Use and Production of Bio Fuels: Biodiesel

Introduction

Transport is one of the crucial themes as far as mitigation of climate change is concerned, as it plays a central role in the domain of greenhouse gas emissions. The WG3 report of the fifth *Intergovernamental Panel on Climate Change* (IPCC, 2014) reported that 25% emissions are a result of the energy sector, 24% from agriculture and stock-raising, 21% from industry, 14% from transport and 6.4% from the construction sector. The remaining 9.6% are to be attributed to other energy sources (data provided in 2010). In this paper, we shall carry out an analysis focused on the transport sector and, more precisely, on that area concerning bio fuels and biodiesel.

Before entering the analysis of the problem, we provide some general information about "biomass". By considering the definition given by the EU Parliament and European Council (EC/2009/28/ Art. 2), the word biomass refers to the biodegradable part of organic products, waste and residues of biological origin as from agriculture (including plants and animal substances), forestry and related industries, including fishing and aquaculture as well as the biodegradable part of industrial and urban waste. During combustion, biomass emits a quantity of CO_2 into the atmosphere equal to the quantity previously absorbed by plants during the photosynthesis[1] process and, for this reason, the growth and combustion cycle of biomass is called "zero balance"[2].

Biodiesel is obtained by squeezing and by transesterification[3] of oily biomass such as that from soy seed and rapeseed (canola). This is the biofuel we intend to deal with in this essay. As we already said above, the use of this renewable source of energy is not necessarily favorable and it has consequences which may act at different levels. This is why the EU has commissioned extensive research aimed at understanding the variety of their impacts, while also quantifying their extent, in terms of both benefits and risks. A summary of these considerations will be presented below.

---

[1] The so called chlorophyll photosynthesis is a reaction which consists in the production of glucose and oxygen starting from the carbon dioxide in the atmosphere and from metabolic water, in the sunshine, as the following formula shows:

$$6CO_2 + 6H_2O + \text{light} \quad C_6H_{12}O_6 + 6O_2$$

[2] Balance is actually a "zero balance" when we avoid taking into consideration any other contribution to the growing of the biomass: if, instead, we contemplate the fact that vegetable and arboreal imply the use of synthetic chemical fertilizers and phytochemicals, besides agricultural machineries, irrigation pumps and means for the transportation of the produce, it all means that a large quantity of fossil fueling is needed and it produces CO_2.That brings to the conclusion that there is no real balance as there is a clear-cut production of CO_2 because of the fossil fuels which are not renewable.

[3] Transesterification consists in the transformation of an ester into another ester by means of an alcohol. Here following, see the represented model: an ester with an alcohol in reported on the left, while, on the right, find another ester plus another alcohol:

Co-funded by the Erasmus+ Programme of the European Union
Grant Agreement n°2019-1-IT02-KA203-063184

Use of biodiesel

Using biodiesel for transportation, instead of gasoline, allows a reduction of two well-known greenhouse gases emission, CO (50% reduction) and CO_2 (78,45%). The reason for the reduction can be found in the mechanism of production of the biomass itself: the carbon emitted during combustion is the one that already existed in the atmosphere, fixed by vegetables crops during their growth. The carbon is not, unlike the case with gasoline, trapped since the distant past in the Earth's crust.

Moreover, a reduction in the emission of aromatic hydrocarbons (71%) is also reported. They are natural compounds, present both in oil and in carbon, that are extremely toxic to the environment, human beings and animals as well as to flora, they are also among the substances responsible for the ozone hole.

Furthermore using biodiesel, sulfur dioxide (SO_2) emissions are almost totally eliminated. This gas, once it has entered the atmosphere, interacts with oxygen and water vapor and forms sulfuric acid[4]. This, on turn, comes back onto the earth in the form of acid rain which acidifies soils and of water resources, so causing serious damage to the natural environment in many industrialized regions.

Very important is also the reduction (50%) in the emission of particulates (fine dust). These are responsible for acute illnesses in humans' respiratory and cardiovascular systems. This is why it has become indispensable to introduce anti-particulates filters to vehicles. With respect to the greenhouse effect, instead, an increase in the quantity of particulates contributes to the increase of what is called aerosol[5], which reduces the global radiative forcing[6], partially compensating greenhouse effect.

