# FOOD VERSUS BIOFUELS – AN ENERGY BALANCE APPROACH

Ionut PURICA[1], Mihai SINDILE[2]

**Rezumat.** *În ultimii ani, producția de combustibili în transporturi a înregistrat, mai întâi, o creștere aproape exponențială, apoi a atins un fel de saturație, cauzată de efectele negative asupra produselor alimentare agricole. Deoarece atât biocarburanții, cât și produsele agricole sunt exprimate în unități de energie, în prezentul studiu încercăm să punem în balanţă unitățile de energie corelate cu suprafeţele de teren disponibile pentru produse alimentare si biocombustibili, în anumite economii, cum ar fi cele din SUA şi România, astfel încât să identificăm împărţirea optimă a terenurilor agricole, cu scopul de a acoperi atât nevoile alimentare de bază, cât și cele legate de biocombustibili. În această primă abordare, alimentaţia e măsurată în consumul uman zilnic într-un aport de energie convertit la porumb echivalent, iar biocombustibilii sunt măsuraţi în combustibilul necesar pentru autoturisme, de asemenea, convertit în porumb echivalent. Aceste două cantități de porumb sunt apoi exprimate în suprafețele de pământ necesar a fi cultivate, urmată de o analiză dinamică a partajării optime între alimentarea populației și aprovizionarea cu combustibili a mașinilor.*

**Abstract.** *In recent years the production of fuels for transportation has seen first an almost exponential increase then a sort of saturation given by the adverse effect on the agriculture of food products. Since both biofuels and agro products are expressed in energy units, we try here to make a balance in terms of energy units that are correlated to land surface available for food and biofuels in given economies e.g. the Romanian and the USA ones, such that to identify the optimal division of agricultural land to cover both the basic food needs and the biofuel ones. In this first approach food is measured in human daily energy intake converted to equivalent corn and biofuel is measured in the needed fuel for cars also converted in equivalent corn. These two corn quantities are then expressed in the land surface needed to cultivate them, followed by a dynamic analysis of the optimal partition between feeding the population and supplying the cars.*

**Keywords:** Biofuels, agro products, Corn for food, corn for cars

## Introduction

Biofuels are not a silver bullet for the energy problems of the world. To solve the issue of dwindling fossil fuel reserves, all viable means of harvesting energy should be pursued to their fullest. However, the fact remains that biofuels are a reliable alternative energy resource. With more development and research, it is possible to overcome the disadvantages of biofuels and make them suitable for widespread consumer use. When the technology is available, many of the disadvantages will be minimized and the market very clearly has potential.

[1]IPE-INCE-Romanian Academy. founding, full member of AOSR, (puricai@yahoo.com).
[2]PhD student, ”Politehnica” University of Bucharest.

Much of this could rely on the ability of energy producers to discover better plants to rise for fuel that use less water, less land, and grows quickly.

No fuel source is completely positive or completely negative.

Consumers need to weigh the pros and cons of biofuels to determine whether they feel comfortable with this resource as an alternative to traditional fuels.

**Advantages**

Costs may decrease when using biofuels.

Biofuel advocates frequently point out the advantages of these plant- and animal-based fuels, such as:

- **Cost**: Biofuels have the potential to be significantly less expensive than gasoline and other fossil fuels. This is particularly true as worldwide demand for oil increases, oil supplies dwindle, and more sources of biofuels become apparent.
- **Source material:** Whereas oil is a limited resource that comes from specific materials, biofuels can be manufactured from a wide range of materials including crop waste, manure, and other byproducts. This makes it an efficient step in recycling.
- **Renewability**: It takes a very long time for fossil fuels to be produced, but biofuels are much more easily renewable as new crops are grown and waste material is collected.
- **Security**: Biofuels can be produced locally, which decreases the nation's dependence upon foreign energy. By reducing dependence on foreign fuel sources, countries can protect the integrity of their energy resources and make them safe from outside influences.
- **Economic stimulation:** Because biofuels are produced locally, biofuel manufacturing plants can employ hundreds or thousands of workers, creating new jobs in rural areas. Biofuel production will also increase the demand for suitable biofuel crops, providing economic stimulation to the agriculture industry.
- **Lower carbon emissions**: When biofuels are burned, they produce significantly less carbon output and fewer toxins, making them a safer alternative to preserve atmospheric quality and lower air pollution.

**Disadvantages**

Despite the many positive characteristics of biofuels, there are also many disadvantages to these energy sources.

- *Energy output:* Biofuels have a lower energy output than traditional fuels and therefore require greater quantities to be consumed in order to produce the same energy level. This has led some noted energy analysts to believe that biofuels are not worth the work.

