THE ROLE OF MUNICIPALITIES IN SUSTAINABLE DEVELOPMENT OF THE PHOTOVOLTAIC SECTOR

O PAPEL DOS MUNICÍPIOS NO DESENVOLVIMENTO SUSTENTÁVEL DO SETOR DE ENERGIA SOLAR FOTOVOLTAICA

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Abstract: This paper presents a study exposing the role of municipalities in sustainable development of the Brazilian's photovoltaic sector. It looked for the current public policies using photovoltaic solar energy source applied to the distributed generation sector, as well as it showed the extrafiscality in public actions that promote sustainable development in the electricity sector and its integration into the architectural reality of Brazilian cities. The general objective of the research is based on tax exemptions and public policies to promote sustainability, aiming at the actions of municipal entities and the integration of solar photovoltaic generating systems into the existing architecture of cities and the encouragement of new buildings with sustainable design. The present work was based on a bibliographic research, characterizing a qualitative and descriptive research. It was observed that sectoral industry is adapting to the cities reality and public policies are giving good results, promoting innovation and sustainability in energy production. It was concluded that the actions of public policies and extrafiscality by the federal entities are helping to increase the use of photovoltaic solar energy in Brazil.

Keywords: Public Policy. Photovoltaic Solar Energy. Sustainable Cities. Sustainable Development.

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Resumo: Este artigo apresenta um estudo expondo o papel dos municípios no desenvolvimento sustentável do setor fotovoltaico brasileiro. Buscou-se pelas atuais políticas públicas de uso de fonte de energia solar fotovoltaica aplicadas ao setor de geração distribuída, bem como evidenciou a extrafiscalidade nas ações públicas que promovem o desenvolvimento sustentável do setor elétrico e sua integração à realidade arquitetônica das cidades brasileiras. O objetivo geral da pesquisa baseia-se nas isenções tributárias e políticas públicas que visam a promoção da sustentabilidade, visando as ações dos entes municipais e a integração dos sistemas geradores por fonte solar fotovoltaica à arquitetura existente das cidades e o incentivo a novas construções com design sustentável. O presente trabalho se baseou em uma pesquisa bibliográfica, caracterizando uma pesquisa qualitativa e descritiva. A indústria do setor está se adequando à realidade das cidades e as políticas públicas estão dando bons resultados, promovendo a inovação e sustentabilidade na produção de energia. Conclui-se que as ações de políticas públicas e de extrafiscalidade pelos entes federativos estão auxiliando no crescimento da utilização da energia solar fotovoltaica no Brasil.

Palavras-chave: Políticas Públicas. Energia Solar Fotovoltaica. Cidades Sustentáveis. Desenvolvimento Sustentável.
1 INTRODUCTION

Energy has become one of the fundamental pillars of contemporary society, permeating all its sectors and becoming necessary to develop human activities. With environmental impacts directly affecting society, the incentive to use environmentally conscious energy sources has gained strength in the past decade.

In this sense, the quality of life of the world population can improve with sustainable economic growth through the planned and efficient use of available energy resources and the development of new energy generation technologies.

Hydroelectricity is the primary energy source in Brazil and it is facing enormous difficulties for its expansion due to the construction of new large reservoirs, mainly available only in the Amazon basin region, interfering in areas of environmental protection or social occupation.

Although it is a country that stands out in relation to other Latin American countries with regard to the generation of electricity from renewable non-hydro sources, Brazil still faces barriers that prevent a use compatible with its potential. In addition, the trend towards renewable sources, such as wind and solar, should represent a reserve of energy capacity to cover hydrological risks and also to contribute to a spread of generation distributed through electricity distribution networks (AQUILA et al., 2017).

The country suffers many economic and environmental losses in periods of drought and have to activate thermoelectric plants, powered by oil, gas, coal and other materials, which have high costs and a higher degree of pollution.

This combination causes electricity bills to increase in value, as well as it leads the government to adopt extra charges called yellow and red flags on electricity bills, bringing more economic losses to consumers. This Brazilian
scenario ended up exposing the fragility of the national electrical system, as the energy matrix is not diversified, making the country at the mercy of nature.

