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DEMANDA, RELEVÂNCIA E POSSIBILIDADES DE IMPLEMENTAÇÃO DE FONTES RENOVÁVEIS DE ENERGIA NO SETOR INDUSTRIAL DO ESTADO DO PARANÁ, LOCALIZADO NO SUL DO BRASIL

DEMAND, RELEVANCE AND POSSIBILITIES TO IMPLEMENT RENEWABLE ENERGY SOURCES IN THE INDUSTRIAL SECTOR OF PARANÁ STATE LOCATED IN SOUTHERN BRAZIL

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Resumo

O Brasil é um país privilegiado com grandes recursos hídricos que permitem a geração de energia hidrelétrica de baixo custo e em grande escala. No entanto, a eletricidade brasileira é altamente cara devido aos muitos impostos e taxas. A primeira opção para atender à demanda por energia é por meio da geração termelétrica, completando um cenário em que as fontes de geração de eletricidade são centralizadas e não diversificadas. O estado do Paraná, localizado no sul do Brasil, tem o preço da energia ainda mais alto do que a média nacional. O setor industrial do Paraná é tradicionalmente agroindustrial, em contraste com as novas indústrias modernas implementadas na década de 1990, especialmente a fabricação de automóveis, que foi bastante prejudicada por esse alto custo. Os impactos ambientais causados pelos grandes projetos hidrelétricos, a poluição do ar, o esgotamento dos recursos naturais e os riscos de depender de poucas fontes refletem a necessidade de repensar esse sistema de geração de eletricidade. O objetivo deste artigo é identificar demandas, interesses e possibilidades de tornar o consumo de eletricidade mais barato, mais limpo e mais diversificado para atender às indústrias paranaenses por meio de fontes renováveis de energia. Conclui-se que a autogeração por biomassa é a mais promissora e já é amplamente utilizada pela agroindústria.

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A energia verde no Mercado Livre tem se tornado cada vez mais barata e atraído cada vez mais indústrias. Além disso, faltam incentivos específicos para as indústrias de pequeno porte. Por fim, observa-se um cenário de incertezas para os próximos anos baseado na instabilidade das políticas públicas que favorece a manutenção de uma trajetória tradicional no desenvolvimento dos projetos de eficiência do setor elétrico brasileiro.

Palavras-chave: Brasil, Setor Industrial, Paraná, Fontes renováveis, Autogeração.

Abstract

Brazil is a privileged country with great water resources that allows low-cost and large-scale hydropower generation. However, the Brazilian electricity is highly expensive because of the many taxes and rates. The first option to attend the demand for energy is through thermoelectric generation, completing a scenario where electricity generation sources are centralized and non-diverse. The state of Paraná, located in southern Brazil, has the energy price even higher than the national average. Paraná's industrial sector is traditionally agro-industrial in contrast with new modern industries implemented in the 1990's; especially the automobile manufacturing that has been greatly impaired by this high cost. The environmental impacts caused by large hydropower projects, air pollution, depletion of natural resources and the risks of depending on a few sources, reflect the need to rethink this electricity generation system. The objective of this article is to identify demands, interest and possibilities to make the consumption of electricity cheaper, cleaner and more diverse to attend Paraná's industries through renewable energy sources. It concludes that Self-generation by biomass is the most promising, and it is already widely used by agroindustry. Green energy at Free Market has become increasingly cheaper and it has attracting more and more industries. In addition, there is a lack of specific incentives for small-scale industries. Finally, it notes a scenario of uncertainties for the coming years based on the instability in public policies that favors the maintenance of a traditional path on the development of the Brazilian electricity sector efficiency projects.

Keywords: Brazil; Industrial Sector; Paraná; Renewable Sources; Self-generation.

1 Introduction

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The current social and economic system has been developing on some pillars, such as large-scale industrial production, over consumption of goods and the use of fossil fuels as main energy source. Since the Industrial Revolution in the XIX century, these non-renewable sources occurred in large-scale and the environmental impact they have caused is striking. In particular, the burning of fossil fuels is a cause to emission of Greenhouse Gases (GHG) and, consequently, of the global warming according to the International Panel on Climate Change (IPCC) (Bruckner et al., 2014).

Energy production is the main cause of GHG emissions worldwide, as a consequence of the fact that 86% of all energy produced is from fossil fuels (Dale, 2016) releasing nitrogen monoxide (NO) and mainly carbon dioxide (CO_2). For this reason, it is easy to see that the reduction of the use of non-renewable sources and, therefore, the substitution by renewable and cleaner sources, is a solution to reduce the emission of GHG.

