Socioeconomic Implications of Biofuels Deployment through an Input-Output Approach. A Case Study in Uruguay

Lechón, Y.[1*], de la Rúa, C.[1,2], Rodríguez, I.[1] and Caldés, N.[1]

1= CIEMAT. Avda Complutense 40 28040 Madrid

2 = Technical University of Munich. Chair of Renewable and Sustainable Energy Systems. Lichtenbergstr. 4a. 85748 Garching b. München. Germany

Abstract

Some countries in the world aim to increase biofuel production and consumption as a way to decarbonize the transport sector and transit to a low carbon economy. Besides their potential environmental advantages compared to conventional fuels, biofuels may also bring other socioeconomic benefits. Using the Input-Output Analysis, this study has looked at the socio-economic impacts associated to the biofuels targets established in Uruguay by estimating the associated gross and net effects on production of goods and services; value added and job creation categorized into rural and non-rural. Next, the impacts on the Uruguay's balance of payments, energy security and tax revenues have been estimated and added to the previous effects. When it comes to value added, bioethanol from sugarcane ranks first among the considered biofuels with 431 million $US\$_{2018}$, followed by bioethanol from sorghum and biodiesel. As to job creation, around 34,000 full time new jobs are created as a result of sugarcane bioethanol, twice as much as from biodiesel. Of these figures, rural employment share represents a 13% and 6% in the case of sugarcane bioethanol and biodiesel respectively. On concluding result from this study is that while biofuel production costs in Uruguay are higher than fossil fuel , when the economic effects on tax revenues and balance of payments are added to

[*] corresponding author details: yolanda.lechon@ciemat.es

the previous socio-economic impacts, the total benefits from biofuels compensate the extra costs. However, this situation may be altered in the future as a result of changes in biofuel production costs, fiscal policies as well as import and export prices variations.

Highlights

- Biofuels production and consumption in Uruguay bring large socioeconomic benefits
- Highest value added and employment (total/rural) impacts from sugarcane bioethanol
- Tax collection from sorghum bioethanol is four times higher than from biodiesel
- Balance of payment from biodiesel is four times higher than from sorghum bioethanol
- Positive effects in energy security are higher for biodiesel than for bioethanol

Key words: biofuels, socio-economic impacts, input-output analysis, employment creation, Uruguay

Word Count: 8,235

List of abbreviations:

ALUR: Alcoholes del Uruguay

ANCAP: Administración Nacional de Combustibles, Alcohol y Portland

ANII: national Agency for Research and Innovation of Uruguay

COMAP: Investment Law Enforcement Commission

DAP: Di-ammonium Phosphate

DDGS: Distillers dried grains with solubles

DNE: National Energy Directorate

FTE: Full time employee

GDP: Gross Domestic Product

GHG: Greenhouse gas emissions

GJ: Giga Joule

iLUC: Indirect land use change

IO: Input-Output

IOT: Input-Output table

IRENA: International Renewable Energy Agency

ktoe: thousand tonnes of oil equivalent

NO_x: Nitrogen oxides

PJ: Peta Joule

$PM_{2.5}$: Particulate matter of diameter lower than 2.5 microns

PM_{10}: Particulate matter of diameter lower than 10 microns

RED: Renewable Energy Directive

SO_2: Sulphur dioxide

TJ: Tera Joule

VOC: Volatile organic compound

1. Introduction

Bioenergy is expected to play an important role towards climate change mitigation and transition to a low carbon economy. Specifically, biofuels production is considered a suitable and available alternative to decarbonize the transport sector in the short term [1]. As a way to support its deployment, targets for biofuel production are included in the current European policies [2] and also in other countries around the world [3–5].

Apart from the environmental benefits, biofuels production and consumption are likely to have important direct and indirect socio-economic effects [6,7]. Among others, bioenergy may induce job and income creation, improve energy security –through reduction on fossil fuel import dependency and increased diversification- and improve health conditions [8,9]. Biofuel production may create new employment and business opportunities along the supply chain [10]. Furthermore, many activities take place in rural areas that are traditionally characterized by high unemployment rates. According to IRENA’s estimations, after solar photovoltaics with a total of 2.7 million jobs in 2016, liquid biofuels, solid biomass and biogas were the largest employers among renewable energies, most of them concentrated in feedstock supply in Brazil, China, the United States and India [11].

However, biofuels chain activities may displace other economic activities and their associated jobs as they compete with other types of agricultural production [12,13]. Therefore, it is important to acknowledge and estimate not only the gross effects of bioenergy production and consumption on the economy and employment but also the net effects. In this sense, a net increase in employment and income generation is more likely to occur when bioenergy makes use of formerly idle factors such as land, capital or labour, than when it displaces these factors from other activities [14].

There exist several methodologies to estimate the socio-economic implications of bioenergy and the selection will depend on the type of question that wants to be answered [15]. Most literature related to the estimation of socio-economic impacts from biofuels use input output modelling (gross or net) to estimate the effects on the economy and the employment created [16,17] while fewer studies investigate the effects on imports reduction, increased energy security and energy supply diversification [18].

Often, when decision or policy makers assess the implications of biofuel support policies, such socio-economic effects are neglected. However, these effects are utterly important in a social cost benefit analysis [19] as they can (partially) compensate the higher costs that biofuels have compared to their fossil counterparts. The social cost benefit analysis framework answers the fundamental question of whether or not the society is better off as result of any given investment or policy [20]. Thus, when considering alternative energy investments, quantifying and monetizing their implications should help energy policy makers identify and promote the energy projects, which maximize social welfare. For this reason, in order to compare the external effects with each other, and with private costs, it is convenient to express them in a common monetary unit. External costs or benefits can be easily considered in a cost-benefit analysis or be internalized through the appropriate environmental policy instruments [21].

To address some of the issues and challenges introduced in this section, the work presented here proposes a set of methodologies to assess the socioeconomic implications of biofuel promotion policies. This methodological framework is later validated through its application to a case study in Uruguay. This work contributes to enlarge the existing literature around biofuels in several ways. The first novelty resides on the extension of the traditional input-output analysis to cover other socio-economic impacts. Despite the relevance of these alternative impacts for policy makers and society in general, they are not frequently included in these types of studies. The paper applies this extended approach to estimate a wider range of socio-economic impacts stemming from biofuel support policies (gross and net effects on production of goods and services; value added creation, rural and non-rural job creation in monetary terms; impacts on the balance of payments, energy security and tax collection). Furthermore, the authors apply and validate the proposed methodology to a concrete case study. For this purpose, the authors have gathered new and original data in Uruguay.

The rest of the paper is structured as follows: After this introduction, section 2 describes the methodologies used to assess the various socio-economic impacts considered in this study and also defines the particularities of the case study. Next, section 3 presents and discusses the obtained results and, finally, section 4 presents the policy recommendations and some concluding remarks.

2. Material and methods

2.1 Socio-economic aspects considered

This paper has made an attempt to propose methodologies to assess a fairly complete set of relevant socio-economic implications of biofuel production activities. However, as shown in table 1 below, some factors have not been considered in the case study due to, among other reasons, the lack of sufficiently detailed data or the need to use more sophisticated methodologies that are out of the scope in this work. Examples of such alternative methods include General Equilibrium Models as used in [8] and [22].

Table 1 includes a summary of possible socio-economic effects from biofuels penetration in Uruguay indicating whether such effect can be considered as a social cost or a benefit. Additionally, it includes the selected indicator that could be used to quantify such effect, whether or not it has been monetized in this study and, finally, if it has been incorporated in the cost-benefit analysis. The remaining of this section introduces the various methodologies that have been used to quantitatively estimate the effects presented in the table.

Table 1. Socio-economic indicators included in the analysis

Relevant factor	**Cost (-) or benefit (+)**	**Indicator**	**Monetized (Y/N)**	**Methodology**	**Considered in the case study (Y/N)**
Economic activity	Positive effect	Value added	Y	Input Output analysis	Y
Employment	Positive effect	Jobs created	Y	Input Output analysis and monetary valuation of employment	Y
Decentralization	Positive effect	Jobs created in rural areas	Y	Input Output analysis and monetary valuation of rural employment	Y
Tax revenue	Positive effect	Tax revenue from the biofuel/fossil fuel chain activities	Y	Identification of relevant taxes and Quantification of tax revenues	Y
Balance of payments	Public benefit	Imports/exports	Y	Identification of imported and exported goods and quantification of monetary implications	Y
Energy security	Public benefit	Energy imports	Y	Identification of energy imports	Y
Technology costs	Positive	Investment and	Y	Financial	Y

	effect	Operation costs of the technology		analysis of the production process	
Price effects	N/A	Goods and services´ prices	Y	General equilibrium models	N
Gender issues	N/A	Number of women employed in the value chain	N	Surveys	N

2.2 Input Output methodology to estimate the effects on value added and job creation

In this work, the input-output analysis is proposed as the methodology to estimate the effects that biofuels will have in terms of value added and job creation on all the sectors of the economy . This methodology measures how changes in the demand for goods and services affect economic activity and the creation of employment in a given area of study [23,24]. In addition to assessing the total impact, the net impacts on the economy and employment- that is considering the displacement effects produced by the substitution of fossil fuels by biofuels in the country- must be estimated [25].

