Research, Society and Development, v. 11, n. 11, e07111133293, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i11.33293

Panorama of photovoltaic energy in poultry in Paraná

Panorama da energia fotovoltaica na avicultura de corte no Paraná

Panorama de la energía fotovoltaica en la avicultura en Paraná

Received: 07/23/2022 | Reviewed: 07/30/2022 | Accept: 08/03/2022 | Published: 08/13/2022

Emmanuel Zullo Godinho
ORCID: https://orcid.org/0000-0001-5281-6608
Paulista State University, Brazil
E-mail: emmanuel.godinho@unesp.br
Mayerlin Edith Acuña Montaño
ORCID: https://orcid.org/0000-0002-0135-5343
Universidade Tecnológica Federal do Paraná, Brazil
E-mail: mayerli013@gmail.com
Lisett Rocío Zamora Ortega
ORCID: https://orcid.org/0000-0003-2321-4522
Paulista State University, Brazil
E-mail: rocio.ortega@unesp.br
E-mail: mayerli013@gmail.com
Fernando de Lima Caneppele
ORCID: https://orcid.org/0000-0003-4498-8682
University of Sao Paulo, Brazil
E-mail: caneppele@usp.br
Luis Fernando Soares Zuin
ORCID: https://orcid.org/0000-0001-8571-7665
University of Sao Paulo, Brazil
E-mail: lfzuin@usp.br

Abstract
Brazil stands out before other countries for having a gigantic area for food production. Paraná is the state that stands out among the nation's states with its gross production value (VBP), which in these values are the agricultural and livestock productions such as poultry farming. Moreover, Paraná stands out for having a high solar irradiation, which leads rural entrepreneurs to seek the use of renewable energies as electric energy, especially photovoltaic energy. With that, the present study refers to a qualitative systematic review, whose objective was to conduct an analysis of the scientific production on the panorama of solar photovoltaic energy in poultry farming in the state of Paraná, in the period from 2012 to 2021. The bibliographical search was carried out in the databases: Scopus and Scielo including others described on the theme, searching for information from government agencies responsible for production indicators, growth and development. This review showed that the State of Paraná has a great potential for photovoltaic solar energy generation, by the levels of solar radiation which is inserted and also for having the largest poultry herd in Brazil.
Keywords: Rural sustainability; Electrical energy; Solar energy.

Resumo
O Brasil se destaca perante outros países por possuir uma área gigantesca para a produção de alimentos. O Paraná é o Estado que se destaca entre os Estados da nação, com seu valor bruto de produção (VBP), que nestes valores estão as produções agrícola e pecuárias como a avicultura de corte. Além disso, o Paraná se destaca por possuir uma alta irradiação solar o que leva aos empresários rurais buscarem utilizar as energias renováveis como energia elétrica principalmente a energia fotovoltaica. Com isso, o presente estudo refere-se a uma revisão sistemática qualitativa, cujo objetivo foi conduzir uma análise da produção científica sobre o panorama da energia solar fotovoltaica na avicultura no estado do Paraná, no período de 2012 a 2021. A busca bibliográfica foi realizada nas bases de dados: Scopus e Scielo incluindo outros descritos sobre o tema, buscando informações de órgãos governamentais responsáveis por indicadores de produção, crescimento e desenvolvimento. Esta revisão mostrou que o Estado do Paraná possui um grande potencial de geração de energia solar fotovoltaica, pelos níveis de radiação solar o qual está inserido e também por possuir o maior rebanho de aves de corte do Brasil.
Palavras-chave: Sustentabilidade rural; Energia elétrica; Energia solar.

Resumen
Brasil se destaca de otros países por tener un área gigantesca para la producción de alimentos. Paraná es el estado que se destaca entre los estados de la nación, con su valor bruto de producción (PVB), que en esos valores son

producciones agrícolas y pecuarias como la avícola. Además, Paraná se destaca por tener una alta irradiación solar, lo que lleva a los empresarios rurales a buscar el uso de energías renovables como energía eléctrica, principalmente la energía fotovoltaica. Así, el presente estudio se refiere a una revisión sistemática cualitativa, cuyo objetivo fue realizar un análisis de la producción científica sobre el panorama de la energía solar fotovoltaica en aves de corral en el estado de Paraná, de 2012 a 2021. La búsqueda bibliográfica se realizó en las bases de datos: Scopus y Scielo, entre otras descritas sobre el tema, buscando información de los organismos gubernamentales responsables de los indicadores de producción, crecimiento y desarrollo. Esta revisión mostró que el Estado de Paraná tiene un gran potencial para la generación de energía solar fotovoltaica, debido a los niveles de radiación solar en los que se inserta y también porque tiene el mayor rebaño de pollos de engorde de Brasil.
Palabras clave: Sostenibilidad rural; Energia electrica; Energía solar.

1. Introduction

Producing food in Brazil, specifically chicken meat, represents great economic importance in the country, generating more than 4.1 million direct and indirect jobs, as well as contributing 11.5% of Brazilian exports, in 2019 the Brazilian production of chicken meat totaled 13.2 million tons, with more than 51 million units of cutting dies. The state of Paraná is the leader in the country, contributing 33.46% of slaughter and 35.85% of chicken exports. Brazil, on the other hand, appears in third place in the world ranking of production and first in the ranking of exports (EMBRAPA, 2021) and (Lacerda *et al.*, 2019).

Aviaries are known as confinement modules that require large volumes of electricity, the challenge is to feed enough energy so that these modules do not come to harm the environment and result in a good supply of generated energy (Souza & Molento, 2015)

In this scenario, photovoltaic generators come in, which are electric energy generation systems that use the most abundant renewable energy source, which is the use of solar radiation (Lira *et al.*, 2019). This form of energy has several benefits, such as ease of installation, not requiring large areas and not generating waste, which is important for the environment, in the south of Brazil, in the west of Paraná, the solar irradiance is affected due to the seasonality, presenting with greater intensity in the summer months and low with incidence in the winter (Barbosa *et al.*, 2017) and (Francisco *et al.*, 2019) and (Stefanello *et al.*, 2018).

