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SUSTAINABILITY POLICIES FOR CIRCULARITY IN LATIN AMERICA

POLITICAS DE SOSTENIBILIDAD PARA LA CIRCULARIDAD EN AMERICA LATINA

PATRICIA RODRIGUEZ-SANCHEZ*
Business Administration Program, Distance Learning Faculty, Universidad Militar Nueva Granada

GABRIEL PLAZAS-GUERRERO**
Business Administration Program, Distance Learning Faculty, Universidad Militar Nueva Granada

MARIANA HERNANDEZ-GONZALEZ***
Industrial Engineering, Systems Department, Universidad Autónoma Metropolitana

Abstract

This paper analyses public policies concerning sustainability in Brazil, Chile, Colombia, and Mexico; and examines their contribution to the transformation of the productivity practices towards circular economy (CE). The findings allow for a distinction among three fields: renewable energy and energy transition, sustainable production and consumption, and waste management. This paper points out elements for formulation of public policies directed towards CE, such as the need for stability and normative clarity to handle actions from active participators; the creation of taxes and economic/financial incentives to industrial updating processes and making of profit out of externalities; the formation and training of human capital to align business' goals with sustainable practices; and both the education and sensitization of the population that drive policies dissemination.

Keywords: *Public policy, sustainable, energetic transition, waste management, circular system, 4R framework.*

JEL Classification: *Q01, Q56, Q57, L50, O54.*

* Universidad Militar Nueva Granada, km 2, Cajicá-Zipaquirá, Colombia. (57+1) 6500000 ext. 8070. E-mail: patricia.rodriguez@unimilitar.edu.co (Corresponding author)
** Universidad Militar Nueva Granada, km 2, Cajicá-Zipaquirá, Colombia. E-mail: gaplazasg@gmail.com
*** Universidad Autónoma Metropolitana, Av. San Pablo 180, Col. Reynosa Tamaulipas, Alcaldía Azcapotzalco, C.P. 02200, CDMX, Mexico. (55) 53189001. E-mail: mhg@azc.uam.mx

Resumen

Este trabajo analiza las políticas públicas de sostenibilidad de Brasil, Chile, Colombia y México y su contribución a la transformación productiva hacia una economía circular (EC). Los hallazgos permiten distinguir políticas públicas en tres campos: energías renovables y transición energética, producción y consumo sostenible, y gestión de residuos. El artículo aporta elementos en la formulación de políticas públicas dirigidas a la implementación de la EC, tales como: la necesidad de estabilidad y claridad normativa para manejar las acciones de los participantes activos; la creación de incentivos fiscales, económicos y financieros para los procesos de actualización industrial y el aprovechamiento de las externalidades; la formación y capacitación del capital humano para alinear los objetivos comerciales con prácticas sostenibles; así como la educación y la sensibilización de la población que impulsen la difusión de las políticas.

Palabras clave: *Política pública, sostenibilidad, transición energética, gestión de residuos, sistema circular, marco 4R.*

Clasificación JEL: *Q01, Q56, Q57, L50, O54.*

1. INTRODUCTION

Regarding the implementation of a circular economy (CE) based upon sustainable practices, it is important to take into account that there are fundamental economic, social, technological and environmental changes that are shaping the future, and consequently it is difficult to anticipate and understand what actions to take. The profusion of changes and the challenges they pose to our economies put pressure on governments, which should change legislation to allow for the adaptation to sustainable consumption and production within a CE. For an effective transition towards CE, governments and public administrations should steer actions and foment coordinated policies to achieved its implementation at a regional and local level (Scarpellini *et al*., 2019; Morseletto, 2020).

Traditionally, the economic system has prioritized development and productive processes which followed a linear behavior (*i.e.*, a "take-make-consume and dispose" model) (Korhonen, Honkasalo, *et al*., 2018), but nowadays, the necessity of an efficient management of resources is pushing all the actors interested on these subjects, including scholars, to start considering circularity as a suitable and cyclical model to reduce environmental impact, create value and economic growth (Lieder & Rashid, 2016).

The human pressure exerted on the planet requires urgent changes in people's behavior and business models (such as use of less natural resources, long-term value

retention, closed loops of products, eco-innovations, industrial symbiosis, economy dematerialization) (Aranda-Usón *et al*., 2020; Morseletto, 2020).

This change must be addressed by public policies from top-down approach at a national level (from governmental bodies and society) in collaboration with industries from the bottom-up approach at a particular level (Lieder & Rashid, 2016). As a result, strategies related to CE aims to have an impact over product cycles and prevent loss of valuable materials in production and consumption (by waste management, reuse, energy and raw materials recovery, and recycling) (Bocken *et al*., 2016; Silvestri *et al*., 2020). Besides, CE aims to contribute to sustainable development from businesses profitability and competitiveness, society prosperity on resources availability for future generations and reducing impact on the environment (Lieder & Rashid, 2016).

According to Lieder & Rashid (2016), CE contributes to the social, environmental and economic perspective of sustainable development. It is through new business models, reduced costs, improvements on productive processes and supply chain, that it can be achieved economic benefits in the CE. Societal benefits depend on the prosperity resulting from cyclical flows, regenerative use of resources to the extent that these practices will be immerse in productive chains and create new employment opportunities. Finally, minimized environmental impacts is one of the key aims of CE. The win comes from reduced virgin resources, wastes and emissions, product-life extension, and renewable energies (Korhonen, Honkasalo, *et al*., 2018).

In a more specific way, Table 1 presents elements within the concept of CE and their contribution to the targets of the United Nations Sustainable Development Goals (SDG) 7, 8, 9, 11, and 12 to 2030. Companies must implement circular solutions in order to achieve sustainability, move to more efficient and less energy-intensive practices, help with the shifting to renewable energy consumption as well as to the decoupling of economic growth from natural resource (Morseletto, 2020).

The information publicly available about CE in Latin America is considerably limited. However, some advancements can be found on this subject. According to the Circular Economy Club (2018) it is estimated that Latin America has only contributed with a 10.2% of the worldwide identified circular initiatives, *i.e.*, 303 cases in total by the time of this study (july of 2019), out of which 36% come from Chile, 19% from Colombia, 18% from Argentina, 13% from Brazil, 10% from Mexico, and 4% from Aruba. This quantity is small when compared to the data about the European Union, which have the 61.7% of worldwide initiatives.

Due to the low level of Latin American participation in circular initiatives (at least documented), public policies should be formulated in such a way as to be fitting to cope with the challenge of sensitizing both consumer and producer about the demand of sustainable goods, and the productive transformation. Although, policies could drive the development of circularity on a given country's area, different factors could influence the adoption of CE activities on a regional or local level, such as industrial situation, companies/industries engagement in value chains, innovation and technology (Aranda-Usón *et al*., 2020).

