REFLECTIONS ON THE ENERGY TRANSITION PROCESS IN ISOLATED SYSTEMS IN THE AMAZON REGION

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# Overview

Faced with a scenario of growing concern about environmental issues, the world's energy sector has been going through a period of profound technological, socio-cultural, political and economic change, known as energy transition. The main aim of this process is to gradually reduce greenhouse gas (GHG) emissions in order to contain the advance of global warming. In this sense, since the commitment to reduce GHG emissions, which began with the Kyoto Protocol, in 1997, many countries have been investing in the expansion of renewable and low-carbon energy sources and vectors and in the development and consolidation of clean technologies. At the 21st Conference of the Parties (COP), held in Paris in 2016, various measures in this direction were outlined and approved by the 195 countries present (BRASIL, 2016), and will be further developed at the 28th COP in 2023.

In the energy sector, actions to reduce the effects of climate change have been mainly focused on decarbonization. In the generation segment, these measures are usually associated with targets to increase the share of renewable and intermittent sources in the electricity matrix and to encourage the development of low-carbon technologies. Given this context, the Brazilian energy matrix stands out due to its large share of renewable energies and extensive transmission network, which guarantees the complementarity of energy generation, system reliability and a dynamic balance between supply and demand. According to EPE (2022a), in 2022 the share of renewable energy was 44.7% of the national energy supply and 78.1% of the electricity supply.

In this context, the Amazon region stands out due to its great availability of energy resources not yet explored, making it one of the main frontiers for the expansion of the Brazilian electricity sector. Composed of nine Brazilian states, around 28 million people currently live in the Legal Amazon, concentrated mainly in the states of Amazonas, Pará, Maranhão, Rondônia and Mato Grosso (EPE, 2022b). Most of the locations in the Amazon region are not connected to the interconnected transmission system and have their own service system, called Isolated Systems (IS). As well as being expensive to generate, based on thermal generation using diesel oil, the IS supply is characterized by many interruptions. Thus, despite its great potential for generating renewable and clean energy, the demand for electricity in the IS of the Amazon Region is mainly supplied by fossil fuels.

This highlights the strategic and priority nature of the Amazon Region in the energy transition process, given that the region concentrates a large part of the Brazilian population that still has no access to electricity. In addition, the region is characterized by the presence of social groups with different ethnic-cultural identities and complex socio-environmental areas, highlighting the importance of an inclusive and just transition process.

The main objective of this article is to analyse how the energy transition process in the Amazon Region has been treated and recognized by the main stakeholders. By surveying scientific production, identifying the main stakeholders and their different discourses, it will be possible to understand the direction of actions and their materialization in the territory.

**Methods**

This study proposes an exploratory methodology, based on three stages: (i) systematic literature review (SLR); (ii) content analysis of institutional documents from the Brazilian electricity sector aimed at discussing energy policy; and (iii) analysis of the discourse of the main stakeholders in the transition process.

Firstly, a systematic literature review (SLR) was carried out on the energy transition in the Amazon region, with an emphasis on the IS. To this end, a bibliometric analysis was carried out in the R software with the Bibliometrix package, using a combination of the following search strings: "Energy Transition", "Just Energy Transition", "Just Transition", "Amazon Region", "Legal Amazon", "Amazon"; "Brazil", "Isolated Systems" and "Renewable Energies", in the Scopus and Web of Science journal databases, from 1993 to 2023. The strings were worked on in 12 different combinations, resulting in a survey of 468 scientific productions.

The second stage of the research involved carrying out a content analysis using MaxQda software, based on the publications of the main institutions in the Brazilian electricity sector (Ministry of Mines and Energy, Energy Research Company, National System Operator, National Electric Energy Agency and Electric Energy Trading Chamber) and organizations associated with the just energy transition (IEMA, IDEEAS, WWF). The third stage dealt with the analysis of the discourse of the different stakeholders published in the media. The research used publications from LinkedIn and Instagram and Folha de São Paulo, published between 2020 and 2023.

Finally, from the survey of the secondary data and information, it was possible to identify how the just energy transition has been treated by the different actors, as well as the main elements of divergence and convergence of positions and discourse published in the media and in scientific and institutional literature.

