



25<sup>th</sup> ABCM International Congress of Mechanical Engineering  
October 20-25, 2019, Uberlândia, MG, Brazil

**COB-2019-2399**

## **ENERGY SYSTEMS BASED ON BIOREFINERIES IN THE CONTEXT OF A CIRCULAR BIOECONOMY – A SYSTEMATIC REVIEW OF THE SCIENTIFIC AND TECHNOLOGICAL LITERATURE**

**Giulia Cruz Lamas**

**Armando Caldeira-Pires**

**Emília de Oliveira Faria**

Universidade de Brasília – Brasília, DF

giuliac.lamas@gmail.com

armandcp@unb.br

emiliaofaria@gmail.com

**Abstract.** *The aim of this project is to assess how energy systems based on biorefineries are associated to the concepts of circular economy and bioeconomy. Biorefinery offers a sustainable green option to enhance the efficiency of utilization of produced biomass, enabling a broad range of marketable bioproducts and bioenergy. The objectives will be accomplished by performing a systematic review of scientific and technological literature by associating keywords to describe these two matters, encompassing a bibliometric analysis of the evolution of these key words in the scientific literature, followed by a deeper assessment of most relevant articles content. Based on the most influential and relevant articles of recent years, a growing influence of biorefineries has been revealed mainly as a support in the transition from linear to circular economy, considering the upward trend in socio-economic-environmental nexus. In this sense, the analyzed publications show that the replacement of fossil fuels by biomass is commonly highlighted in the framework of biorefinery, especially in integrated systems. Moreover, although it still has limited scope and devaluation of final products, this reality can be reversed for their better acceptance.*

**Keywords:** *energy systems, biorefinery, circular economy, bioeconomy, systematic review.*

### **1. INTRODUCTION**

In last decades it has been undoubtedly noticed world economic development, population growth, urbanization process expansion, increasing of consumption, massive flow of information, people, capital and services. Consequently, environmental transformations from those phenomena are of sizable relevance and have been employed as object of reflection not only to academia and the scientific community, but also to international organizations, governments and civil society. Environmental problems associated with scarcity of natural resources in a globalized context has created a phenomenon of increasing interdependence between countries, resulting in rules of governance and international cooperation (Bursztyn and Bursztyn, 2012).

Within this framework, one of the major global concerns of the present day is related to the dependence on fossil fuels and to the concomitant increasing levels of carbon dioxide (CO<sub>2</sub>) in atmosphere, which has led to a global impetus for the deployment of renewable and ecological technologies (Mohan et al Mohan et al., 2016). Faced with these challenges, a shift from linear economic view to circular economy is increasingly necessary, giving more prominence to renewable resources and biomass consumption (Mohan et al., 2017, Sadhukhan et al., 2017).

The human usage of biogenic materials or biomass as raw material for energy, however, is no novelty. Recently, there is a renewed interest in the effective exploitation of energy systems based on biorefineries, driven by the goal of reducing the ecological footprint and achieving a more secure supply of renewable resources (Mohan et al., 2016).

In this sense, sustainability gains notoriety and assumes a determining role in the global research agenda and in policies (CEPAL, 2016). Therefore, bioeconomy, whose ultimate goal is the conservation of natural resources, provides renewal, circularity and multifunctionality. High performance and success have been achieved and there is a growing understanding of its role in delivering a more intelligent and sustainable future (Bell et al., 2017; Dupont-Inglis and Borg, 2017).

Based on the above considerations, the present study aims to assess the emergent literature on biorefineries in the context of circular bioeconomy from different fields. To accomplish this objective, a systematic review of the scientific

and technological literature is performed through seeking to answer a guiding question: “How important is a biorefinery in the context of circular bioeconomy?”. Accordingly, schools of thought have been described in Tab. 1.

Table 1. Schools of thought and its definitions and chosen keywords.

Schools of thought	Definition	Keywords
Bioeconomy	The European Commission defines the bioeconomy as the one which “encompasses the sustainable production of renewable biological resources and their conversion and that of waste streams into food, feed, bio-based products [...]” (Union, 2012).	Biobased economy; biotechnomy; and bioeconomy.
Circular Economy	“A ‘circular economy’ would turn goods that are at the end of their service life into resources for others, closing loops in industrial ecosystems and minimizing waste (...)” It would develop a new sufficiency economic logic: “reuse what you can, recycle what cannot be reused, repair what is broken, remanufacture what cannot be repaired” (Stahel, 2016).	Circular economy; blue economy.
Biorefineries	“A biorefinery is a facility (or network of facilities) that integrates biomass conversion processes and equipment to produce transportation biofuels, power, and chemicals from biomass. This concept is analogous to today’s petroleum refinery, which produces multiple fuels and products from petroleum” (Cherubini, 2010).	Biorefinery.