TABLE 1

RELATIONSHIP BETWEEN CIRCULAR ECONOMY AND SDG TARGETS

Selected elements within the concept of Circular Economy	SDG	Specific Target of SDG
Minimized environmental impacts caused by human activity	12. Responsible Consumption and Production	**12.4** By 2020, **achieve the environmentally sound management of chemicals and all wastes throughout their life cycle**, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order **to minimize their adverse impacts on human health and the environment**
Decoupling the use of natural finite resources from economic growth	7. Affordable and Clean Energy	**7.2** By 2030, increase substantially the share of **renewable energy** in the global energy mix
	8. Decent Work and Economic Growth	**8.4** Improve progressively, through 2030, global resource efficiency in consumption and production and **endeavour to decouple economic growth from environmental degradation**, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.
	12. Responsible Consumption and Production	**12.1** Implement the **10-year framework of programmes on sustainable consumption and production,** all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries
Regenerative resource use (cyclical materials flows, renewable energy sources and energy cycles)	7. Affordable and Clean Energy	**7.3** By 2030, double the global rate of improvement in **energy efficiency**
	9. Industry, Innovation and Infrastructure	**9.4** By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and **greater adoption of clean and environmentally sound technologies and industrial processes**, with all countries taking action in accordance with their respective capabilities.
	12. Responsible Consumption and Production	**12.2** By 2030, achieve the sustainable management and **efficient use of natural resources**
Identify and establish technical and biological cycles that allow to extend the use of resources as long as possible	11. Sustainable Cities and Communities	**11.6** By 2030, **reduce the adverse per capita environmental** impact of cities, **including by paying special attention** to air quality and **municipal and other waste management**
	12. Responsible Consumption and Production	**12.3** By 2030, halve per capita global food waste at the retail and consumer levels and **reduce food losses along production and supply chains**, including post-harvest losses
		12.5 By 2030, s**ubstantially reduce waste generation through prevention, reduction, recycling and reuse**

Source: Own elaboration based on (Ellen MacArthur Foundation, 2013; Kirchherr *et al*., 2017; Lieder & Rashid, 2016; United Nations, 2016).

Therefore, such policies might bring along, through circular business models, an improvement in productive processes (Urbinati *et al*., 2017); and might foster a boost to innovation, competitiveness, and economic growth. According to Aranda-Usón *et al*. (2019) there are some barriers that need to be addressed, such as lack of financial resources, lack of public institutions support, insufficient investments in circular activities from private sectors, difficulty supplying recycled products, lack of interest from shareholders and stakeholders, lack of trained professionals in the subject (Scarpellini *et al*., 2019).

Thus, the contribution of this paper to the existing literature are threefold. First, the purpose of the study is to analyze public policies concerning sustainability in the cases of Brazil, Chile, Colombia, and Mexico; and examines their implications to the transformation of the productivity practices characterized by a model of "take-make-consume-dispose" towards a CE with cyclical flows of reduced inputs (raw materials, energy, water and land use) and outputs (waste and emissions) (Lieder & Rashid, 2016; Korhonen, Honkasalo, & Seppälä, 2018). Second, we present details regarding some actions took among three fields: renewable energy and energy transition, sustainable production and consumption, and waste management. Third, we analyze and propose some initiatives and guidelines that affect and improve the aims, objectives, plans, or specific actions of the main economic agents such as policymakers, companies, and stakeholders in general.

This paper is structured as follows: The second section presents the theoretical framework about CE and its relationship with both sustainability and the SDGs. Subsequently it is presented the methodological framework that underlies the research and determines its design. Through the fourth section the results and discussion concerning the subjects of energetic efficiency, sustainable industries, and waste management are presented. Finally, section concludes.

2. THEORETICAL FRAMEWORK

2.1. Circular Economy

Recent studies over CE have shown a predominant interest by policy makers and business advocacy organizations in finding a potential model that could led to attain an equilibrium between the conservation of the environment and the economic growth (Urbinati, Chiaroni, & Chiesa, 2017; Korhonen, Honkasalo, & Seppälä, 2018; Korhonen *et al*., 2018). The discussion on CE has been focused on a "regenerative industrial transformation" where product and material-life are extended through alternative flowing cycles of reuse, allowing to develop sustainable production and consumption (Urbinati *et al*., 2017). Although it comprises different levels of analysis, presently there is neither a consensual definition about its subject nor a unique approach towards it (Kirchherr *et al*., 2017). The Ellen MacArthur Foundation (2013) defined the CE as:

> An industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models (Ellen MacArthur Foundation, 2013).

This definition reveals some important elements and traits of a circular system, such as the regeneration of the whole system and the creation of circular value proposals from the stage of business models. Such an approach entails a rethinking of production processes, which implies a shrinkage of the leakage rate concerning waste, emissions and energy (Korhonen, Honkasalo, & Seppälä, 2018). Within an ideal and desirable CE framework, the depletion of any raw material should not exist. This type of economy is based upon the recycling of raw materials and their reintegration to the productive chain (Marrone *et al*., 2018).

After a review comprising 114 definitions of CE Kirchherr *et al*. (2017) define it as an economic system based on business models which work under the 4R framework. This framework comprises operations related the 3R model that includes Reducing, Reusing and Recycling, besides Recovering materials.

The CE system integrates all the stages of the production/distribution and consumption processes; and it does it for all of its three levels, *i.e.*, micro, meso, and macro, in order to accomplish the three dimensions of sustainable development: environmental, economic and social (Kirchherr *et al*., 2017). The micro level comprises the necessities for implementing cleaner production and reducing environmental impacts since product-design stage. The meso level includes the systems established between different organizations such as clusters or industrial parks where environmental improvements need to be addressed along the supply chain; and, finally, the macro level includes the structures that are required in order to insert cities, regions, and countries into the (Ghisellini *et al*., 2016).

CE's knowledge framework concerning the Rs is ample and diverse in terms of its conceptualization and is not yet thoroughly disseminated across society. There are even some authors that present the following 9 levels:

1. Refuse: which consists in preventing use, buying, or packaging. 2. Reduce: which consists either in using the products for longer time or sharing their use, and/or using less material to produce them. 3. Reuse: which consists either in promoting the acquisition and reselling of second-hand products, or their being shared among users. 4. Repair: which consists basically in replacing damaged parts instead of dumping the product. 5. Refurbish: which implies restoring and/or bringing a product up for upgrading. 6. Remanufacture: which consists in creating new products from recycled components, or reconditioning, reprocessing or restoring them. 7. Repurpose/Rethink: which consists in adapting discarded goods to new functions. 8. Recycle: which consists in processing materials to be reused. 9. Recover (of energy): which consists in energy recovery from waste streams (energy production). It can also refer to the collecting of recyclable products and materials (Potting *et al*., 2017).

As a result of CE dynamics, a path towards sustainability in economic, social and environmental issues is created; and concerning the conservation of natural resources there is a reduction in costs and risks. Moreover, there is also an improvement in public image, in product design and marketing innovations, and in the creation of business models. Furthermore, social aspects are improved, including the minimization of social value destruction throughout the entire system, more healthy working conditions, job creation, sharing economy, collaborative decision making, and a growing awareness about consumption culture (RLi - Council for the Environment and Infrastructure, 2015; Korhonen *et al*., 2018).