In Brazil, these scenarios are considerably different from the global average. This South American country has an emerging economy strongly depending on the production and export of agricultural and mineral commodities. Consequently, the largest GHG emission is not from energy production or industrial processes, but from land-use change and forestry, which are responsible for more than 50% of the emissions (SEEG, 2016). In addition, the Brazilian river network is one of the largest and most diverse in the world, allowing that the main source of energy generation to be by hydroelectric power plants, which represents 64% of the national energy matrix (ANEEL, 2017).

In this context, the state of Paraná, located in Southern Brazil, is an interesting object of study because it has an even less diverse energy matrix than the national average, 94.4% of which is hydroelectric power.

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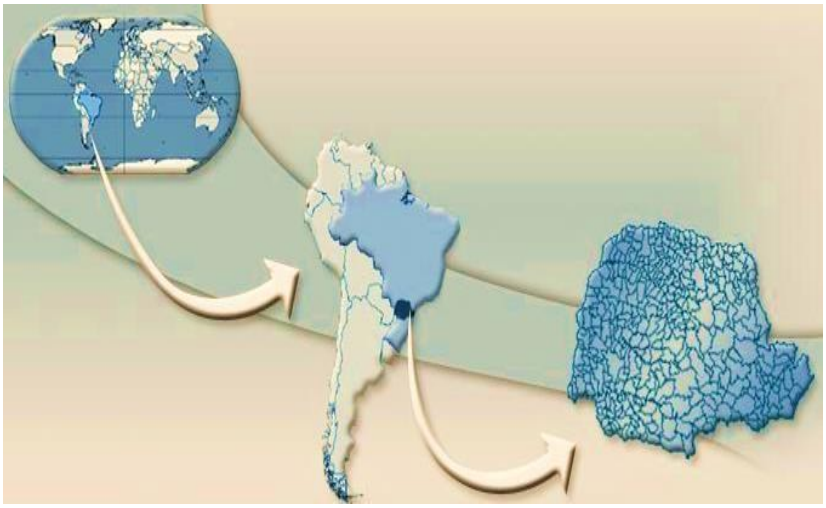

Figure 1. Location of the state of Paraná in Southern Brazil and the location of Brazil in the world map.
Source: The Paraná's Information and Communication Technology Company Website. [Online] Available: http://www.celepar.pr.gov.br/modules/conteudo/conteudo.php?conteudo=41

In addition, GHG emissions are mainly from agricultural activity (33%) and energy production is the third leading cause (25%) (Dale, 2016). However, it must be considered that the production of hydroelectric power is also a source of GHG emission, mainly methane, due to the decomposition of organic matter under anoxic conditions at the bottom of the reservoirs (Pueyo and Fearnside, 2011).

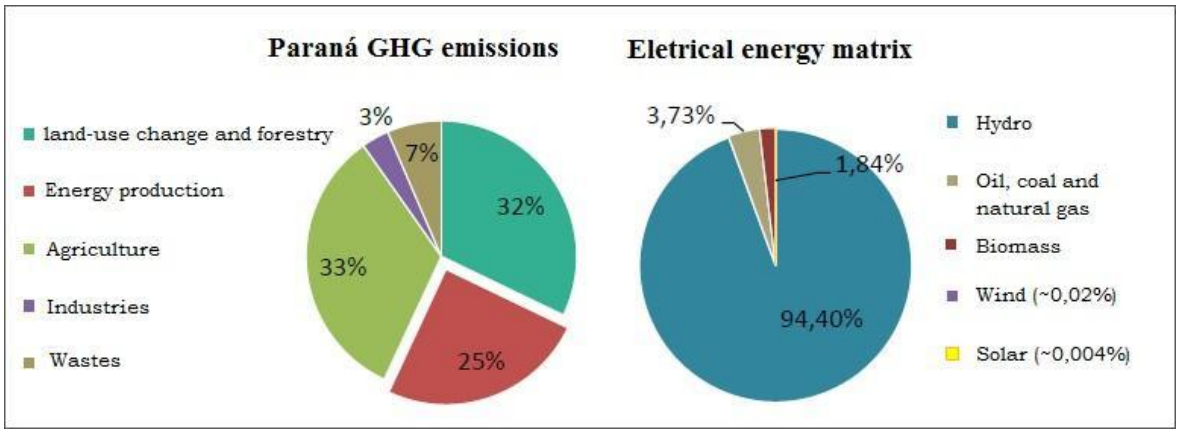

Figure 2. Greenhouse gas emissions by Paraná's economic sector (at left), and Paraná electricity generation matrix (at right)
Source: Dale, S. (2016). Energy in 2015: A year of plenty. London: BP. [Online] Available: http://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-spencer-dale-presentation.pdf; EPE - Energy Research Company (2017). Balanco Energético Nacional. Rio de Janeiro, Brazil. Available: https://ben.epe.gov.br/downloads/Relatorio_Final_BEN_2017.pdf