Renewable energies such as solar photovoltaics give the possibility that each property can generate its own energy, in order to relieve the interconnected system, investing more in distributed micro-generation and mini-generation from photovoltaic source as a solution to obtain energy security in times of droughts, which are the periods of greatest solar irradiation, or in times when nature instability may harm the country’s energy production.

Based on this fact, the 10-Year Expansion Plan 2024 (EPE, 2017) prioritized the participation of these renewable sources as one of the main guidelines to supply the growing consumption of electricity in the next 10 years, with focus on maintaining the grid stable and the energy service safe. So, encouraging the use of renewable energy in the country is happening by the implementation of public policies through various federative entities.

Thus, this research aims to expose the role of municipalities in sustainable development of the Brazilian’s photovoltaic sector. So, it looked for the current public policies using photovoltaic solar energy source applied to the distributed generation sector, as well as it showed the extrafiscality in public actions that promote sustainable development in the electricity sector and its integration into the architectural reality of Brazilian cities.

For the development of this study, qualitative, exploratory, descriptive, bibliographic and documentary research were used, where articles and doctrines were analyzed, with a descriptive bias. The research was exploratory in order to cover all fields, with the possibility of collecting necessary information to obtain satisfactory results. The research has the purpose to result from intellectual reasons, when based on the desire to know for the simple satisfaction to act (GIL, 2010).
2 DEVELOPMENT

2.1 Public Policies and Photovoltaic Solar Energy in Brazil

In Brazil, the wide energy production system is far from large consumption centers, which demands great costs with the transmission of electricity. In addition, we have a growing economic demand for expanding generation capacity. If the question of the feasibility of constructing new hydroelectric plants is debated, it has been taken into consideration that this is a large civil construction project and requires a high financial contribution. In this scenario, it is important to discuss other forms of energy generation, capable of meeting the growing demand for national energy (BORBA, 2015).

Although there is a high potential for solar irradiation in Brazil, as shown in Figure 1, only with the advent of the Brazilian's National Electric Energy Agency (ANEEL) Normative Resolution No. 482 of 2012 that the systems connected to the network, called distributed generation, became reality working as credit compensators. So, according to Villalva and Gazoli (2012), micro-generation and mini-generation powered by renewable energy sources were systematized, connecting in low and medium voltage distribution systems.
Even though the use of distributed generation has some negative aspects, like its intermittent condition of production, it also brings several benefits to society, avoiding blackouts due to lack of energy, and to the electrical system, relieving its transmission lines and complementing the national energy matrix (BARBOSA; AZEVEDO, 2013).

Source: GLOBAL SOLAR ATLAS (2017).
The distributed generation provided consumers a greater independence from the electricity distributors in relation to electricity consumed amount, including aiding in the stability of the national electricity system. In addition, there are technical benefits in which distributed generation brings great advantages. These benefits could be the possibility of installation in urban areas that already have buildings, the reduction of environmental impacts on energy production and the access to electricity in remote areas not served by the national electricity system. Another benefit is that the energy compensation system allows consumers to use solar photovoltaic energy, avoiding the use of batteries with short life and polluting waste disposal (NARUTO, 2017).

The environmental impact related to the deployment and operation of photovoltaic systems is very low and it is considered environmentally friendly. Thus, the arrangement of photovoltaic panels on roofs of existing buildings do not require environmental licenses in most Brazilian states. In addition, the current approval for photovoltaic systems requires several items of electrical engineering design, also Brazilian National Institute of Metrology, Quality and Technology (INMETRO) certificate or international certifications, varying to the plants proportion (NARUTO, 2017).

Therefore, systems that were installed correctly following the electrical and structural standards have a guaranteed quality within the national territory and risks of operation of this type of system are very low, especially when compared to nuclear plants. Thus, the disadvantages are reduced to an adequacy of the current transmission system, the inclusion of security measures and the need to inspect existing systems (MICHELETTI, 2017).

It cannot be denied the importance of preserving the environment, in addition to the extreme need for society as a whole to find effective means in preserving and restoring damage caused over time by mankind, so it could be able to maintain balance of the environment for future generations. Today the
population are experiencing a new reality full of uncertainties, environmental and technological risks, which have great consequences for the collective (SMANIO; JUNQUEIRA, 2017).