## 2. METHODOLOGY

The intention of this systematic bibliometric review is to determine which are the most relevant articles and journals of the last decade and to analyze the evolution of the terms, in relation to the topics of interest – Bioeconomy, Circular Economy and Biorefineries. Moreover, it is desired to analyze qualitatively the chosen publications in order to evaluate and confirm the importance of a biorefinery in the context of circular bioeconomy.

Thus, the adopted methodology involves three phases: (1) Systematic Approach; (2) Bibliometric Analysis; (3) Discussion of the results of phase (2) (Cronin et al., 2008; Saavedra et al., 2018).

For phase (1) procedures of systematic research, used by (Guarnieri et al., 2015), have been considered: (i) formulation of a guiding question; (ii) inclusion and exclusion criteria; (iii) selection of literature and further access; (iv) evaluation of literature’s quality, adopting *Methodi Ordinatio* (Pagani et al., 2015); (v) analysis and synthesis.

Step (i) is the guiding question mentioned above, in introduction section. For steps (ii), Scopus® have been adopted as the main database and Web of Science (WoS) as well on behalf of their sizable relevance to scientific literature. Nevertheless, given the high number of results in Scopus®, the filter that have been applied was “type of documents”, choosing only “articles”, “reviews” and “articles in press”. In contrast, no such filter has been applied on WoS due to its reduced number of results. Publications from the first available year on each base up to the 2018 year have been considered.

From the chosen databases, an exploratory preliminary search with keywords was performed to perform step (iii). Initially, different searches were performed using the keywords “bioeconomy”, “circular economy”, then including synonyms for both for a broader spectrum of articles. Finally, the search with the term “biorefinery” was retracted.

In addition, the central keywords and their synonyms were combined with the Boolean operators AND (retrieved results must contain one term and the other) and OR (retrieved results must contain one term or the other), including the special character asterisk (\*) as a substitute sign to broaden the scope of the search. By including the latter, the search for the string “biorefiner \*” will encompass results containing words starting with “biorefinery” (ig: “biorefinery” and “biorefineries”). This search algorithm can be analyzed more synthetically in Fig. 1:

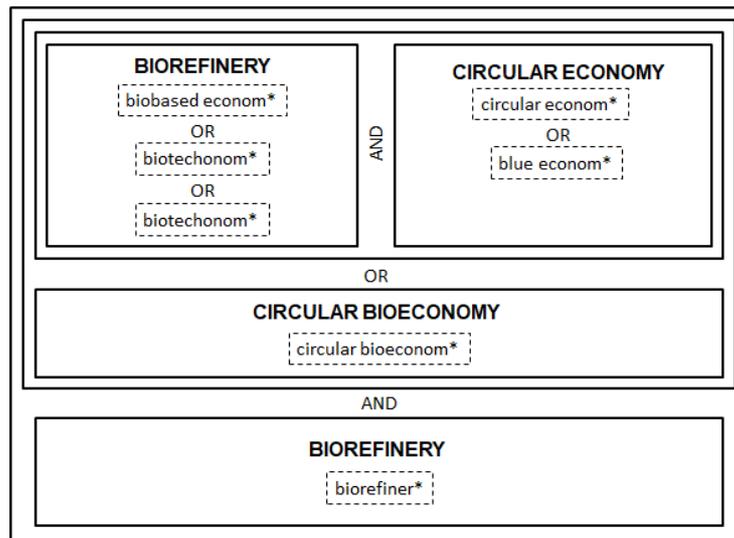


Figure 1. Search algorithm scheme.

In all, through the final query:  $\{[(\text{biobased econom}^*) \text{ OR } (\text{biotechnom}^*) \text{ OR } (\text{bioeconom}^*)] \text{ AND } [(\text{circular econom}^*) \text{ OR } (\text{blue econom}^*)] \text{ AND } [(\text{biorefiner}^*)]\}$ ; it has been identified 34 publications on WoS and 410 on Scopus®, with Scopus® accounting for 67.65% (23 publications) of WoS results, namely, WoS results returned only 11 unrepeated articles. Given, however, the high number of results returned, it was necessary to carry out evaluation of literature’s quality of step (iv). Accordingly, it has been adopted *Methodi Ordinatio* (Pagani et al., 2015), which describes with more precision and detail the impact of each article through its impact factor and number of citations. Then, the first 10 articles were chosen according to the parameters: impact factor greater than 3 and number of citations greater than 16.

### 3. RESULTS AND DISCUSSION

#### 3.1 Descriptive Analysis

Figure 2 shows all countries and territories referred to researched publications. The countries that publish the most about this subject are United States, accounting for 11.46%, and India, accounting for 11.22% of the total of 421 scientific work from the baseline. The countries identified on the map, in descending order, are United States: 11.46%; India: 11.22%; Italy: 10.97%; Germany: 9.02%; Spain: 8.54%; China: 7.80%; Brazil and Netherlands: 5.85% each; Belgium: 5.36%; Canada and Denmark: 4.39% each; Finland and France: 4.14% each; South Korea and Sweden: 3.90% each; Australia: 3.17%; and Mexico: 2.68%.