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Global warming is an environmental problem that is closely linked to the energy issue and the attempts to avoid or minimize it causes many international frictions for the possibility of slowing economic growth. Given that industries are the largest consumers of electricity in the state of Paraná, representing 25% of total consumption in 2016 (FIEP, 2016), the use of alternative sources of energy by this sector becomes a significant contribution to reduce greenhouse gas emissions without compromising the state industrial development.

Electric power is essential for industrial production; therefore, it also must be analyzed as an economic resource. Although hydropower generation may be quite low-cost, the many taxes and rates on Generation, Transmission and Distribution (GTD) services do not reflect the water privilege of Brazil and Paraná for this purpose.

The energy tariff varies widely throughout the national territory and even within the states, because it is fixed by each local concessionaire. The main concessionaire of Paraná is the Energy Company of Paraná - Copel, which is responsible for supplying energy in 393 of the overall 399 existing state's municipalities. The energy tariff is the price charged in R$/ kWh (Brazilian Real per Kilowatt-hours), and involves costs with GTD, energy losses, state taxes (Tax on Circulation of Goods and Transportation and Communication Services - ICMS, which is presently 29% in Paraná), federal taxes (Social Integration Program – PIS and Social Contribution on Revenues - COFINS), sectorial charges and concessionaire's rates (ANEEL, 2008). Copel's rates are the Energy Tariffs - TE and the Tariffs for the Use of the Distribution and Transmission System - TUSD/TUS.

For Copel customers, 40 to 45% of the energy tariff constitutes taxes, rates and subsidies (ANEEL, 2017). Comparing to other Brazilian states, Paraná has the fourth most expensive energy tariff among the country's industries, paying 12.5% more than the national average (SENAI, 2016). This scenario harms the industry in terms of competitiveness, because the asymmetry of taxes leads the Paraná's production to have no advantage over some other state or region; and, in general, Brazil loses competitiveness in relation to the industry of other countries.

Therefore, the objective of this article is to identify the demand, advantages and disadvantages, as well as the possibilities of inserting alternative and renewable sources of electric energy in sectors of Paraná's industry. Then to verify, in particular, their applications through self-generation and through buying energy in Free Market, allowing identifying

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which factors make difficult or motivate the implementation of these sources, comprising the current public policies.

2 Materials and Methods

First, it was necessary to think about reconciling the two fields in question, that is, Industry and Energy with a vision of decentralization and diversity in electricity generation. Thus, it was possible to explore the topic in a bibliographical review, starting with the reading of articles, monographs, dissertations and paper news, consolidating a familiarity with the subject from what is available in the literature. Identifying key data sources was an important step. Copel's information and operation, for example, is fundamental to diagnose the generation, consumption and costs of electricity, since the company is the main responsible for the generation and distribution of the resource in Paraná.

The data from Fiep, the Paraná State Industry Federation was essential. Its initiatives, research, reports and historical data are up-dated and reliable, since it works directly with the industries and reflects the interests of the sector. Fiep is also able to encourage new technologies, such as alternative energy sources, into the state industry. Both Copel and Fiep were fundamental for the accomplishment of this study. An interview with a representative of Fiep, João Arthur Mohr, included another stage of the research with the objective of knowing Fiep's effective actions and projects related to energy. In this way, it was also possible to speculate on the future scenario, in short- and long-term, of the energy issue for the industrial sector.

In general, data and documents analysis, reflection and investigation comprised the methodology that allowed accomplishing the proposed objectives.

3 Results and Discussion

3.1 The Brazilian Free Market of energy

At Regulated Contracting Environment - RCE or Regulated Market, the energy contracting in Paraná state is performed between the industry and COPEL, which is the public generation service concessionaire. This method of contracting does not allow price negotiation, that is, each consumer unit only pays one monthly energy bill, including energy

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distribution and generation services, with rates established by the Brazilian Electricity Regulatory Agency, ANEEL (Agência Nacional de Energia Elétrica).