Bearing in mind that the environment is a fundamental right, the State is responsible for protecting this right and must create public environmental policies, apply sanctions and create mechanisms that encourage sustainable development (ALMEIDA, 2017). Therefore, aiming at a sustainable future based on preserving the environment and maintaining sustainable development is an undeniable goal. Therefore, the State has a crucial role in the development of actions that can combat setbacks and, at the same time, implement new public policies that help in this development. Regarding the photovoltaic solar energy sector, public policies aim to encourage the use of distributed generation in the country.

Among the roles of law, one is to implement public policies with the orderly and coordinated intention of the State in economic activity. The tax law is an important instrument for this purpose, which is why the environmental tax has been consolidated (CORBETTA, 2017).

According to Cavalcanti (2017), one of the first incentive programs promoted to the electric energy sector was the Incentive Program for Alternative Electric Energy Sources (PROINFA), launched in 2004, with the objective of increasing the national energy matrix through the participation of wind energy, biomass and Small Hydroelectric Power Plants, generating energy and connecting with the Brazilian’s National Interconnected Electric System (SIN). At that time, photovoltaic solar energy was not included, due to the lack of economic and strategic viability.

In 2014, Brazilian’s National Bank for Economic and Social Development (BNDES) launched the Progressive Nationalization Plan (PNP) for the photovoltaic sector, aiming to encourage the national industry. This plan was
part of the Economic Acceleration Program (PAC) and aims to promote financing according to the nationalization indexes of the products, based on the parameters of the methodology already used by the bank, known as BNDES Finame (TORRES FILHO; COSTA, 2012).

In the tax context, there are public tax exemption policies such as the National Council for Finance Policy (CONFAZ) Agreement No. 101 of 1997 with Tax on Circulation of Goods and Services (ICMS) exemption incentives for photovoltaic modules and cells, provided that there is a 0% Taxes Over Industrialized Products (IPI) tax rate or an exemption for these products, valid for national products and imported. Brazil also has the CONFAZ Agreement No. 16 of 2015, which gives the States and the Federal District the opportunity to grant ICMS incentives for micro and mini-generation, for residential, commercial and industrial users. In addition, Brazil has Law No. 13,169 of 2015 which deals with the exemption of the Social Integration Program (PIS) and the Contribution to Social Security Financing (COFINS) for micro and mini-generation for residential, commercial and industrial consumers who produce their own energy under the terms of ANEEL Resolutions No. 482 of 2012 and No. 687 of 2015.

Another important factor in the aforementioned public policies to encourage the photovoltaic sector are the Reserve Energy Auctions and the New Energy Auctions, which from 2014 to 2018, contracted more than 3 GW of energy generation through solar photovoltaic source. EPE's projection is that the source will accumulate 9,660 MW of installed capacity by the end of 2026, which takes into account the Ten-Year Expansion Plan (MAXIMO, 2018). Figure 2 illustrates the price reduction of energy auctions for solar photovoltaic plant projects, which is mainly linked to the reduction in investment costs and the increase in the capacity factor of the plants.

The Support Program for Technological Development of the Semiconductor and Display Industry (PADIS) is the set of tax incentives aimed
at attracting investments to the photovoltaic solar sector, in which there are IPI and PIS/COFINS incentives, directly impacting the Brazilian industry. After these incentives, Law No. 13,169 of 2015 was published with an environmental tax objective, which granted exemption from PIS/COFINS on energy produced in distributed generation and injected into the grid, whose growth is predominantly of photovoltaic solar energy (VALADÃO; CARNAÚBA, 2017).

The Climate Fund is a program linked to the Ministry of the Environment, which provides resources, including non-reimbursable resources, to finance studies, projects and undertakings that aim to reduce the impacts of climate change and adapt to its effects, having as a strong ally the photovoltaic solar
energy due to the small rate of environmental degradation produced by the generating source (SILVA; VIANA, 2017).