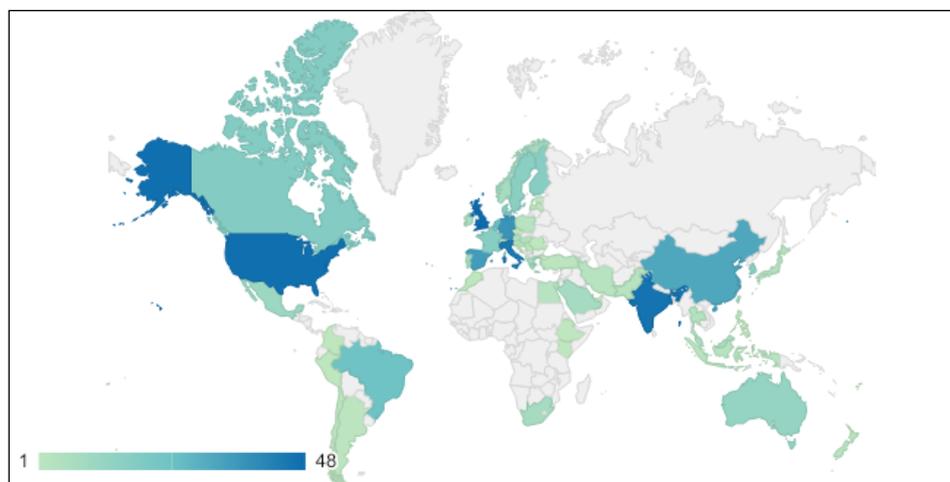


Figure 2. Map graph to show publications by country or territory.

Twelve major subject areas are identified in Fig. 3, and “Environmental Science” represents 54.63% of the total. Studies in this area concentrate efforts in energy, chemical engineering, chemistry, biological sciences, engineering,

business, management and accounting. It should also be noted that the sum of documents with respect to each subject area, 953 publications, is considerably higher than the total of 421 publications, thereby exposing a presumable interconnection of more than one area to the same publication.

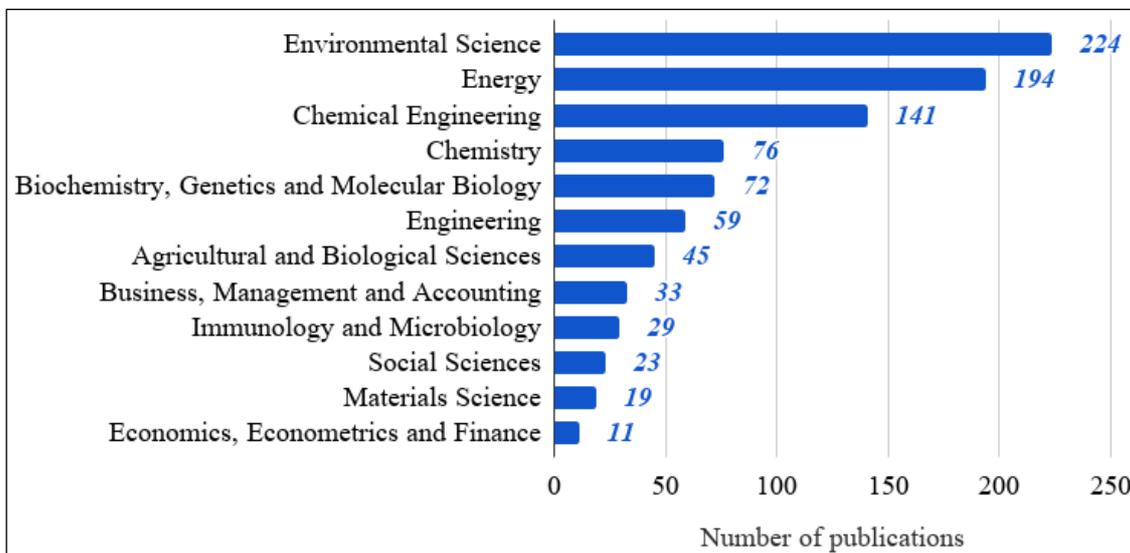


Figure 3. Twelve major research areas.

Table 2 signals eight authors with higher number of published documents. The above list ranks them in order of impact factors (h-index). The first two authors placed are: researcher Sels Bert from Technical University of Denmark in Denmark (DK), with studies on chemical engineering, materials science, environmental science and energy for instance; and researcher Venkata Mohan at Kyung Hee University in South Korea (SK), with studies on environmental science, energy and chemical engineering by way of example. Considering the sum of the publications listed in the table, 17 publications, it is observed that authors linked to institutions in the United States account for 53% of scientific production.

Table 2. Eight authors with the highest number of published papers (NP), h-index (HI), affiliations, number of published documents and countries or territories of affiliations. Source h-index: Scopus®.