In this scenario, in the present study we seek to understand the panorama of photovoltaic solar energy in poultry in the state of Paraná through a qualitative systematic review of the literature of articles on the subject. From the analysis, we present an overview of these studies in the last 10 years.

2. Methodology

This study derives from a *Systematic Bibliographic Review* – SBR research, defined by (Dessbesel *et al.*, 2018) and (Godinho & Caneppele, 2021), which presents a research model, where the main data of the literature on a given topic is used, thus building a bibliographic survey present reliable data for the next surveys. The review was guided in stages, namely: survey of the theme, planning phase of the systematic review, selection of journals, application of exclusion and data inclusion filters, critical evaluation and finally data synthesis (Teixeira *et al.*, 2010). The structure of the work had the following format: Survey of the theme: planning phase of the systematic review, in which the theme was defined, as it was subdivided from the central theme Solar Rural Energy.

i. Planning phase of the systematic review: collecting keywords in scientific articles in the area in order to select the keywords for data collection
ii. Selection of databases: the databases chosen were the Scientific Electronic Library Online - Scielo® and Scopus® by Elseiver, which brings together national and international scientific journals. The keywords for the search were "*Photovoltaic energy*" and "*Broiler poultry*" and "*Gross production value*" and "*Parana*".

iii. Applications of data exclusion and inclusion filters: after searching the databases, it was necessary to define the inclusion and exclusion criteria for the research.

As inclusion criteria, we selected:

a) Publications in the periods from 2012 to 2021 and in English and Portuguese;

b) Only articles with research and articles and review.

Exclusion criteria:

a) Theses and dissertations, conference proceedings (national and international) dealing with scientific research, literature review and theoretical essays;

b) Not available in full;

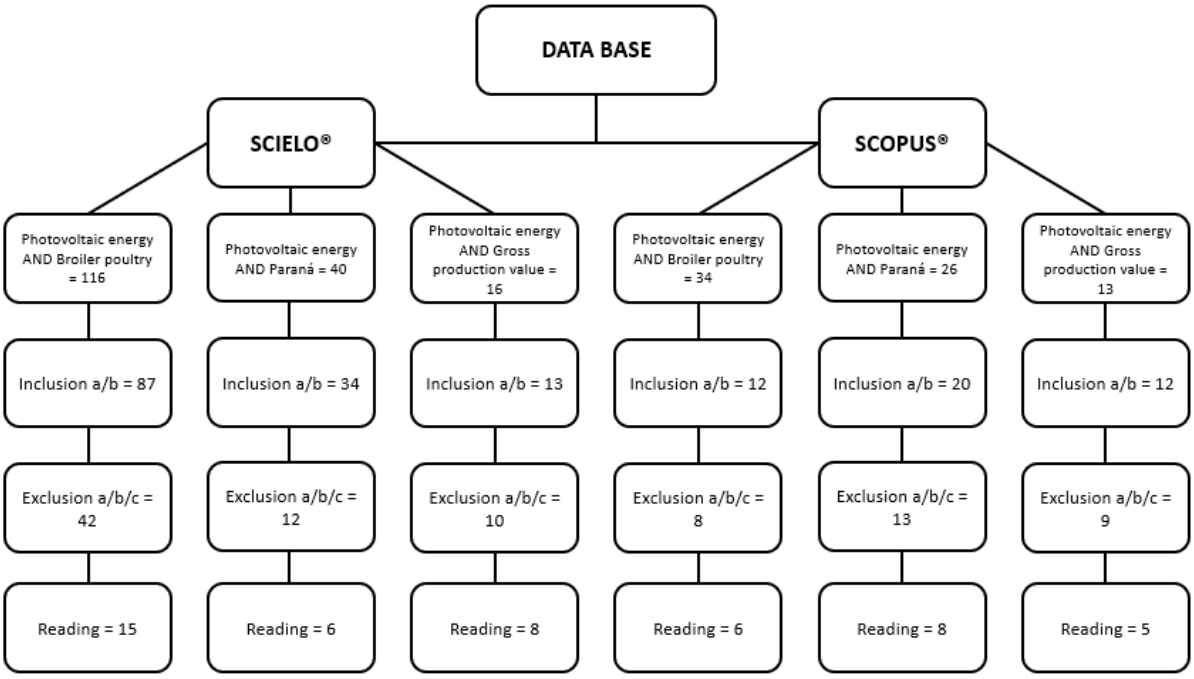
c) Articles for more than 10 years.

iv. Data collection: 172 papers were found among research and review articles in the Scielo database and 73 in the Scopus database. The first inclusion criterion related to studies from 2012 to 2021 was applied and resulted in 134 at Scielo and 44 at Scopus. For the exclusion criteria (b, c), we finished with 64 in Scielo and 30 in Scopus. After being saved in a digital Mendeley® platform, we read the titles and the research summary, resulting in 29 in the Scielo database and 19 in the Scopus database.

v. Critical evaluation: a critical evaluation of the studies (data) was carried out according to the central objective of the review, analyzing the potential of energy generation and the panorama of solar energy in the State of Paraná / Brazil.

vi. Summary of data: qualitative systematic review, that is, a careful analysis of the panorama of solar energy used in broiler poultry in Paraná.

Figure 1 - shows the steps taken to collect the data for the systematic bibliographic review.



Source: Authors (2022).

3. Results and Discussion

The configured search generated a total of 48 articles. After a selection by reading the titles and abstracts, the publications were considered potentially eligible and were read in their entirety. At the end of the analysis, it was completed with fifty articles that completed the conditions of inclusion for the study and are listed in this section. The selected articles were published between 2012 and 2021.