The use of biodiesel is also associated with the increasing emissions of nitrogen oxides (NO_X) to cars' exhaust (10 - 15%), which are greenhouse gases. It is however important to stress that, by considering the

---

[4] The chain of reactions that leads to the formation of acid rain is herewith reported and discussed. Sulphur dioxide in the atmosphere SO_2 is oxidized, so forming an intermediate reaction:

$$SO_2 + OH\cdot \quad HOSO_2\cdot$$

As the intermediate is highly reactive exactly because of the unpaired electron (·), there immediately is one more reaction:

$$HOSO_2\cdot + O_2 \quad HO_2\cdot + SO_3$$

In the presence of water, Sulphur trioxide SO_3 becomes rapidly converted into Sulphuric acid H_2SO_4:

$$SO_3 + H_2O \quad H_2SO_4$$

[5] Atmospheric aerosol is composed by liquid or solid particles suspended in the air. It may form out of natural origins (ex: volcanoes) or anthropogenic (ex: emissions from industry and transport) and can influence climate in multiple complex modes, because of its interaction with the radiation and with the clouds, either in terms of cooling or in terms of warming. Altogether, models and observations indicate that aerosol of anthropogenic origin has, on average, exerted an influence of cooling on the earth since pre-industrialization, the which has partially made up for that medium global warming due to the greenhouse gases, which would have occurred in case its influence were missing. The envisaged reduction of emissions of anthropogenic aerosol, undertaken by political acts aimed at making the quality of air healthier, could, in the future, "unmask" this warming (IPCC, 2014).

[6] Radiative forcing, W/m^2, is defined as the difference between solar radiation absorbed by the Earth and the reflected radiation: a positive radiative forcer brings greater radiation into the system and contributes to its warming, while a negative one involves a larger quantity of radiation coming out and so contributing to the cooling of the system. Radiative forcing is influenced by a compound of greenhouse gases, and this is why IPCC (2014) defined it as "the influence a given factor plays in altering the balance between in-going and out-coming energy of the system Earth-atmosphere and it indicates the importance of that factor as a potential modifier in the field of climate change".

Co-funded by the Erasmus+ Programme of the European Union
Grant Agreement n°2019-1-IT02-KA203-063184

whole production chain, the biodiesel supply chain emits about 20% fewer nitrogen oxides than the oil supply chain. A number of nitrogen oxides are then reduced, among which N_2O_3 (dinitrogen trioxide) and N_2O_5 (dinitrogen pentoxide) which are water-soluble. Because of atmospheric humidity they may form nitrous acid and nitric acid, both present in acid rain.

Production of biodiesel

In order to examine the problem in a global perspective and take into account the various impacts, it is not enough to limit it to the analysis of the emissions produced in the use of biofuels but it is necessary to include an evaluation of the consequences of its production.

Biodiesel is produced in countries other than those that make use of and benefit from it, mainly in African countries (Locke & Henley, 2013).

An example of an effect of the production process is the following: the conversion of arable land dedicated to the growing of crops into areas where biodiesel is produced implies an increase of the price of raw materials in the Majority World (compared to high transport costs of food imported from other countries), resulting in the increase of food insecurity[7] both from the point of view of availability and of access to food.

Still considering the use of soils, the spreading technique of monoculture for the production of biodiesel has implied a reduction in biodiversity and has enhanced the risk of growing species of insects and bacteria which strongly damage crops. As a consequence, it causes an increase of the price of the few raw materials left. An intensive use of monoculture also raises the risk of soil erosion and the progressively increase of its vulnerability; this contributes to the increase in food insecurity from the point of view of stability, because both local economics and populations come to face times of shortage in the production of crops. The increased vulnerability of agricultural lands caused by insects and parasites also involves a larger use of pesticides which contain nitrous oxide (N_2O), a greenhouse gas that contributes also to the ozone hole.

The introduction of biomass cultivation might however support the production of crops of small landowners and land administrators, who may sell and/or hire their own lands or reach an agreement with large companies. The companies can provide technical knowledge about the production of biomass (fertilizers,

[7] In 1996, the *World Food Summit* defined food security as a situation when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). The 2009 *World Summit on Food Security* extended this definition, describing the four pillars of food security:

- availability: is the supply side of food security, determined by the level of production, stock levels and imports of food in the local area. Availability of foraged foods may also be important in certain contexts. Weather, yields, soil conditions, planting decisions, transport and storage infrastructure and a change in the trade regime can all affect availability;
- access: is the economic and physical access to available food, mainly from the household perspective. This can be from purchases, gifts or transfers of food. Households' economic access to food is determined by overall household income, disposable income for food and food prices. Ease of physical access to markets to acquire food is influenced by the proximity of markets and other food sources (fields, forests etc.) and the existence and quality of infrastructure;
- use: is the way individuals are able to consume food, which has a direct impact on nutritional status and is closely linked to feeding practices, preparation and distribution of food between household members;
- stability: is the maintenance of food security through time while an individual or household may temporarily be food-secure, outside shocks such as food price volatility, unemployment or harvest failures may undermine food security. Shifting demographics within a household, such as the birth or death of a child or other household member, may also affect the stability of food security over time.