Author	NP	HI	Affiliation	Documents	Country/Territory
Sels, B.F	5	71	KU Leuven	316	Belgium
Venkata Mohan, S.	13	53	Kyung Hee University	276	South Korea
Thomsen, M.	5	25	Aarhus Universitet	73	Denmark
Mohan, S.V.	6	20	Mohan, Srinivasula Venkata	67	India
Thrän, D.	5	14	Deutsches Biomasseforschungszentrum gemeinnützige GmbH	110	Germany
Sarkar, O.	5	11	Indian Institute of Chemical Technology	19	India
Bezama, A.	5	9	Helmholtz Zentrum für Umweltforschung	39	Germany
Butti, S.K.	5	5	Indian Institute of Chemical Technology	15	India

In order to obtain a better visualization about the thematic evolution of the main keywords, it has been mapped the network on Science Mapping Analysis Software Tool (SciMAT) software (Cobo et al., 2012, 2011). Through this tool it was possible to generate two different graphs: evolution map and thematic network. By manipulating the software algorithm the parameters were defined in spite of running the software analysis: unit of analysis: words (authorRole=true, sourceRole=true, addedRole=true); kind of network: co-occurrence; normalization measure: equivalence index; cluster algorithm: centers simples; maximum cluster size: 12; minimum cluster size: 3; evolution measure: Jaccard index; overlapping measure: Inclusion index.

Cluster spheres radius are associated with the used indicators, such as h-index, number of documents and sum of citations. The density of the cluster reveals, therefore, the importance that the theme gains or loses over the periods. Between consecutive periods, solid lines linking clusters indicate that thematic networks share the keyword that identifies them or that the keywords are part of other's themes. Dashed lines indicate that clusters share themes or keywords distinct from the ones that flag them (Cobo et al., 2012).

The thematic convergence of clusters between 2008 and 2018 can be analyzed in Fig. 4. The evolution between the main clusters stands out in blue, all directly sharing the themes to which they refer, since the lines that interconnect them

remain continuous. Likewise, the emergence with expressive density of the term “bioeconomy”, in 2017, should be emphasized.

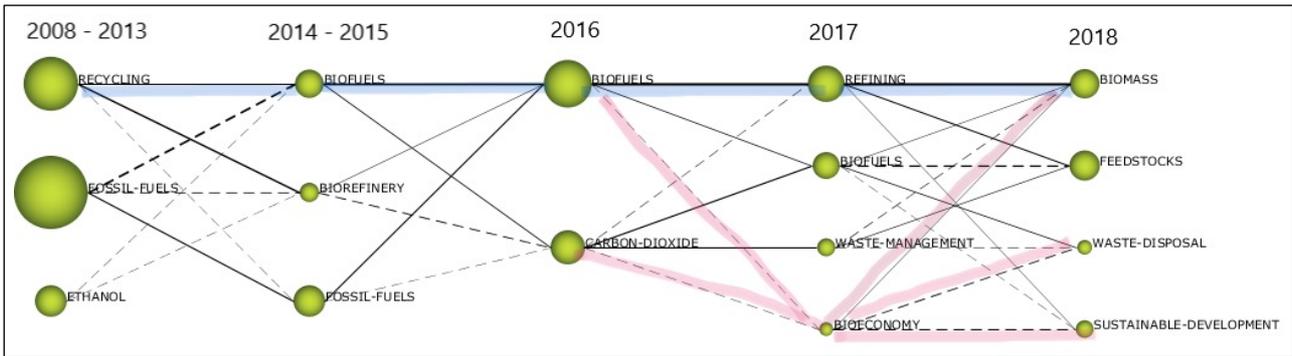


Figure 4. Evolution Map – coreDocuments-sumCitations.

It may be observed the highlight in pink (Fig. 4), where “bioeconomy” cluster is linked externally (dashed line) to the previous “biofuels” and “carbon dioxide” clusters, both of 2016, by the common “climate-change” and “sustainability” themes. As for the later clusters in 2018, to which it is also externally linked to “waste-disposal” and “sustainable-development”; and directly linked to the term “biomass”.

In addition, it is possible to analyze the thematic network graph “biomass” cluster (Fig. 5), the major one in 2018. From the lines highlighted in blue, it is identified that the “biomass” theme plays the role of linking the three basic themes of this present paper: “circular economy”, “bioeconomy” and “biorefineries”; pointing its soaring thematic contribution.

