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A comparison of the European renewable energy directive default emission values with actual values from operating biodiesel facilities for sunflower, rape and soya oil seeds in Italy

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ABSTRACT

The European Union (EU) set a binding greenhouse gas (GHG) emission reduction target for transportation biofuels and other bioliquids. In this study, the GHG emissions of biodiesel chain from sunflower, rapeseed and soybean were calculated in compliance with the European Union Renewable Energy Directive 2009/28/EC (RED).

Input data used for the agricultural step were referred to the Umbrian region for sunflower and rapeseed and to the Veneto region for soybean, while data obtained from the main Italian biodiesel plants were employed for the processing step. Results showed that GHG emissions were higher than default values reported in the RED for sunflower and rapeseed and lower for soybean. Only sunflower biodiesel does not reach the minimum value of GHG saving (35%). The main differences with data used in the RED concern cultivation step, while the processing step has overall the same values of GHG emissions. Finally, three case studies were examined in order to identify possible improvements to make the analyzed supply chains more sustainable.

1. Introduction

The perspective of oil depletion, the concerns of energy security and global warming are the main drivers of biofuels promotion by public authorities in industrialized countries. While full substitution of gasoline and diesel is technically possible, sustainability conditions are the bottleneck that should limit the global market share of biofuels to 10–15% in the long term [1].

The instability of oil prices and the low competitiveness of sustainable biofuels when oil prices decrease under a certain threshold claim for stable incentives in the early development of biofuels markets. Due to controversies about the energy and greenhouse gas (GHG) balances of biofuels, however, public authorities in several countries imposed minimum targets for biofuels to be eligible for incentives, i.e. sustainable biofuels.

In June 2009 the European Parliament adopted the Directive 2009/28/EC [2] as part of the new Renewable Energy Directive (RED). It amended and repealed the Directive 2003/30/EC [3] on the promotion of biofuels, that explicitly sets reference values for the share of biofuels of all fuels. In particular Directive 2003/30/EC called for a biofuel market share of 5.75% to be implemented by each Member State by December 2010. The 2009 Directive sets instead a mandatory overall target of a 20% share of energy from renewable sources

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of the EU's gross final consumption in 2020, even if not every Member State has to exactly meet this criterion. Twenty percent will supposedly be the average over all Member States. Depending on the current share of renewable energy sources, each Member State has to achieve an individual target.

The new Directive does not set targets for specific sectors, except for the transport one. The share of energy from renewable sources in all forms of transport has to be at least 10% of the final consumption of energy in transport by 2020. This does not explicitly refer to the share of biofuels and could also be achieved by electricity in cars or in rail transport. However, it is likely that this target will act as a driver for the use of biofuels, as other technologies are unlikely to reach large market shares by 2020. The new 2009 Directive establishes also sustainability criteria for biofuels that do not have a counterpart in the 2003 Directive. Biofuels not fulfilling these newly formulated sustainability criteria may not be taken into account for:

a calculating the shares of energy from renewable sources;
b measuring compliance with the targets set in the Directives;
c the eligibility for financial support for biofuels.

Among the most important sustainability criteria, the GHG emission savings from the use of biofuels or bioliquids compared to fossil fuels have to be at least 35%. From 2017 onwards these savings have to be at least 50% and from 2018 onwards 60% for biofuels produced in installations that start their production in 2017 or later.

The RED indicates the reference GHG emission values (typical and default values – Annex V, part D) for the entire production chain (cultivation, processing and transport). Typical value is an estimate of the representative GHG emission for a particular biofuel production pathway, while default value is calculated by multiplying typical value for processing emissions by 1.4. Economic operators can use default values or own actual data, applying the GHG saving calculation methodology, described in the following paragraphs, to demonstrate that their products satisfy GHG thresholds. Only for the cultivation phase, the Directive delegates to the Member States the evaluation of the GHG emissions for each area classified as level 2 in the nomenclature of territorial units for statistics (NUTS).

The aim of the present paper was to investigate if the biodiesel production from rapeseed, soybean and sunflower may be a viable alternative in Italy to the achievement of European targets. In particular, it was investigated if these chains are able to reach the minimum value of GHG saving, considering the current Italian context. For this purpose, agronomic data were referred to two NUTS 2 areas: Umbria for sunflower and rapeseed and Veneto for soybean. This choice was carried out considering both data availability and crop diffusion in the Italian territory. With regard to the biodiesel production process, data supplied by the main Italian biodiesel plants were examined.

According to the RED, each chain was divided into three steps (cultivation, processing and transport); in this way, it was possible to determine if GHG emissions from cultivation step are lower than the default value defined in the RED and if those relating to the processing step can be considered consistent for the Italian production. Especially the first comparison is important because Italy decided to apply the actual values of typical GHG emissions from cultivation to all the Italian NUTS 2 areas and all crops [4], renouncing the possibility to adopt any default values for the cultivation phase. The paper investigates if GHG emissions of the cultivation phase lower than those proposed in the Directive may occur for crops and NUTS 2 areas analyzed, allowing economic operators to simplify the calculation even for national supply chains.

2. System description

Biodiesel production system evaluated in this work consisted of three main processes: cultivation, processing and transport (Fig. 1).

For each crop the cultivation technique typical of the relative NUTS 2 area was assumed.

As regards sunflower, the soil preparation practices are constituted by a ploughing at the depth of 0.5–0.6 m after wheat harvesting, followed by a harrowing at the depth of 0.05–0.15 m in the sowing time. Sowing is generally performed from mid March to mid April, employing 6 kg ha^{-1} of seeds [5]. Rapeseed is grown in rotation with wheat, whose straw has to be removed from the field because it can lead to an excessive macroporosity at the top layer of the soil. Afterward it is necessary to refine the soil with a medium depth ploughing (0.25 m), routing and harrowing operations. Sowing is planned in the mid September with 7 kg ha^{-1} of seeds [6].

Veneto region was chosen for soybean cultivation because it accounts for 48% of the national soybean production [7]. Italian soybeans are planted from the end of April through the end of May and harvest runs from the first of October through the end of November, then oil seeds are dried and transported to the biodiesel production plant.

Biodiesel production consists of several processing steps including: oil extraction, oil refining and transesterification. Solvent extraction with hexane is considered in this study. Solvent is removed from the seed cake remaining from oil extraction while the oil is clarified and centrifuged. The crude oil obtained by solvent extraction contains impurities. Some of them, such as seed fragments and meal fines, are oil insoluble and thus can be readily removed by filtration. Others, including free fatty acids, hydrocarbons, ketones, tocopherols, glycolipids, phytosterols, phospholipids, proteins, pigments and resins, are soluble or form stable colloidal suspensions in the oil. Most of these have to be removed by chemical or physical refining processes. In this study both types of refining were considered. The main difference is related to the degumming stage, that allows to remove phospholipids. In the physical refining, degumming is carried out only with the addition of water to the oil. After a certain reaction period, the hydrated phospholipids are separated by means of centrifuges. In the chemical refining, phospholipids become flocculants by adding hot water acidulated with phosphoric acid. The next step of the