In order to ensure the safe use of photovoltaic solar modules, the government developed the Brazilian Photovoltaic Labeling Program (PBE) by INMETRO through Ordinance No. 4 of 2011, in order to analyze the quality, energy efficiency and safety of national and imported products. This program has brought many benefits to the solar photovoltaic sector, as it standardizes the minimum criteria so that investors in the sector feel safe when investing in the sector (MAXIMO, 2018).

For centralized generation projects also known as solar plants, the government launched through the Special Incentive Scheme for Infrastructure Development (REIDI), which aims to benefit these generating plants with photovoltaic solar source with the exemption of PIS/COFINS for products photovoltaic modules, inverters, metallic structures and others (SILVA; VIANA, 2017).

The Union and the States are rapidly developing public policies and extra-taxation in the sector. Some municipalities in the country have implemented their public policy programs to take their cities to a level of energy sustainability, encouraged by new technology.

2.2 Municipal Public Policies for Sustainable Cities

Over the years, the country has developed several public policies through programs aimed at fostering and developing the photovoltaic industry, the use of public policies in order to improve technological development, ends up promoting cost reduction to the sector, allied to this to other projects that are aimed at granting tax benefits (EDQUIST, 1997). Within the scope of photovoltaic solar energy, the number of public policies has grown, always
aiming at the diversification of the national energy matrix, energy security, the promotion of competitiveness and innovation in the sector.

Many Brazilian cities have encouraged the use of renewable energy as a sustainability policy, such as the Palmas Solar Program, in the city of Palmas, capital of the State of Tocantins. The program was created by the Palmas Solar Law (Complementary Law No. 327 of 2015) and regulated by Municipal Decree No. 1,220 of March 28, 2016. Through Palmas Solar, the municipality offers in return tax benefits to anyone who adopts the generation of photovoltaic energy in homes, businesses or industries. The discounts reach up to 80% in the Property Tax and Urban Land (IPTU) for five years.

As well as discounts on the Property Transfer Tax (ITBI), on the first property transfer. Depending on the possibilities offered to citizens, the capital Palmas went much further, and created SECRES (Extraordinary Municipal Secretariat for Strategic Affairs, Fundraising and Sustainable Energies), secretariat who has been implementing the project to install a solar park in the municipality. The Municipal Decree No. 1,553 of 2018 seeks to make the renewable energy project in the municipality viable, with the main goal of obtaining energy sufficiency from all municipal public bodies (PALMAS, 2018).

Another capital that is becoming a reference in the solar sector is Belo Horizonte, the capital of Minas Gerais is developing several initiatives to reduce greenhouse gas emissions and combat climate change. Among the various actions of the municipality, the city sustainable seal project instituted in 2012, was an unprecedented initiative in the country, and aims to encourage sustainable construction by the private and public sectors (PROGRAMA CIDADES SUSTENTÁVEIS, 2017).

The Environmental Sustainability Certification Program (PBH) certified 51 properties by the end of 2016, having issued a report stating that the emission
of 690 tons of CO$_2$ was avoided. The municipality encourages the use of the sun for a few years to heat water by a solar heating system, having become a national reference, and since the permission to connect to the Belo Horizonte network it has been encouraging the use of generation distributed by photovoltaic solar source, having as example the photovoltaic solar plant installed in the Mineirão stadium, which generates the energy the stadium needs and what is left is sent to the grid of the energy company CEMIG (PROGRAMA CIDADES SUSTENTÁVEIS, 2017).

The Ministry of the Environment has been developing studies and reports on the civil construction sector and its impacts on sustainable development. Based on Agenda 21 for sustainable construction, seeking to make environmental sustainability viable, it also embraces economic and social sustainability, which emphasizes the quality of life of individuals and communities. Regarding energy, it is recommended to use a solar thermal collector to heat water, wind energy and photovoltaic solar energy in a distributed generation system (MMA, 2018).

