Bioenergy development in the Republic of Columbia

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Abstract. Biofuels are a mixture of organic matter that is used as fuel in internal combustion engines. Biofuel production can pose a serious threat to food security, biodiversity, and climate change if not regulated and tightly controlled. However, it is also true that in this type of initiative there are many opportunities presented in its renewable nature and its intensive work needs that need to be explored. If sustainable development becomes the policy of the biofuels industry, growth paths and opportunities can be traced for developing countries such as Colombia. Consequently, a country can take advantage of the "follower" advantages if it learns from previous experiences such as the Brazilian one. Employment and natural preservation opportunities are possible with certified product.

1 Introduction

Colombia is a country rich in natural resources with high potential for the development of the biofuel industry. Biofuel production in Colombia has been increasing due to the adoption of a series of decrees allowing the use of biofuels (in combination with gasoline and diesel). [2] The country is currently one of the main producers of sugar cane and palm oil, the main raw materials used in its bioenergy sector. Colombia is becoming not only the second largest producer of bioethanol in Latin America after Brazil, and the third largest producer of biodiesel after Argentina, but is also steadily expanding its sugar cane and palm production. It is worth to note that Colombia is ahead of the rest of Latin America in creating a regulatory framework. While other Latin American countries are just beginning to create it, in Colombia it has become a reality [3]. The country has more than 7 million hectares of land available for planting energy crops, that is, those used for the production of biofuels. This means that the boundaries of energy crop cultivation can be expanded withoutimpact of food security [4]. Biodiesel in Colombia is made from the African oil palm. It has a long-term yield, and given the favorable environmental conditions for the cultivation of the African oil palm in Colombia, its oil production from this type of raw material is widely developed in several regions of the country. It is the oil that is subsequently used for the production of biodiesel.

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Bioethanol is made from sugar cane that grows in the Cauca River region. The ideal agro-climatic conditions of the region make it possible to harvest sugar cane throughout the year. The Colombian government is supporting African oil palm and sugarcane growers by expanding irrigation areas and investing in infrastructure to make these raw materials more competitive.

The purpose of this work is to identify and analyze the external and internal factors of the development of the biofuel industry in Colombia using the example of the bioethanol and biodiesel production.

Tasks are the following:

- to give a preliminary assessment of the prospects of the development biofuel production in Colombia;
- to identify the advantages and disadvantages of bioethanol and biodiesel production in Colombia and compare them with competing countries ;
- to conduct a SWOT analysis of the development of the biofuel industry in Colombia.

2 Methods

To analyze the external and internal factors of the development of the biofuel industry in Colombia, SWOT analysis can be applied [1]. By using this method, we estimate attractiveness of biofuels as a source of energy, assess the competitiveness with biofuel producing countries, study the use of biofuel technologies. This method helps us analyze Colombia's legislation on the development and use of biofuels and assess the impact of the biofuel industry on the environment.

3 Research results and discussion

Biodiesel production depends on the supply of palm oil to the market. Colombia is the fourth largest palm oil producer in the world after Indonesia, Malaysia and Thailand [2]. Colombia is 5 times larger than Malaysia in the area of oil palm cultivation. It is Malaysia that is considered the first producer of palm oil in the world, and has a serious problem of soil fatigue, therefore, the development of new projects in the field of bioenergy is reduced and investments in the production of palm oil are increasing [5]. As mentioned in the introduction, sugarcane for bioethanol production grows in the Cauca River region. Due to its agro-climatic conditions, this region is considered one of the best sugarcane growing on the planet.

Colombia needs legislative support and a developed infrastructure for the development of the biofuel industry. Over the past 20 years, important legislative acts have been adopted that allow the introduction of biofuels mixed with gasoline and diesel. The National Fuel Alcohol Program aims to produce anhydrous alcohol, the characteristics of which make Colombia a country with exceptional opportunities to develop and enter the international biofuel market. The national government issued Law No. 693 of September 12, 2001, stating that from 2005, gasoline produced in Colombia must be a mixture of 90% gasoline and 10% bioethanol (E-10), which will reduce harmful emissions to the environment. Laws of this kind provide an opportunity for the development of a sustainable production process and biofuel infrastructure [6].

Today, according to Colombian legislation, the use of a mixture of E-20 (20% ethanol and 80% of gasoline) is recommended, however, the raw materials for the production of mixtures E-10 and E-20 are insufficient, and in Colombia there is a need to import raw materials for the production of biofuels and fuel mixtures. From March to June 2020, the price of ethanol was higher than that of gasoline, and from July to November 2020, the

price of ethanol remained at the level of gasoline, because ethanol was produced in the country and was one of the most expensive in the world in terms of pricing [2].

