



Wind energy in Brazil: From the power sector's expansion crisis model to the favorable environment

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ABSTRACT

Since the 1970s, demands arising from the impacts of the power sector on the natural environment were added to studies regarding the strategic power sector and its impact on the economic and financial crises. Thus, the development of alternative technologies reflected the new institutional guidelines and overcame the technological paradigms that were based on increasing installed capacities. Consequently, multiple debates that consider the energy use potential of each region and its contributions to sustainable development occurred. This paper presents the information that is necessary for understanding the relationships of the development model that was founded based on waste and the expanding technologies that exploit natural resources. Actions that are aimed at developing renewable energy resources are structured based on the instability of the technological maintenance paradigm and are guaranteed by expanding technologies that were used prior to 1970. In addition, we evaluated the current institutional arrangements that are used to promote wind energy. In this case, greater attention was given to the European experience because Europe provides multiple examples of successful legal frameworks that promote wind energy. In addition, Europe is a benchmark for emerging market countries, such as Brazil.

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1. Introduction

The expansion of the Brazilian electricity market prior to 1970 was observed through its gains at an economic scale and was obtained by the development and use of technologies that ensured that the generation and transmission of equipment would steadily increase. Thus, the model was supported by

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continuously overcoming technical difficulties. In addition, the model was intrinsically related to the necessary adjustment demands of the institutional and economic models that were adopted by the nation's state economies. This paradigm assures the maintenance and institutional stability of the technology practice.

Since the 1970s, the limitations that were imposed by thoughts focused on the relationships between the energy sector activities and their impacts on the natural environment were added to the strategic aspects of the electricity sector and the impacts of the economic and financial crises experienced by the nation's states. Thus, the traditional expansion model lost momentum, which promoted the research and development of new technologies that contribute to the new institutional order and current technological paradigm [1].

In this sense, the development of so-called alternative technologies (renewable) directly reflects the new institutional guidelines and overcomes the technological paradigm that is based on increasing the expansion capacity by generating plants. Thus, discussions regarding distributed generation that consider the exploitation of each region's energy potential and its contribution to sustainable development are encouraged.

The term "sustainable development" has changed. This term is currently used by international markets as an adjustment tool that guarantees new world capitalist expansion order. This capitalist expansion order strongly differs from the aspirations of environmental movements when questioning the "development" routes. In addition, this term aims to guarantee the current and future society quality of life based on a development model that was constructed by maintaining the natural dynamics of the planet [2,3].

This paper aims to expand necessary reflection space and to understand the relationships between waste development and the need for new technologies for exploiting natural resources. This process will promote the incessant search for greater energy availability. This study is divided into six sections. Section 2 highlights the relationships between energy, development and crisis. Section 3 discusses waste economics regarding renewable energy. Section 4 discusses the exhaustion of the power sector's Expansion Model. The current institutional arrangements that are used to promote wind energy are developed in Section 5. Section 5 places more emphasis on the European experience because Europe provides multiple examples of successful legal frameworks for promoting wind energy. In addition, Europe serves as a benchmark for emerging market countries, such as Brazil. The difficulties and developments of the Brazilian wind markets are presented in Section 6. Finally, Section 7 highlights the conclusions and recommendations.

2. Energy, development and crisis

Throughout human history, energy changes have been constrained by deprivation, scarcity of raw materials, restrictions regarding access to raw material sources, and the removal of previous power structures. Hemery et al. [4] mark the first major breakthrough in the energy matrix, as described in the book of Genesis, as the moment that Adam was expelled from Paradise and condemned to the divine curse of heavy farm work. "*Cursed is the ground because of you; in pain you shall eat of it all the days of your life (...) by the sweat of your face you shall eat bread.*" In this context, the mechanical energy produced by the human body is converted into a tool or machine through work.

Historically, ways to overcome obstacles of work were pursued. This pursuit established the liturgy of progress and development. In addition, this pursuit resulted in successive material

production innovation. Thus, history is concerned with the continued growth performance of natural systems, increasing machine and energy system complexity, population growth and (most importantly) increased human labor productivity.

Regarding increasing labor productivity, all measured gains were closely related to improvement processes through energy systems. Technical advances in energy systems were aimed at meeting the increasing energy demands of a man while subtracting the bodily energy released by a man.

Since the implementation of the first technical innovations that were aimed at exploiting energy resources outside of the human body, increasing controlled energy has resulted in increased labor productivity. Thus, agricultural production, navigation, mechanical, and thermal energy production, and individual collective transportation processes improved.

At the end of the last century, mankind was faced with the realization that increases in technology and productivity result in decreasing energy use. Following this realization, there has been a growing need to increase the primary energy quantities that are necessary for economic system operation and for obtaining energy without increasing its availability.

From the breakdown of the technological paradigm (and well before the 1970s), humanity was faced with the challenge of redirecting its energy systems and the economic processes that overcome the irregularities observed in the historical curve of increasing energy efficiency gains with technological innovations.

In this scenario, issues related to the impacts of the development model, which was adopted at that time, began to form the international agenda, which questions the fact that this development style has always driven progress at the expense of natural resource devastation.

In addition to permanent concerns regarding the exhaustible aspects of non-renewable resources and guaranteeing free access to them, economic and energy dependence on non-renewable energy sources, mainly fossil fuels, has caused global concern regarding carbon dioxide (CO₂) emissions into the atmosphere.

In recent decades, the debate surrounding increasing global average temperatures has led to a scientific method for affirming close relationships between energy production and use (from fossil fuels) and the contribution of this energy to "global warming" as a result of increased greenhouse gas emissions.

Therefore, in this scenario of imminent non-renewable energy resource shortages, restrictions on free access to energy sources and a structured legal framework that establishes impediments and/or containment barriers for expanding use of non-renewable energy resources, renewable resource technology and usage becomes even more important.

Renewable sources point toward this set of uncertainties to ensure energy provision in a new economic development model that is environmentally sustainable and establishes emergency actions. Thus, the substitution of conventional sources should begin immediately to shorten the environmental impacts of its use.

The imperative need to create conditions that are essential for changing the energy consumption profile is also postulated. Thus, the inherent instabilities of the energy process can be minimized when conditioned with short-term changes that are caused by shortages and/or massive price increases.

However, because energy is vital for productive activities and is directly reflected in socioeconomic relations, the expansion of renewable sources follows the current goods and services production model. Thus, it is fundamentally important to understand the process of producing goods. In addition, it is important to identify potential ways for adjusting these sources to economic system functions and to the medium and long-term effects of their expanding use.

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