Within the relation between CE and sustainability it is possible to identify activities which take place through circular value chains, that directly contribute to the achievement of the SDGs. Table 1 shows the relationship between specific targets from SDG 7, 8, 9, 11, and 12 and selected elements within CE previous described. The quest for energetic efficiency within circular processes (Reduce, Reuse, Remanufacture, Recover, Recycle) relies upon the assurance of a sustainable energetic system, subject of the 7th SDG, in countries in which access to sustainable energies as well as to less pollutant technologies and fuels support productive and economic endeavors.

In regard to the achievement of the 8th, 9th, 11th and 12th SDGs, circular production systems offer opportunities for sustainable innovation, work creation, and development of more efficient businesses through Reduce, Reuse, Repair, Remanufacture, Repurpose, Refurbish, and Recycle activities. The later ones are less intensive in resource consumption and seek the reduction of waste and emissions. They also promote employment generation and the integration of the system in sustainable value chains. As the 9R framework is more recent and less mention in CE definitions comparing to 4R from Kirchherr *et al*. (2017), sustainable policies in Latin America were analyzed based on the later framework (Reduce, Reuse, Recover, Recycle).

3. METHODOLOGY

The present research was made through a systematic literature review, official government websites and documents concerning existing policies on the subject of study following three main steps. First, the countries to be studied were selected. The 2017 GDP (gross domestic product) and the domestic market size (total population) of 28 Latin American countries were assessed during the first stage of the research. According to the World Bank the main economies in the region are Argentina, Brazil, Chile, Colombia and Mexico, and it was decided to take into account their cases, with the exception of Argentina's, as the basis for the study. It was decided not to use Argentina in the analysis, due to its deep financial crisis since the beginning of the millennium and accentuated in 2008 by the subprime crisis, which caused the country to fall into default in 2014 (Thomas & Cachanosky, 2016). This situation causes great political and economic instability in the country, affecting its main macroeconomic indicators as GPP, inflation and the exchange rate during the period of study so it is

expected that the policies and strategies of that moment will focus on the solution to these problems and not to sustainability and CE. The omission of Argentina comes as a result of its lagging state when compared to Brazil, Chile and Colombia (Parkes, 2016).

Next step was to analyze existing environmental and industrial policies regarding production and consumption, sustainability and circularity from each country. As a result of the review, three legislative guidelines were prioritized for being directly related to the SDGs and CE: renewable energies, sustainable production and consumption, and policies for integral management of solid waste. The scope and reach of this research have been restricted to those policies that impulse activities directed towards the attainment of the goals of energetic efficiency (7th SDG) and the consumption, production and waste management to achieve sustainable industries (8th, 9th and 12th SDGs).

The third step consisted in a systematic literature review from specialized scholarly databases on public policies concerning sustainability and circularity for the selected countries. The search was pursued within Web of Science, ScienceDirect, and Scopus databases. After a first reading of the public policies found in government sites the following queries were carried out: ((Colombia OR Brazil OR Mexico OR Chile) AND policy AND (("circular economy") OR ("renewable energy") OR ("sustainable consumption") OR ("sustainable production") OR ("waste management"))).

The outcomes were restricted to those in English, Spanish, or Portuguese published throughout the last 5 years (from 2013 to 2018), in order to analyzed the most recent academic publications on the subject and based on the most prominent CE definition from Ellen MacArthur Foundation in 2012. After cross-checking the results obtained from the three databases the trove was reduced to 591 documents. Finally, abstracts were reviewed and selected those documents that analyzed policies and activities related to energetic efficiency, sustainable production and consumption and waste management, even those related to activities for the 4R framework (Reduce, Reuse, Recover, and Recycle) (Kirchherr *et al*., 2017), for a total of 74 papers.

The analysis of public policies concerning sustainability and circularity, especially on energetic efficiency, sustainable production and consumption and waste management, was reinforced by the main standpoints and analyses over policies made by the scholars from the studied countries.

4. RESULTS AND DISCUSSION

The current legislation in the four countries includes public policies which are devoted to sustainability and are also in accordance with the SDGs. Although these policies are not directly formulated in terms of CE, they imply activities related to it. Table 2 shows a sample of some selected initiatives (public policies, laws, programs, plans) found. It is important to stress the fact that most policies and laws have been formulated or updated throughout the last 10 years; a fact that can offer a certain grade of assurance concerning their attuning to the current needs of those countries.

TABLE 2

SELECTED SUSTAINABLE PUBLIC INITIATIVES IN BRAZIL, CHILE, COLOMBIA AND MEXICO BY 2018

Sustainability subject/Country	Brazil	Chile	Colombia	Mexico
Renewable energy	• Law 10.438 of 2002 – Program of Incentives to Alternative Energies Sources. PROINFA • 10-year Energy Expansion Plan (2010)	• National Energy Strategy 2012-2030 (2012) • Energy 2050: Chilean Energetic Policy (2015). • Framework Law on Climate Change (2018- Draft)	• Law 1715 of 2014 -Integration of non-conventional renewable energies into the National Energetic System • National Climate Change Policy (2017)	• Law of Electrical Industry (2014) • Special Program for the Use of Renewable energy (2014) • Law of Energetic Transition (2015) • National Water Law (1992 last reform 2016)
Sustainable production and consumption	• Action Plan for The Sustainable Production and Consumption (2008) • National Policy on Climate Change (2009) • Sector Plans on Climate Change (2010-2011) • National Climate Change Adaptation Plan (PNA) (2016)	• Green Growth National Strategy (2013) • Clean production schedule 2014-2018 (2013) • Productivity and Growth Agenda (2014) • National Program for Sustainable Consumption and Production (2016) • Corfo Strategic Food Program (2017) • Education Policy for Sustainable Development (2017) • Infrastructure, Development and Inclusion Agenda Chile 3030 (2017)	• National Policy of Sustainable Production and Consumption (2010) • National Policy for Integral Management of Biodiversity and Its Ecosystem Services PNGIBSE Policy (2012) • Green and sustainable Business Plan (2014) • CONPES 3866-Productive Development Policy (2016) • Strategy to reach circular Economy (2018)	• General Law of Ecological Balance and Environmental Protection (1988, last reform 2018) • National Strategy for The Sustainable Production and Consumption (2012) • General Law on Climate Change (2012) • National Strategy Climate Change (2012)
Waste management	• National Environment Policy (2010) • Law 12305/10 – National policy for solid waste (2010) • National Sanitation Plan Basic (2007)	• Policy for the integral management of solid waste (2005). • Framework Law for waste management, extended responsibility of producer and promotion to recycling (Law 20.920) (2016) • Inclusion Policy of Base Recyclers 2016-2020	• CONPES 3874 National policy for the integral management of solid waste (2016) • National Policy Integrated Waste Management of Electrical and Electronic Devices (2013) • CONPES 3918 Strategy for Implementation of ODS in Colombia (2018)	• General Law for the prevention and integral management of waste LGPGIR (2003) • National Program for the prevention and management comprehensive waste 2017-2018 (2017)

Source: Own elaboration.

