Complete profile on…
Bioethanol, energy for sustainable development

The bioethanol sectors – wheat and maize bioethanol – are forging ahead: their environmental assessment leads to very positive conclusions, they create real added value and should generate several thousand direct jobs. Such benefits have been highlighted in a series of studies in which ARVALIS – Institut du végétal was involved.

The cereal bioethanol sector meets three major objectives: reduced environmental impact compared to fossil fuels, development of economic activity which is a source of direct or indirect revenue for the Government, and the creation and retention of jobs in production areas.
Recent independent studies, in which ARVALIS - Institut du végétal was involved, quantify this impact according to two scenarios: one maintaining the current production structure, known to be unable to meet integration objectives set by Europe, the other running until 2010 and including the creation of new bioethanol production units in order to meet those objectives. This long-term projection scenario plans, for the wheat sector, 10 million hectolitres of bioethanol produced from 2.7 million tonnes of wheat or maize, which represents around 360 000 hectares.

Positive environmental assessment

In terms of energy, a single argument, now refuted, served to denigrate bioethanol until the 1990s: its manufacture required more energy than it produced. This puzzle was solved through various American and British studies, as well as a study into French production, led by PricewaterhouseCoopers (1) in 2002, with the financial backing of ADEME (2) and DIREM (3).

This study showed that, with regard to current production, the wheat bioethanol sector releases twice as much energy as it consumes non-renewable energy (2002 data). It also highlighted the fact that, according to a long-term projection scenario (to year 2010) including the construction of new wheat bioethanol plants, this ratio will rapidly improve, to reach 3.5 times more energy released by bioethanol than the amount of non renewable energy needed to manufacture it.

When applied to petrol, this assessment shows poorer results: 1.25 times more non-renewable energy is consumed to produce petrol than the amount of energy contained in that petrol.

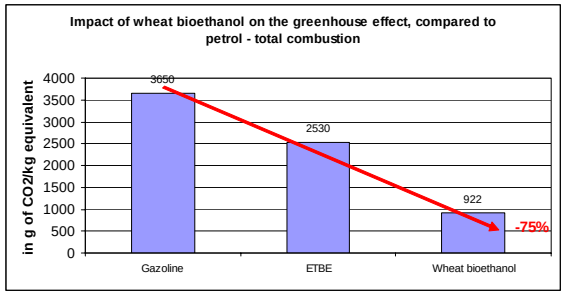
Limiting energy consumption

The capacity of the crop (which bioethanol comes from) to capture solar energy, helps obtain those positive energy conversion efficiency. The plant uses solar energy to grow. At the same time, it fixes this energy in its carbonaceous chains (complex carbohydrate). Hence, the more biomass produced, the more energy fixed per hectare.

Therefore, one hectare of maize yielding 110 quintals (11 tonnes) of grain is going to fix 160 GJ (gigajoules) per hectare in the grain, whereas one hectare of wheat yielding 90 quintals (9 tonnes) will fix 129 GJ. To carry out an energy assessment at the crop stage, this fixed energy must be compared to the non-renewable energy used to produce the crop.

1

Subsiding one tonne of petrol with one tonne of bioethanol reduces GGE by 75%



Source: ADEME / DIREM 2002

This consumption includes the energy used to manufacture the inputs (fertilizer, pesticides), the energy used to manufacture the farming equipment (tractors), and the energy used to power those tools (diesel, oil). Overall, this energy consumption represents 16 to 20 GJ per hectare, depending on the type of crop, which means 10 to 15 times less than the amount of energy fixed. 80% of this crop energy consumption is concentrated in two areas: nitrogen fertilization, which represents 50 to 60% of the energy consumption per hectare, and fuel consumption (30% of the energy consumption). It is therefore essential to optimize nitrogen inputs in order to improve the energy conversion efficiency of the crop, and consequently of the bioethanol sector. This conclusion applies to all crops from which biofuels are produced.