Input-Output (IO) methodology allows analysing trade relationships of economic sectors through the use of Input Output Tables (IOTs). The input-output (IO) analysis began as a method to analyze national or regional economies as interconnected systems of industries that affect each other directly or indirectly.

Input-output (IO) analysis was first developed by Wassile Leontief, who represented the inputs required to produce a unit of output in each economic sector based on the accounting surveys from industries and companies in a symmetrical tables called IO Tables [26]. The IO tables comprise two main components, the inter-industry flows or transaction matrix, which describes the flows from sector i to sector j, and the final demand. Intermediate goods and services are those which will be further processed by other sectors. The following table represents the main components of an IO table.

Table 2: Structure of a simplified national input-output table

		Processing sectors (intermediate demand)				Final demand	Total output
		1	2	…	n		
Processing sectors	1	z_{11}	z_{12}	…	z_{1n}	Y	x
	2	z_{21}	z_{22}	…	z_{2n}		
	…	z_{31}	z_{32}	…	$z_{..n}$		
	N	z_{n1}	z_{n2}	…	z_{nn}		
Payment sectors	Value added	v_1	v_2	…	v_n		
	Import	m_1	m_2	…	m_n		
Total outlays		X					

Total output from one sector is described by the following Eq.1- Eq.5:

$$x_i = z_{i1} + z_{i2} + \cdots + z_{in} + y_i \qquad \text{Eq.1}$$

This equation will be set for all sectors included in the IO table and can be described using matrix notation:

$$x = \begin{bmatrix} x_1 \\ \cdots \\ x_n \end{bmatrix}; \quad Z = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix}; \quad y = \begin{bmatrix} y_1 \\ \cdots \\ y_n \end{bmatrix} \quad \text{Eq.2}$$

where x is a vector that expresses the total output, Z is the IO matrix and y is the final demand vector.

Leontief normalized the cost requirements by sector through the technical coefficients which are denoted as:

$$a_{ij} = z_{i1}/x_j \qquad \text{Eq.3}$$

The technical coefficients can be expressed as a matrix, as well, and by substituting z_{ij} in equation 1 for the technical coefficients, the total output can be defined by the following matrix equation:

$$x = Ax + y \qquad \text{Eq.4}$$

Reorganizing equation 4, following expression is obtained:

$$x = (I - A)^{-1}y \qquad \text{Eq.5}$$

where $(I - A)^{-1}$ is the Leontief inverse matrix, or the multiplier matrix, that expresses the total production of each sector required to satisfy the final demand. That is the direct and indirect requirements per unit of final demand. The multiplier effect is defined as the ratio between the total production X and the demand Y and can be seen as the impact that an increase in final demand has on total production.

Thanks to the IO analysis, it is possible to analyze the economic impacts in an economy derived from a change in the final demand of goods and services, such as new infrastructure development and planning. Complementing the IO tables' information with sectorial employment or value added creation data, the IO analysis allows estimating the employment impacts and effects on Gross Domestic Product (GDP) associated to any given investment in any sector or industry together with its upstream sectors or industries that are directly and indirectly stimulated. Because of this reason, it is also a useful analysis to show the leakages effects between sectors.

To include any extension environmental or social-, it is necessary to consider an additional matrix or vector that provides the amount of employment or the value added generated by each activity sector per monetary unit of output is required. Including this vector into equation 5, the resulting expression for the quantification of these effects is:

$$e_i = l_i(I - A)^{-1}y \qquad \text{Eq.6}$$

where l_i is the vector describing the direct impacts coefficients (per unit of output) and $e_i$is the total impact , direct and indirect, associated to the total output that satisfies the final demand.

With this tool it should be possible to analyze the potential impacts associated with a change in the final demand. However, due to the limited number of sectors included in the IO databases, it is not possible to assign the final demand required by the project to one unique sector, which would produce or fulfil the demand (in this case biofuel production sector). In order to avoid this aggregation problem, an alternative approach has been adopted by defining all goods and services required to produce biofuels. The final demand vector describes then the technical coefficient for each biofuel, as an intermediate sector but is treated exogenously as a final demand. The estimation of the biofuel expenditures used in the case study is shown in Table 4.

In this case study, the IO matrix of the Uruguayan economy has been used. The Uruguayan Central Bank is the body in charge of preparing the input-output matrix in Uruguay. The last published matrix refers to the year 2005 and contains information, in thousands of Uruguayan pesos, for 56 industrial activities and services, including four sectors related to agricultural activities. From this table, the technical coefficients for each economic activity have been calculated as an intermediate step required to obtain the Leontief inverse matrix. Only the domestic demand excluding imported products in the analyzed biofuels' chains has been considered.

Input Output analyses are not initially aimed to estimate future effects, since they are based on statics IOTs [25]. For this reason, these tables are better suited to represent mature technologies which production structures are not expected to dramatically change in the mid-term. Biofuels production sector in Uruguay is at its first stage of industrial development and the most updated IO Table in Uruguay does not account its inputs and outputs in a specific activity sector. When the sector will be accounted in future tables, some effects, such as substitution of goods and services, might appear due to differences in prices of similar goods and services, leading to a new structure of inputs and outputs in the other economic sectors and activities. One possible solution to estimate these adjustments is the use of a price Input-Output model. However, results will suffer from a higher degree of uncertainty. As this is not a desirable effect, this work has implemented some measures to overcome these limitations.

Instead of creating a new sector for biofuels production in Uruguay, the activity has been considered as an exogenous demand, avoiding assumptions concerning how biofuels will be distributed among other economic activities and any other effect in the production structure of other economic sectors. By doing so, we go one step backwards in the supply chain, losing some additional effects but gaining certainty. Furthermore, apart from the estimation of the total socio-economic effects of biofuels production, as an exogenous final demand; also the net effects are assessed, in the same way, as an exogenous impulse. In this sense, the effects of biofuels production on the mid-term are considered but the uncertainty is reduced.

In order to calculate the impacts on employment in Uruguay, an employment vector to be used in eq 6 is required. In order to construct this vector, the sectorial employment average data referring to the years 2012, 2013 and 2014 obtained from the Microdata of Continuous Household Survey, published by the National Institute of Statistics of Uruguay, have been used [27]. The employment vector reflects the relationship between the number of full time employees in each sector of the economy and the total production of each sector in the reference year. For this relationship to better reflect the current situation, the vector has been constructed considering the average production by sectors from 2012 to 2014.

In the Input Output Matrix of the Uruguayan economy, the value added is represented by the rows:

- D.11 Wages and salaries
- D.12 Social contributions from employers
- D.21 - D.31 Taxes less subsidies on products
- D.29 - D.39 Taxes less subsidies on production
- B.2 Gross operating surplus
- B.3 Gross mixed income

The sum of the value that appears in these rows for each of the sectors represents the value added of each sector and can be expressed as a % of the total production of that sector. This is the way in which the value added vector to be used in eq. 6 has been constructed. Employment and value added vectors are provided in Annex A.

An important aspect when valuing job creation is the location of such employment. In the case of biofuels production and unlike fossil fuels production, virtually all economic activity and job creation generated throughout its life cycle takes place domestically.

Furthermore, a fraction of such job creation usually takes place in disadvantaged rural areas where job creation and increased economic stimulation have a greater value for society.

It is important to highlight that the consideration of job creation as a social benefit will depend on the labor market conditions of the region or country considered. In other words, if there is an efficient labor market in which there is no unemployment (only the natural rate of unemployment), the generation of new jobs cannot be considered as a social benefit. On the contrary, if the country faces an inefficient labor market in which there is an unemployment rate higher than the natural rate of unemployment, there exists a positive social and economic impact since any new job implies that the Government will not have to be spent more money in unemployment subsidy. Therefore, in the event that the impact on net total employment is positive and there is an unemployment rate above the natural rate of unemployment, the creation of new jobs from biofuels should be treated as a positive externality.

As for value added creation, it is already expressed in monetary terms and should be considered as a social benefit. On the contrary, job creation results must be monetized in order to be considered in a social cost benefit analysis. In this regard, the valuation in economic terms of the jobs created throughout the biofuels life cycle is estimated considering the government savings resulting from the avoided unemployment subsidy.

In the case study application, and following this approach, the amount that each unemployed worker would receive in the form of unemployment subsidy in accordance with Law No. 18.3993 [28] has been used. When the unemployment rate is higher than 5%, the new employees are assumed to get back into the labor market and stop receiving the unemployment subsidy. In Uruguay, the 2015 average unemployment rate was 7.5% [29] and, in the absence of sectoral data, the general unemployment rate has been used as reference. Taking into account the average remuneration of each sector of the Uruguayan economy and the number of jobs generated during the lifetime of the plant across all economic sectors, the total saving for the government has been calculated.