4.1. Renewable Energy and Energy Transition

In the four countries studied the advocacy strategies for the use of clean technologies and combustibles have begun to bear fruit for the transformation of the energy matrix with wide opportunities of growth in non-conventional energy sources. This shift is an important step towards the development of a circular industrial process; as well as with the reduction of greenhouse gases for decarbonization of economies. The Figure 1 shows Brazil as the country with a biggest proportion of non-conventional renewable energies (wind power, solar power, and biofuels), which amount to 15% of its total production. In second place appears Chile with 10%. Mexico is the country with the biggest proportion of energy production from traditional sources such as coal, gas, and diesel, which conjointly amount to 82% of the total. Mexico and Brazil are the only two countries which have nuclear energy production.

Sectors like the cement industry tried to transform the energy matrix by means of the use of mineral coal and charcoal instead of petroleum coke. However, the efficiency of this change has not been as higher as expected. Additionally, it has been found that some industries present a meager rate of efficiency concerning their energy use (Lima *et al*., 2018).

The Brazilian State stands out as one of the biggest producers of energy worldwide, although, most of the fuels used are firewood and diesel in thermal and electric energy generation, respectively. The main consumer of final energy inside this country is the industrial sector, which is responsible for a third of the total consumption, while only 28.6% of small enterprises generate their own energy.

The Brazilian government has formulated different programs and laws to promote the use of renewable energies at industrial level. Program INNOVA offers subsidies, subventions and loans; also, PROINFA Law includes the creation of long-term renewable energy auctions, which take place within an environment characterized by both financial stability and reduction of the risk at the level of the renewable's market (Aquila *et al*. 2017). Notwithstanding that those programs are focus on financing and investment aspects and integration of small producers to the national energy market, there are some obstacles such as the few intervention regarding regulation over renewable energy projects, the bureaucratic delays that could discourage new players to the market, and low budget to support research and innovation. Others are governance issues, like not enough entities to control and to implement the policy, few coordination among national and federal policies, the lack of long term view and foresight planning beyond fossil fuels; as a result is the lack of defined priorities and the prevalence of some renewable energy sources over others (Mendonça *et al*., 2018), ineffective solutions to promote renewable fuels (de Melo *et al*., 2016), and negative impacts on investments, regulations and policies. It is missed, along the policies reviewed, exemptions and tax reductions to imported technology (considering the dependency of the country on it) (Lima *et al*., 2018), incentives in order to achieve innovations in power generation and transmission systems (Dantas *et al*., 2018), as well

as support in risks reduction in the implementation of renewable energy generation systems for small industries (de Melo *et al*., 2016).

The privileged Mexican mega-biodiversity, in conjunction with the worldwide trend towards sustainability are two of the main factors at the root of the promulgation of the Energetic Transition Law. This law encourages the private investment, the research, and the development and formation of human capital. Mexico expects to reach a rate of 50% renewable energy by the year 2050 (OLADE, 2017). However, there are still some troublesome legislative aspects that must be addressed. Among them one of the most important is the existence of several laws that are contrary to the tenets of renewables, like those which offer subsidies to fossil fuel, and therefore promote the use of non-renewable energy sources. This laws affect in a negative way the research on renewable energies, and make it intermittently focused on solar, biomass, and wind power (Pérez-Denicia *et al*., 2017).

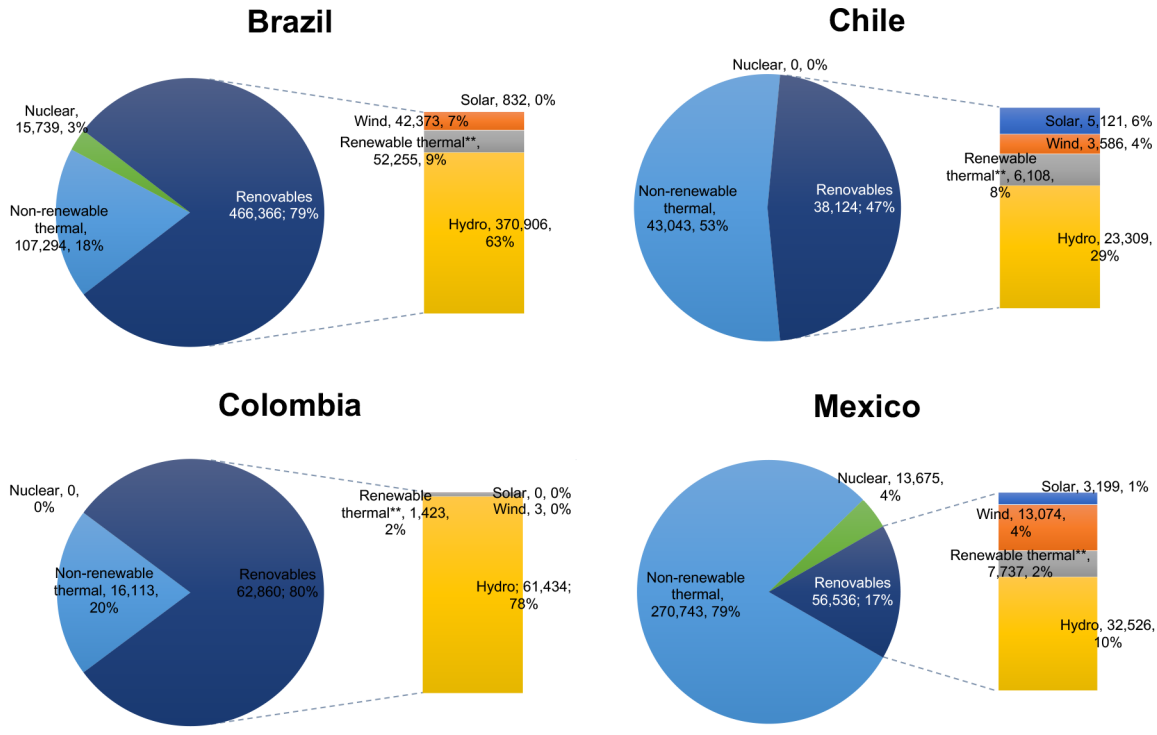
The energy situation in Colombia presents a good outlook regarding sustainability (see Figure 1). Incentives to the efficient energy use by the industry have had a positive impact on production, while the energetic consumption has decreased. This has happened thanks to the policies devoted to fuel switching; which have had incidence on the reduction of emissions nationwide. Some loopholes and troublesome aspects of public policy that have been neglected thus far are related with the difficulties for the acquisition of new technology, the high costs for investment, the lack of coordination between public and private sectors, and the lack of planning about the development of energy sources (Gómez-Navarro & Ribó-Pérez, 2018). It is also necessary to consider the discouragement produced by the impossibility, bearing upon the users, of selling their energy surplus to the electricity market. In fact, it was just until 2018 that this was allowed to small and medium size companies generating more than 1 MWh/h (Rodríguez-Urrego & Rodríguez-Urrego, 2018). The use of a uniform electricity tariff is an obstacle considering it does not cover the cost of energy generation from new technologies. This requires either subsidies to renewable energy generation or market freedom to set differentiated prices (Gómez-Navarro & Ribó-Pérez, 2018).