The articles analyzed have the highest production in 2020, in which there is an increase of 23% in relation to the previous year. Of the 48 articles analyzed, 23 in the Portuguese language (48%), while in the English language, 25 corresponding articles (52%).

Chart 1 organizes the analyzed works, as a result of the systematic review, with the authors' name, year and title.

Chart 1 - Article registration matrix.

N°	Autor/ Autores	Titulo
1	(TIEPOLO *et al.*, 2017)	" Atlas Solar User Manual ". 1st Edition
2	(EPE, 2020)	2020 Statistical Yearbook of electricity: 2019 baseline year
3	(Stefanello *et al.*, 2018)	The Importance of Public Policies for the Promotion of Photovoltaic Solar Energy in Brazil
4	(Custódio & Oliveira, 2017)	the Brazilian Legislation on Land Use and Occupation and Its Systemic Dissonance with Reducing Factors in the Reflection of Solar Energy
5	(Tawa *et al.*, 2020)	Accurate output forecasting method for various photovoltaic modules considering incident angle and spectral change owing to atmospheric parameters and cloud conditions
6	(Lima *et al.*, 2020)	An overview of photovoltaic energy conversion principles
7	(Girotti *et al.*, 2019)	Analysis of urban morphology to maximize photovoltaic power generation in Belenzinho, São Paulo
8	(Visser *et al.*, 2019)	Assessing the impacts of a utility-scale photovoltaic solar energy facility on birds in the Northern Cape, South Africa
9	(Horta, 2017)	Bioavailability of phosphorus from composts and struvite in acid soils.
10	(Souza & Molento, 2015)	Good agricultural practices in poultry farming in the state of Paraná: Focus on animal welfare
11	(Imai *et al.*, 2020)	Computational simulation as an optimization tool for photovoltaic solar energy generation
12	(Pereira *et al.*, 2020)	Reliability of The International Fitness Scale questionnaire: a systematic review and meta-analysis to systematic review and meta-analysis
13	(Lira *et al.*, 2019)	Contribution of photovoltaic systems connected to the electrical network for reducing CO2 in the state of Ceara
14	(Askarzadeh & Dos Santos Coelho, 2015)	Determination of photovoltaic modules parameters at different operating conditions using a novel bird mating optimizer approach
15	(Vumbugwa *et al.*, 2020)	Effects of current mismatch due to uneven soiling on the performance of multi-crystalline silicon module Strings
16	(Boquimpani *et al.*, 2019)	Energy efficiency: LED lighting systems, distributed in direct current and using photovoltaic energy
17	(EMBRAPA, 2021)	Embrapa Swine and Poultry
28	(Barbosa *et al.*, 2017)	Photovoltaic Solar Energy in the Semiarid Region: Potential, Current Scenario and Perspectives
19	(Gönen & Kaplanoğlu, 2019)	Environmental and economic evaluation of solar panel wastes recycling
20	(Mustafa *et al.*, 2020)	Environmental impacts on the performance of solar photovoltaic systems

21	(Didoné *et al.*, 2014)	Strategies for zero energy office buildings in Brazil with an emphasis on BIPV
22	(Santos *et al.*, 2014)	Bioclimatic study of coastal, rugged and semi-arid regions of the state of Sergipe for broiler and laying poultry
23	(Bender *et al.*, 2020)	Study of economic parity and energy performance of photovoltaic solar facades in the extreme south of Brazil
24	(Tercan *et al.*, 2020)	Geographic information system-based investment system for photovoltaic power plants location analysis in Turkey
25	(Martín & Pérez-Ramírez, 2019)	Heading to Distributed Electrocatalytic Conversion of Small Abundant Molecules into Fuels, Chemicals, and Fertilizers
26	(Sisodia & Mathur, 2019)	Impact of bird dropping deposition on solar photovoltaic module performance: a systematic study in Western Rajasthan
27	(Da Silva & Branco, 2018)	Is floating photovoltaic better than conventional photovoltaic? Assessing environmental impacts
28	(Dessbesel *et al.*, 2018)	The teaching and learning process of mathematics for deaf students: a systematic review
29	(L. Q. Liu *et al.*, 2015)	Optimal azimuth and elevation angles prediction control method and structure for the dual-axis sun tracking system
30	(Rosa, 2016)	Panorama of Solar Photovoltaic Energy in Brazil
31	(Lin *et al.*, 2017)	Parameters extraction of solar cell models using a modified simplified swarm optimization algorithm
32	(El Iysaouy *et al.*, 2020)	Performance analysis of partially shaded photovoltaic array using magic square view configuration for shade dispersion
33	(Assadeg *et al.*, 2019)	Performance of grid-connected solar photovoltaic power plants in the Middle East and North Africa
34	(Mathijssen *et al.*, 2020)	Potential impact of floating solar panels on water quality in reservoirs; pathogens and leaching
35	(Perazzoli *et al.*, 2020)	Proposal of criteria and minimum requirements for environmental licensing of photovoltaic power plants in Brazil
36	(Elsheikh & Abd Elaziz, 2019)	Review on applications of particle swarm optimization in solar energy systems
37	(Sreenath *et al.*, 2020)	Solar photovoltaics in airport: Risk assessment and mitigation strategies
38	(Júnior *et al.*, 2019)	Sustainability in residential building in the municipality of Dourados, MS
39	(C. Liu & Liu, 2020)	The global peak forecasting method for PV array based on the conservation of energy at uniform and partial shading
40	(Francisco *et al.*, 2019)	The influence of meteorological parameters in the generation of energy in photovoltaic panels: A case study of Smart Campus Facens, SP, Brazil
41	(Paulus *et al.*, 2019)	Use of electric and solar energy sources in aviaries in the municipality of Tupãssi-PR
42	(Calsi Silva *et al.*, 2020)	Procedimiento del cálculo de la potencia nominal de un generador fotovoltaico
43	(Chaves, 2021)	Tecnologias de eletricidade limpa podem resolver a crise climática
44	(Feitosa *et al.*, 2021)	Environmental impact of different agricultural production systems
45	(Cardoso *et al.*, 2021)	Distributed generation of photovoltaic solar energy: impacts of aneel's new regulation proposal on investment attractiveness
46	(Tiepolo *et al.*, 2016)	Energia solar no Estado do Paraná - Potencial, Barreiras e Políticas Públicas
47	(Michels *et al.*, 2009)	Avaliação do bombeamento de água em um sistema alimentado por painéis fotovoltaicos
48	(Becerra-Díaz & Ando Junior, 2021)	Investigation of the effect temperature on the performance of the photovoltaic solar design for the western Region of Paraná - Brazil