# Results

The RSL reveals a low level of scientific production on the subject of energy transition in the IS of the Amazon Region. In this sense, a small number of productions on this subject were identified with a focus on the Amazon Region. When applying the keyword "Isolated Systems" to the Amazon Region, no records were found. The productions mapped with this theme are related to international experience, with case studies in countries such as Greece, India and South Africa. On the other hand, when we broaden the search with the string "Renewable Energy", the number of productions increases significantly, with most of them focused on technical studies involving the implementation of photovoltaic or hybrid systems associated with battery storage. It can thus be seen that the topic of the just energy transition is still little covered in scientific literature, even at world level. Furthermore, interest in the topic is recent, and has grown exponentially since 2019.

At the same time, an analysis of the content of institutional documents reveals the cross-cutting nature of the topic of energy transition in the most diverse areas of the electricity sector. In the sector's institutions, the issue arises mainly in the technical and regulatory sphere, directly related to actions that enable the expansion of renewable energies, notably wind and solar power. However, programs such as PROINFA (Incentive Program for Renewable Energy Sources) and the sector's new institutional model of 2004 have not taken IS into account. In the Amazon region, there is a strong focus on the expansion of transmission networks and programs to universalize access to electricity, such as the Light for All Program (LpT) and More Light for the Amazon (MLA). The social aspects of the energy transition in the Amazon region are directly addressed by institutions such as IDEEAS, IEMA and WWF. These organizations end up representing the demands of these social groups and carry out various studies.

Beyond the analysis of scientific production and documentary analysis, it is important to understand the actors involved in this energy transition process. In this sense, the research identified the main stakeholders, based on bibliographic research, namely: (i) Associations: non-profit representative entities working in sectors related to energy and the environment; (ii) Education and Research Centres: laboratories, research groups, institutes, universities, technical schools, departments or specialized centers in topics related to energy, the environment and the energy transition; (iii) Energy Companies: private actors with actual or potential involvement in the energy transition process; (iv) Government entities: public companies, autarchies or government entities involved in financing, regulating, standardizing or developing public policies associated with the just energy transition; (v) Society: social groups directly and indirectly impacted by the energy transition process; (vi) Financing Entities: public or private institutions capable of enabling the financing of actions aimed at the energy transition; (vii) Distributors: concessionaires responsible for electricity supply services in the Amazon Region.

The analysis of stakeholder discourse reveals a gap in the analysis of the environmental, social, ethnocultural, productive and inclusion components, which end up being limited to discussions and studies carried out by associations and education and research centers. The major decision-makers and those responsible for formulating sectoral guidelines, represented in the studies by the actors "Government entities" and "Financing entities", approach the issue of energy transition from a technical and regulatory perspective. Little is discussed about the impact of these actions on the population and local demands. The lack of a regulatory framework in Brazil on the energy transition contributes to the topic being spread out among the different government entities, in a phase that is still taking shape.

**Conclusions**

The aim of this article was to understand how the socio-energy transition process has been taking place in the Amazon Region, especially in the IS, from the perspective of scientific production and the speeches of the main stakeholders. Despite the great availability of renewable energy resources, the demand for IS in the Amazon Region is still met mainly by fossil fuels, making it urgent to prioritize them in the planning of the national energy transition and the consequent development of solutions in the political, technical and economic spheres.

The insertion of energy supply solutions in the region involves challenging conditions, however, several studies already indicate ways to reduce dependence on diesel oil and expand the participation of renewable sources in the region. To this end, it will be necessary to consolidate planning that integrates low-carbon energy solutions with social and regional development policies that ensure the best distribution of the social benefits of the region's energy resources, guaranteeing access to renewable and clean energy.

Although there has been progress in scientific production and in the inclusion of the issue among the most diverse stakeholders, the solutions adopted by the electricity sector for the energy transition process in the IS of the Amazon Region remain part of the technical and economic order, and are therefore developed within the limits possible for the market, involving pragmatic actions limited to the adoption of renewable technologies, without contributing to protecting rights, mitigating and compensating for the impacts and damage caused by energy generation projects to local communities.

In conclusion, the results of the research show that although there are agents interested in promoting an energy transition process in the Amazon region, there are still a number of challenges to be faced. In this sense, the transition must guarantee access to quality, sustainable energy for the entire population, going beyond the technical and economic aspects and affirming a just transition.

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