Law 1715 of renewable energies, emphasizes in the promotion of clean energies, and renewable energies as key cornerstone for Remote and Non Interconnected Zones. It highlights the economic incentives as tax reduction and accelerate depreciation of assets (Rodríguez-Urrego & Rodríguez-Urrego, 2018), nonetheless, the investment required for its adoption is much higher than the investment in traditional systems and lower returns (Gómez-Navarro & Ribó-Pérez, 2018).

The Chilean case is characterized by an increase in the intensive use of imported fossil fuel consumption to generate electricity (see Figure 1). This trend is bolstered by the increasing demand from the mining sector. However, Chile has promoted several mixed economy projects (of public-private nature), focused on the development of large-scale renewable energy sources to reduce CO2 emissions. Additionally, measures in taxes to carbon emissions, have been enacted (Nasirov & Agostini, 2018).

FIGURE 1

ELECTRICITY GENERATION BY SOURCE IN SELECTED COUNTRIES*, 2018 (GWH).



* Brazil and Colombia data from 2017. **Includes biofuels and waste.
Source: Own elaboration base on IEA (2019).

Indeed, this country has become one of the largest solar power markets in Latin America thanks to its friendly market conditions and its policy reforms (Nasirov & Agostini, 2018) (see Table 2). These conditions have allowed for the implementation of projects such as the Solar Thermal Power Laboratory, the non-conventional renewable energy (biogas) plant of El Molle, several photovoltaic plants as well as solar and wind power parks, programs concerning the development of solar roofing, and the geothermal power plant at Cerro Pabellón, which generates 340 GWh per year (OLADE, 2017).

Although, the country has become one of the largest solar markets in Latin America, thanks to its extensive solar resources, favourable market conditions, and successful political reforms, Nasirov & Agostini (2018) consider that there is a lack in public financing and in guarantees to the private financing for the implementation of solar power technologies to mining projects. There is also a lack of investment in human capital, especially in regard to skills of design management directed to counter users fears and resistance to technological change. Likewise, public policies do not address the use of renewable sources in conjunction with the pursuit of ways to improve the efficiency of the energetic system while favoring the consumer's savings capacity systems (Román-Collado *et al*., 2018).

Chile energetic matrix depends on external fuels prices and changes in costs of investments, therefore, in order to promote renewable energies, it is required a strong regulatory intervention. Exploit the country's geothermal potential by medium and long term energy policies, skilled human capital, and incentives to overcome financing risk and the high costs implied in developing projects (Sánchez-Alfaro *et al*., 2015).

The political analysis has been focused on the barriers against the implementation of renewable energies, especially from the standpoint of the 7th SDG. Other points of interest have been the access to less pollutant technologies and fuel sources (see Table 2). Colombia and Brazil stand out due to the implementation of biofuels as a measure to reduce CO2 emissions. This has created a strong market for biofuels presenting characteristics similar to those of traditional fuels. However, the greater consumption of biofuels has brought pressure upon the producers, and it has had negative consequences, especially concerning the use of soils (Espinoza *et al*., 2017).

The literature review has shown that the public policies adopted in the countries studied consider strategies that contribute to the decrease of both energy consumption in productive processes and CO2 emissions. It is possible to identify some difficulties which are common to all the countries and can be extrapolated to the entire region, *e.g.*, those which hamper the creation of transmission lines for the adoption of new technologies and the need for technical support. Other troublesome situation concerns the energetic centralization, which in turn reinforces the dependence on fossil fuels. Lastly, there are difficulties concerning the access to financing, and elements that cause a lack of coordination between nationwide and statewide policies, negatively affecting the private investments (Munoz *et al*., 2017).

Generally, both the scholarly and governmental publications of the studied countries have been focused on the reaching of sustainability from a viewpoint centered around the concept of energetic efficiency. The attainment of such efficiency requires the existence of financial patterns fitting the requirements, in terms of economic support, of both small and medium size enterprises interested in adopting sustainable power sources, and in reaching power self-sufficiency (Lima *et al*., 2018).

4.2. Industrial Policy for Sustainable Consumption and Production

The transformation of industry into a sustainable cycle supported by environmentally friendly practices requires two key elements: the establishing of a clear and stable regulatory framework, and social pressure from the consumers. This pressure would foster and boost the educational and sensitization processes about subjects such as clean production and sustainability which are required by the entrepreneurial communities (Alessandra *et al*., 2018).

Some obstacles to the advancement of circularity and sustainability include the lack of research centers and legislation, as the constant political changes (A. C. da Silva *et al*., 2017). Sociocultural factors, such as senior managers' commitment, and the importance they give to aspects such as the implementation of clean technologies could appear as factors which hinder sustainable processes, growth of productivity rates, incentives to industrial updating, the fostering of technical and professional knowledge, formation of skilled labor, and the increasing of access to information (Huang *et al*., 2016).

In the Brazilian case, among the challenges detected (Miranda & Kruglianskas (2013), stand out the necessity of an information system about pollutant sources to strengthen cooperative networks among companies, a must for circularity. It is also needed an expansion of the technical support about clean production from a sector focused approach. There is required also a set of incentives for the adoption of clean production policies and training programs directed to the workforce. Existing policies and programs

According to Tricallotis, Gunningham, & Kanowski (2018) in Chile the processes of auto-regulation and sustainable certification are carried out mainly by private companies which have vastly superseded the role of the State and been shown to be more efficient. The government has reduced its activity to the support of the processes of development and adoption of sustainable certifications, although among Latin American countries, it has many policies and programs to support sustainability (see Table 2). Therefore, the government should lead an industrial policy that foster both research and development of sustainable projects to boost the re-structuring of the economy (Rauch *et al*., 2016).

After reviewing public initiatives in Table 2, it was not found explicit policies related to CE in the countries under study. Findings show that the Latin American countries have not fully adapted to the relatively new concept of CE into their public

policymaking. Policies concerning sustainable production and consumption mainly target environmental regulation, generation of dignified and stable work, and the development of sustainable infrastructure. In what concerns to CE there is no trace of any policy which could enhance and regulate practices such as sharing economy (Reduce), acquisition of reconditioned, reprocessed or restored products (Remanufacture); all of them key practices in the CE that involve the rational use of resources, components and materials, in technical and biological cycles (Ellen MacArthur Foundation, 2013; Kirchherr *et al*., 2017).

Regarding energy and waste management initiatives (see Table 2) it was found a lack of strategies addressing the regulation and supervision of practices such as the reuse of materials (Recycling), and the buying of energy produced through processes of waste treatment (Recovery), both of them practices that enhance circularity in productive chains (Marrone *et al*., 2018).