Food shortage may become an issue with biofuel use.

- *Production carbon emissions:* Several studies have been conducted to analyze the carbon footprint of biofuels, and while they may be cleaner to burn, there are strong indications that the process to produce the fuel - including the machinery necessary to cultivate the crops and the plants to produce the fuel - has hefty carbon emissions.
- *High cost:* To refine biofuels to more efficient energy outputs, and to build the necessary manufacturing plants to increase biofuel quantities, a high initial investment is often required.
- *Food prices:* As demand for food crops such as corn grows for biofuel production, it could also raise prices for necessary staple food crops.
- *Food shortages:* There is concern that using valuable cropland to grow fuel crops could have an impact on the cost of food and could possibly lead to food shortages.
- *Water use:* Massive quantities of water are required for proper irrigation of biofuel crops as well as to manufacture the fuel, which could strain local and regional water resources.

**Corn for food or for cars?**

For every 10 ears of corn that are grown in the United States today, only 2 are consumed directly by humans as food. The remaining 8 are used in almost equal shares for animal feed and for ethanol. And, for the 12 months from August 2011 to 2012, the U.S. biofuels industry used more corn for fuel than domestic farmers did for livestock feed – a first for the industry. This significant milestone in the shifting balance between crops for food versus fuel shows the impact of government subsidies for the biofuels industry. And, it could represent a tipping point in the conflict between food and fuel demand in the future.

Over the past year, U.S. farmers used 5 billion bushels of corn for animal feed and residual demand. During the time timeframe, the nation used more than 5.05 billion bushels of corn to fill its gas tanks. And, while some of the corn used to produce these biofuels will be returned to the food supply (as animal feed and corn oil), a large proportion of this corn will be solely dedicated to our gas tanks.

According to Rabobank's head of agricultural research, Luke Chandler, this shift in the balance between food and fuel could be the tipping point in world grain markets. China, once able to supply its internal corn demand, currently expects to import (from the U.S.) a few million tons of corn per year. This will likely place additional stress on the United States corn industry, as it will introduce another source of demand (and corresponding market pressures) for the nation's corn harvests.

**The basic approach taken – energy balance**

Although all food is having a tag with information on the amount of energy, usually in kcal, and biofuels are expressed in energy equivalent units, we know of no attempt as yet to make a balance between the two in order to have a common measure related to finding an optimal partition of agricultural land such that to ensure enough food for the population and to assess how many cars may be supplied with biofuel from the remaining land. In order to do this we start with the data in Annex 1 that gives the amount of energy associated to various food products. Obviously one may make a long discussion on the associated energy content but our purpose is to show how the problem may be approached, therefore we do not get into these details in this paper, but simply present a synthesis of various methods in the Table 1.

**Table 1** *(compiled from various sources)*

| Methods for determining energy content of foods | | | | Per adult-day energy consumption | | Difference in prevalence of low energy intake |
|---|---|---|---|---|---|---|
| Energy conversion factor | Description | | | | | |
| | Protein based on | Carbohydrates by difference | Energy from fibre | *Kcal* | % | |
| Atwater | Jones | Total | # | *2 739* | 101.2 | -1.8 |
| ME2 | Jones | Available | Included | *2 714* | 100.3 | -0.6 |
| Merrill and Watt* | Jones | Total | # | *2 706* | 100 | 0 |
| ME1 | Jones | Available | Ignored | *2 698* | 99.7 | 0.2 |
| $NME2^{AA}$ | Total AA | Available | Included | *2 634* | 97.3 | 3.3 |
| $NME2^{Jones}$ | Jones | Available | Included | *2 632* | 97.3 | 3.4 |
| $NME2^{6.25}$ | 6.25 | Available | Included | *2 631* | 97.2 | 3.5 |
| $NME1^{AA}$ | Total AA | Available | Ignored | *2 621* | 96.9 | 4.1 |
| $NME1^{Jones}$ | Jones | Available | Ignored | *2 619* | 96.8 | 4 |
| $NME1^{6.25}$ | 6.25 | Available | Ignored | *2 618* | 96.7 | 4.1 |

As we see the Atwater conversion factor is giving an energy intake per adult-day of 2739 kcal. We will consider this as the basic data for our calculation of food energy needs for the population of Romania and of the USA just to choose a medium to small economy and a large one.

In order to continue with the calculations we take from the Annex 1 the value of corn energy (Total carbohydrates) i.e. 4.03 kcal/g. This value shows that the intake per adult-day of energy may be expressed in corn equivalent as a quantity of 2739/4.03 = 679.65 g. For a year (365 days) this quantity amounts to 248073.2 g or 248.07kg/adult.