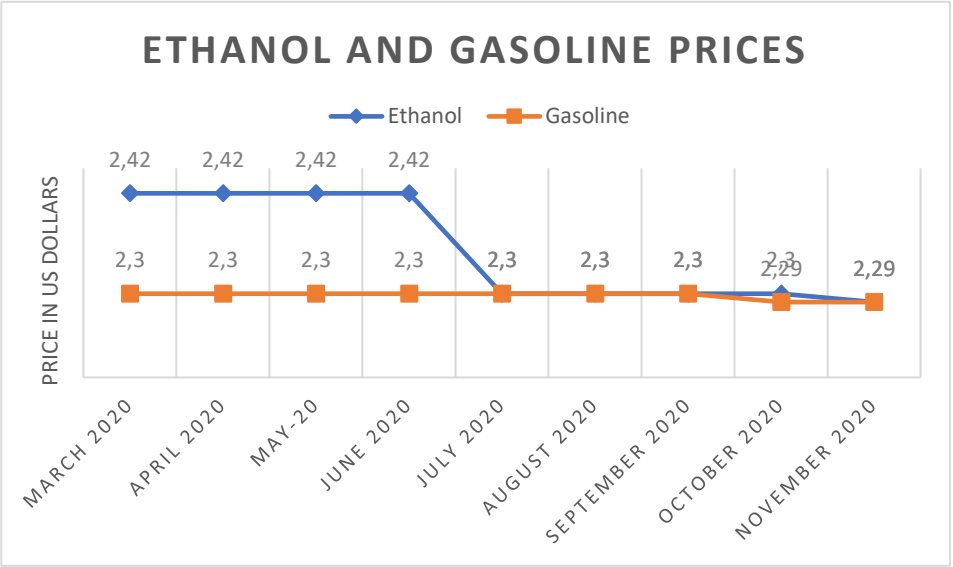

Fig. 1. Comparison of prices for 1 liter of ethanol and gasoline in Colombia in 2020 (in US dollars) [9]

Several countries in Latin America and the Caribbean are promoting biofuel policies because of the variety of raw materials and needs for their use. Biofuel production provides an opportunity for sustainable development of the region in the economic, environmental, social and technological spheres [2]. Brazil, Argentina and Colombia are among the top bioethanol and biodiesel producers in the world, according to a biofuel study published by the Economic Commission for Latin America and the Caribbean. Today in Colombia there is a deficit of B-5 biofuel in the region of 61%. This means that there is an increased demand for biodiesel in the country, but the possibilities for its production are insufficient. This deficit allows to stimulate business and entrepreneurship in Colombia for the construction of biorefineries for the production of biodiesel [2]. Biodiesel is one of the most important biofuels used as a replacement for conventional diesel. The countries of the European Union (EU) are the main producers in the world, while the largest production of biodiesel in the EU is concentrated in Germany. Research by Swiss Federal Laboratories for Material Science and Technology, Europe's most recognized environmental impact assessment organization, has shown that biodiesel produced from the oil palm in Colombia is environmentally friendly and reduces greenhouse gas (GHG) emissions by more than 83 %

Colombia's biodiesel exceeds the GHGemission reduction requirements set by the European Union and the US Environmental Protection Agency. If all existing biofuel plants in Colombia were operating at full capacity, CO_2 emissions would be reduced by about 1.8 million ton per year [13].

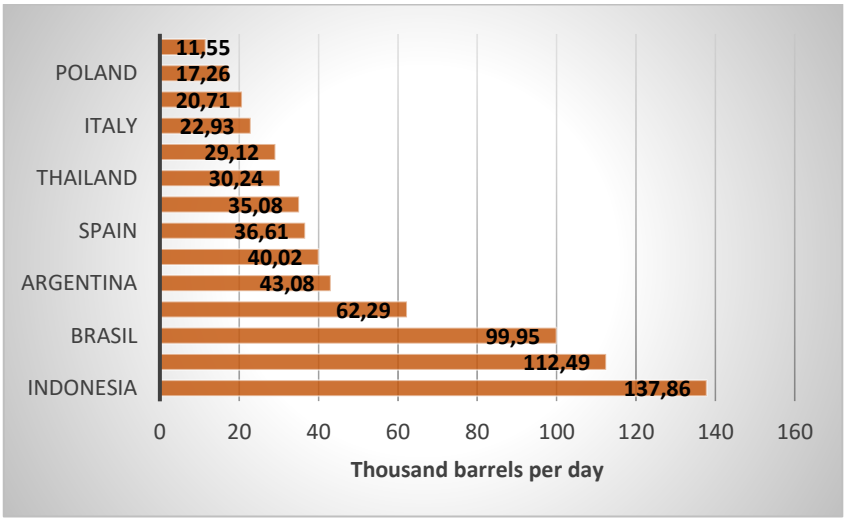

Fig. 2. Biodiesel world producers in 2019, [10] thousand barrels per day

The United States of America is the largest producer of bioethanol.They are followed by Brazil, China, EU [7].].