Some programs oriented towards the establishment of a CE have had outstanding results in relation with both sustainable circular processes and the key participation of the consumer. For instance, Colombian government Green Network's Red Verde post-consumption programs (Red Verde, 2018) promote the collection and management of products which have completed their life cycle or have been discarded by the consumer. Within this system, agents such as the government, the universities, research centers, bridge organizations, and consumers are called to play proactive roles in the path towards the implementation of circularity as a core aspect of production (Ellen MacArthur Foundation, 2013).

4.3. Waste Management for Circularity

Waste management is a key strategy for obtaining inputs through activities like recycling, composting, transformation of energies (biomass), etc. Most countries have public policies and recycling programs, but there is a lot of criticism against them. For instance, the waste is usually deposited in open dumps, or it is indiscriminately burnt, which intensifies air pollution. In developing countries, the figure of the recycler and the activity of re-mining are commonplace, but his/her labor conditions usually are contrary to human dignity and more proper of a labor exploitation system, within which poverty and health risks are the lot commonly imposed upon workers (Guibrunet *et al*., 2017). Moreover, the growing economic growth and population lifestyle changes in Latin America imply waste challenges. The overall idea at the core of that waste management policy should consider waste as an economic asset for industries. The output of one industry should be the input of another.

The Mexican case is an extreme example. In this country most of the waste is neither collected nor treated. Instead, 92% of rural waste is burnt or left into non-controlled deposits. At a nationwide scale 24% of waste was burnt (Reyna-Bensusan *et al*., 2018). Accordingly, the necessity of a regularization of the garbage collection

service, which should cover all the households and industrial facilities, have been suggested.

The Brazilian law about waste management establishes that the final destination of solid waste is a priority, and promotes the reuse and the recycling as ways to minimize the necessity for disposing waste into landfills. The implementation of this policy has had to face up some difficulties, especially in the cases of small towns. It has happened mainly due to the lack of administrative capacity, technical skills and knowledge available, for diagnosing the conditions of the waste materials and taking actions against the abandonment of waste on open dumps (Marino *et al*., 2018).

In spite of the implementation of management plans, there are negative concurrent aspects such as an inefficient recycling rate (just 53.3% of waste is deposited into landfills and 64.8% of municipalities make a separate collection of recyclable materials), high costs bearing upon the whole system, and the political, social and economic exclusion of the recyclers (Ibáñez-Forés *et al*., 2018). Therefore, policy should formally integrate the recyclers into the sphere of the political decision making, promote landfills instead of rubbish dumps, as well as to pursue clusters and networks so that materials and waste circulate.

In Chile both rural and urban waste are deposited into landfills and rubbish dumps. It is highlighted the nationwide policies, especially those promoting high standards of waste management and the development of new landfills. These last actions have derived into the privatization of landfills, and the adjudication of the service to big private companies, which tend to be mainly focused on some cities that enjoy big economic resources. Something similar had happened previously in Colombia (Guibrunet *et al*., 2017).

One criticism that constantly arises against the policies that are being described is that most of the programs have been focused on plastic and paper recycling, while other kinds of waste materials have been neglected. This situation shows how important is the development of environmentally focused education programs; and how urgent is the sensitization of the population about recycling and effective separation of waste, which eventually could permit a reduction in management costs. Indeed, it could also complementarily serve to the creation of value chains around recycling processes (da Silva, 2018; Ibáñez-Forés *et al*., 2018). On this matter, there are certain kinds of systemic problems that usually hinder the prospect of a better and smoother transition towards sustainability and CE. Among them the clientelism that is endemic in Latin America occupy a special place. This problematic landscape is compounded with disruptive administrative changes (or resistance to change), financial problems (including those related with access to financial sources), pressures coming from communities, and handicaps in the capacity of governance (Guibrunet *et al*., 2017).

One advice that is often presented at an international stage, and which have been adopted by the countries here studied, consists in the advocacy for an extended

responsibility of the producer. It means that the companies must engage themselves in the management of the goods they produce even until the last stage of their life cycle (Park *et al*., 2018).

Colombia was one of the first countries to adopt such a measure in the year 2007 and impose financial and operative responsibilities to the producers and marketers but it does not involve other agents who also are partakers inside the consumption chain. Additionally, the government does not stimulate a complete recuperation of products (CE).

The implementation of a broaden responsibility on the part of the producer would impulse a change in industrial product design practices. It would allow for a greater product recyclability, and eventually for a reduction in the generation of dangerous or hazardous waste materials. Moreover, such changes would allow for the adoption of new green business models, upon which it would be possible to reduce the cost of managing products during the last stages of their life cycle (Park *et al*., 2018).

Finally, it is evident that, in all the countries, there are some elements that must be subjected to improvement, among which are especially important the spaces consecrated to landfill location, the infrastructure, and the costs which are incurred throughout the recycling processes (Park *et al*., 2018). Additionally, the governments must take care of the informality in the management chain of waste in small towns. They must also financially incentivize the creation of green-circular business models and take a bigger care of the value chains through which the recycling processes might be transformed, therefore allowing for an improvement in the management of both production inputs and outputs.

5. CONCLUSIONS

The analyses of both public policies and literature show the existence of initial efforts in the direction of sustainable actions, undertaken from the industry and the society, in the countries studied. Some of these actions have the potential to contribute to the formation of a CE structure. However, there are regional economic and cultural conditions that lessen the impact of such policies. These conditions have not been addressed with the required strength, and consequently it cannot be affirmed that the regulation needed to attain circularity at an industrial level is already in place.

Even though the existence of public policies about renewable energies, sustainable production and consumption, and waste management is evident, their impact has been limited. It is also evident the necessity of strengthening some aspects of these policies, among which stand out the sources of financing, and the mechanisms and terms of regulation. Additionally, it has been identified the necessity of developing action plans to allow for the applicability of the policies. This state of the affairs occurs in a region characterized by social and cultural undertones not necessarily aligned with the sustainable practices intended.

In what concerns the content within which are integrated the reviewed policies it has been spotted the necessity of an increase in incentives to industrial updating technologies, especially in the field of renewable energies. It should allow for the making of profit out of externalities, including the selling of energy surpluses, and the promotion of a differentiated tariff upon energy generated out of non-traditional sources. It would be adequate to establish incentives promoting the efficient use of renewables.

Other aspect that must be further clarified pertains to the establishment of a legal framework to handle the conflicts that could arise from the transition towards a circular and sustainable economy. It is also indispensable to contemplate the prospect of holding the producer co-responsible in what concerns the generation of polluting emissions, including among them the solid waste.

The importance of addressing the social dimension of sustainability is also explicitly stated, whereby it is also recommended to establish strategies which would permit that small as well as medium businesses have an active participation. It is also recommended to establish strategies that would allow for a regulation of the work of those who manage waste disposal, since it is currently done under social and economic marginal conditions.

On the other hand, and concerning the waste management, it is necessary to establish a knowledge about the current state of landfills, including information on aspects such as their capacity and their useful life cycle. It is also recommended the conformation of cooperation networks in support of research, development, and innovation. These should be on charge of the implementation of new technologies to produce renewable energy, and of the advancement of clean production practices.

