy production	76000 MJ/ha	76000 MJ/ha	76000 MJ/ha	76000 MJ/ha
- energy consumption	17460 MJ/ha	17460 MJ/ha	17460 MJ/ha	17460 MJ/ha
- input/output	1:4,3	1:4,3	1:4,3	1:4,3
- energy benefit	330 %	330 %	330 %	330 %
OIL EXTRACTION	**Cold pressing**		**Pressing & extraction**	
- energy consumption	900 MJ/ha	900 MJ/ha		
	Rape oil	**Rape cakes**	***Rape oil***	***Rape schrot***
- production	1,02 t/ha	2,1 t/ha	1,22 t/ha	1,9 t/ha
- energy production	37700 MJ/ha	38400 MJ/ha	45100 MJ/ha	31000 MJ/ha
- total energy used	9100 MJ/ha	9260 MJ/ha	13550 MJ/ha	9310 MJ/ha
- input/output	1:4,4	1:4,1	1:3,3	1:3,3
- energy benefit	310 %	310 %	230 %	230 %
ESTERIFICATION				
- energy consumption	-	-	7630 MJ/ha	7630 MJ/ha
	-	-	Biodiesel	***Glycerin***
- production	-	-	1,21 t/ha	0,112 t/ha
- energy production	-	-	44890 t/ha	1900 MJ/ha
- total energy used	-	-	20310 t/ha	870 MJ/ha
- input/output	-	-	1:2,55	1:2,55
- energy effiecncy	-	-	155 %	155 %

The secondary system product is the rape cake that can be used successfully in the animal breeding sector. The fodder value and energy content in rape cakes from cold pressing of rapeseed oil are presented on **Tables 2 and 3**.

Bee keeping

Very interesting is the melliferous use of rape crop as bee keeping is an important component of the Romanian agriculture (for centuries) and honey an important export product.

The proposed integrate system for biodiesel producing and use has a high-energy efficiency and represents a feasible solution for a further national energy strategy development (see **Table 4**).

CONCLUSIONS

The study shows some conclusions among which are:

1) The proposed integrate system for the biodiesel produce and use is energetically efficient and does not require much investment.
2) According to the natural conditions for agriculture in Romania, the winter rapeseed oil (WRO) and its methyl ester (RME) represent the best choice of alternative fuels.
3) There is large unused potential for rape cultivation in Romanian agriculture.
4) All the integrate system phases are suitable for farm implementation.
5) A lot of the Romanian farmers are determined to implement the proposed integrate system for biodiesel production and use.
6) Renewable energies will come into operation in gradual steps when they become competitive or are supported by governments.

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