Source: Authors (2022).

This study is dedicated to analyzing the work related to electrical energy obtained from photovoltaic systems for the benefit of poultry in the state of Paraná. For that, the results are divided into four parts, they are: presentation of research in which there is an evaluation of the agricultural sector in Paraná; information on poultry farming in Brazil and Paraná; description of photovoltaic energy and the benefits of its application in rural areas.

Some patterns can be identified among the different publications 21% of the selected articles referred to Normative Resolution n° 482/12 or the new Normative Resolution n° 687/15. 62% of the selected publications are directly related to the keyword "Photovoltaic", 35% with "Solar energy", 19% with "Renewable energy" and 5% with "Poultry".

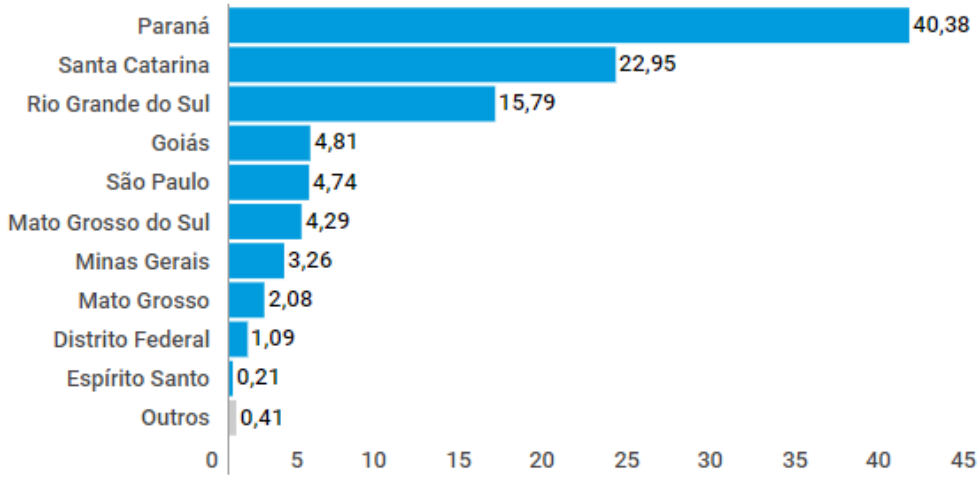
3.1 Paraná in the agricultural sector

In 2019, agricultural production in the state of Paraná totaled R$ 97.7 billion, a value 3% higher than that recorded in 2018. The production of animal protein was highlighted, mainly the broiler chicken reaching 18% of the participation of the main crops (Alves, 2020).

3.2 Broiler poultry in Brazil and Paraná

In the researchers analyzed, we verified that the broiler production chain stands out in the Brazilian economy, the third largest world producer and the main exporter of international chicken meat Souza and Molento (2015), in addition to the State of Paraná being the main producer and exporter the country of this important source of animal protein, according to Figure 2.

Figure 2 - Largest broiler producers and exporters per ton in 2019.



Source: Embrapa (2020).

Figure 2 shows the largest broiler producers by states in Brazil, with an impressive advantage for Paraná in relation to the second place which is Santa Catarina, with more than 120% of chickens produced. This production shows that the electric energy market can expand more and more with great security, in addition to bringing sustainable benefits and cost reduction for production.

According to Souza and Molento (2015) in the State of Paraná, twenty-nine units approved by the Ministry of Agriculture were identified to export to a general list of countries and/or the European Union.

Despite the economic relevance of Brazilian poultry production, animal welfare regulation is scarce at the farm level

(Souza & Molento, 2015). Thermal comfort inside the premises considerably interferes with production, therefore the control of the internal environment of the aviaries becomes essential for the success of the activity (Santos *et al.*, 2014). Thermal comfort is of paramount importance for poultry productivity, the body increase of only 4°C is already characterized as hyperthermia in birds, and the decrease of 8°C is sufficient for hypothermic condition (Marangoni, 2019).

The aviaries require large amounts of electrical energy, mainly the Dark-House system, which consists of an automated system using exhaust fans, evaporative panels, water system, feed distribution, air circulation control, temperature and light (Sreenath *et al.*, 2020). Broiler poultry producers are changing the internal lighting systems of the aviaries to photovoltaic energy, considering that in the medium and long term costs tend to reduce significantly, in addition to working with sustainable managements (Paulus *et al.*, 2019).