Generally speaking, the policies common challenges to be surmounted in every country are the need of stability, normative clarity, and the necessity of economic, financial, and tax incentives. Likewise, there is a necessity for an easier and more efficient access to financing and credit, as well as for human capital formation, sensitization of the population about sustainability, and prioritization of a long-term vision strategical policy planning.

This analysis leads to conclude that to achieve the SDGs and the objectives each country has established, the role of the State is of utmost importance, and should be focused on two goals: The generation of adequate and attractive incentives for industry and society to adopt sustainable practices; and the formulation of a more apt regulatory system, which should allow the governments to efficiently and meaningfully counter actions against sustainability.

Finally, from the review of the literature and government documents arises future challenged research topics of considering in the context of Latin American countries such as analysis from cross-sectoral /cross-national strategies towards sustainability and specifically circularity, studies over the importance of stimulating bottom-up participative policies to bring about the emergence of change in productive practices,

and the impact of the implementation of circular activities over businesses and consumer awareness.

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REFERENCES

ALESSANDRA, N., ENRICO, C., GIULIO, D. S., & ANDREA, T. (2018). Industrial Sustainability: Modelling Drivers and Mechanisms with Barriers. *Journal of Cleaner Production*, 194, 452-472, https://doi.org/https://doi.org/10.1016/j.jclepro.2018.05.140

AQUILA, G., PAMPLONA, E. DE O., QUEIROZ, A. R. DE, ROTELA JUNIOR, P., FONSECA, M. N., DE QUEIROZ, A. R., ROTELA JUNIOR, P., & FONSECA, M. N. (2017). An overview of incentive policies for the expansion of renewable energy generation in electricity power systems and the Brazilian experience. *Renewable and Sustainable Energy Reviews*, 70 (August 2016), 1090-1098, https://doi.org/10.1016/j.rser.2016.12.013

ARANDA-USON, A., PORTILLO-TARRAGONA, P., MARIN-VINUESA, L. M., & SCARPELLINI, S. (2019). Financial resources for the circular economy: A perspective from businesses. *Sustainability (Switzerland)*, 11 (3), 888, https://doi.org/10.3390/su11030888

ARANDA-USON, A., PORTILLO-TARRAGONA, P., SCARPELLINI, S., & LLENA-MACARULLA, F. (2020). The progressive adoption of a circular economy by businesses for cleaner production: An approach from a regional study in Spain. *Journal of Cleaner Production*, 247, 1-12, https://doi.org/10.1016/j.jclepro.2019.119648

BOCKEN, N. M. P., DE PAUW, I., BAKKER, C., & VAN DER GRINTEN, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33 (5), 308-320, https://doi.org/10.1080/21681015.2016.1172124

CIRCULAR ECONOMY CLUB (2018). *MasterList-Circular economy mapping week*, https://goo.gl/e5dRv4

DA SILVA, A. C., MEXAS, M. P., & QUELHAS, O. L. G. (2017). Restrictive factors in implementation of clean technologies in red ceramic industries. *Journal of Cleaner Production*, 168, 441-451, https://doi.org/10.1016/j.jclepro.2017.09.086

DA SILVA, C. L. C. L. (2018). Proposal of a dynamic model to evaluate public policies for the circular economy: Scenarios applied to the municipality of Curitiba. *Waste Management*, 78, 456-466, https://doi.org/10.1016/j.wasman.2018.06.007

DANTAS, G. DE A., DE CASTRO, N. J., DIAS, L., ANTUNES, C. H., VARDIERO, P., BRANDÃO, R., ROSENTAL, R., & ZAMBONI, L. (2018). Public policies for smart grids in Brazil. *Renewable and Sustainable Energy Reviews*, *92*, 501-512, https://doi.org/10.1016/j.rser.2018.04.077

DE MELO, C. A., DE MARTINO, J., & BAJAY, S. V. (2016). Nonconventional renewable energy governance in Brazil: Lessons to learn from the German experience. *Renewable and Sustainable Energy Reviews*, 61, 222-234, https://doi.org/10.1016/j.rser.2016.03.054

ELLEN MACARTHUR FOUNDATION (2013). *Towards the Circular Economy: Economic and business rationale for an accelerated transition*.

ESPINOZA, A., BAUTISTA, S., NARVAEZ, P. C., ALFARO, M., & CAMARGO, M. (2017). Sustainability assessment to support governmental biodiesel policy in Colombia: A system dynamics model. *Journal of Cleaner Production*, 141, 1145-1163, https://doi.org/10.1016/j.jclepro.2016.09.168

GASPAR, M., JULIÃO, J., & TJAHJONO, B. (2018). Circular Economy in a Multiple Helix Perspective : A Review. *Economics, Management and Marketing (MAC-EMM 2018)*, 121-130.

GHISELLINI, P., CIALANI, C., & ULGIATI, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production Journal*, 114, 11-32, https://doi.org/10.1016/j.jclepro.2015.09.007

GOMEZ-NAVARRO, T., & RIBO-PEREZ, D. (2018). Assessing the obstacles to the participation of renewable energy sources in the electricity market of Colombia. *Renewable and Sustainable Energy Reviews*, 90 (February), 131-141, https://doi.org/10.1016/j.rser.2018.03.015

GUIBRUNET, L., SANZANA CALVET, M., & CASTAN BROTO, V. (2017). Flows, system boundaries and the politics of urban metabolism: Waste management in Mexico City and Santiago de Chile. *Geoforum*, 85, 353-367, https://doi.org/10.1016/j.geoforum.2016.10.011

HUANG, X. X., HU, Z. P., LIU, C. S., YU, D. J., & YU, L. F. (2016). The relationships between regulatory and customer pressure, green organizational responses, and green innovation performance. *Journal of Cleaner Production*, 112, 3423-3433, https://doi.org/10.1016/j.jclepro.2015.10.106

IBAÑEZ-FORES, V., COUTINHO-NOBREGA, C., BOVEA, M. D., DE MELLO-SILVA, C., & LESSA-FEITOSA-VIRGOLINO, J. (2018). Influence of implementing selective collection on municipal waste management systems in developing countries: A Brazilian case study. *Resources, Conservation and Recycling*, 134, 100-111, https://doi.org/10.1016/j.resconrec.2017.12.027

IEA - INTERNATIONAL ENERGY AGENCY (2019). *Data & Statistics - IEA*, https://www.iea.org/data-and-statistics?country=COLOMBIA&fuel=Energy supply&indicator=Electricity generation by source

KIRCHHERR, J., REIKE, D., & HEKKERT, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127 (September), 221-232, https://doi.org/10.1016/j.resconrec.2017.09.005

KORHONEN, J., HONKASALO, A., & SEPPÄLÄ, J. (2018). Circular Economy: The Concept and its Limitations. *Ecological Economics*, 143, 37-46, https://doi.org/10.1016/j.ecolecon.2017.06.041

KORHONEN, J., NUUR, C., FELDMANN, A., & BIRKIE, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544-552, https://doi.org/10.1016/j.jclepro.2017.12.111