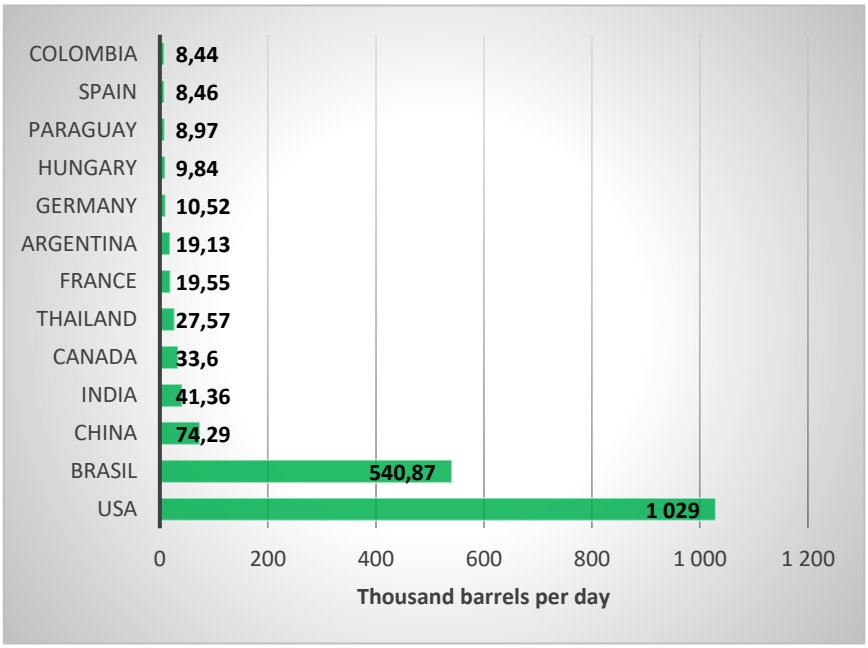

Fig. 3. World producers of bioethanol in 2019 [11], thousand barrels per day.

The production of bioethanol from sugar cane is of high standard. It requires a well-paid workforce, and there are also more severe environmental restrictions than, for example, in neighboring Brazil. For example, in Colombia, the formation of the same amount of compost and waste from ethanol production is unacceptablecompared with Brazil. Companies must maintain tight control over the generation of this types of waste and therefore invest more in waste recycling production processes. The production of biodiesel and bioethanol from energy crops reduces GHG levels and environmental pollution

compared to the production of traditional fuels. However, according to estimates of the life cycle of biofuel production, only the cultivation of energy crops in agricultural areas can cause serious damage to the environment [8]. Food competition is another negative factor in the production of biofuels from crops. The demand for agricultural products is increasing, and, consequently, prices are growing. High pricing benefits farmers who make money by selling their crops. Consumers are forced to pay more for food. In poor and developing countries, higher food prices lead to an increase in hungry populations. Higher prices for some crops are causing other problems. To seize the opportunity for price increases, farmers around the world are looking to convert their food crops into production crops. As much of the arable land in North America and Europe is already used for food production, biofuel agriculture is expanding into tropical regions in Brazil, Colombia and Indonesia, where large areas for energy crops are still available. The problem is that a significant part of these areas are covered with tropical forests. When they are cleared to create agricultural land, farms and ranches, dead trees release carbon dioxide and other greenhouse gases into the atmosphere (in amounts equal to burning fossil fuels). In addition, the destruction of tropical forests leads to the displacement of indigenous people and the death of many species of plants and animals. This is how the cultivation of crops for biofuel production has a negative impact on the environment [6].

However, if energy crops are grown on abandoned agricultural land and areas not covered by natural ecosystems, they may have less environmental impact and greenhouse gas emissions in the case if assumed that fertilizers and pesticides are not overused for cultivation [8].

Table 1. SWOT-analyses of biodiesel in Columbia

Strong sides	**Weaknesses**
Developed infrastructure Large scale production Rich raw material bas	Significant production costs Environmental restrictions The need for the export of raw materials
Opportunities	**Threats**
Interest from business objects Biofuel demand growth prospects Attracting investment	Impact on biodiversity Rising prices for food crops Environmental pollution

4 Conclusions

Colombia is currently a country that has great potential in its biofuel sector. Colombia's climate, territory and raw material reserves allow for the production of biofuels in quantities that allow Colombia to take a leading position in the global biofuel market. The biofuel manufacturing sector enjoys the backing of the Colombian government and several laws to help develop it. One of the weaknesses of the biofuel sector in the country is the price of biofuels versus gasoline. Bioethanol prices in Colombia are some of the most expensive in the world, and this greatly affects its widespread use compared to gasoline. Colombia is highly competitive in terms of palm oil production as it has ideal weather conditions and large areas for growing oil palm. Also, the oil palm provides the highest yields of all oilseeds per hectare of land. Colombia has more laws than other countries that allow biofuels to be produced from agricultural waste. This is an advantage at the environmental level, but it is also a limitation at the industrial level, since it is impossible to produce enough biodiesel or bioethanol for supply to the country. In conclusion, it can be added that the current situation in the biofuels sector in Colombia has grown strongly in a very short time, this has led to significant growth in this sector and positions Colombia as

one of the countries in Latin America with the most development in the biofuels sector, together with Brazil and Argentina.

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