The Free Contracting Environment - FCE, also known as Free Market, is a business environment where sellers and buyers can freely trade electric power with each other. This allows industrial and commercial consumers to contract their energy supply, negotiating price, terms and commercial conditions directly with Generators and Marketers.

By contracting energy in a customized way, the activities become more competitive [26]. Beside pays the energy negotiated, Copel's distribution service (or the distribution service of another local concessionaire), which has a regulated rate is also billed. In addition to choosing the type of contract that best benefits its demand, the Free Market consumer can choose to buy only renewable energy and from decentralized production. That happens because the energy can be conventional or incentivized. The conventional one is generated through any sources such as large hydroelectric plants and thermoelectric plants. Incentivized energy is the one generated through renewable sources as such Small Hydroelectric Power Plants, bioenergy, wind and solar power (Mercado Livre de Energia).

The incentivized energy is allowed to consumers that demand 3MW in maximum, which are denominated Special consumers (ANEEL, 2006). So, there are two types of consumer, Special and Free, provided by ANEEL, regarding the conditions of supply voltage, connection date and contracted demand charge and power source, as shown in the following table:

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Table 1
Classification of Free Market's consumers in Special and Free according to the conditions of voltage, date of connection and demand contracted as set by ANEEL's Resolution n. 247/2006

Consumer	Contracted demand	Connection date	Supply Voltage	Energy Source
Free Consumer	Equal or higher than 3,000 KW	After 07/08/1995	Any voltage	Any source (conventional or incentivized)
		Before 07/08/1995	Equal or higher than 69 kV	
			Less than 69 kV	Incentivized
Special Consumer	Between 500 KW and 3,000 KW	Any time	Equal or higher than 2.3kV	Incentivized

This means that larger industries (therefore, requiring a greater load) may choose to use incentive energy while smaller industries can only purchase this type of source.

For industries, Free Market has been very promising. Since the last few years, the Industry has been consuming much of its electricity through the Free Contracting Environment. In September 2016, the industrial consumption in Brazil hit a record: 70% was through FCE (ABRACEEL, 2017).

In Paraná, less than 1% of the industries contract energy at the Free Market, however, the consumption of these units represents 46.9% (IPARDES, 2017). This may happen, possibly, because the Free Market in Paraná has attracting, in general, few large-scale industries with the highest consumption of electricity. Therefore, the small-scale industries, which are usually Special consumers, may still find some difficulties to migration into the FCE. Even with incentives such as discounts from 50% of the distribution and transmission rates (TUSD/TUST).

Copel itself entered the Free Market as an energy marketer. In March 2018, the average commercialization price of the company for conventional energy was around R$ 258 / MWh and the incentivized energy was around R $ 305 / MWh (COPEL ENERGIA, 2017). If the cleaner and decentralization sources of energy are more expensive, the Free consumer (that can opt between conventional or incentivized sources) is discouraged from contracting

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them. Special consumers (as small-scale industries) may face more difficulties in making the transition to Regulated from Free Market, precisely because of the higher prices in incentivized energy.

In addition, Copel also participates in Free Contracting Environment as a generator and distributor of energy. Therefore, initiatives to reduce the costs in GTD in Paraná for Free and Special consumers, which may stimulate access to the Free Market, depend directly from Copel.

3.2 Renewable Self-generation energy by Paraná's industries

Self-generation allows supplying all or part of an industrial demand since it is destined for its exclusive use. In general, there are advantages to the savings in the payment of transmission services (for self-generation in the own industrial plant), reduction of network losses in the power system and an energy produced with better quality. Each industry has its peculiarity in relation to its production and demand for energy so each project is unique and depends on many factors. However, some well-developed sectors in Paraná, such as food of plant and animal origin, pulp and paper, sugar-energy, furniture and wood industries, fit easily in the generation of energy from biomass.

Fossil fuels, as well as biomass, have plant or animal origin (such as natural gas, coal and oil), but they take millions of years to form. Besides the advantage of being renewable, the biomass also has a much lower degree of pollution, especially when it comes to emissions of sulfur dioxide and greenhouse gases. From the industrial point of view, some sectors generate wastes that can be reused according to their energetic potential. Biomass is a low-cost source, since as the raw material costs can be zeroed for some waste, including those produced locally. In the same way, in most cases, its use saves on disposal processes, as well as contributing to the environment.