For the entire population of the countries (approx. 21 M people for Romania and approx. 317 M people for USA) the corn equivalent production should be of 5.21 Mt, respectively 78.6 Mt.

Considering a production of 4000 kg corn/hectare the agricultural land surface needed to feed the total population results to be 1.3 Mha for Romania and 19.7 Mha for USA.

With this we have arrived at an evaluation of the needed land surface to feed the population. Let's see how much surface is needed to 'feed' the existing cars in the countries.

The number of vehicles in Romania is about 8 million. Considering that each vehicle makes 20000 km/year and consumes on average 8l/100 km of gasoline, we have the consumption per car per year of 1600 l. The total annual consumption of gasoline is 12.8 Gl. For the USA a recent study by Eco Watch, on Carbon emissions reduction, is giving a number of 3000 Gcar.miles/year (240 Mvehicles at the same km/year amount) considering the same consumption we have the annual consumption for the USA is 384Gl.

To convert into corn equivalent we consider that there is a consumption of 1.5 l ethanol/l gasoline (ethanol has a lower calorific power than gasoline) and to produce 1 l of ethanol one needs 3.13 kg of corn.

The data above gives a quantity of corn of 60.1 Gkg respectively 1802.88 Gkg. Considering the same production of 4000 kg/ha the surface needed to supply fuel for all the vehicles in Romania would be 15.04 Mha and in USA 450.72 Mha.

So, basic food and biofuel amounts to 1.3 + 15.04 = 18.34 Mha for Romania. The arable land surface of Romania is 37.8% of the country's total surface of 237500km$^2$ i.e. 8.98Mha.

The arable land surface in the USA is 16.29% of the total surface of 9161966 km$^2$ i.e. 149.22 Mha. The needed surface for food and biofuels in USA is 19.7 + 450.72 = 470.42Mha.

In USA the total surface needed for food and transportation of 470.42 Mha is definitely larger than the 149.22 Mha. The same applies to Romania where the total needed surface for food and transport is 18.34 Mha versus a total surface of 8.98 Mha.

It is clear though that an economy cannot rely only on the basic food needs so it is normal to consider that a quantity of last reserve is set aside every year to cover any type of contingency related to food availability that may occur, also there is the need of to feed the livestock as mentioned above. If we consider that this quantity should cover 2 years of food needs then the surface for Romania will be 2×1.3 Mha = 2.6 Mha while the one for the USA will be 2×19.7 Mha = 39.4 Mha.

**Optimal partition of arable land between food and biofuels crops**

Considering the calculations above we see that the surface of land needed for food is smaller than the total arable surface of both Romania and USA. This allows finding the optimal partition of the surface between food and biofuel. The remaining surface for biofuels being smaller than the one needed to provide biofuel for all the vehicles in each country the result of the optimal calculation provides either the number of cars that may be fully supplied with biofuels or the percentage of biofuel in all vehicles fuel.

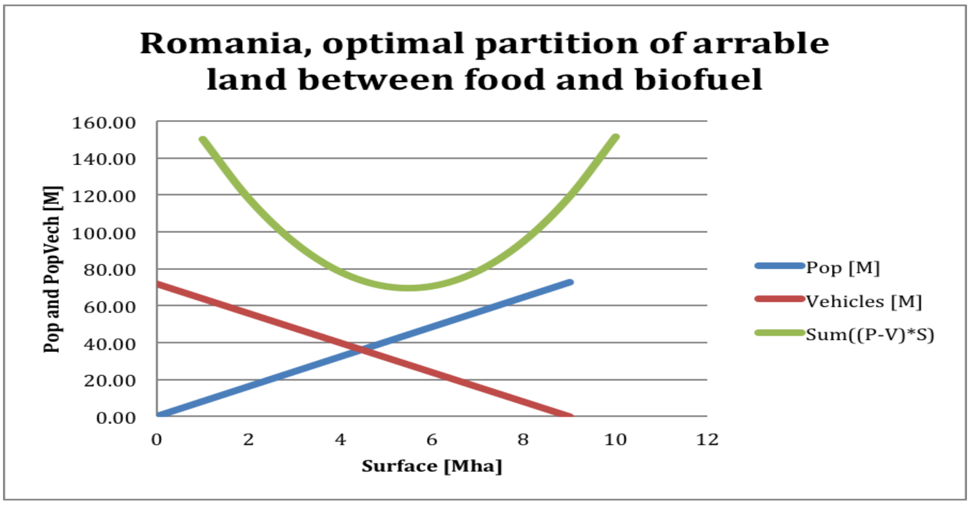


**Fig. 1.** (author's calculation.)

The basic logic for the optimization is that the less surface is available for population food (doubled for risk coverage purposes), then, more is available for biofuel, and there is a minimum value of the difference of the surfaces under the two lines that gives the optimal surface partition. The vertical axis measures the population equivalent (i.e. double population for food and number of vehicles multiplied by 15 for biofuel).