The incentive to use energy generation by solar photovoltaic source has obtained good results, however the sector has been experiencing many problems. The International Energy Agency (IEA) has been carrying out several studies on the insertion of photovoltaic technology in urban areas, especially in single-family residential architecture, which have large areas of roofs, mostly located in areas with little shading, different from central cities with taller buildings that shade their surroundings at certain times of the day. The integration of distributed generation focuses on production closer to the areas of consumption, in this sense the use of photovoltaic systems proves to be very viable (SALAMONI, 2004).
2.3 Challenges for Integrating Photovoltaic Solar Generation Systems in Brazilian Cities

Brazil is an independent economy, and economic growth is crucial to providing the necessary resources for its sustainable energy development. The expansion of energy generation from renewable sources would not only increase the country's economic growth and halt the deterioration of the environment, but would also create an opportunity for a leading role in the international system and improve Brazil's competition with more developed countries (PAO; FU, 2018).

Energy is one of the basic vectors of the infrastructure necessary for territorial and urban development, with the infrastructure having the concept of a basic set of goods and services made available in order to integrate human beings into the so-called development. The availability of infrastructure occurs in a given territory through the intervention of man to the environment, which, in the case of energy generators by sources of photovoltaic solar energy, has been finding a social environment formed by cities that already have an architectural identity.

Taking into account that Brazil is a country formed largely by immigrants from various parts of the world, architectural cultures have expressed themselves in different ways in each city or region, where we have several architectural styles within the country (REIS et al., 2012).

The IEA's annual reports address solutions and perspectives for the urban energy market, identifying the best applications that balance cost, efficiency and sustainability in green roof integration projects. This time, the objective is for distributed generation to grow in the urban territory, give consumers greater autonomy and help the country's electrical matrix (IEA, 2007).
The integration of distributed generation focuses on distributed generation as it allows proximity to areas of consumption. In this sense, the use of photovoltaic systems proves to be very feasible, but there was a need to adapt to existing architectures. Although nowadays architects and engineers are more attentive when elaborating projects, in order to deliver roofs with greater use of solar energy, there are still many constructions that need to make the generator system more flexible (RÜTHER, 2004). Although crystalline silicon photovoltaic modules are still the majority of these existing integrations, their arrangement occurs in the countless variations of existing buildings. The photovoltaic solar energy market is constantly working to expand and improve the factors of integration with the architectural landscape already existing in the country's cities. In addition, other types of solar cells that are appearing on the market may already be viable in some cases, such as thin films and organic photovoltaic cells.

Due to the possibility of connecting to the network is still recent, Brazilian industries and installers are seeking to adapt to the architectural reality of cities, in order to find solutions in the integration of systems with current buildings. The national metallurgical industry has been strongly encouraged to produce materials that provide this integration of photovoltaic generating systems to existing buildings, see Figure 3, developing various solutions for colonial roofs, metal, slabs, fiber cement and many other types of roofs used in our country (REIS; MOREIRA, 2015).

The scenario of solar energy in Brazil, being part of low latitude countries, has promising indications for photovoltaic systems, and the photovoltaic integration with pre-existing roof architecture in general reduces the initial investment costs, as it prevents the customer have to create a new structure or even have to remodel your roof to receive the system. With many
exceptions, after all, the roofs that precede the solar photovoltaic expansion in the country were not designed to receive this integrated system in them, having to take several assumptions in consideration such as: weight, aerodynamics, quality of the material used to make the roof and durability.

For there to be good practices in the photovoltaic sector, there must be good communication between integrating companies, the national structural industry, electrical engineers with other engineering areas, especially civil engineers, thus bringing greater security in the process of integrating photovoltaic systems into existing architectural buildings (ZOMER et al., 2016).

Figure 3 – Arrangement of photovoltaic elements in buildings
Despite the obstacles encountered by the solar energy sector to integrate photovoltaic systems in the country's cities, the new future scenario seems to conceive professionals more engaged in developing more sustainable projects. The projects for the new constructions should focus on own energy generation.

Thinking about it, the company TESLA launched solar roof tiles called Solar Roof that replace the conventional roof, uniting the roof and the photovoltaic generator system in a single product. Following this same concept, other companies such as the Chinese Hanergy have been developing new thin

Source: Thomas and Grainer (1999).
film technologies and integrating them into colonial tiles made of more resistant materials for the production of energy (TESLA, 2020).

With or without problems, the expansion of the photovoltaic sector in Brazil is a reality. The responsible sectors should not only think about the solutions for integration, but also analyze the good practices of this integration, so that the expansion is qualitative and sustainable.