Within the creation of total employment (direct, indirect and induced), it is appropriate to distinguish between rural and non-rural areas. This distinction is justified because society positively values rural job creation as a way to reverse the migration flows from rural to urban area in order to achieve a more prosperous life. In order to identify those rural jobs, those sectors that mainly develop their activity in the countryside are identified. In the case of the Uruguayan economy those sector are sectors A01111, A01119, A01120, A01130, A01211, A01219, A01220 and A02000[†]). Thus, the employment generated in rural areas is considered as an additional societal benefit to the one previously estimated. The value that each country attributes to job creation in rural contexts can be used to value the rural employment in monetary terms. In this case study and according to official sources of the Investment Law Enforcement Commission (COMAP) of the Ministry of Economy and Finance, the Uruguayan government values 1.15 times higher the employment created in rural areas than in non-rural areas.

The evaluation of socio-economic external effects has to be carried out quantifying the expected net effects resulting from the replacement of conventional fuels by biofuels to

[†] A01111: Rice and related agricultural services; A01119: Other cereal crops and related agricultural services; A01120: Vegetables and legumes crops and related agricultural services; A01130: Fruit trees, vineyards and related agricultural services; A01211: Milk and dairy products elaborated on farms and associated services; A01219: Cattle rising (except for milk production) and associated services; A01220: Birds and eggs production and associated services; A02000: Wood and other forest products and associated services

properly take into account the displaced activities.Socio-economic effects associated with the creation of added value and employment generation include the effects produced by the necessary investments and the activity expenditures of the plants that produce biofuels. The socio-economic effects resulting from the fossil fuels that are no longer produced and consumed because of the introduction of biofuels in the market must be subtracted.

Furthermore, the introduction of bioethanol or biodiesel in the fuel market would foreseeably reduce the consumption of gasoline or diesel, respectively. The production of these fossil fuels also has associated socio-economic externalities in terms of added value and jobs. In this context, the substitution dynamics is not always easy to define. Gasoline for example, which is produced in the country's refineries, is just one of the petroleum products produced simultaneously in the refinery when refining crude oil. Thus, the reduction of gasoline consumption does not necessarily imply a reduction in gasoline production or refinery activity, since the demand for products that are produced simultaneously - diesel, fuel oil, etc. - remains. This would cause the effects of displacement in the refining sector to be reduced. It is possible that the gasoline that was left to be consumed was destined for export instead of reducing the activity of the refinery, which would require an analysis of the receiving markets.

On the other hand, the introduction of biodiesel in the fuel market would foreseeably reduce the consumption of diesel. In some countries like Uruguay, the demand for diesel is what determines the refinement of crude oil. Therefore, a reduction in diesel consumption implies a reduction in the activity of the refinery. However, the demand for products that are produced simultaneously in the refinery - gasoline, fuel oil, etc. ... - remains. This effect would result in an increase of imports of these products. It is also possible that diesel fuel that was not consumed was used for exports instead of reducing refinery activity, which would also require an analysis of the receiving markets.

In any case, it would be necessary to carry out a detailed analysis of the petroleum products market and the operation of the refining sector in the country in order to estimate the marginal effects of this reduction in diesel consumption. In this work, as a preliminary estimate of the net effects, it has been considered that biofuels perfectly replace fossil fuels when it comes to its energy content. Thus, in order to estimate the net effect of biofuel deployment in Uruguay, the added value and employment derived from the production of 1 liter of gasoline or diesel have been quantified following the same approach as in the cases of bioethanol and biodiesel. Next, such effects have been subtracted from those calculated for bioethanol or biodiesel and thus net effects have been obtained.

2.3 Methodologies to estimate the effects on tax revenues, balance of payments and energy security

Following [30] and [31], the impact on tax revenues resulting from the deployment of biofuels in Uruguay has been estimated. For this purpose, the estimated total increase in GDP associated to biofuel deployment by sector as well as the tax related information by sector included in the final rows of the input-output table of Uruguay have been considered. Moreover, information on the specific taxation scheme of the biofuel company and the personal income tax in Uruguay have also been used. As a result, the following impacts have been estimated: a)Taking into account the increase in total added value by sector associated to biofuels during the analyzed period and the information on tax revenue by sector displayed in the input-output tables, the following impacts have been estimated: (i) the increase in the tax revenue on national goods and services, (ii) the increase in tax revenue on imported goods and services, (iii) workers´ social contributions and (iv) tax revenues minus production subsidies.

b) Tax revenue resulting from the biofuel company's business activity.

c) Tax revenue resulting from Personal Income Tax. For this, the contribution to the GDP resulting from biofuels production and the estimation of the percentage of income tax by GDP (2.2%) can be considered. As a result, the tax revenue associated to the income tax can be estimated.

In order to take into account the net fiscal contribution, the aforementioned calculations for fossil fuels have also been undertaken. The only difference between biofuels and fossil fuels is found in the second step. This is due to the fact that there is already an economic sector that includes this activity and only the corresponding taxes should be taken into account.

In order to take into account the impact that the introduction of biofuels will have on the balance of payments, the authors propose to consider the amount of raw materials, fossil fuels and biofuels that would be consumed and avoided annually in the analyzed scenario. In addition, the goods and services that would not be imported and those that would be exported as a result of the substitution of fossil fuels by biofuels -taking into account the whole life cycle and also the by-products generated-, would also be considered. As an illustration of this approach, Table 3 shows the products imported or exported and the considered net effect in the case study of biodiesel and sorghum bioethanol production in Uruguay.

Table 3. Imported and exported goods included in the analysis

Biodiesel		Sorghum bioetanol

Effect	Products	Effect	Products
(-) import	Imported diésel	(-) import	Imported gasolina
(-) import	Glycerine commercialization in the domestic market substituting imported coke	(-) import	Distillers dried grains with solubles (DDGS) commercialization in the domestic market substituting imported animal feed
(+) export	Glycerine commercialization for export		
(-) import	Protein meal commercialization in the domestic market		
(+) export	Protein meal commercialization for export		
	Transformation inputs		Transformation inputs
(+) import	Methanol	(+) import	Enzymes (alpha amylase)
(+) import	Potassium methylate	(+) import	Enzymes (glucoamylase)
(+) import	Citric acid	(+) import	Enzymes (protease)
(+) import	Cleaning agent	(+) import	Yeasts
(+) import	Antioxidant	(+) import	Urea
(+) import	Additives	(+) import	Di-ammonium Phosphate (DAP)
(+) import	Cellulose filters	(+) import	Antifoam
		(+) import	Antibiotic
		(+) import	Chemicals for treating water
		(+) import	Dispersant
		(+) import	Sodium carbonate
		(+) import	Sodium Chloride (NaClO2)

Preserving energy security in a context of fossil fuels dependence from geopolitically unstable countries entails, for many countries, a high cost [32]. For this reason, the improvement in energy security through the promotion of domestic renewable technologies, can lead to substantial geopolitical benefits and costs savings.

With regard to the risks associated with current fossil fuel import dependency, the literature distinguishes between short and long-term risks [33,34]. Short-term risks are generally associated with shortages in supply caused by accidents, terrorist attacks, extreme weather conditions or falls in the supply network. On the contrary, long-term risks tend to refer to imbalances in the structure of the energy supply, inadequate infrastructure to supply markets and lack of the adequate regulatory and institutional framework to avoid supply disruptions.

According to [35], the risks associated with energy insecurity can have a different nature:

• Technical risks: include system failures due to adverse weather conditions, lack of capital investment or inadequate maintenance of the energy system.

• Economic risks: they refer to the imbalances between the demand and the energy supply.

• Political risks: referred to government decisions to suspend energy supply for political reasons, armed conflicts, civil unrest or failures in energy regulation.

• Environmental risks: they refer to the possible damages generated by accidents (spills or nuclear accidents) and polluting emissions, including greenhouse gas (GHG) emissions.

Among the different measures that governments implement to mitigate such risks, the promotion of renewable energies plays a prominent role as it reduces environmental risks –such as climate change and damage in the event of an accident-. Additionally, the generation of energy domestically reduces the dependence on geopolitically unstable countries and reduces political risks. In economic terms, biofuels can contribute to fix balance-of-payments disadjustments and reduce the volatility of energy prices, highly dependent on the evolution of oil prices. Therefore, one way to economically assess the impact that biofuels can have on aspects related to energy security is to estimate the cost reduction associated with the measures that governments implement to face the different risks of energy insecurity. In the case of Uruguay, the government does not incur in any cost related to energy security protection measures. As such, and following the same methodological approach followed by Santamaría *et al* for the Spanish case study [36], the impact of biofuels deployment on energy security has been approximated by estimating the fossil fuels imports savings.