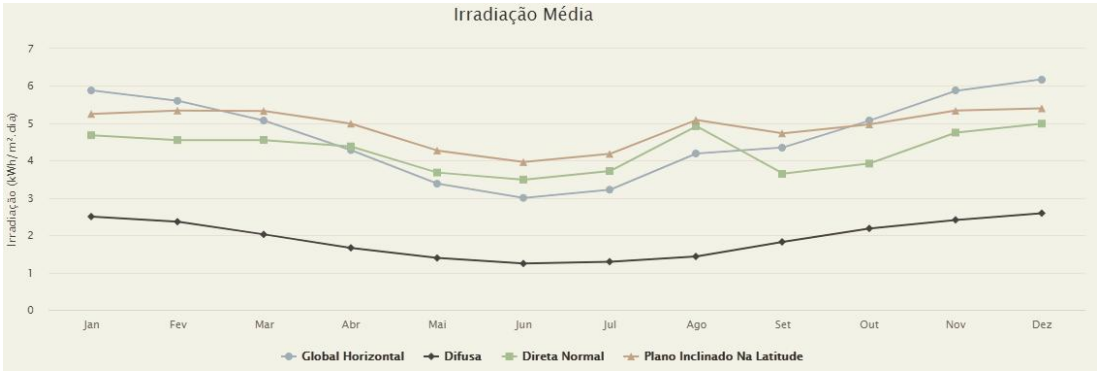
3.3 Photovoltaic energy and its application in rural areas

Photovoltaic solar energy has emerged as a sustainable electric generation option, applicable in remote locations where expansion of the conventional grid requires investments with prohibitive costs in relation to solar generation (Barbosa *et al.*, 2017). Constituting a strategic renewable source for Brazil due to the high levels of irradiation, presenting a positive solar potential for electricity generation (Stefanello *et al.*, 2018) and (Imai *et al.*, 2020).

The state of Paraná has a daily average irradiation over a year of 1,960 MW (MegaWatts), it is located among the states with the greatest photovoltaic potential, with São Paulo being the main with 7,100 MW/means and Roraima with 65 MW/means being the state with the lowest photovoltaic potential (Rosa & Gasparin, 2016).

These results can be compared with those obtained by Stefanello; Marangoni and Zeferino (2018) and Perazzoli *et al.* (2020), which recorded the performance of photovoltaic systems in the state of Paraná, due to the average levels of irradiation, according to Figure 3.

Figure 3 - Average irradiation in the state of Paraná.



Source: Perazzoli; Gobbi and Tiepolo (2020).

The energy conversion factor for photovoltaic systems, it was found that, according to Figure 3 that at the beginning and at the end of the year the electricity generated exceeds the middle of the year compared to the months of May, June and July due to the lower photoperiod characteristic of autumn and winter seasons. Analyzing the data in the Figure, it is possible to conclude that Paraná has great potential to advance in this area. Currently, solar radiation is one of the most relevant renewable energy sources (Lima *et al.*, 2020).

Taking advantage of the energy from the Sun, which is an inexhaustible and free source according to the time scale of life on planet Earth (Chanchangi *et al.*, 2020). Photovoltaic use consists of transforming solar energy into electrical energy due

to the effects of solar radiation on a semiconductor metal plate (Albuquerque *et al.*, 2017). The solar radiation incident in the Earth's atmosphere is formed by direct radiation, which reaches the surface without undergoing deviation in its path and which produces sharp shadows, and the diffuse radiation that originates from multi-directions due to the scattering in the atmosphere outside the beam straight through molecules, aerosols and clouds (Perazzoli *et al.*, 2020).

Finally, in several ways photovoltaic solar energy is approached, with appreciation for consolidating the habit for the use of renewable energies. To promote the installation of photovoltaic panels, Resolution n° 482 of 2012 from the National Electric Energy Agency (ANEEL) was created and was updated by the new Normative Resolution n° 687/1, with some incentives for its application, although it should be noted that the regulation still does not offer sufficient guarantees to significantly boost the sector (Barboza *et al.*, 2016); (Lira *et al.*, 2019) and (Mustafa *et al.*, 2020).

The resolution governs the micro and mini generation of energy by consumers, allowing users to install generator systems and generate their own energy, and the surplus energy can be exported to the electric grid and generate credit on the energy bill (Didoné *et al.*, 2014).

In the aviaries for solar photovoltaic system equipment Paulus; Bortolini and Primieri (2019) they studied application in rural property in the municipality of Tupãssi, Paraná where they presented appropriate solar energy production, adequately supplying the energy of the five aviaries, satisfying the economic viability from the project. Following the same approach Barboza *et al.*, (2016) developed a study on a possible alternative to promote the economic, social and environmental balance of rural properties, obtaining the following results, the producer needs around 30,126 KWh/year of energy electricity, with aviary consumption of: aviary 1 - 6,068 KWh/year and aviary - 2 6,620 KWh/year.

The application of solar energy systems has several positive aspects that justify the implementation: They generate the minimum of environmental impact and high generation potential according to irradiation levels, they provide for the reduction of CO emissions, they are easy to install and low maintenance, the plates generating energy vary from 20 to 25 years, and in some cases can reach 30 years Barboza *et al.* (2016) and Gönen and Kaplanoğlu (2019) and the negative aspects can be: high costs, specialized labor for maintenance, waste generation.

The authors Chanchangi *et al.*, (2020), mention that there was a notable growth due to the price decrease, disagreeing with the previous statement. In the study by Gönen and Kaplanoğlu (2019) he mentions that it is possible to mitigate the environmental impact of waste by reusing materials for the production of photovoltaic modules. Another author points out that photovoltaic installations generate impacts on bird populations due to habitat loss and collision mortality (Visser *et al.*, 2019). In the study by Pimentel da Silva and Branco (2018) they state that 22 out of 32 impacts are classified as positive, 4 a neutral and 6 require further study.

4. Final Considerations

After analyzing the articles presented, it was found that solar energy can be used in poultry houses in the city of Paraná, as it has a good location for the installation of photovoltaic devices for electrical generation, in addition to being a state with one of the highest average irradiations. throughout the year and mainly because it has the largest poultry flock in Brazil. Considering the support for resolution nº 482 of 2012 that encourages the use of clean energy, the strategy of incorporating solar power plants in poultry farms seeks to reduce energy costs and aim at a sustainable future.