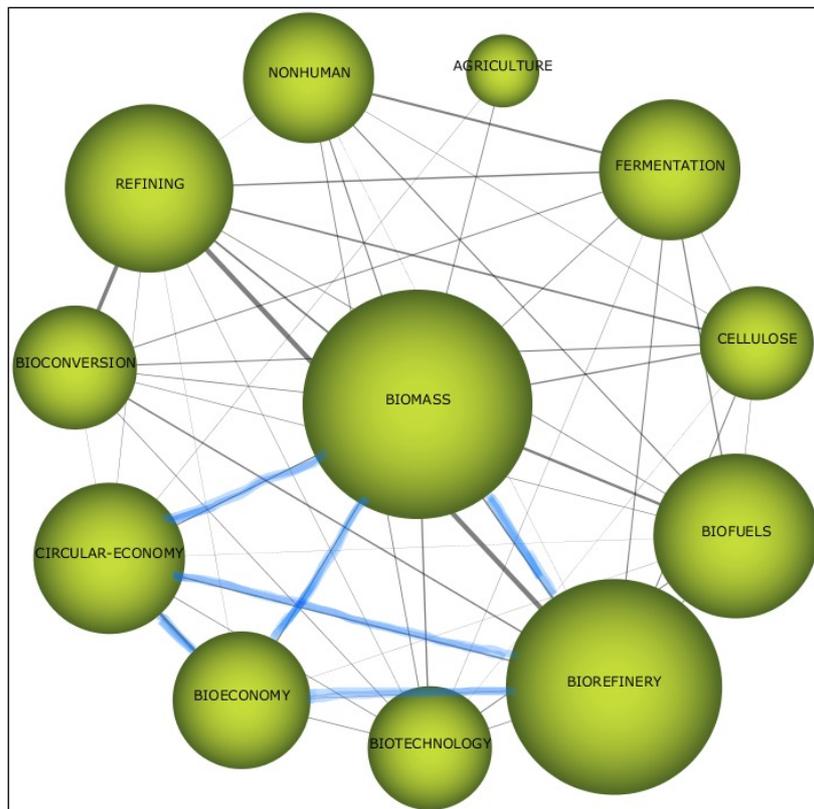


Figure 5. Thematic Network – Min frequency: 12 and Min co-occurrence: 3

### 3.2 Content analysis

Biorefineries have configurations analogous to oil refineries, integrating conversion processes and technologies for the production of energy, chemicals or fuels (Mohan et al., 2016). More than that, a biorefinery is “the sustainable processing of biomass into a spectrum of marketable products and energy” (Chandel, Garlapati, Singh, Antunes, & da

Silva, 2018). Energy systems based on biorefineries are therefore an alternative for switching from fossil fuels originated from petrochemical refineries to the use of waste and the production of marketable bioenergy and bioproducts.

The concept of circular economy can thus be applied at the interface between engineering and chemistry, requiring strategies regarding process efficiency, material recyclability and product design to facilitate disassembly and reuse (Erythropel et al., 2018). Although, its implementation requires new technological, organizational and product solutions (Purkus, Hagemann, Bedtke, & Gawel, 2018). In this sense, biorefineries are capable of foment the transition from traditional linear economies to new, circular economies, in addition to exploring the application of bioeconomics.

Given this context, many biorefinery models have been proposed and “hypothesize closed loop approach wherein waste is valorized through a cascade of various biotechnological processes addressing circular economy” (Mohan et al., 2016).

Indeed, food waste (FW) has been a major focus of study, being a subject discussed by many researchers. Likewise, waste biomass is readily available and can be used as a low-cost fuel and is therefore a promising global energy source (Sikarwar, Zhao, Fennell, Shah, & Anthony, 2017).

As a result of being one of the most generated bio-waste in the world, FW is a potential raw material for the generation of biobased products through bioprocesses which result in biofuels, bioelectricity and biomaterial. The approach of this type of biorefinery can be further facilitated by bioprocess models adapted for waste use and also product recovery. Thus, it is clear the need to optimize individual bioprocesses in order to promote the circular biomaterial bioeconomy (Dahiya et al., 2018).

FW is also an object of interest for biosolvent production since fossil fuel exploration has limited supply, high economic and environmental impacts; and reduce the negative impact on the environment if not processed. With the integration of bioprocesses, aiming at maximizing resource recovery, the process is economically viable (Dahiya et al., 2018).

Such process integration gives rise to the concept of integrated biorefinery, which “couples fuel production with a range of value-added products, such as platform chemicals, materials, and polymers” (Clarke, Tu, Levers, Bröhl, & Hallett, 2018). This is made possible by the fact that the compatibility of biorefineries and oil-based refineries also involves their infrastructures, making them “a vital parameter for ensuring long-term sustainability” (Sikarwar et al., 2017). In order to achieve both technical and economic viability, the available infrastructure should be fully exploited to avoid obsolete costs and investments.

In addition to integration, it is crucial to analyze the location of the biorefinery as biomass costs vary according to region, area and seasonal availability, being a decisive factor for investors' general interest in investing in biorefineries. Indeed, it is useful to have an agreement between biomass suppliers in localized and centralized biorefineries, as this supply is a critical issue throughout the year (Chandel et al., 2018).

In addition, in many situations waste generation cannot be completely eliminated. Therefore, “closed loop (“waste as feedstock”) systems, recycling, and interconnection of multiple product streams can be highly effective in valorizing waste streams and making progress toward circular economies” (Erythropel et al., 2018).