3. Calculations. Case study

The biofuel chains considered in this work are the production of: (i) bioethanol from sugarcane, (ii) bioethanol from sorghum, and (iii) biodiesel from a mixture of vegetable oils, waste oils and animal fats. Economic data on these production processes were provided by ALUR and the National Energy Directorate (DNE).The study analyzes the production of bioethanol from sugarcane in a production plant of the company Alcoholes del Uruguay (ALUR) and located in Bella Unión (Uruguay) [37].Sugarcane is cultivated by farmers of the region and processed to produce ethanol and refined sugar. The plant has a co-generation system for electricity and steam, which burns wood chips and bagasse. This energy is used in different production processes of the plant. The surplus electricity is sold to the National network. Besides the production of sugar and ethanol, two other products are obtained, vinasses and compost. In some cases, they are considered as waste and must be treated as such but they may also have other alternative uses. Although the vinasses obtained from the process are currently applied as fertigation and the compost is used to improve the structure of the cultivated soil, in this study it is considered waste‡.

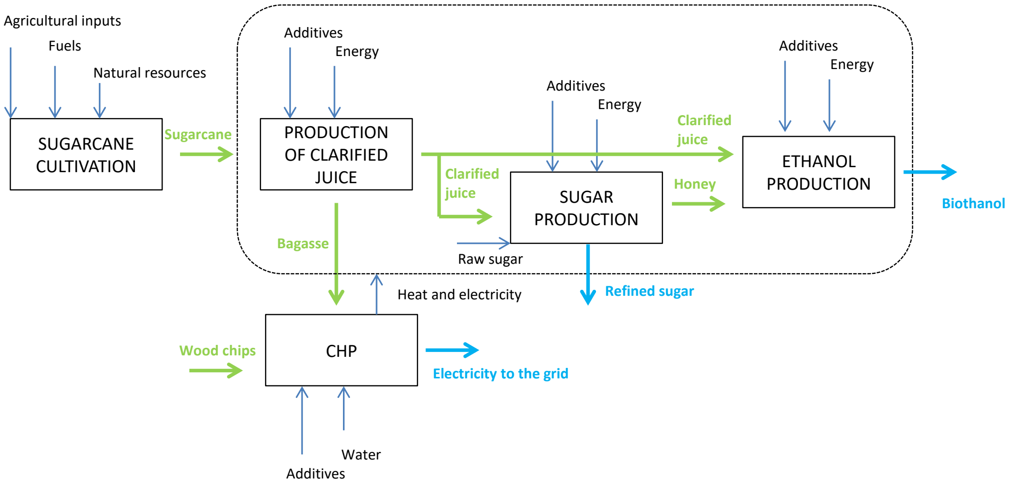

Figure 1. Description of the production stages, main requirements and main co-products of sugarcane bioethanol production

Bioethanol is also produced from sorghum in a plant also owned by ALUR and located in Paysandu (Uruguay) [38]. Apart from bioethanol, the plant coproduces Distillers Dried Grains with Solubles (DDGS) that are used as animal feed.

‡ Currently, the vinasses are applied as fertilizers and the compost is used to improve the structure of the cultivated soil. However, this is a particular situation that is expected to change in the short term, as their discharge in the environment can contaminate soil and groundwater due to their salts, metals and dissolved solids content [56]. Therefore, the study does not consider them as co-products but as waste.

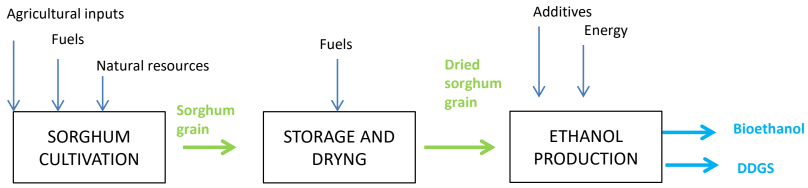

Figure 2. Description of the production stages, main requirements and main co-products of sorghum bioethanol production

ALUR produces biodiesel in two industrial plants. Plant 1 is located in Paso de la Arena [39] and has been operating since 2010. Plant 2 is located in Capurro [40] and has been in operation since 2013. Both plants use the same mixture of raw materials to produce biodiesel: 15% of rapeseed oil, 53% of soybeans oil, 30% of animal fat and 2% of waste oil. Apart from biodiesel, the plants produce glycerin as a co-product. Vegetable oil and animal food are obtained in the oil extraction and rendering processes.

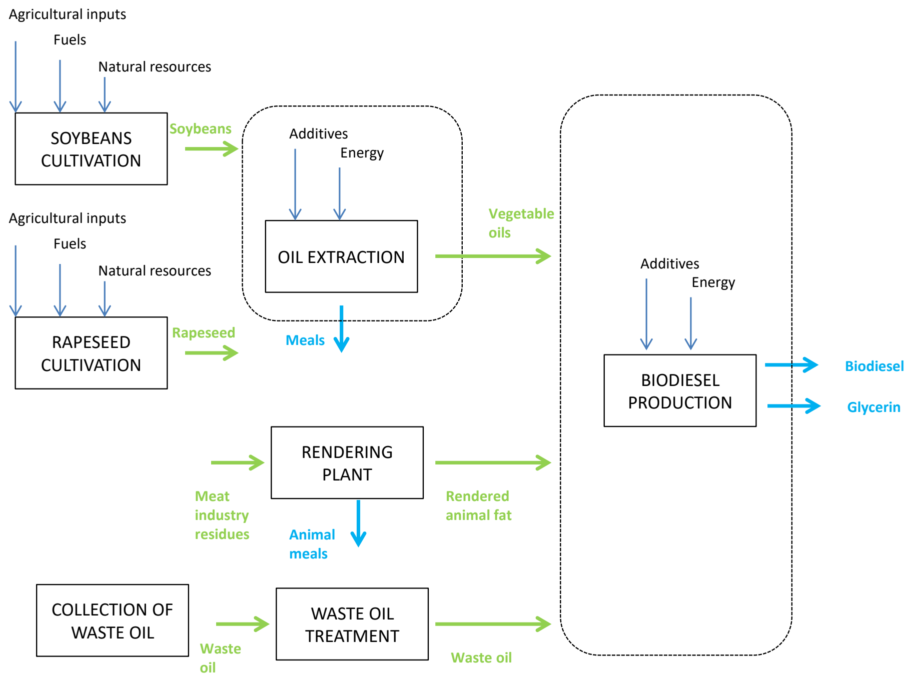

Figure 3. *Description of the production stages, main requirements and main co-products of soybean oil biodiesel production*

Uruguay aims to increase biofuel production as a strategy to decarbonize its transport sector. Law 18.195 [41] promotes and regulates the production, commercialization and use of biofuels. It mandates a 5% bioethanol blend after 2015 and 5% biodiesel blend starting in 2012. Furthermore, the government mandates that such targets must be fulfilled with locally produced biofuels. The assessment of externalities and other effects has been performed for the period 2007 to 2033 under a biofuel penetration scenario that results from this policy objective:

Table 4. Biofuel penetration scenario (2007-2033) (m^3)

	2007	2008	2009	2010	2011	2012	2013	2014	2015-2033
Sugarcane bioethanol	26,970	26,970	26,970	26,970	26,970	26,970	26,970	26,970	26,970

Shorgum bioethanol	0	0	0	0	0	0	0	0	35,288-45,000
Biodiesel	0	0	25	10,983	18,234	20,455	34,110	44,886	59,540-65,912

Concerning the production of agricultural raw materials for biofuel production, the following hypotheses have been considered:

- In the case of soybeans, the production of soybeans for biodiesel production is not considered an additional demand, given that the price paid by the producer of biofuels –ALUR- is the same as for the export. Second, the area of soybean that is grown in the country is assumed to be the same as if there were no biodiesel production and the soybeans used by ALUR would be used for export if the activity of this company did not exist. Therefore, the only additional demand for goods and services would be the demand of the industrial stages.
- In the case of rapeseed, most of the producers started to plant rapeseed as a winter crop substituting wheat. In this scenario rapeseed replaces wheat and, in order to simplify the calculations, it is assumed that wheat and rapeseed impact equally in the agricultural phase. Therefore, also in this case there would not be an additional demand for goods and services from the agricultural stages, but only from the industrial stages.
- In the case of sorghum, the assumption is that no farmer incorporates new land to plant sorghum, but displaces other crops such as corn. In this scenario sorghum replaces corn and to simplify the calculations the assumption that its impact is the same is considered. Therefore there would be no additional demand for goods and services from the agricultural stages, but from the industrial stages.

- Finally, in the case of sugarcane ethanol, all sugarcane is used for ALUR production and no other agricultural activities are envisaged in its place. However, given that there were some areas planted with sugarcane before the existence of ALUR, the scenario considers that, even without this industrial activity, there would be about 3100 hectares of sugarcane cultivated. Therefore, in this scenario, only the incremental effect will be considered.