Based on the systematic review worked on the Scopus® and Scielo® databases according to the inclusion and exclusion search parameters, the state of the art of this theme was visualized and was presented in general. It is possible to observe that the production of scientific literature is still scarce, with a significant increase in publications starting in 2014, which is a topic that needs further research and dispersion of knowledge through publications, in addition to the fact that the

topic was very specific. Very little information was found involving the city of Paraná with solar energy. Demonstrated a great gap to be researched, this topic needs to be discussed more comprehensively by the scientific community and contains a list of motivation for new scientific works for future publications.

References

Albuquerque T. C., Maldonado, M. U., Vaz, C. R. (2017). Um levantamento da produção intelectual sobre energia solar fotovoltaica. Revista Brasileira de Energias Renováveis, 6(5), 915-939.

Alves, L. N. (2020). Valor bruto da produção: Análise dos Resultados Preliminares 14 de agosto de 2020. Curitiba. http://www.agricultura.pr.gov.br/Pagina/VBP-2019-Analise-resumida-dos-resultados-preliminares.

Askarzadeh, A., & Dos Santos Coelho, L. (2015). Determination of photovoltaic modules parameters at different operating conditions using a novel bird mating optimizer approach. Energy Conversion and Management, 89, 608–614. https://doi.org/10.1016/j.enconman.2014.10.025

Assadeg, J., Sopian, K., & Fudholi, A. (2019). Performance of grid-connected solar photovoltaic power plants in the Middle East and North Africa. International Journal of Electrical and Computer Engineering, 9(5), 3375–3383. https://doi.org/10.11591/ijece.v9i5.pp3375-3383

Barbosa, R. R., Pinheiro, R., Delgado, D. B. M., & Carvalho, M. (2017). Energia Solar Fotovoltaica no Semiárido: Potencial, Cenário Atual e Perspectivas. *Anais do II Congresso Internacional da Diversidade Do Semiárido*.

Barboza, L. G. S., Dacroce, N. P. D., Hofer, E. (2016). Análise de viabilidade de implantação de um sistema de geração de energia fotovoltaica numa propriedade familiar rural: um estudo com base no PRONAF Mais Alimentos. *V Simpósio de Gestão de Projetos, Inovação e Sustentabilidade*, p. 17, 2016.

Becerra-Díaz, C., & Ando Junior, O. H. (2021). Investigation of the effect temperature on the performance of the photovoltaic solar design for the western region of Paraná-Brazil. DYNA (Colombia), 88(217), 185–199. https://doi.org/10.15446/dyna.v88n217.91140

Bender, L. V., Leitzke, R. K., Freitas, J. R. de, Cunha, E. G. da, & Salamoni, I. T. (2020). Estudo da paridade econômica e do desempenho energético de fachadas solares fotovoltaicas no extremo sul do Brasil. Ambiente Construído, 20(4), 489–508. https://doi.org/10.1590/s1678-86212020000400484

Boquimpani, C. L., Motta, A. L. T. S. da, Souza, O. L. de C., & Oliveira, C. H. V. do R. (2019). Eficiência energética: sistemas de iluminação com LEDs, distribuídos em corrente contínua e utilizando energia fotovoltaica. Ambiente Construído, 19(4), 303–316. https://doi.org/10.1590/s1678-86212019000400357

Calsi Silva, B. X., Angulo Abanto, J. R., Conde Mendoza, L. Á., Muñoz Cerón, E., Grieseler, R., Guerra Torres, J. A., De la Casa Higueras, J., & Palomino Töfflinger, J. A. (2020). Procedimiento del cálculo de la potencia nominal de un generador fotovoltaico. Tecnia, 30(1). https://doi.org/10.21754/tecnia.v30i1.834

Cardoso, D. S., Locatelli, P. S., Ramalho, W., & Asgary, N. (2021). Distributed generation of photovoltaic solar energy: impacts of ANEEL`s new regulation proposal on investment attractiveness. Revista de Administração Da UFSM, 14(2), 423–442. https://doi.org/10.5902/1983465961993

Chanchangi, Y N *et al.* (2019). An analytical indoor experimental study on the effect of soiling on PV, focusing on dust properties and PV surface material. *Solar Energy*, 203:46-68.

Chaves, A. S. (2021). Tecnologias de eletricidade limpa podem resolver a crise climática. Revista Brasileira de Ensino de Física, 43. https://doi.org/10.1590/1806-9126-rbef-2021-0361
Custódio, M. M., & Oliveira, E. R. de. (2017). a Legislação Brasileira De Uso E Ocupação Do Solo E Sua Dissonância Sistêmica Com Fatores Redutores Da Refletância Da Energia Solar. Revista de Direito Da Cidade, 9(3), 867–892. https://doi.org/10.12957/rdc.2017.27045

Da Silva, G. D. P., & Branco, D. A. C. (2018). Is floating photovoltaic better than conventional photovoltaic? Assessing environmental impacts. Impact Assessment and Project Appraisal, 36(5), 390–400. https://doi.org/10.1080/14615517.2018.1477498

Dessbesel, R. da S., Silva, S. de C. R. da, & Shimazaki, E. M. (2018). O processo de ensino e aprendizagem de Matemática para alunos surdos: uma revisão sistemática. Ciência & Educação (Bauru), 24(2), 481–500. https://doi.org/10.1590/1516-731320180020014

Didoné, E. L., Wagner, A., & Pereira, F. O. R. (2014). Estratégias para edifícios de escritórios energia zero no Brasil com ênfase em BIPV. Ambiente Construído, 14(3), 27–42. https://doi.org/10.1590/S1678-86212014000300003