Another point that confirms the importance of FW biorefineries is that, besides the waste, “the carbon footprint of food waste is estimated to contribute to the green-house gas (GHG) emissions by accumulating approximately 3.3 billion tonnes of CO<sub>2</sub> into the atmosphere per year” (Yadav et al., 2017). Asian countries are largely responsible for the urban FW generation, which is expected to rise almost double over the period 2005 to 2025 (Dahiya et al., 2018). In Brazil, according to the Food and Agriculture Organisation (FAO), there was a considerable increase in carbon dioxide emission (Fig. 6) from about 308 Tg in 1990 to 452 Tg in 2016, an increase of approximately 47%, data only in relation to agriculture, not counting the increase in other means, such as industrial and urban.

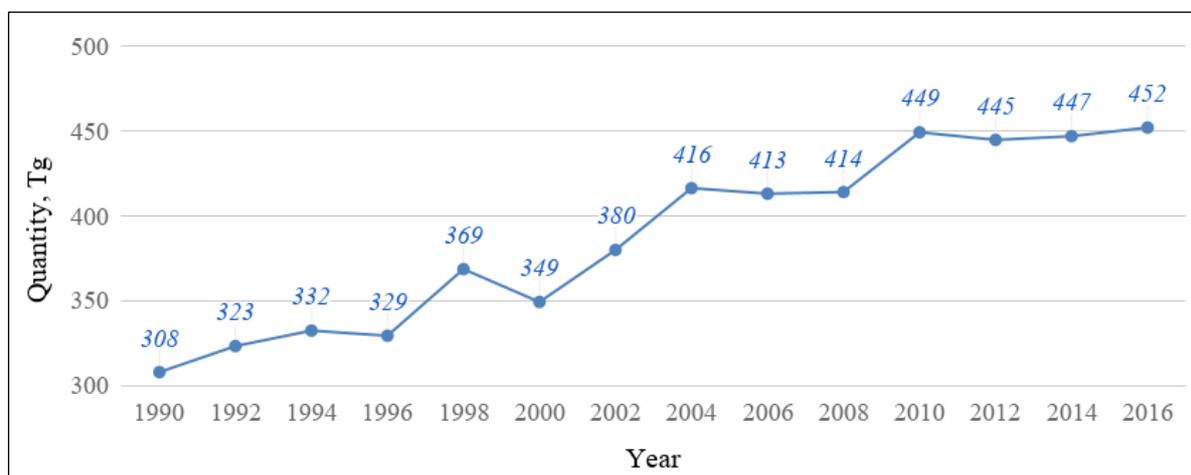


Figure 6. Emissions CO<sub>2</sub> in Brazil from agriculture. Data available from: <http://www.fao.org/faostat/en/#country/21>

Although the chemical production configurations of platforms from renewable resources have the potential to save fossil energy, they eventually consume more energy due to the intense water-removal. Considering the CO<sub>2</sub> captured during the plant's growth, the replacement of petrochemicals with biofuels is once again efficient for reducing carbon dioxide, such as methanol and lignocellulose ethanol production (Erythropel et al., 2018). On the other hand, "it should be noted that the influence of biofuel generation on the environment through GHG emissions, generation of co-products, influence on water resources, biodiversity, land usage, etc" (Sikarwar et al., 2017).

The economy based on sustainable biomass production offers advantages for the climate and the agricultural economy, especially as a consequence of public policies for its correct implementation. To this extent the increase of biomass from the cultivation of crops and trees also makes it feasible to intensify soil carbon sequestration and to increase farmers' incomes, as well as improving air quality (Clarke et al., 2018).

Encouraging the production of biofuels enables the development of the rural economy as well as reducing GHG and seems, therefore, to be "a significant and viable route in diminishing such social issues to a considerable extent" (Sikarwar et al., 2017). It can be confirmed by dint of current policies and strategic plans, which, if properly managed, agree that waste becomes a source of more valuable products (Mata, Martins, & Caetano, 2018).

Anyhow, there is controversy regarding the use of food crops for biofuel production, and first generation are the most present in this controversial debate in the scientific and technological literature. In contrast, "second generation biofuel production, using agricultural residues, grasses, and agroforestry products (lignocellulosic biomass), provides a renewable feedstock without competing directly with food, but processing of lignocellulosic biomass is more intensive (in both energy and cost)" (Clarke et al., 2018).

Effectively, chemicals and fuels resulting from biorefineries "must meet standards in accordance with market requirements and should be economically competitive with fossil fuel-derived products" (Sikarwar et al., 2017).

Although the balance between economic and environmental factors tends to be economical, there is usually no adequate accounting for toxicity and CO<sub>2</sub> emissions under strictly economic analysis. Thus, it is evident the need to promote evaluation on several aspects, in order to obtain a balance of favorable and unfavorable conditions. Even so, "if oil prices remain low, competing with conventional feedstocks may not be a viable approach" (Clarke et al., 2018).

In addition, commercial production of renewable fuels and chemicals has not been industrially successful "because of high capital and operating expenditures, irregularities in biomass supply chain, technical process immaturity, and scale up challenges" (Chandel, Garlapati, Singh, Antunes, & da Silva, 2018). This is materialized by the fact that most models already proposed still have a "limited scope and the final products have low economic value" (Mata, Martins, & Caetano, 2018).