This agricultural scenario has some implications in terms of global land use, both in Uruguay and abroad. Figure 4 shows the land used in Uruguay for biofuel raw material production (minimum and maximum land occupancy according to the expected biofuel penetration scenario). This land would be used for growing other crops in the reference scenario (in a scenario without biofuel production). As it is not foreseen an increase in the Uruguay's agricultural land and due to the fact that the demand for these crops remains, this translates into an increase of the imports for some agricultural commodities such as corn, wheat and soybeans. Considering Uruguay's main exporters for these crops (China and Paraguay) and the average yields in these countries, it is possible to estimate the additional demand for land that would occur as shown in the figure. The socioeconomic implications of these land use changes are out of the scope of this paper and have not been estimated.

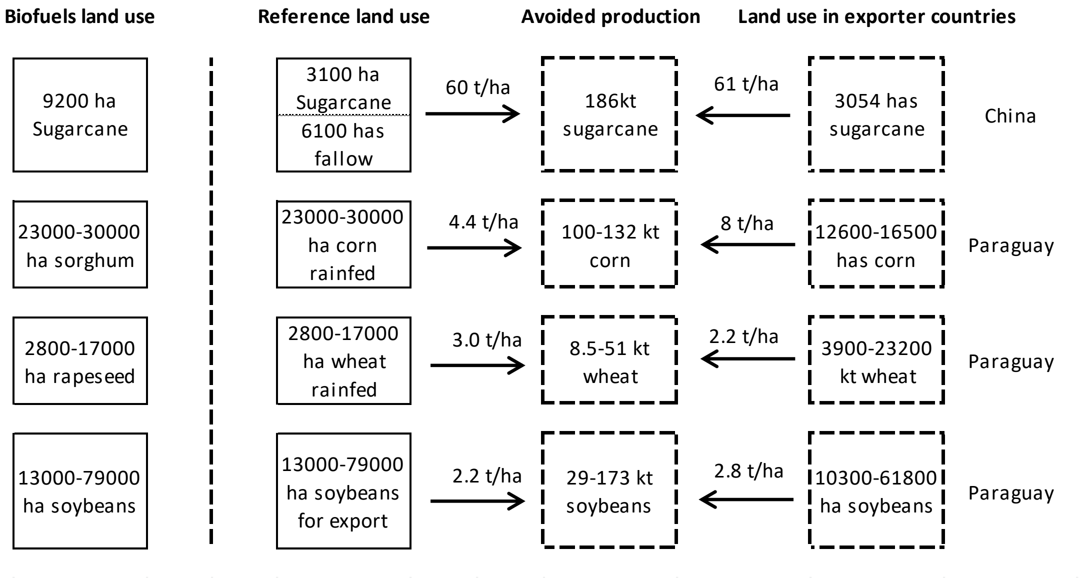

Figure 4. Additional demand for agricultural land in other countries other than Uruguay as a consequence of the domestic agricultural land use for biofuels production

Table 5 shows the demand of goods and services required for the production of the studied biofuels throughout the whole period. Since the interest was only in the effects produced on the National economy, only the domestic demand of goods and services (excluding the effects of imported products in the analyzed biofuels' chains) has been considered.

Table 5. Total final demand of goods and services due to the production of biofuels

FINAL DEMANDS	Million US$$_{2018}$	%
Sugarcane bioethanol production		
Bioethanol plant	714.22	111%
Avoided electricity demand	-0.34	0%
Avoided sugar demand	-197.97	-31%
Induced demand	128.24	20%
TOTAL	644.14	100%

Biodiesel production		
Milling plant operation	61.11	16.61%
Tallow supply	110.80	30.11%
Biodiesel plant operation	53.04	14.41%
Tallow plant investment	0.00	0.00%
Biodiesel plant investment	14.47	3.93%
Milling plant investment	10.81	2.94%
Induced demands	117.76	32.00%
TOTAL	368.00	100%
Sorghum bioethanol production		
Gathering	98.00	21%
Bioethanol plant operation	141.13	31%
Bioethanol plant investment	115.73	25%
Induced demands	101.32	22%
TOTAL	456.19	100%

Sugarcane bioethanol value chain produces electricity and sugar as byproducts. The demands arising from the avoided production of electricity in the national grid and sugar have also been subtracted to account for this consequential reduction in economic activity in the country. In the case of biodiesel and sorghum bioethanol production there is also coproduction of other goods throughout the value chain. The approach here has been to allocate the expenditures between the different coproducts following an economic criterion. The allocation factors applied to the co-products in sorghum bioethanol production are 93% to ethanol and 7% to DDGS and for the production of biodiesel, 42% to biodiesel and 58% to the rest of co-products. The final allocated demands related to the biofuels are shown in table 5. A 5% discount rate has been applied to all costs and revenues along the considered period in order to obtain their net present value.

The required goods and services have been assigned to the different sectors of the Uruguayan economy according to the nature of the different expenditures. All these data are used to describe the final demand vectors required to conduct the input-output analysis. Induced demands have been calculated considering the vector that measures the employees' wages in each sector of the economy per unit of total sectorial output (see Annex B). Part of this total compensation is destined to savings (8%), part is spent in social security expenditures (19.6%) and part (2.2% of total value added) is spent in the Personal Income Tax. The rest is spent in the different sectors of the economy following the household consumption distribution shown in Annex B.

4. Results

4.1. Value added and employment effects

Table 6 below shows the results from the application of the methodologies and assumptions presented above to the Uruguayan case study. Results shown include total economic activity produced, value added and employment creation as well as the multiplier effect.

Table 6. Socio-economic benefits of biofuel production in Uruguay.

IMPACTS	UNITS	TOTAL sugarcane bioetanol	TOTAL sorghum bioetanol	TOTAL Biodiesel
Economic activity	Million US$$_{2018}$	1,078	683	544
Value added	MIllion US$$_{2018}$	431	343	286
Total employment	Full time employees	33,921	21,655	15,587

	(FTE)			
Rural employment	Full time employees (FTE)	4,428	1,922	1,039
Multiplier effect		1.67	1.50	1.48
Total biofuel production	PJ	8.59	11.87	29.67
IMPACTS	UNITS			
Economic activity	$US\$_{2018}$/GJ	121	58	18
Value added	$US\$_{2018}$/GJ	48	29	10
Total employment	FTE/TJ	3.95	1.59	0.53
IMPACTS	UNITS			
Economic activity	$US\$_{2018}$/l	2.6	1.2	0.6
Value added	$US\$_{2018}$/l	1.0	0.6	0.3
Total employment	FTE/Ml	84.04	33.65	17.19

The highest impacts on economic activity, added value and employment correspond to sugarcane bioethanol followed by sorghum bioethanol and biodiesel. The same order is maintained for impacts by GJ and per liter of biofuel. The multiplier effect is considerably greater in the sugarcane bioethanol production chain, followed by the sorghum bioethanol and biodiesel production. According to these results, bioethanol production from sugarcane has a greater indirect impact on the economy than the other chains. Biodiesel production, on the contrary, produces the lowest indirect impacts while bioethanol production from sorghum accumulates the lowest valued added in absolute terms. The production of bioethanol from sugarcane accumulates more value added along all activities involved directly and indirectly throughout the supply chain, although it represents only 40% of the total production of goods and services. This is probably due to the stimulation of economic sectors of lower value added.

Sugarcane bioethanol production chain shows the greatest impacts in all the analyzed aspects. The underlying reason for this result is that in the case of bioethanol production and unlike for the other biofuels, a large part of the impacts of agricultural activities have been considered to be attributable to the activity of ALUR and would not exist if the company did not have any activity. The following figure shows graphically these results displaying a disaggregation between direct and indirect effects.