3 FINAL CONSIDERATIONS

Since 2012, the country has been investing in the solar energy sector and much of public policy has been promoting the sector. The exemption from ICMS, PIS and COFINS was an important step in the development of the photovoltaic sector, opening greater economic viability to the final consumer.

Although, in the case of the ICMS, as it is a matter of State or District nature, it has a lot of discrepancy and some claims of the solar energy associations to cover other parts of the electricity bill.

Brazilian cities are gradually adapting their legislation to welcome the photovoltaic sector. The so-called sustainable cities seek to encourage the use of generating systems by renewable sources, each municipal entity in its form has been playing a role in integrating and fostering this new reality.

With planning, photovoltaic systems can expand and integrate the networks and architectures of cities in the country, as energy is a basic factor of infrastructure, and must be thought and developed on the environmental, economic and social sustainability.

The government has a duty to promote and elaborate public policies, financing, investments and a lot of research, so that the technological development of national industries is promoted, the economic viability to the final consumer will become a reality and these actions can guarantee greater sustainability to the country in its energy matrix.
REFERENCES

ALMEIDA, W. C. Direito, desenvolvimento e meio ambiente: teoria e prática. Curitiba: CRV, 2017.

AQUILA, G.; PAMPLONA, E. O.; QUEIROZ, A. R., ROTELA JUNIOR, P.; FONSECA, M. N. An overview of incentive policies for the expansion of renewable energy generation in electricity power systems and the Brazilian experience. Renew. Sustain. Energy Rev. 70, pp. 1090-1098, 2017.

BORBÁ, E. N. Energia hidrelétrica e seus principais riscos hoje no Brasil: o caso das PCH’s, Rio de Janeiro: UFRJ, 2015.

CAVALCANTI, C. C. T. (coord.). O direito da energia no contexto ibero-brasileiro. Rio de Janeiro: Synergia, 2017.

CORBETTA, J. M. Taxa ambiental como instrumento de política pública na defesa do meio ambiente. In: CAVALCANTE, D. L.; CALIENDO, P. (coord.). Políticas públicas, tributação e energia solar. Curitiba: CRV, 2017. p. 43-66.

EDQUIST, C. Systems of Innovation: Technologies, institutions and organizations. London: Pinter, 1997.

EPE [Empresa de Pesquisa Energética] (Brasil). Plano Decenal de Expansão de Energia 2026. Ministério de Minas e Energia. Brasília: MME/EPE, 2017. Available in: <http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-40/PDE2026.pdf>. (accessed 10 Jul. 2019).

______. Projetos fotovoltaicos nos leilões de energia. Ministério de Minas e Energia. Brasília: MME/EPE, 2018. Available in: <http://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-265/topico-417/EPE-DEE-NT-091_2018-r0.pdf>. (accessed 12 Jul. 2019).
GIL, Antônio Carlos. **Como elaborar projetos de pesquisa.** 5. ed. São Paulo: Editora Atlas, 2010.

GLOBAL SOLAR ATLAS. **Download maps for your country or region:** Brazil Mid-size maps. The World Bank Group, 2017. Available in: <https://globalsolaratlas.info/downloads/brazil>. (accessed 23 Jan. 2019).

IEA [International Energy Agency]. **World Energy Statistics.** 2007.

LAKATOS, Eva Maria; MARCONI, Marina de Andrade. **Metodologia do trabalho científico.** 7. ed. São Paulo: Editora Atlas, 2012.

MAXIMO, Rosely (ed.). **Solar:** anuário 2018. São Paulo: Brasil Energia, 2018.

MMA [Ministério do Meio Ambiente] (Brasil). **Construção Sustentável.** Brasília, 2018 Available in: <https://www.mma.gov.br/cidades-sustentaveis/urbanismo-sustentavel/constru%C3%A7%C3%A7%C3%A3o-sustent%C3%A1vel/>. (accessed 20 Jul. 2019).

MICHELETTI, D. H. **Energia solar fotovoltaica e projeto de microgeração residencial.** Revista Lumière Electric, n. 234., p. 72-6, Editora Lumière, São Paulo: 2017.