Reducing greenhouse gas effect

The main advantage of bioethanol production concerns greenhouse gas emissions (GHGE). Substituting one tonne of petrol with one tonne of ethanol reduces GGE by 75% *(figure 1)*. Indeed, to release 1 kg of petrol, the petrol sector emits 3 650 g of CO2 equivalent, which impacts on the greenhouse gas effect, whereas the ethanol sector emits only 922 g per kilo produced.
Only carbon dioxide (CO2) from fossil origins - emitted during the combustion process - contributes to increasing the greenhouse gas effect. Indeed, fossil fuel combustion resembles a discharge of carbons stored as hydrocarbon. Those hydrocarbon stocks re-form very slowly: between 25 and 50 millions years for petrol. Fossil CO2 emissions therefore contribute to shifting the balance of the carbon cycle, whilst adding to the massive increase in greenhouse gases which has been taking place over the last two hundred years.

Conversely, combustion of products coming entirely from biomass - such as bioethanol - produces CO2 which does not contribute to increasing the greenhouse effect. The CO2 emitted by biomass is thought to be rapidly (one to two years) offset by the plant previously absorbing CO2 present in the atmosphere. This refers to the fact that biomass is annually renewable, which gives bioethanol unique qualities regarding the greenhouse effect.

Greenhouse effect gas emissions from the bioethanol sector are linked to CO2 emissions, themselves linked to fossil energy consumption, as well as to emission of another GHG, nitrous oxide (N2O).

CO2 emissions are essentially due to the industrial process using fossil energy. It accounts for nearly 70% of GHG emissions for wheat bioethanol. The remaining 30% is attributed to the crop. Half of those emissions linked to the crop are due to N2O emissions from the fields, connected to the level of nitrogen fertilization. In order to maintain such a positive environmental assessment, much care must be devoted to optimizing nitrogen fertilization.

What is the environmental cost?

However, assessing the impact of bioethanol on the environment cannot be restricted to assessing the energy balance and greenhouse effect gases. In order to evaluate its global environmental impact, a Life Cycle Assessment method can be used.

This method lists a large number of impacts, giving them an economic cost linked to a monetary estimation of their environmental or social detrimental impact, before comparing this to the damage caused by the petrol sector.

This type of study follows very precise methodological processes and is based on official data. This method was applied to the wheat bioethanol sector for the first half of 2004 (5).

What conclusions can we draw? Compared to the same volume of petrol, environmental costs associated with the bioethanol sector are 41% lower than those of the petrol sector. Substituting one hectolitre of petrol with one hectolitre of wheat bioethanol reduces environmental costs by 2.6 €/hl in the current production context. In the context of a long-term projection scenario planning the creation of new production capabilities, the gap between the two sectors widens, and the environmental saving achieved through using wheat bioethanol then rises to 3.8 €/hl.

Associated economic impact

The bioethanol sector has many associated economic impacts. They have always been assessed by comparison to the existing petrol sector. It is a first approach in each case, limited to the wheat bioethanol and petrol sectors, everything else being equal. In the case of long-term projection scenarios, only the volume of bioethanol produced has been increased. The price of inputs and the taxation levels applied are those applying in 2003.

A preliminary analysis of each branch of the sector highlighted the creation of 8 million euros added value in 2004. This added value is divided between agricultural requisites suppliers, (9%), agricultural production (32%), bioethanol plant (40%), and transport of bioethanol (17%). By comparison, the petrol sector creates 2.5 million euros added value, divided between refining and transport.
By 2010, the creation of new wheat bioethanol production units should create 128 million euros added value, compared to 54 million euros for petrol. The breakdown of added value by field of activity remains roughly the same.

The wheat bioethanol sector therefore creates more wealth than the traditional fuel sector. Even better, it is divided more equally between the sector's various fields.

Flexible vehicle: with an ethanol engine.

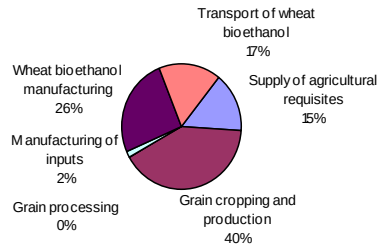
"Flexible Fuel Vehicles" are cars equipped with special engine which can be powered by both ethanol and petrol, separately or mixed, without the need for any technical modifications. Engine mapping adapts to the percentage of ethanol, thanks to a probe measuring the amount of exhaust oxygen. An "activated carbon" system absorbs petrol fumes, reducing volatilization-induced loss. Such versatility means those flexible vehicles are easy to use. In Brazil, where this type of engine has been marketed by General Motors, Ford, Volkswagen, PSA and Renault for two years, flexible vehicles already account for 35% of cars on the road and, nationally, 30 000 filling stations sell ethanol. Why such a success? In Brazil, bioethanol is produced from sugar canes, which have high energy conversion efficiency, and its price is very competitive. At the pump, pure ethanol is half as expensive as a 22% blend. Flexible vehicles could be the answer to reaching level of use targets in France. This would require the ethanol sector to develop a special ethanol distribution network, whilst guaranteeing that their product meets European emission standards.