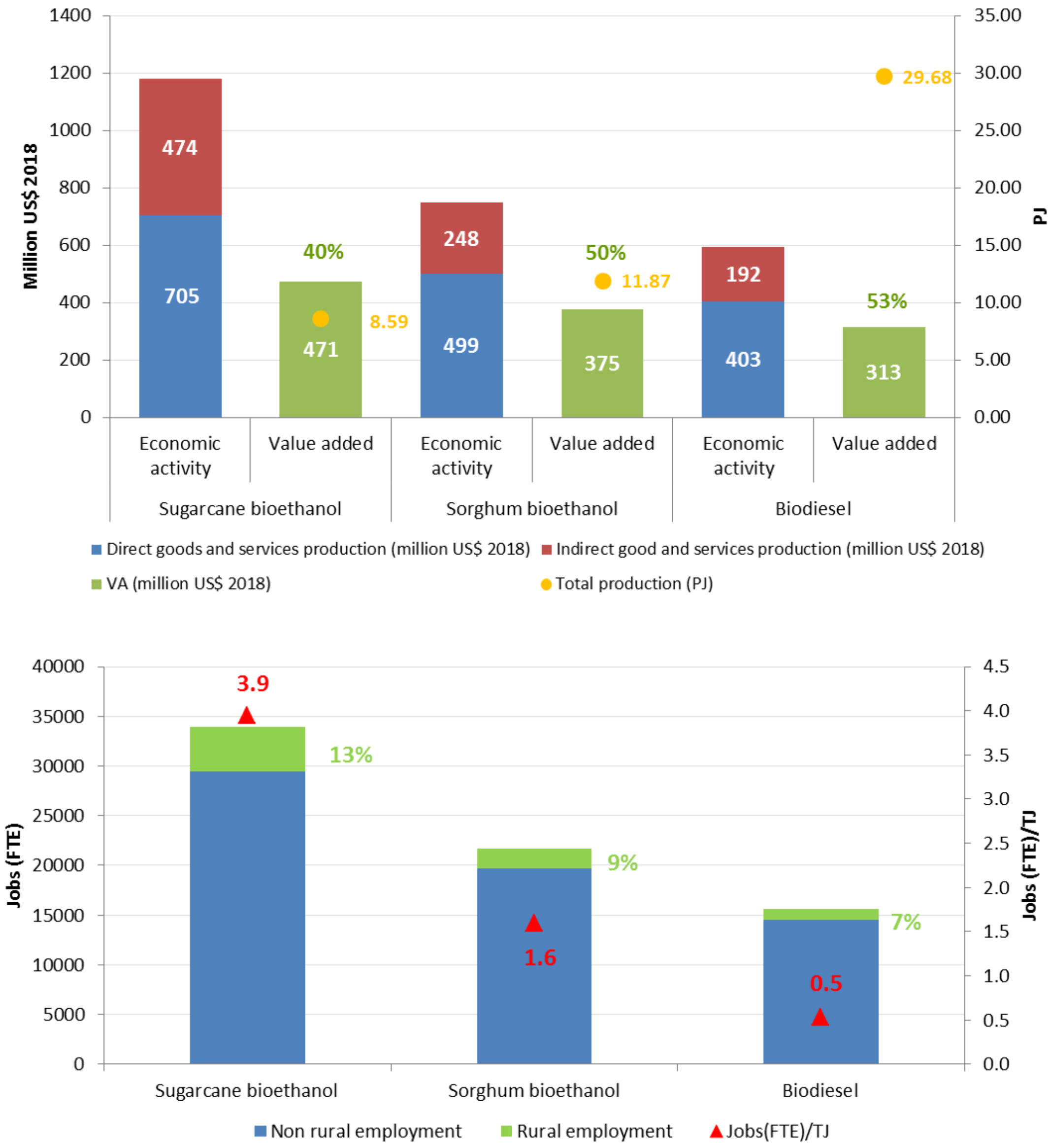

Figure 5. Economic activity, value added and employment related to each analyzed biofuel

In terms of employment, sugarcane bioethanol is the biofuel producing the highest number of total employments (expressed as fulltime employment or FTE) and relative employments (expressed as FTE/TJ) followed by sorghum bioethanol and biodiesel. The percentage of rural employment is also the highest in the case of sugarcane bioethanol. The reason here is that, in the case of bioethanol production, the agricultural activity has been considered attributable to the activity of ALUR. When it comes to value added creation of gasoline production in Uruguay, it has been estimated in 4.73 US$/GJ and that of diesel in 4.34 US$/GJ. Total employment generated has been estimated in 0.14 FTE/TJ for both gasoline and diesel. From this employment only 6.1E-05 and 8.4E-05 FTE/TJ are created in rural contexts for gasoline and diesel respectively.

4.2. Effects on tax revenues and balance of payments' results

Results in terms of the impact on tax revenues, balance of payments and reduction in fossil fuel imports are shown in table 7. These results were only calculated for sorghum bioethanol and biodiesel production due to the lack of data in the case of sugarcane bioethanol production. Such results are also expressed in net terms (once the avoided effects from fossil fuels have been subtracted). Total net increase in tax revenue amounts 399 million US$ in the case of sorghum bioethanol and 96 million US$ in the case of biodiesel. These amounts are around 0.1% and 0.03% of total tax revenue in the country respectively. Expressed in terms of US$ per l of biofuel sorghum, bioethanol production would produce a net increase of 0.71 US$/l and biodiesel production a net increase of 0.15 US$/l.

When it comes to the impact on the balance of payments, sorghum bioethanol production produces a net benefit of around 227 million US$ and biodiesel 1008 million US$. These amounts represent a 2% and 10% of the balance of imports and exports respectively. Biodiesel production results in a higher net benefit (1.59 US$/l) than in the case of bioethanol (0.40 US$/l). In both cases there is a net reduction of fuel imports (considered as a net increase in energy security) of 0.74 US$/l in the case of biodiesel and 0.29 US$/l in the case of bioethanol. In both cases the most important effects are due to the reduction of diesel, gasoline and protein meal imports.

Table 7. Net effects on tax collection and balance of payments

	Sorghum bioethanol		Biodiesel	
	million $US\$_{2018}$	$US\$_{2018}$/l	million $US\$_{2018}$	$US\$_{2018}$/l
Taxes over domestic goods and services	12	0.02	5	0.01
Taxes over imported goods and services	2	0.004	1	0.002
Social contributions to workers	23	0.04	20	0.03
Taxes minus subsidies	4	0.01	5	0.01
Tax collection from ALUR or petrol/diesel	347	0.62	55	0.09
Income tax collection	11	0.02	11	0.02
TOTAL NET IMPACTS ON TAX COLLECTION	399	0.71	96	0.15
NET IMPACTS ON BALANCE OF PAYMENTS	227	0.40	1008	1.59
FROM WHICH NET IMPACTS ON ENERGY SECURITY	165	0.29	468	0.74

4.3. Social benefits results

Production costs of biofuels in Uruguay are higher than fossil fuel production costs at the refinery in Uruguay. The costs of producing biofuels in Uruguay have been measured by the prices paid by the company ANCAP[§] to ALUR for each liter of biofuel

[§]Administracion Nacional de Combustibles, Alcohol y Portland – state-owned company involved in the production of petroleum products, Portand cement and alcoholic beverage in Uruguay

[42]. The production cost of gasoline and diesel in the Uruguayan refineries have been calculated using the information on price construction from [43]. Sugarcane bioethanol is paid at a higher price by ANCAP compared to sorghum bioethanol and therefore the cost difference with gasoline production costs is higher. These extra costs have been estimated in 1.59 US$/l for sugarcane bioethanol, 0.79 US$/l in the case of sorghum bioethanol and 0.39 US$/l in the case of biodiesel.

For the analyzed policy to be optimal, such extra costs should be compensated by the net social benefits of biofuel production and consumption. In this respect, figure 6 shows the results from the social benefits assessment, once the results of all socio-economic effects have been quantified in monetary units and compared to the extra costs of producing biofuels in comparison to fossil fuels. This comparison is only made for sorghum bioethanol and biodiesel (for sugarcane bioethanol, some of the social benefits could not be calculated due to lack of data). The largest benefits are obtained from the production of biodiesel followed by the production of sorghum bioethanol. Contrary to the results derived from the input-output analysis -in which sorghum bioethanol had larger effects than biodiesel in terms of value added and employment-, when including tax revenue and balance of payment effects, the situation is reversed. Although the tax revenue is four times higher in the case of sorghum, the high balance of payment resulting from biodiesel counterbalances it. Considering the effects on tax revenue and balance of payments calculated for sorghum bioethanol and biodiesel on top of the effects on value added and employment, the extra costs are fully compensated by all socio-economic benefits.

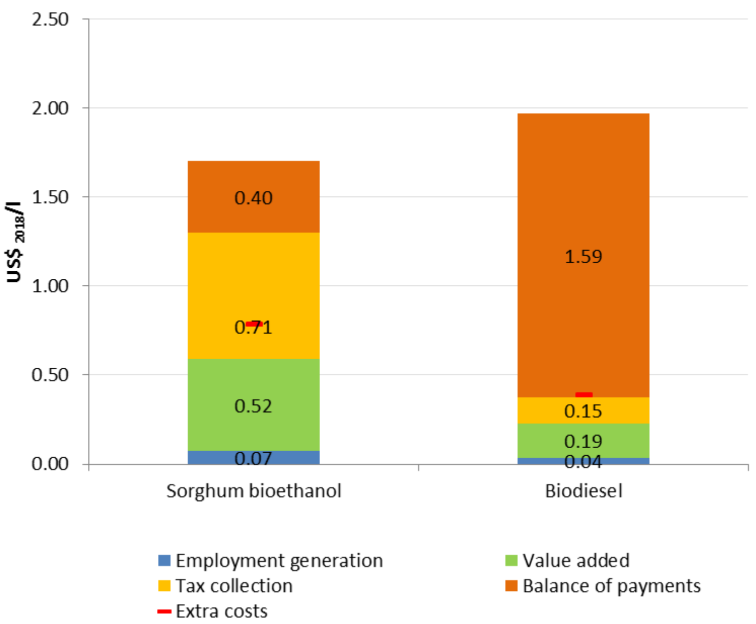

Figure 6. Social benefits, in terms of employment, value added, tax collection and balance of payments, related to sorghum bioethanol and biodiesel and their extra costs compared to their conventional reference fuels.