NARUTO, D. T., 2017. **Vantagens e desvantagens da geração distribuída e estudo de caso de um sistema solar fotovoltaico conectado à rede elétrica.** Monografia de Graduação. Rio de Janeiro: UFRJ, 2017. Available in: <http://monografias.poli.ufrj.br/monografias/monopoli10020290.pdf>. (accessed 21 May 2019).

PALMAS, Prefeitura de. **Palmas Solar movimentou mais de R$ 2,5 milhões na Capital em dois anos.** Secretaria Municipal Extraordinária de Assuntos Estratégicos, Captação de Recursos e Energias Sustentáveis. Palmas (TO), 2018. Available in: <https://www.palmas.to.gov.br/secretaria/energias-sustentaveis/noticia/1506947/palmas-solar-movimentou-mais-de-r-25-milhoes-na-capital-em-dois-anos/>. (accessed 23 Jul. 2019).

PAO, H. T., FU, H. C. **Renewable energy, non-renewable energy and economic growth in Brazil.** Renew. Sustain. Energy Rev. 25, pp. 381-392, 2018.

PROGRAMA CIDADES SUSTENTÁVEIS. **Capital Nacional de Energia Solar.** Belo Horizonte, 2017. Available in: <https://www.cidadessustentaveis.org.br/boas-praticas/capital-nacional-de-energia-solar>. (accessed 13 Aug. 2019).
REIS, L. B. et al. Energia, recursos naturais e a prática do desenvolvimento sustentável. 2. ed. Barueri, SP: Manole, 2012.

REIS, J.; MOREIRA, S. Geração distribuída e centralizada no Brasil: potencial, barreiras e perspectivas. Revista Fotovolt, São Paulo, Aranda Editora, v. 1, n. 2, p. 14-5, nov., 2015.

RÜTHER, R. Edifícios Solares Fotovoltaicos: o potencial da geração fotovoltaica integrada a edificações urbanas e interligada à rede elétrica pública no Brasil: Editora UFSC/LABSOLAR. Florianópolis, 2004.

SALAMONI, I. T. Metodologia para cálculo de geração fotovoltaica em áreas urbanas aplicada a Florianópolis e Belo Horizonte. PPGEC, UFSC, Florianópolis, 2004.

SILVA, C. S. A. da; VIANA, I. C. A proposta de remanejamento fiscal de Fritjof Capra e as políticas públicas de energia solar. In: CAVALCANTE, D. L.; CALIENDO, P. (coord.). Políticas públicas, tributação e energia solar. Curitiba: CRV, 2017. p. 151-66.

SMANIO, G. P.; JUNQUEIRA, M. A. (org.). Políticas públicas como instrumento de efetivação da cidadania, desenvolvimento e solidariedade. Curitiba: CRV, 2017.

TESLA, Inc. Solar for New Roofs. California (USA), 2020. Available in: <https://www.tesla.com/solarroof> (accessed 13 Aug. 2020).

THOMAS, R.; GRAINER, T. Photovoltaic in buildings - a design guide: Department of trade and industry. Londres, 1999.

TORRES FILHO, E. T.; COSTA, F. N. BNDES e o financiamento do desenvolvimento. Campinas, SP: Economia e Sociedade, v. 21, n. especial, p. 975-1009, dez., 2012.

VALADÃO, M. A. P.; CARNAÚBA, F. R. A extrafiscalidade como forma de implementação do desenvolvimento sustentável. In: CAVALCANTE, D. L.; CALIENDO, P. (coord.). Políticas públicas, tributação e energia solar. Curitiba: CRV, 2017. p. 83-114.

VILLALVA, Marcelo G.; GAZOLI, Jonas R. Energia solar fotovoltaica: conceitos e aplicações. São Paulo: Editora Érica, 2012.
ZOMER, C. D. et al. Integração fotovoltaica à arquitetura e simulações de desempenho energético no centro de pesquisa e capacitação em energia solar da UFSC. RBS Magazine, Ponta Grossa, Grupo FRG, v. 2, n. 11, p. 36-40, jul./ago., 2016.

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