Co-funded by the Erasmus+ Programme of the European Union

Grant Agreement n°2019-1-IT02-KA203-063184

agrochemical products, a variety of seeds), and/or adequate technological means and, in exchange, the landowners can guarantee the companies preferential treatment when buying raw material. This innovation may increase crops and, consequently, the availability of food products, thus conveniently contributing to improving food security[8], even if this would happen only to the involved social class, which means to a small part of the population.

Finally, the presence of biodiesel crops, managed by large companies, may require enhancing the building of local infrastructure (such as roads, electricity networks) paid by the company itself or by the government. This general improvement may, on turn, bring some benefits including facilitation in traveling, so also favoring working and studying opportunities, as well as an easier way of reaching market places. This would also increase both economic and physical access for people to food stock.

Bibliography and citations

Cames, M. & Helmers, E. (2013). *Critical evaluation of the European diesel car boom – global comparison, environmental effects and various national strategies*. Environmental Sciences Europe, 25(15). DOI: 10.1186/2190-4715-25-15

Casadei S., Caserini S., & Pastorello C. (2014). *Perspectives of Reduction of Greenhouse Gases Let out in Road Transportation. Climalteranti* (blog), March 2, 2014, http://www.climalteranti.it/2014/03/02/prospettive-di-riduzione-di-gas-serra-dal-trasporto-su-strada/#more-3663

Casadei S., Caserini S., & Vitullo M. (2014). *Conflicts in Polcies on Climate and Air: the Case of Diesel*. *Climalteranti* (blog), January 27, 2014, http://www.climalteranti.it/2014/01/27/i-conflitti-fra-le-politiche-sul-clima-e-sullaria-il-caso-del-diesel/

Caserini S., Vitullo M., Grassi G., & Brocchieri F. (2016). *The Proposal of European Effort Sharing until* 2030: -33% for Italy. *Climalteranti* (blog), September 15, 2016, http://www.climalteranti.it/2016/09/15/la-proposta-di-effort-sharing-europeo-al-2030-33-per-litalia/#more-5983

EEA Report (2013). *Greenhouse gas emission trends and projections in Europe 2012*. EEA Report No. 6/2012. ISSN 1725-9177

EPC (European Parliament and Council) Directive 2009/28/CE of the EPC of April 23rd 2009 about the promotion of the use of energy from renewal sources, including modification and repeal 2001/77/CE e 2003/30/CE, L 140/16, 5.6.2009, http://eur-lex.europa.eu/legal-content/IT/TXT/PDF/?uri=CELEX:32009L0028&from=IT

Giliberto J. (2016). *The Biodisel of the Future from Marghera*. *Il Sole 24ore* (periodical paper), January 16, 2016, http://www.ilsole24ore.com/art/impresa-e-territori/2016-01-16/da-marghera-bio-diesel-futuro-081452.shtml?uuid=ACjpcRBC

Hill, N., Brannigan, C.; Smokers, R.; Schroten, A., van Essen, H., and Skinner, I. (2012). *Developing a Better Understanding of the Secondary Impacts and Key Sensitivities for the Decarbonisation of the EU's Transport Sector by 2050*. Final project report produced as part of a contract between European Commission Directorate-General Climate Action and AEA Technology plc; see website www.eutransportghg2050.eu

International Energy Agency (2016). CO2 emissions from fuel combustion, (Highlights, 2016 edition). IEA Bookshop, http://www.iea.org/publications/freepublications/publication/KeyCO2EmissionsTrends.pdf

IPCC (2014). *Climate Change: Synthesis Report*.

Locke, H. & Henley, G. (2013). A Review of the Literature on Biofuels and Food Security at a Local Level. Assessing the State of the Evidence. ODI.

Ministry of Economic Development Department of the Environment and of the Tutelage of the Terrain and the Sea, Department of Transport and Infrastructure (2013). *2013 Guide to Fuel Saving Strategies and to Cars' Emissions of CO2* http://images.to.camcom.it/f/VigilanzaRegolazione/19/19961_CCIAATO_182013.pdf

[8] From Govareh J., Jayne T.S. & Nyoro J. (1999). *Smallholder Commercialization, Interlinked Markets and Food Crop Productivity: Cross-country Evidence in Eastern and Southern Africa.* Lansing, MI: Università del Michigan; cited in Locke & Henley.

Co-funded by the Erasmus+ Programme of the European Union

Grant Agreement n°2019-1-IT02-KA203-063184

Wikipedia, https://it.wikipedia.org/wiki/Biodiesel

Co-funded by the
Erasmus+ Programme
of the European Union
Grant Agreement n°2019-1-IT02-KA203-063184