Despite not considered in this study -which focuses on socio-economic impacts-, it is important to note that there exist other environmental benefits arising from the substitution of fossil fuel by biofuels. Such environmental benefits are very relevant and should also be considered in a comprehensive social cost benefit analysis. In the first place, biofuels contribute to reducing greenhouse gas emissions that cause global warming of the earth climate. External benefits of each tone of biofuel substituting fossil fuels are subject to a high degree of uncertainty but can be very high depending on the valuation method. According to the calculations of the present research for the Uruguayan biofuels [44–46] sugarcane bioethanol utilization as transport fuel avoids the emission of 55 gCO_2 equiv/MJ, while sorghum bioethanol avoids 50 gCO_2 equiv/MJ and biodiesel 59 gCO_2 equiv/MJ. The external benefits are around 0.015 US$/l for bioethanol and 0.026 US$/l for biodiesel. For the estimation of these benefits a social damage cost of CO_2 of 11.64 $US\$_{2018}$/t CO_2 was used which is quite low compared to other values used in the literature [47] that can be as high as 77 US$/t CO_2 as recommended by the UK government.

Other important external environmental benefits associated to the use of biofuels in transport are related to the reduction of local air pollution impacts. Fuel combustion does not only emit GHG but it also emits particulate matter (PM_{10}, $PM_{2.5}$), nitrogen oxides (NO_X), sulphur dioxide (SO_2), and volatile organic compounds (VOC). These substances have a negative impact on human health [48] especially in urban contexts. Air pollution also causes building degradation, agricultural damage and has negative effects on natural ecosystems [49]. Biofuels are supposed to reduce some of these pollutant emissions to some degree especially those of particulate matter and SO_2 but not totally [50].

Although the magnitude of these impacts are location dependent, the values are taken from [47] as an example of the estimated value that they might reach when considering the environmental external costs of petrol and diesel by different causes including pollution. Average pollution related external costs results for Europe were around 0.10 US$ per liter of petrol and 0.24 US$ per liter of diesel. Since Uruguayan cities are less densely populated than European ones, marginal damage costs of pollutant emissions there might be lower than in Europe.

Promoting first generation biofuels production and consumption as considered in this study has been contested worldwide due to several issues. In the first place, it has been argued that diverting farmland or crops for biofuels production to the detriment of the food supply may influence the international price of food commodities [51]. Although there is disagreement about the significance of the issue and factors really affecting the price system, this debate has produced a political response in Europe. This refers to the introduction of a limit to the contribution made from biofuels and bioliquids produced from food crops to the overall objectives of the new Renewable Energy Directive (RED) in Europe [52]. Additionally, growing biofuels on existing agricultural land can displace food production to non-agricultural land and that may result in an increase in a release of C stored on soils and vegetation. This phenomenon, known as indirect land use change emissions or iLUC, gives rise to CO_2 emissions that, in some cases, can be very substantial [53].

Finally, it should be noted that the analysis performed is a snapshot of the current prevailing situation that can be different in the future. For example, the extra costs will most likely decline as the technologies become more cost competitive with time. Furthermore, effects on tax revenue are subject to changes in the fiscal policy of the country and effects in the balance of payments are dependent on the import and export prices.

5. Discussion

There exist various practical implications and policy recommendations that can be derived from this study. First, it should be considered that the aim of the paper is not to propose optimal decarbonization scenarios for the country's transport sector. That would require completely different methodologies and tools. The authors start from the stated objectives and try to understand, using detailed and real data, what are the socioeconomic implications. Biofuels now represent a 6% of final energy consumption in transport sector and less than a 5% of current biomass used in the country [54]. As can be seen in table 4 the production of biofuels in the country is not expected to grow much from today's values. The transition to a low carbon transport sector in Uruguay will probably not be based only on in biofuels but will use other alternatives such as electrification of urban mobility [55] and energy efficiency measures. With an electricity sector with more than a 90% penetration of renewables, electrification seems to be a good opportunity for Uruguay in order to reduce CO_2 emissions. This is however not studied in this paper.

The current biomass use in Uruguay is quantified in around 2,155 ktoe [54]. From this amount, biofuels represent less than 5%. The majority of biomass goes to the production of bioelectricity. Therefore, biofuels production and use, even in the case that they are produced with second generation technologies based on residues, are not compromising the use of the biomass potential in other sectors.

Despite the results obtained in this paper seem to indicate that biofuel support policies are currently justified from a socio-economic point of view, the authors recommend that a similar assessment was conducted in the future when the context conditions change (tax regimes, prices, costs, macro-economic variables, alternative more advanced technologies, etc.). Furthermore, in order to maximize the socio-economic benefits, it is recommended to maintain the largest share of local content throughout the biofuel value chain in Uruguay and, to the extent possible, in rural areas. Next, it is recommended to revise the existing biofuel support policies (such as through fiscal incentives and other measures) as the biofuel production costs decline. Additionally, other future lines of research could be focused on expanding the scope of this work by assessing other type of impacts such as food security implications. Finally, decision makers should not neglect the environmental benefits derived from biofuel deployment as well as other potential negative effects (such as the impact on food security). Finally, it is recommended to implement the required measures to minimize the risk of societal harmful effects while fostering the positive ones. In this sense, it would also be recommended to expand the cost benefit analysis by considering the environmental implications of the analyzed biofuel deployment in Uruguay.

6. Conclusions

The present study has analyzed the socio-economic effects associated to the substitution of diesel and gasoline by biofuels produced in Uruguay. This study has focused on a wide variety of socio-economic impacts assessed through different methodologies.

A first analysis was carried out to estimate the value added and employment creation in the National economy using an input-output analysis. Results showed that bioethanol from sugarcane leads to the highest impacts in all considered terms. Additionally, job creation has been categorized into rural and non-rural employment. The first accounts for 13% of the total employment in the sugarcane bioethanol while for sorghum bioethanol and biodiesel, it only accounts for 9% and 7% respectively. In a second analysis, employment generation effects have been monetized taking into account the two already mentioned categories.

Socio-economic benefits from the production and use of biofuels have been compared against the extra costs resulting from blending these biofuels with petrol and diesel. The comparison showed that there is still an important total cost differential that is not currently compensated by the social benefits when only impacts in terms of value added and job creation are accounted for. However, when the economic effects on tax revenue and balance of payments are considered, the benefits outreach the costs. Although the tax collection derived from sorghum bioethanol is four times higher than from biodiesel, important biodiesel positive effects on the balance of payments counterbalances it. In the future, this situation could change as biofuel production costs decline and fiscal policies as well as import and export prices may change. Additionally, other benefits would arise if the environmental effects of substituting fossil fuels by biofuels are accounted for.

Results obtained in this research seem to indicate that biofuels -bioethanol from sugarcane and sorghum and biodiesel- production and consumption in Uruguay bring important social benefits in terms of job creation, decentralization, value added creation, tax revenues, net effects on balance of payments and energy security.

These results have to be understood taking into account the distinctive features of each biofuel. Sugarcane used for bioethanol is cultivated by farmers in the region. The non-existence of ALUR bioethanol plant would lead to the abandonment of sugarcane cultivation in the region. On the contrary, the remaining raw materials, currently used to produce biofuels, displace other raw materials that were being cultivated previously in the region.

Finally, some policy recommendations arise from this research. Among others, it would be desirable to monitor the context conditions of the biofuels sector in the country to optimize the implemented policies. It would also be recommended to maintain the largest share of local content throughout the biofuel value chain in Uruguay and, to the extent possible, in rural areas. As to future lines of research, it is recommended to expand the scope of this work by assessing other type of impacts such as land use impacts and food security implications. In this sense, decision makers should not neglect the environmental benefits derived from biofuel deployment as well as other potential negative effects (such as the impact on food security) and try to implement the required measures to minimize the risk of societal harmful effects while fostering the positive ones.