Increased tax revenue

Based on those economic figures, it was possible to estimate the tax revenue generated by each of the two sectors. The revenue taken into account here is the amount of income tax paid by the sector's employees, corporate tax, business rates, property tax, specific agricultural taxes, as well as social solidarity contributions paid by companies. The TIC (former TIPP, French domestic tax on petroleum products) was calculated separately.

Overall, the tax revenue generated by the bioethanol sector amounted to 2.4 million euros in 2003. By 2010, based on the calculation hypothesis used for 2003, this revenue will rise in line with an increase in production, to reach 49 million euros. For 2003, the tax revenue from the petrol sector is estimated at 0.2 million euros, to reach an estimated 5 million euros in 2010.

2



Jobs created by the wheat bioethanol sector are spread over all the various fields of activity within that sector

Reducing oil meal imports

The demand for distillation by-products on the French market gives wheat bioethanol an unusual advantage. Indeed, due to its high protein content, wheat distiller's dried grain is an interesting animal feed supplement. It can partially replace soyameal in the diet. This has a positive impact on the sector's trade balance. One tonne of wheat distiller's dried grain is equivalent to importing 0.6 tonnes of soyameal, which means that by 2010, soyameal imports could definitely have been reduced by 15%, amounting to a saving of 137 million euros.

** 1 barrel = 159 l of crude oil*

Increased autonomy in terms of energy supply

The development of the bioethanol sector will also help reduce our energy dependence. France still imports half the primary energy it consumes and those imports mainly come from politically unstable areas. As for fuel, 98% of what France consumes is imported. The development of a new fuel sector would help reduce this dependence, whilst also reducing an ever-increasing energy bill. In order to quantify the value of bioethanol in terms of energy autonomy, the people leading the study gave bioethanol an average value of 22 €/t. At the same time, the value of one barrel of oil was set at 27 $. As a result, energy autonomy was set at 0.7 million euros for 2003 and 16 million euros for 2010.

Afsaneh LELLAHI
a.lellahi@arvalisinstitutduvegetal.fr

from Perspectives Agricoles n° 310 march 2005

Associated social impact

If we consider equal production volumes, the wheat bioethanol sector retains and creates more jobs than the petrol sector. This statement is based on calculations which break the key stages of production down and allocate them fields of activity. The jobs associated with each field of activity are then allocated proportionally to the turnover of that sector.

By 2010, bioethanol should therefore have created 2 050 jobs, spread out equally between all the stages involved in this sector *(figure 2)*. By comparison, the petrol sector would create 256 jobs by the same date. The environmental assessment of the sector helped produce a preliminary quantification of its environmental, economic and social benefits, compared to petrol. We must now compare all those benefits to the tax exemption given to the sector by the Government. In fact, in 2010, over ¾ of the tax exemption will be offset by the reduction of indirect costs, the increase in tax revenue and the reduction of the energy bill. By improving the cost effectiveness of the sector, bearing in mind that it is getting stronger through a measured aid from the Government considering the level of return which is expected, and based on definite environmental benefits, the cereal bioethanol sector fully deserves to be dubbed the "energy source for sustainable development".

(1)http://www.ademe.fr/partenaires/agrice/publications/documents_francais/synthese_bilans_energetiques_fr. pdf
(2) ADEME : Agence De l'Environnement et de la Maîtrise de l'Energie (Environmental and Energy Control Agency)
(3) DIREM : Direction des Ressources Energétiques et Minérales – Ministère de l'Industrie (Department in charge of Energy and Mineral Resources - Department of Industry)
(4) The improvement of energy conversion efficiency from bioethanol is linked to the possibility, in new units, of recycling and selling to the food sector part of the CO2 emitted by the facilities. Part of the energy cost is then allocated to this new product, reducing the energy cost allocated to bioethanol.
(5) Evaluation of externalities and associated economic, social and environmental impact of the bioiethanol sector in France.
PricewaterhouseCoopers –May 2004.