

Macro-environment influence on the Brazilian photovoltaic solar energy sector development

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Abstract: Photovoltaic cell effectiveness has gradually improved since its creation in 1883. It has been observed, alongside this improvement, a growing awareness that the search for non-polluting and renewable sources is necessary since the current world energy matrix is composed of sources proven to be harmful to the environment (such as oil, coal, and natural gas). The use of photovoltaic energy is rising in Brazil. It is expected to grow more in the following years due to favorable macro-environment conditions. These conditions favor the strategic administration of companies since it helps in the decision-making process and consequently influence the organization's and economic sectors' success and development. Thus, this work aims to characterize and identify the current macroeconomic scenario in Brazil, after analyze how the macro-environment influences and which factors offer opportunities or threats and discuss how this scenario influences the photovoltaic solar energy sector. PESTEL (Political, Economic, Social, Technological, Ecological, and Legal), Systematic Review, and SURVEY methods will be used, characterizing this research as qualitative, exploratory, bibliographical, and documental approaches. The PESTEL framework will allow the macro-environment to be divided into six segments, thus ensuring a structured database. After the division, the Systematic Review will be used to explore specific research questions in a targeted and objective way, allowing, in the end, to understand better what is and what is not known. Finally, the SURVEY will aim to present the macro-environmental factors identified and analyzed to a group of experts, who will contribute to interpreting each factor as a potential opportunity and or threat to the development of the photovoltaic solar energy sector in Brazil. As a result, it is expected to map and understand the influence of the Brazilian macro-environment in developing the solar photovoltaic market and discuss the potential to make the Brazilian macro-environment more favorable for the sector's development.

Key-words: Photovoltaic Solar Energy; Strategic Management; PESTEL; Strategic Analysis

1. INTRODUCTION

Worldwide interest in renewable energy to meet social and economic demands has increased, especially since the beginning of the 21st century, due to the acceleration in energy demand, the rising price of fossil fuels, and the effects of climate change ^[1]. However, the world energy matrix is made up of almost 80% fossil energy ^[2]

Among the renewable energy options, photovoltaic energy is the most present on the earth's surface and inexhaustible, so it is one of the most targeted options for the composition of the world energy matrix ^[3]. Its operation occurs through the photovoltaic process in which photovoltaic cells convert solar energy

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into electrical energy ^[4]. In 2019 solar photovoltaic energy grew 22% globally, representing about 1.1% in the energy matrix, adding up to 6.6GWh, totaling a growth of 92.1% compared to the year 2018^[5,6].

The social and environmental benefits of this type of energy, accompanied by the reduction in its generation cost, have strengthened its potential to contribute to sustainable development in many countries ^[7]. No wonder that, in a growing trend, countries around the world have adopted policies to encourage solar photovoltaic energy. According to Pischke et al. (2019)^[8], using the factor called "policy density," they show that developed and developing countries have presented consistent renewable energy policies.

Normative Resolution No. 687/2015 in Brazil is an example of a renewable energy policy. It allows the Brazilian population to generate electricity from renewable sources for consumption and authorizes the distribution of surplus energy, i.e., that which was produced but not used. After the approval of the Resolution, the solar energy market entered the expansion process and, in 2017, began to gain notoriety. In 2021, Brazil will be in the 13th position among the leading countries in photovoltaic energy.^[9]

The sector of photovoltaic solar energy in Brazil estimates growth of 105% in the total installed until the year 2021, in which it will go from 8.3GW to 17.2GW in the own generation, in other words, distributed energy. As for centralized generation, that is, large plants, a growth of 67.8% is estimated, going from 4.6GW to 7.8GW. This growth is expected to continue for the next five years, with an estimated growth of 4,124 MW by 2025. ^[10]

Going deeper into the state level, Piauí is the country's largest producer of solar energy, followed by Ceara. This state, in turn, is in third place in the growth potential, which would be 433MW. The largest state is Minas Gerais, with a production capacity of 1.2 GW. ^[11]

For Strategic Management, the development of markets (such as the renewable energy sector) and an organization is not only given by resources and competencies or the industrial competitiveness level but also by the influence of the so-called macro-environment. That is, strategic decisions can be influenced by factors beyond the boundaries of the competitive environment ^[12]. Even external environments, such as the macro-environment, can be decisive for innovation processes in companies.^[13]

Analyzing the macro-environment is essential because it can reveal opportunities and threats to the business sector's objectives. However, macro-environmental factors and their level of influence on economic activity can vary from country to country. Each nation has particular social, cultural, political, economic, and institutional characteristics, which still change over time. Hence the need for constant monitoring and analysis ^[14, 15]

Scientific studies have recently been published on the macro-environment of countries and their influence on various economic sectors, including the energy sector. Some of them are: Faller and Almeida (2014), Gottschamer and Zhang (2016), Leviakangas (2016), Lima (2016), Segura et al. (2018), Song et al. (2017). ^[16,17,18,19,20,21]

Concerning Brazil and the solar P.V. sector, no publications were identified that evaluate the macro-environment as a whole, but works that evaluated specific dimensions and or factors of this

environment, such as Carstens and Cunha (2019) who discussed the political, economic, and innovation challenges the growth of solar P.V. in the country. Ferreira et al. (2018) analyzed the economic issues related to the generation and use of solar P.V. in Brazil. Mitscher and Ruther (2012) and Barbosa et al. (2020) evaluated the economic and policy performance for the development of residential solar P.V. El-gamal and Demajorovic (2020) evaluated the barriers and prospects for large-scale electricity generation through solar photovoltaic panels. More specific work was also identified, such as Varella et al. (2009), who evaluated Brazil's equipment industry for photovoltaic power generation. ^[22,23,24,25,26,27]

Thus, considering the worldwide and Brazilian advance of the solar photovoltaic market and the importance of the macro-environment, it is essential to understand and discuss the current Brazilian macro-environmental that influences the solar photovoltaic sector.