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Annex A. Employment and value added vectors

Sector	Sector description	Employment	Value added
		FTE / k$	%
A01111	Rice and related agricultural services	2.27E-03	48.29%
A01119	Other cereal crops and related agricultural services	1.68E-04	26.54%
A01120	Vegetables and legumes crops and related agricultural services	1.14E-03	61.94%
A01130	Fruit trees, vineyards and related agricultural services	1.33E-03	64.39%
A01211	Milk and dairy products elaborated on farms and associated services	4.41E-03	66.13%
A01219	Cattle rising (except for milk productuon) and associated services	6.64E-04	80.46%
A01220	Birds and eggs production and associated services	3.86E-04	35.18%
A02000	Wood and other forest products and associated services	1.82E-03	66.35%
B05000	Fishery products	9.86E-04	56.76%
CTTTT0	Crude oil, natural gas, sand, clay and other minerals and associated services	5.06E-04	47.30%
D15110	Meat and meat processing and preservation products	9.73E-04	16.18%
D15120	Products of the elaboration and conservation of fish	3.86E-04	41.32%
D15130	Products of the elaboration and conservation of fruits, vegetables and hortalizas; other products	1.96E-03	37.22%
D15140	Oils, fats and flours without defatting of seeds, nuts and oil seeds; oils of vegetable and animal origin	1.46E-03	21.85%
D15200	Dairy products	6.80E-04	31.48%
D15311	Processed rice and other rice products	7.14E-04	13.78%
D15319	Flour and other milling products except rice	1.02E-03	14.57%
D153R0	Feed products, corn oils and starch products	2.01E-03	12.62%
D154R0	Bakery and food products	1.54E-03	34.46%
D154S0	Production of sugar, cocoa, chocolate, confectionery and other food products	3.54E-04	52.49%
D15520	Common and sparkling wines	1.05E-04	23.59%
D15530	Malted drinks and malt	8.46E-04	33.71%

D155S0	Distilled alcoholic beverages; ethyl alcohol obtained from fermented substances; non-alcoholic beverages; table waters	1.15E-03	42.08%
D16000	Tobacco and cigarrets	2.88E-04	33.56%
D171T0	Yarns and fabrics	2.73E-03	39.13%
D17RT0	Textil products	1.22E-03	25.90%
D18TT0	Clothing	3.70E-03	36.23%
D191T0	Processed leathers	1.02E-02	14.40%
D19200	Footwear	3.60E-03	22.14%
D20TT0	Sawing products and other articles of wood, except furniture	6.70E-04	52.62%
D210T0	Paper and cardboard and its products	4.15E-04	28.59%
D22TT0	Newspapers and magazines	1.76E-03	43.25%
D23TT0	Refinery products and nuclear fuel	4.60E-04	14.32%
D24RT0	Fertilizers and pesticides	3.95E-04	9.25%
D24ST0	Pharmaceutical products	2.17E-03	32.58%
D24UT0	Chemical products except fertilizers and pesticides	4.32E-04	25.42%
D25TT0	Rubber and plastic products	9.62E-04	31.73%
D26TT0	Manufacture of other non-metallic mineral products	8.34E-04	35.01%
DRRTT0	Manufacture of common metals, fabricated metal products, special and general-purpose machinery; office, accounting and computer machinery; electrical, radio, television and communications equipment; parts and pieces	1.67E-03	42.34%
DSSTT0	Manufacture of motor vehicles, trailers and semi-trailers and other types of transport equipment	2.34E-03	27.82%
DUUTT0	Furniture manufacturing; manufacturing industries ; recycling	1.66E-03	38.17%
ETTTT0	Supply of electricity, gas, steam and hot water; water collection, treatment and distribution	6.60E-04	62.24%
F45TT0	Construction of buildings and other constructions	6.66E-04	37.43%
GTTTT0	Wholesale and retail trade, repair of motor vehicles, motorcycles, personal effects and household goods.	1.73E-03	63.51%
H55TT0	Hotels and restaurants	8.77E-04	44.10%
I60TT0	Transport by land and pipelines	1.50E-03	49.99%

IRRTT0	Water transport; airway; complementary and auxiliary transport activities; activities of travel agencies	6.41E-04	43.63%
I64TT0	Mail and Telecommunications	7.05E-04	70.46%
JTTTT0	Financial intermediation services	4.95E-04	73.56%
K70TT0	Real estate services	5.59E-05	81.07%
KRRTT0	Rental of machinery and services provided to companies	1.43E-03	63.67%
L75TT0	Servicios del gobierno central excepto enseñanza y salud y de gobiernos departamentales; servicios de seguridad social de afiliación obligatoria	1.72E-03	68.15%
M80TT0	Teaching services	1.81E-03	80.52%
N85TT0	Social and Health Service	1.67E-03	53.22%
OTTTT0	Other community, social and personal service activities	1.59E-03	56.78%
P95000	Domestic services	4.41E-03	100.00%

Annex B. Employees' compensation and household expending distribution

Sector	Sector description	Employees' compensation	Household expending distribution
		(thousand $/thousand $ total output)	%
A01111	Rice and related agricultural services	0.090	0.00%
A01119	Other cereal crops and related agricultural services	0.051	0.00%
A01120	Vegetables and legumes crops and related agricultural services	0.201	0.00%
A01130	Fruit trees, vineyards and related agricultural services	0.196	0.00%
A01211	Milk and dairy products elaborated on farms and associated services	0.250	0.00%
A01219	Cattle rising (except for milk productuon) and associated services	0.112	0.00%
A01220	Birds and eggs production and associated services	0.097	0.00%
A02000	Wood and other forest products and associated services	0.076	0.00%
B05000	Fishery products	0.177	0.00%
CTTTT 0	Crude oil, natural gas, sand, clay and other minerals and associated services	0.072	0.00%
D15110	Meat and meat processing and preservation products	0.046	7.31%
D15120	Products of the elaboration and conservation of fish	0.142	0.55%
D15130	Products of the elaboration and conservation of fruits, vegetables and hortalizas; other products	0.088	4.26%
D15140	Oils, fats and flours without defatting of seeds, nuts and oil seeds; oils of vegetable and animal origin	0.068	0.71%
D15200	Dairy products	0.121	3.04%
D15311	Processed rice and other rice products	0.059	0.54%
D15319	Flour and other milling products except rice	0.119	0.00%
D153R 0	Feed products, corn oils and starch products	0.038	0.00%
D154R 0	Bakery and food products	0.157	5.29%
D154S0	Production of sugar, cocoa, chocolate, confectionery and other food products	0.048	1.15%

D15520	Common and sparkling wines	0.108	0.73%
D15530	Malted drinks and malt	0.108	0.00%
D155S0	Distilled alcoholic beverages; ethyl alcohol obtained from fermented substances; non-alcoholic beverages; table waters	0.131	3.95%
D16000	Tobacco and cigarrets	0.156	2.84%
D171T0	Yarns and fabrics	0.104	0.00%
D17RT 0	Textil products	0.150	0.38%
D18TT 0	Clothing	0.084	3.86%
D191T0	Processed leathers	0.061	0.00%
D19200	Footwear	0.090	1.52%
D20TT 0	Sawing products and other articles of wood, except furniture	0.195	0.00%
D210T0	Paper and cardboard and its products	0.163	0.00%
D22TT 0	Newspapers and magazines	0.189	0.72%
D23TT 0	Refinery products and nuclear fuel	0.027	0.00%
D24RT 0	Fertilizers and pesticides	0.027	0.00%
D24ST 0	Pharmaceutical products	0.201	0.00%
D24UT 0	Chemical products except fertilizers and pesticides	0.098	0.00%
D25TT 0	Rubber and plastic products	0.123	0.00%
D26TT 0	Manufacture of other non-metallic mineral products	0.148	0.13%
DRRT T0	Manufacture of common metals, fabricated metal products, special and general-purpose machinery; office, accounting and computer machinery; electrical, radio, television and communications equipment; parts and pieces	0.112	0.90%
DSSTT 0	Manufacture of motor vehicles, trailers and semi-trailers and other types of transport equipment	0.149	0.00%
DUUT	Furniture manufacturing; manufacturing industries ;	0.128	1.05%

T0	recycling		
ETTTT 0	Supply of electricity, gas, steam and hot water; water collection, treatment and distribution	0.117	9.29%
F45TT 0	Construction of buildings and other constructions	0.110	0.73%
GTTT T0	Wholesale and retail trade, repair of motor vehicles, motorcycles, personal effects and household goods.	0.181	1.55%
H55TT 0	Hotels and restaurants	0.104	8.12%
I60TT0	Transport by land and pipelines	0.220	8.58%
IRRTT 0	Water transport; airway; complementary and auxiliary transport activities; activities of travel agencies	0.127	0.00%
I64TT0	Mail and Telecommunications	0.195	3.36%
JTTTT 0	Financial intermediation services	0.286	1.60%
K70TT 0	Real estate services	0.010	3.66%
KRRT T0	Rental of machinery and services provided to companies	0.207	0.00%
L75TT 0	Servicios del gobierno central excepto enseñanza y salud y de gobiernos departamentales; servicios de seguridad social de afiliación obligatoria	0.538	0.00%
M80TT 0	Teaching services	0.503	3.14%
N85TT 0	Social and Health Service	0.339	7.71%
OTTT T0	Other community, social and personal service activities	0.205	10.08%
P95000	Domestic services	0.964	3.27%