Western Paraná is already well developed in this respect. The local economy is strongly strengthened by agroindustry, where 26% of all grain crops in the state are produced (mainly soybeans, wheat and corn), as well as 30% of poultry production and 25% of cattle farming of Brazil (Cibiogás, 2016). Pig farms also have great prominence being well developed in Western and Southwestern Paraná. Still must be mentioned the cassava starch producing, which Paraná is the third largest Brazilian state producer. The processing of

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cassava for the production of flour or starch generates large amounts of liquid waste with high organic loading rate, which produces biogas through its decomposition.

Animal husbandry allows the generation of biogas through the anaerobic digestion of organic matter such as animal manures, sewage sludge, household and agricultural wastes, industrial effluents and aquatic plants (COPEL, 2016). The digesters are usually of simple construction, low-energy consumption, low operational costs, use to demand small areas and it can be applied in large scale of production. Therefore, it was already a widespread source of energy (not only electric, but also as thermal and steam power) for small agro-producers, but was expanding and requiring the development of more complex industrial systems accompanying the growth and consolidation of agroindustry (SENAI, 2016).

Forest residues also have important energy potentials within the timber, furniture and paper and pulp industries. The pulp and paper industries generate a large part of their energy consumed (50 to 60%) from the black liquor produced in the industrial process itself and from biomass in general (wood waste) (Coelho and Ieno, 1993). That industrial sector requires a lot of energy for its production, but also has many opportunities to exploits the energetic potential of the pulp, the black liquor and the lignin. An example of exploitation of this potential is a Klabin's industrial plant (operating since 2016), a paper and pulp producer, in the city of Ortigueira (in Eastern Center Paraná). The plant has the potential to generate up to 270 MW, enough to supply all the energy demanding, only with the use of biomass in cogeneration in a closed system that allows the reuse of chemicals and does not generate waste and effluents (KABLIN, 2016).

The timber industries produce firewood, charcoal or logs, but also a large amount of wood waste, which can also be used to generate electricity through burning. Already the furniture industry has its wastes transformed into pressed wood called briquette. The briquette has 50% of the burning power of the oil fuel, but its price is three times lower (Brito, 2017). However, the great potential resource for electric power generation in Brazil is the sugarcane bagasse. The sugar-alcohol or sugar-energy industry, which is well developed mainly in Northern Paraná, produces a large amount of waste, which can be used to generate electricity, mainly in cogeneration systems (electric and thermal power). Unlike the wood, the sugarcane cultivation and processing is carried out in large and continuous areas, and the use of waste

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(bagasse, straw and stillage) is facilitated by the centralization of production processes (CCEE, 2018).

At ethanol production, about 28% of the sugarcane is processed into bagasse and practically incinerated in the production of a low-pressure steam, which 37% of this steam is used in the turbines for the electricity generation (ANEEL, 2005). The vinasse is another residue of the processing of sugarcane and has polluting potential. To produce one liter of alcohol, it generates 12 liters of vinasse. This residue is usually disposed of in sacrificial areas or used as fertilizers with caveats, but also has the potential to obtain biogas by its digestion. Considering the data from the sugarcane harvest of 2012/2013, the state of Paraná could produce over 167,000,000 m³ of biogas annually, with a potential of 240 GWh of electricity per year (SENAI, 2016). Sugarcane bagasse is the main fuel for self-generation in the food and beverage industrial sector, which is one of the largest and most important in Paraná (EPE, 2017).

In general, any industry with a reasonable production of effluents and organic waste can carry out some type of process for the generation of solid, liquid or gaseous biomass. The industrial sectors presented are the most promising and efficient for this practice in Paraná, in addition to already showing some adherence to this energy use. However, in many cases the efficiency / production is low and the bioenergy is only used to complete the demand. In addition, biogas tends to be moist and could have a chemical composition with corrosion characteristics, what could damage the equipment. Another disadvantage is that the supply of the organic material used often depends on the seasonality of its production and can be altered by environmental and climatic factors.

The self-generation of hydroelectricity by an industry is usually done through auctions of the concession or authorization to consume the energy produced by a plant. The Small Hydroelectric Power Plants and the Hydroelectric Power Station are highlighted as a decentralized solution to hydro generation. However, these plants have some challenges for construction, such as the delay of the Brazilian bureaucratic cycle to installation a SHP, the high investment and long return period, which are factors that make the project unviable for many companies, especially the small-scale industries.

It is also important to explore the possibilities for solar and wind power sources. Both can be used by using the remaining spaces in the industrial plant, such as building roofs in

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case of solar panels, and open areas, in case of small-scale wind turbines. The fast technological advance for these sources also allows the construction of wind farms and photovoltaic plants with prices lower and lower. Nevertheless, this measure requires areas of size compatible with demand, as well as studies of the incidents of winds and solar radiation.