As shown in the figure 1, for Romania the optimal surface is 2.6 Mha and the number of vehicles possible to be fuelled with biofuel is about 3.5 M. This represents 43% of the total number of vehicles or in terms of biofuel one may say that land resources may ensure a mix of approx. 40% biofuel in the total fuel for vehicles transportation in the country.

The same calculation done for the USA, as shown in the figure 2, gives an optimal surface of about 40 Mha for food and a number of 59 M vehicles that is about 24% of the total number, or, the available land surface for biofuels may supply about 24% of the total fuel consumption of the vehicles in the USA.

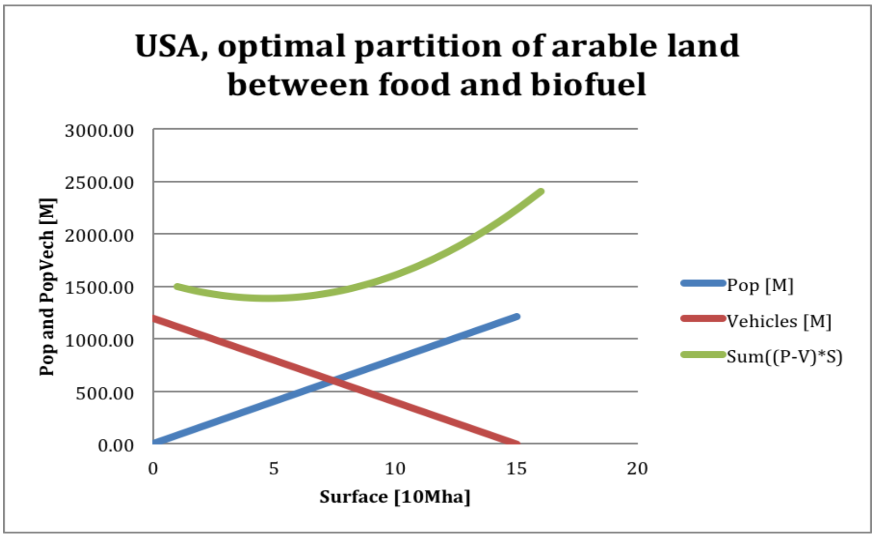


**Fig. 2.** (author's calculation).

## Conclusions

The approach we have taken to assess the possibility to partition the available agricultural land between growing equivalent corn to feed the existing population of a country and to grow corn to produce biofuel for the cars is leading to several main conclusions.

The first relates to the fact that feeding the population is paramount to anything else and ensuring the necessary quantities, including risk coverage, determines the basic agricultural land surface to keep untouched by alternative uses.

The second relates to the possibility to determine how much biofuel may be available from the remaining agricultural land such as to be able to determine the size of the cars fleet of the specific economy that could be supplied with that amount of biofuel.

The third conclusion gives a way to evaluate what would be the percentage of biofuel in the total fuel. This is done based on the existing number of cars in the country and the available biofuel versus the need of fuel for those cars. Obviously if the supply of biofuel is larger than the need, the exporting option is opened, which is not the case for either Romania or USA.

The fourth conclusion is also related to export of food that exceeds the need (including basic reserves).

For Romania we have that the available land surface can sustain both the population of the country (including one year of reserve food) and provide 43% biofuel in the fuel needed for the cars presently existing in the country. We suggest a full EU analysis be done with the aim to evaluate the food vulnerability and the measures to reduce it. For the USA the percentage of biofuel is 24% this being a sign of the larger motorization of that economy.

Finally we mention that the approach we have taken is a basic one that has to be extended to consider the rotation of basic cultures (corn, wheat and sun flower), the crops for animal stock, as well as the technological changes needed to fully use biofuels in car motors. Moreover, a thorough evaluation of the GHG emissions should be done given that agriculture is both a source and a sink of emissions.

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[3] Emily E. Adams, **U.S. Carbon Dioxide Emissions Down 11 Percent**, EcoWatch.

**Annex 1**. Amount of energy associated to various food products.

| | **Protein** kcal/g (kJ/g)§ | **Fat** kcal/g (kJ/g)§ | **Total carbohydrate** kcal/g (kJ/g)§ |
|---|---|---|---|
| Cornmeal, whole ground | 2.73 (11.4) | 8.37 (35.0) | 4.03 (16.9) |