El Iysaouy, L., Lahbabi, M., Baskys, A., & Oumnad, A. (2020). Performance analysis of partially shaded photovoltaic array using magic square view configuration for shade dispersion. Journal of Solar Energy Engineering, Transactions of the ASME, 142(6). https://doi.org/10.1115/1.4046877

Elsheikh, A. H., & Abd Elaziz, M. (2019). Review on applications of particle swarm optimization in solar energy systems. International Journal of Environmental Science and Technology, 16(2), 1159–1170. https://doi.org/10.1007/s13762-018-1970-x

EMBRAPA, E. B. de P. A. (2021). Estatísticas - Portal Embrapa. Central de Inteligência de Aves e Suínos. https://www.embrapa.br/suinos-e-aves/cias/estatisticas

Godinho, E. Z.; Caneppele, F. de L. (2021). Lógica fuzzy aplicada ao pré-tratamento do capim-elefante: uma revisão bibliográfica sistemática. Research, Society and Development, 10(15), e439101523302. http://dx.doi.org/10.33448/rsd-v10i15.23302.

EPE. (2020). Anuário Estatístico de Energia Elétrica 2020 - Ano base 2019. Empresa de Pesquisa Energética, 256. https://www.epe.gov.br/pt%0Ahttp://www.epe.gov.br

Feitosa, E. D. O., Lopes, F. B., de Andrade, E. M., de Magalhães, A. C. M., & de Freitas, C. A. S. (2021). Environmental Impact of Different Agricultural Production Systems. Revista Ciência Agronômica, 52(1), 1–9. https://doi.org/10.5935/1806-6690.20210003

Francisco, A. C. C., De Miranda Vieira, H. E., Romano, R. R., & Monteiro Masalskiene Roveda, S. R. (2019). The influence of meteorological parameters in the generation of energy in photovoltaic panels: A case study of Smart Campus Facens, SP, Brazil. Urbe, 11, 1–15. https://doi.org/10.1590/2175-3369.011.e20190027

Girotti, C., Marins, K. R. de C., & Lara, A. H. (2019). Análise da morfologia urbana para maximização de geração de energia fotovoltaica no Belenzinho, em São Paulo. Ambiente Construído, 19(4), 7–22. https://doi.org/10.1590/s1678-86212019000400340

Gönen, Ç., & Kaplanoğlu, E. (2019). Environmental and economic evaluation of solar panel wastes recycling. Waste Management and Research, 37(4), 412–418. https://doi.org/10.1177/0734242X19826331

Horta, C. (2017). Bioavailability of phosphorus from composts and struvite in acid soils | Biodisponibilidade do fósforo em compostos e struvite aplicados em solos ácidos. Revista Brasileira de Engenharia Agricola e Ambiental, 21(7), 459–464.

Imai, H. E., Bósio, L. F., Silva Junior, A. A. da, Berto, L. K., Yamaguchi, N. U., & Rezende, L. C. S. H. (2020). Simulação computacional como ferramenta de otimização na geração de energia solar fotovoltaica. Urbe. Revista Brasileira de Gestão Urbana, 12. https://doi.org/10.1590/2175-3369.012.e20190343

Júnior, O. M., Souza, C. C. de, Nepomuceno, P. H. T., & Antunes, B. M. (2019). Sustentabilidade em edifício residencial no município de Dourados , MS Sustainability in residential building in the municipality of Dourados , MS Durabilité dans le bâtiment résidentiel dans la municipalité de Dourados , MS Sostenibilidad en Edificio Res. 475–486.

Lacerda, Z. A., Carlos Pereira, C. M., Balbino, E. M., Meneghetti, C., de Souza Silva, L. P., & Santos, T. C. (2019). Behavioral analysis and productive performance of piglets in the post-weaning phase in enriched environments. Revista Academica Ciencia Animal, 17. https://doi.org/10.7213/1981-4178.2019.17009

Lima, A. A., Menezes, N. P., Santos, S., Amorim, B., Thomazi, F., Zanella, F., Heilmann, A., Burkarter, E., & Dartora, C. A. (2020). Uma revisão dos princípios da conversão fotovoltaica de energia. Revista Brasileira de Ensino de Física, 42. https://doi.org/10.1590/1806-9126-rbef-2019-0191

Lin, P., Cheng, S., Yeh, W., Chen, Z., & Wu, L. (2017). Parameters extraction of solar cell models using a modified simplified swarm optimization algorithm. Solar Energy, 144, 594–603. https://doi.org/10.1016/j.solener.2017.01.064

Lira, M. A. T., da Silva Melo, M. L., Rodrigues, L. M., & de Souza, T. R. M. (2019). Contribution of photovoltaic systems connected to the electrical network for reducing CO2 in the state of Ceará. Revista Brasileira de Meteorologia, 34(3), 389–397. https://doi.org/10.1590/0102-7786343046

Liu, C., & Liu, L. (2020). The global peak forecasting method for PV array based on the conservation of energy at uniform and partial shading. Energy Reports, 6, 113–122. https://doi.org/10.1016/j.egyr.2020.12.002

Liu, L. Q., Liu, C. X., Wang, J. S., Yang, K., Zhang, W. Y., & Gao, H. M. (2015). Optimal azimuth and elevation angles prediction control method and structure for the dual-axis sun tracking system. JVC/Journal of Vibration and Control, 21(2), 402–407. https://doi.org/10.1177/1077546313484050

Marangoni, A. (2019). Energia solar para granjas: como e porque investir? https://www.marangoni.com.br/conforto-animal/2019/11/08/energia-solar-para-granjas-como-e-porque-investir

Martín, A. J., & Pérez-Ramírez, J. (2019). Heading to Distributed Electrocatalytic Conversion of Small Abundant Molecules into Fuels, Chemicals, and Fertilizers. Joule, 3(11), 2602–2621. https://doi.org/10.1016/j.joule.2019.09.007