2. RESEARCH OPPORTUNITIES

- Does the Macro-environment present factors that can be decisive for the possibilities of development of economic sectors and the competitiveness of organizations?
- There are no specific scientific works that present an analysis of the entire macro-environment and its relationship with the Brazilian solar P.V. sector.

3. OBJECTIVES

3.1 Objective

Map and discuss the current macro-environmental conditions that Brazil offers to the solar P.V. sector.

3.2 Specific objectives

- Characterize Brazil's current macro-environment
- Analyze how the macro-environment influences the solar P.V. sector
- Identify which factors offer opportunities and threats to the P.V. sector

4. METHOD

The method proposed for this project is based on the approaches of strategic analysis of the organizational macro-environment. To this end, the PESTEL framework, the Systematic Review, and the Survey method will be combined.

The PESTEL framework allows structuring the macro-environment into six segments (Political, Economic, Social, Technological, Ecological, and Legal) and proposes to analyze each segment through a sequence of steps (Scanning, Correlation, and Evaluation)

In the scanning and correlation phase, the Systematic Review method will be used to identify, select, analyze, and synthesize data or evidence from bibliographic and/or documentary sources ^[28]. Denyer and Tranfield (2009) and Xiao and Watson (2019) reinforce that systematic review allows the



exploration of specific research questions in a targeted and objective way, allowing in the end to better understand what is and what is not known.^[29,30]

In this research, one has the challenge of integrating the systematic review process into the first two steps of the PESTEL analysis by proposing the following steps:

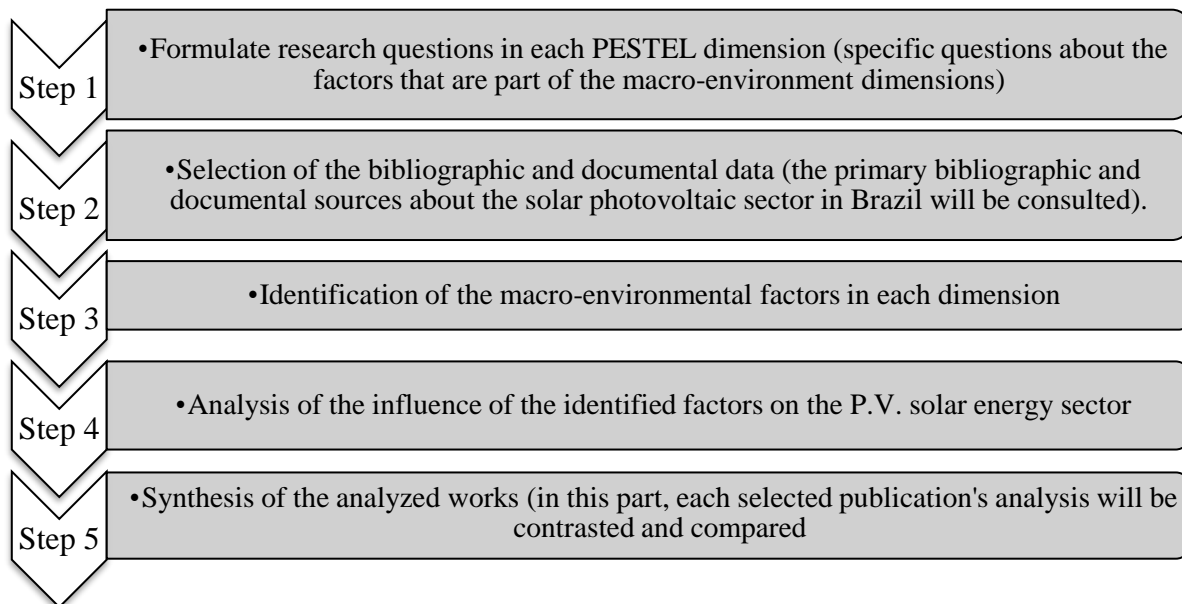


Figure 1. Steps of integrating the systematic review with PESTEL

For the last stage of the PESTEL analysis, the SURVEY method will be used, presenting the identified and analyzed macro-environmental factors to a group of experts. They will contribute to the interpretation process of each factor (as a potential opportunity and or potential threat to the development of the solar photovoltaic sector in Brazil).

5. EXPECTED RESULTS

- Understand how the Brazilian macro-environment is structured and how it currently influences the solar P.V. sector;
- Identify and discuss the most important factors, being opportunities or threats to the sector;
- Discuss the potential to make the Brazilian macro-environment more favorable for the sector's development.

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