In fact, in industries, "one of the main difficulties is poor characterization of toxicity properties of intermediates or waste products; in practice these may be challenging to isolate and purify and traditionally chemists have not had incentives to do so". Finally, according to the principles of Green Chemistry, for chemists the innovative goal, through innovative design, is to strive to create life cycle techniques to avoid waste (Erythropel et al., 2018).

In this sense, one way to bring the processes in line with the competitive market price is the improvement of the products, especially, through the waste to wealth approach (Chandel, Garlapati, Singh, Antunes, & da Silva, 2018). This can be confirmed with recent global bio-renewable chemical market data, which was, in 2015, "6.8 billion US\$, with a compound annual growth rate (CAGR) of 22.8% from 2010 to 2015" and which, by 2021, "is expected to be 12.2 billion US\$" (Chandel, Garlapati, Singh, Antunes, & da Silva, 2018).

In fact, a "new biofuel policy in Brazil so called Renova Bio, is promoting to use corn for ethanol production so corn stover seems a promising feedstock for 2G ethanol production". In addition, among the various promising bio-chemicals that have emerged out in recent years and which will have the high demand in future in Brazil were ethylene and farnesene plywood, which may play a central role in the consolidation of the bioeconomy (Chandel, Garlapati, Singh, Antunes, & da Silva, 2018).

The biorefinery approach for spent coffee grounds (SCG) valorization, for instance, proposed in recent work, also shows numerous advantages over its implementation, while considering potential issues. It stands out that "the questions concerning the collection and separation life cycle steps need to be tackled, essential to obtain SCG with adequate quality, specifically free from contaminants that may limit the efficiency of the treatment processes, and with sufficient quantity to justify the development and implementation of a bio-refiner" (Mata, Martins, & Caetano, 2018).

Another example is valorization of citrus processing waste (CPW) which has considerable potential for transition toward bioeconomy, including in Brazil, on which a study was conducted to profile a Life Cycle Assessment in the environmental burdens of orange production in its different areas. The central focus is, through the implementation of an integrated biorefinery platform, in order to enable green valorization, the mitigation of negative environmental effects and the economic feasibility of the process (Satari & Karimi, 2018).

#### 4. CONCLUSIONS

In summary, in light of all analyzed studies in this present review, it is possible to recognize the fundamental role that energy systems based on biorefineries play in the implementation of circular bioeconomy, notably in the current context with the aim of reducing environmental footprint. In this sense, the replacement of fossil fuels by biomass – as a sustainable and renewable resource – is highlighted in the framework of biorefinery, especially in integrated systems. Moreover, although it still has limited scope and devaluation of final products, this reality can be reversed from public

policies and incentives from Non-Governmental Organizations (NGOs) and research institutions for their better acceptance.

## 5. ACKNOWLEDGEMENTS

The author wish to thank the financial support from National Council for Scientific and Technological Development (CNPq).