Mathijssen, D., Hofs, B., Spierenburg-Sack, E., Vanasperen, R., Vanderwal, B., Vreeburg, J., & Ketelaars, H. (2020). Potential impact of floating solar panels on water quality in reservoirs; pathogens and leaching. Water Practice and Technology, 15(3), 807–811. https://doi.org/10.2166/wpt.2020.062

Michels, R. N., Ricieri, R. P., Gnoatto, E., Sousa, S. N. M. de, Silva, S. de L., & Fischborn, M. (2009). Avaliação do bombeamento de água em um sistema alimentado por painéis fotovoltaicos. Engenharia Agrícola, 29(3), 370–379. https://doi.org/10.1590/s0100-69162009000300004

Mustafa, R. J., Gomaa, M. R., Al-Dhaifallah, M., & Rezk, H. (2020). Environmental impacts on the performance of solar photovoltaic systems. Sustainability (Switzerland), 12(2), 1–17. https://doi.org/10.3390/su12020608

Paulus, C., Bortolini, J., & Primieri, C. (2019). Uso de fontes de energia elétrica e solar em aviários no município de Tupãssi-PR Use of electric and solar sources in poultry houses in Tupãssi-PR. Introdução A avicultura é um dos setores com maior importância na economia brasileira, sendo ela uma das . January 2017, 1–13.

Perazzoli, D. L., Gobbi, E. F., & Tiepolo, G. M. (2020). Proposta de critérios norteadores e requisitos mínimos para licenciamento ambiental de usinas fotovoltaicas no Brasil. Engenharia Sanitária e Ambiental, 25(2), 333–344. https://doi.org/10.1590/s1413-41522020187883

Pereira, D. de A., Correia Júnior, J. L., Carvas Junior, N., & Freitas-Dias, R. de. (2020). Reliability of questionnaire The International Fitness Scale: a systematic review and meta-analysis. Einstein (Sao Paulo, Brazil), 18, eRW5232. https://doi.org/10.31744/einstein_journal/2020rw5232

Pimentel da Silva, G. D.; Branco, D. A. C. (2018). Is floating photovoltaic better than conventional photovoltaic? Assessing environmental impacts. Impact Assessment and Project Appraisal, 36(5):390–400.

Rosa, A. R. O. de. (2016). Panorama Da Energia Solar Fotovoltaica No Brasil. Revista Brasileira de Energia Solar Ano, 7, 140–147.
Santos, G. de B., Sousa, I. F. de, Brito, C. O., Santos, V. da S., Barbosa, R. de J., & Soares, C. (2014). Estudo bioclimático das regiões litorânea, agreste e semiárida do estado de Sergipe para a avicultura de corte e postura. Ciência rural, 44(1), 123–128. https://doi.org/10.1590/S0103-84782013005000148

Sisodia, A. K., & Mathur, R. kumar. (2019). Impact of bird dropping deposition on solar photovoltaic module performance: a systematic study in Western Rajasthan. Environmental Science and Pollution Research, 26(30), 31119–31132. https://doi.org/10.1007/s11356-019-06100-2

Souza, A. P. O., & Molento, C. F. M. (2015). Good agricultural practices in broiler chicken production in the state of Paraná: focus on animal welfare. Ciência Rural, 45(12), 2239–2244. https://doi.org/10.1590/0103-8478cr20141877

Sreenath, S., Sudhakar, K., & Yusop, A. F. (2020). Solar photovoltaics in airport: Risk assessment and mitigation strategies. Environmental Impact Assessment Review, 84(December 2019), 106418. https://doi.org/10.1016/j.eiar.2020.106418

Stefanello, C., Marangoni, F., & Zeferino, C. L. (2018). A Importância Das Políticas Públicas Para O Fomento Da Energia Solar Fotovoltaica No Brasil. VII Congresso Brasileiro de Energia Solar, 2005.

Tawa, H., Saiki, H., Ota, Y., Araki, K., Takamoto, T., & Nishioka, K. (2020). Accurate output forecasting method for various photovoltaic modules considering incident angle and spectral change owing to atmospheric parameters and cloud conditions. Applied Sciences (Switzerland), 10(2). https://doi.org/10.3390/app10020703

Teixeira, M. C. T. V., Mecca, T. P., Velloso, R. de L., Bravo, R. B., Ribeiro, S. H. B., Mercadante, M. T., & Paula, C. S. de. (2010). Literatura científica brasileira sobre transtornos do espectro autista. Revista Da Associação Médica Brasileira, 56(5), 607–614. https://doi.org/10.1590/s0104-42302010000500026

Tercan, E., Saracoglu, B. O., Bilgilioğlu, S. S., Eymen, A., & Tapkın, S. (2020). Geographic information system-based investment system for photovoltaic power plants location analysis in Turkey. Environmental Monitoring and Assessment, 192(5). https://doi.org/10.1007/s10661-020-08267-5

Tiepolo, G. M., Junior, J. U., Pereira, Ê. B., Pereira, S. V., & Alves, A. R. (2016). Energia Solar no Estado do Paraná - Potencial, Barreiras e Políticas Públicas. Congresso Brasileiro de Planejamento Energético, September, 1–12.

Visser, E., Perold, V., Ralston-Paton, S., Cardenal, A. C., & Ryan, P. G. (2019). Assessing the impacts of a utility-scale photovoltaic solar energy facility on birds in the Northern Cape, South Africa. Renewable Energy, 133, 1285–1294. https://doi.org/10.1016/j.renene.2018.08.106

Vumbugwa, M., Mccleland, J. L. C., van Dyk, E. E., Vorster, F. J., & Serameng, T. J. (2020). Effects of current mismatch due to uneven soiling on the performance of multi-crystalline silicon module strings. Journal of Energy in Southern Africa, 31(1), 62–72. https://doi.org/10.17159/2413-3051/2020/v31i1a7571