LIEDER, M., & RASHID, A. (2016). Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, 115, 36-51, https://doi.org/10.1016/j.jclepro.2015.12.042

LIMA, L. P. DE, RIBEIRO, G. B. DE D., & PEREZ, R. (2018). The energy mix and energy efficiency analysis for Brazilian dairy industry. *Journal of Cleaner Production*, 181, 209-216, https://doi.org/10.1016/j.jclepro.2018.01.221

MARINO, A. L., CHAVES, G. DE L. D., & SANTOS JUNIOR, J. L. DOS (2018). Do Brazilian municipalities have the technical capacity to implement solid waste management at the local level? *Journal of Cleaner Production*, 188, 378-386, https://doi.org/10.1016/j.jclepro.2018.03.311

MARRONE, M., TAMARINDO, S., & MARRONE, M. (2018). Paving the Sustainability Journey: Flexible Packaging Between Circular Economy and Resource Efficiency. *Journal of Applied Packaging Research*, 10 (2), 53-60.

MENDONÇA, H. L., VAN ADUARD DE MACEDO-SOARES, T. D. L., & FONSECA, M. V. DE A. (2018). Working towards a framework based on mission-oriented practices for assessing renewable energy innovation policies. *Journal of Cleaner Production*, 193, 709-719, https://doi.org/10.1016/j.jclepro.2018.05.064

MIRANDA, F. DE, & KRUGLIANSKAS, I. (2013). Improving environmental permitting through performance-based regulation : a case study of Sao Paulo State , Brazil. *Journal of Cleaner Production*, 46, 15-26, https://doi.org/10.1016/j.jclepro.2012.09.017

MORSELETTO, P. (2020). Targets for a circular economy. *Resources, Conservation and Recycling*, 153 (November 2019), 104553, https://doi.org/10.1016/j.resconrec.2019.104553

MUNOZ, F. D., PUMARINO, B. J., & SALAS, I. A. (2017). Aiming low and achieving it: A long-term analysis of a renewable policy in Chile. *Energy Economics*, 65, 304-314, https://doi.org/10.1016/j.eneco.2017.05.013

NASIROV, S., & AGOSTINI, C. A. (2018). Mining experts' perspectives on the determinants of solar technologies adoption in the Chilean mining industry. *Renewable and Sustainable Energy Reviews*, 95, 194-202, https://doi.org/10.1016/j.rser.2018.07.038

OLADE - ORGANIZACION LATINOAMERICANA DE ENERGIA (2017). *2017 Yearbook Energy Statistics*.

PARK, J., DIAZ-POSADA, N., & MEJIA-DUGAND, S. (2018). Challenges in implementing the extended producer responsibility in an emerging economy: The end-of-life tire management in Colombia. *Journal of Cleaner Production*, 189, 754-762, https://doi.org/10.1016/j.jclepro.2018.04.058

PARKES, R. (2016). Argentina: The new frontier. *Renewable Energy Focus*, 17 (3), 115-117, https://doi.org/10.1016/j.ref.2016.05.007

PEREZ-DENICIA, E., FERNANDEZ-LUQUEÑO, F., VILARIÑO-AYALA, D., MONTAÑO-ZETINA, L. M., & MALDONADO-LOPEZ, L. A. (2017). Renewable energy sources for electricity generation in Mexico: A review. *Renewable and Sustainable Energy Reviews*, 78, 597-613, https://doi.org/10.1016/j.rser.2017.05.009

POTTING, J., HEKKERT, M., WORRELL, E., & HANEMAAIJER, A. (2017). Circular Economy: Measuring innovation in the product chain. *PBL Netherlands Environmental Assessment Agency*, 2544, 46.

RAUCH, E., DALLASEGA, P., & MATT, D. T. (2016). Sustainable production in emerging markets through Distributed Manufacturing Systems (DMS). *Journal of Cleaner Production*, 135, 127-138, https://doi.org/10.1016/j.jclepro.2016.06.106

RED VERDE (2018). *Red Verde*, http://www.redverde.co/

REYNA-BENSUSAN, N., WILSON, D. C., & SMITH, S. R. (2018). Uncontrolled burning of solid waste by households in Mexico is a significant contributor to climate change in the country. *Environmental Research*, 163 (February), 280-288, https://doi.org/10.1016/j.envres.2018.01.042

RLi - COUNCIL FOR THE ENVIRONMENT AND INFRASTRUCTURE (2015). *Circular Economy: From Wish to Practice* (Issue June), http://ec.europa.eu/environment/circular-economy/index_en.htm

RODRIGUEZ-URREGO, D., & RODRIGUEZ-URREGO, L. (2018). Photovoltaic energy in Colombia: Current status, inventory, policies and future prospects. *Renewable and Sustainable Energy Reviews*, 92 (April), 160-170, https://doi.org/10.1016/j.rser.2018.04.065

ROMAN-COLLADO, R., CANSINO, J. M., & BOTIA, C. (2018). How far is Colombia from decoupling? Two-level decomposition analysis of energy consumption changes. *Energy*, 148, 687-700, https://doi.org/10.1016/j.energy.2018.01.141

SANCHEZ-ALFARO, P., SIELFELD, G., VAN CAMPEN, B., DOBSON, P., FUENTES, V., REED, A., PALMA-BEHNKE, R., & MORATA, D. (2015). Geothermal barriers, policies and economics in Chile-Lessons for the Andes. *Renewable and Sustainable Energy Reviews*, *51*, 1390-1401, https://doi.org/10.1016/j.rser.2015.07.001

SCARPELLINI, S., PORTILLO-TARRAGONA, P., ARANDA-USON, A., & LLENA-MACARULLA, F. (2019). Definition and measurement of the circular economy's regional impact. *Journal of Environmental Planning and Management*, 62 (13), 2211-2237, https://doi.org/10.1080/09640568.2018.1537974

SILVESTRI, F., SPIGARELLI, F., & TASSINARI, M. (2020). Regional development of Circular Economy in the European Union: a multidimensional analysis. *Journal of Cleaner Production*, 255, 120218, https://doi.org/10.1016/J.JCLEPRO.2020.120218

THOMAS, C., & CACHANOSKY, N. (2016). Argentina's post-2001 economy and the 2014 default. *Quarterly Review of Economics and Finance*, 60, 70-80, https://doi.org/10.1016/j.qref.2015.08.002

TRICALLOTIS, M., GUNNINGHAM, N., & KANOWSKI, P. (2018). The impacts of forest certification for Chilean forestry businesses. *Forest Policy and Economics*, 92 (March), 82-91, https://doi.org/10.1016/j.forpol.2018.03.007

UNITED NATIONS (2016). *Sustainable Development Goals*. Sustainable Development Goals, https://sustainabledevelopment.un.org/

URBINATI, A., CHIARONI, D., & CHIESA, V. (2017). *Towards a new taxonomy of circular economy business models*, https://doi.org/10.1016/j.jclepro.2017.09.047