One of the biggest challenges to make solar and wind power more efficient is the difficulty of storing what is produced by turbines and panels. An immediate way to reduce this problem is to connect the new systems to the existing network. Thus, during the day all energy is consumed, and at night (or while there is no consumption), the rest is supplied to Copel in exchange for credits for later consumption, when it will be necessary to complete the demand.

An industry that has its own source of energy for self-consumption can compensate financially with the sale of its surplus in the Free Market, in addition to being exempt from some charges (as CDE, TUST and TUSD) on self-consumed energy. Considering that, 70% of self-generation in Brazil is already by the industrial sector and independent producers (Mendes, 2011), any incentives given for this practice will be positive for the valorization of the industrial sector and will affect the final consumers of these self-generators.

3.3 Actions and visions of the Paraná State Industry Federation – Fiep

The Paraná State Industry Federation defends the interests of the sector and its actions are a reflection of its future directions. Through testimony and interview with João Arthur Mohr, consultant of the Infrastructure Council of Fiep, it was possible to identify not only personal views of the interviewee, but also of the institution he was representing.

While the use of solid biomass of forest residues and sugarcane bagasse is already established, Mohr highlighted the biogas energy exploration by the agricultural industry as very important for the sector, since they often require simple installations and supply a good part of the electric energy demand. In this context, Fiep offers consulting materials with feasibility studies and research into the potential of biogas energy development, as well as introducing new technologies, strategies, current legislation and proposing specific applications for various industrial sectors.

In addition, Fiep also seeks a direct channel to negotiate public policies and action plans in the energy sector. An important action in this context is to get Paraná to join the

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agreement 16/2015 of the Confaz - National Council of Finance Policy, which exempts the state tax ICMS collection on generation of energy from renewable sources. The other states that have adhered to the agreement, have the tax levied only on what was consumed from the network, without charging on what was self-generated. Thus, in Paraná the ICMS is levied on all consumption, regardless if part of that energy, was generated by the consumer itself. The measurement favors Distributed Generation systems (electric power generation carried out next to or close to the consumer).

Mohr also highlighted Fiep's investments in natural gas in quantity, quality and at a fair price for the industry. For Mohr, the transition to a renewable energy matrix requires a firm energy source to ensure the safety of the system. Natural gas, in addition to ensuring this safety, still has advantages over other fossil fuels, such as LPG and coal, as it is less polluter.

4 Conclusions

Electricity in Brazil, even more in Paraná, is very expensive and it becomes even more significant when consumption is large, as is the case of industries. Therefore, reducing electricity expenditures is important to enable industrial growth and all the economic and social benefits that result. Fiep's actions related to energy efficiency have proven the interest of the sector that the institution represents, especially when the motivation is to reduce costs and become more independent of the Regulated Market.

Among the ways to reduce energy costs, self-generation showed great potential and adhesion to bioenergy production, since the resources are often quite accessible, as wastes from industrial production that have some energetic value. Yet, difficulties to deploy a system to exploit this potential can arise, such as the initial investment, lack of technical knowledge and low efficiency.

It was also identified the lack of opportunities for small-scale industry, for which self-generation could be financially infeasible. The scenario for them in Free Market is also more inhospitable. Being classified as Special consumers, small-scale industries are restricted to incentivized energy that are cleaner and most decentralized and diverse sources; however, these are more expensive, sometimes even with the reduction of distribution taxes. Thus, there is a need for more specific incentives for small-scale industries by the public policies, as well as starting by Fiep.

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As for self-generation through solar and wind power, it also requires a high investment to supply a good part of the industry's demand, in addition to the physical space. Nevertheless, to supply the consumption of headquarters and offices, turbines and panel installations are more accessible, although the return period could still be high.

It was also identified that industries are still quite dependent on natural gas and, if it depended on Fiep, the tendency is that their use only increases. This is a reflection of a disadvantage of renewable energies, which is efficiency to be subject to environmental factors such as rainfall, solar radiation and wind speed.

The industrial process itself is already quite polluting, but the industries must assume also an environmental responsibility with the large amount of electricity that they consume. Environmental impacts are inevitable for all human intervention in the planet, but a more diverse, decentralized and renewable energy matrix is capable of reducing the intensity of these impacts caused by productive sector. Thus, it is possible to provide energy, such fundamental resource, in a more accessible, innovative and cleaner way, valuing the local industries.

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