## 6. REFERENCES

- Bell, J., Paula, L., Dodd, T., Németh, S., Nanou, C., Mega, V., e Campos, P., 2017. "EU ambition to build the world's leading bioeconomy-Uncertain times demand innovative and sustainable solutions". *New Biotechnology*.
- Bursztyn, M., e Bursztyn, M. A. (2012). *Fundamentos de Política e Gestão Ambiental*. Rio de Janeiro: Garamond.
- CEPAL, 2016. *Horizontes 2030 a igualdade no centro do desenvolvimento sustentável*. In CEPAL (Ed.), 36º período de sessões da CEPAL, pp. 1–82, Cidade do México.
- Chandel, A. K., Garlapati, V. K., Singh, A. K., Antunes, F. A. F., & da Silva, S. S. (2018). "The path forward for lignocellulose biorefineries: Bottlenecks, solutions, and perspective on commercialization". *Bioresource Technology*, 264, 370–381.
- Cherubini, F., 2010. The biorefinery concept: using biomass instead of oil for producing energy and chemicals. *Energy Convers. Manag.* 51, 1412e1421.
- Clarke, C. J., Tu, W.-C., Levers, O., Bröhl, A., & Hallett, J. P. (2018). "Green and Sustainable Solvents in Chemical Processes". *Chemical Reviews*, 118(2), 747–800.
- Cobo MJ, López-Herrera AG, Herrera-Viedma E, Herrera F. "SciMAT: A new science mapping analysis software tool". *J Am Soc Inf Sci Technol* 2012;63:1609–30.
- Cronin, P., Ryan, F., e Coughlan, M., 2008. Undertaking a literature review: A step-by-step approach. *British Journal of Nursing*, 17, 38–43.
- Dahiya, S., Kumar, A. N., Shanthi Sravan, J., Chatterjee, S., Sarkar, O., & Mohan, S. V. (2018). *Food waste biorefinery: Sustainable strategy for circular bioeconomy*. *Bioresource Technology* (Vol. 248). Elsevier Ltd.
- Dupont-Inglis, J., e Borg, A., 2017. "Destination bioeconomy - The path towards a smarter, more sustainable future". *New Biotechnology*.
- Food and Agriculture Organization of the United Nations (FAO), 2019. "Food and agriculture data – Brazil indicators". 18 Jul. 2019 <<http://www.fao.org/faostat/en/#country/21>>.
- Erythropel, H. C., Zimmerman, J. B., De Winter, T. M., Petitjean, L., Melnikov, F., Lam, C. H., ... Anastas, P. T. (2018). The Green ChemisTREE: 20 years after taking root with the 12 principles. *Green Chemistry*, 20(9), 1929–1961.
- Guarnieri, P., Sobreiro, V. A., Nagano, M. S., & Marques Serrano, A. L., 2015. "The challenge of selecting and evaluating third-party reverse logistics providers in a multicriteria perspective: A Brazilian case". *Journal of Cleaner Production*, 96, 209–219.
- Gutiérrez-Salcedo, M., Martínez, M.Á., Moral-Munoz, J.A., Herrera-Viedma, E., Cobo, M.J., 2018. "Some bibliometric procedures for analyzing and evaluating research fields". *Appl. Intell.* 48, 1275–1287.
- Marques, T., Reis, N., Gomes, J.F.S., 2018. "Responsible Leadership Research : A Bibliometric Review". *Brazilian Adm. Rev.* 15, 1–25.
- Mata, T. M., Martins, A. A., & Caetano, N. S. (2018). "Bio-refinery approach for spent coffee grounds valorization". *Bioresource Technology*, 247, 1077–1084.
- Mohan, S. V., Chiranjeevi, P., Dahiya, S., e Kumar, A. N., 2017. "Waste derived bioeconomy in India: A perspective". *New Biotechnology*, 40, 60–69.
- Mohan, S. V., Nikhil, G. N., Chiranjeevi, P., Nagendranatha Reddy, C., Rohit, M. V, Kumar, A. N., e Sarkar, O., 2016. "Waste biorefinery models towards sustainable circular bioeconomy: Critical review and future perspectives". *Bioresource Technology*, 215, 2–12.
- Pagani RN, Kovaleski JL, Resende LM. "Methodi Ordinatio: a proposed methodology to select and rank relevant scientific papers encompassing the impact factor, number of citation, and year of publication". *Scientometrics* 2015; 105:2109–35.
- Perianes-Rodriguez, A., Waltman, L., van Eck, N.J., 2016. "Constructing bibliometric networks: A comparison between full and fractional counting". *J. Informetr.* 10, 1178–1195.

- RN Pagani, JL Kovaleski, LM Resende., 2015. “Methodi Ordinatio: a proposed methodology to select and rank relevant scientific papers encompassing the impact factor, number of citation, and year of publication”. *Scientometrics*, 105: 2109.
- Purkus, A., Hagemann, N., Bedtke, N., & Gawel, E. (2018). “Towards a sustainable innovation system for the German wood-based bioeconomy: Implications for policy design”. *Journal of Cleaner Production*, 172, 3955–3968.
- Saavedra, Y.M.B., Iritani, D.R., Pavan, A.L.R., Ometto, A.R., 2018. “Theoretical contribution of industrial ecology to circular economy”. *J. Clean. Prod.* 170, 1514–1522.
- Sadhukhan, J., Martinez-Hernandez, E., Murphy, R. J., Ng, D. K. S., Hassim, M. H., Siew Ng, K., ... Andiappan, V., 2017. “Role of bioenergy, biorefinery and bioeconomy in sustainable development: Strategic pathways for Malaysia”. *Renewable and Sustainable Energy Reviews*, (June).
- Satari, B., & Karimi, K. (2018). “Citrus processing wastes: Environmental impacts, recent advances, and future perspectives in total valorization”. *Resources, Conservation and Recycling*, 129, 153–167.
- Sikarwar, V. S., Zhao, M., Fennell, P. S., Shah, N., & Anthony, E. J. (2017). “Progress in biofuel production from gasification”. *Progress in Energy and Combustion Science*, 61, 189–248.
- Stahel, W. R. (2016). “The Circular Economy”. *Nature*, 531, 435–438.
- Yadav, M., Vivekanand, V., Chawade, A., Kushwaha, S. K., Pareek, N., & Paritosh, K. (2017). “Food Waste to Energy: An Overview of Sustainable Approaches for Food Waste Management and Nutrient Recycling”. *BioMed Research International*, 2017, 1–19.
- Union, E., 2012. *Commission adopts its Strategy for a sustainable bioeconomy to ensure smart green growth in Europe*, (February), 1. 19 Mar. 2019 <[http://europa.eu/rapid/press-release\\_MEMO-12-97\\_en.htm#footnote-1](http://europa.eu/rapid/press-release_MEMO-12-97_en.htm#footnote-1)>.

## 7. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.