Brazil–India Renewable Energy Cooperation

Connecting the Continents

Maria Cândida Arrais de Miranda Mousinho

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"The lack of a robust relationship between Brazil and India is one of the most glaring puzzles of our times. The complementarity of their economies and the similarity of per capita incomes represent a wealth of possibilities for the exchange of knowledge and policy experiences. This book offers insightful policy recommendations on how to solve this puzzle in a very promising and pressing area: renewable energy. A must read for policymakers."

—Mauricio Moreira, *Chief Economist of IDB's Integration and Trade Sector*

"In her book, Maria Cândida Mousinho offers a prospective view of the potential for greater Indo-Brazilian cooperation in the field of renewable energy. A must read for scholars and policymakers interested in identifying opportunities for collaboration, and an example of how scholarly work and policy can walk hand in hand to advance projects of common interest of countries."

—Karin Costa Vazquez, *Associate Professor, Assistant Dean, and Executive Director of the Center for African, Latin American and Caribbean Studies at O.P. Jindal Global University*

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Only those who dialogue can build bridges and bonds.

(Papa Francisco).

Our ability to reach unity in diversity will be the beauty and the test of our civilization

(Mahatma Gandhi).

To
God, source of energy
Yolanda, Rita, Godoy and Tereza
Brazilian and Indian Societies
All people who believe in cooperation as a way of overcoming challenges

Foreword by Nanda Kumar Janardhanan

Energy transition presents two of the most debated challenges to humanity today. First transitioning to a cleaner fuel mix with zero or near—zero not only demands huge technical and economic advancements but also requires a substantial change in the way energy systems operate. Across the world, the huge energy-consuming systems have been designed to depend on an uninterrupted supply of energy—a prerequisite for the global economy to function normally. The critical challenge here is to ensure that the transition does not affect the economic landscape adversely. Secondly changing the energy infrastructure and fuel sources demand a remarkable level of investment both in terms of monetary resources and advanced technology. A sustained supply of clean, efficient, near-zero emission energy is undeniably highly technology-intensive. Due to these inherent limitations of energy transitions, countries have not been able to shed their affinity toward fossil fuels completely, despite climate mitigation initiatives persistently gaining attention across the world. Nevertheless, several countries have been able to design their strategies for energy transition, in tune with the Paris Climate agreement as well as the long-term climate mitigation target to limit the global temperature rise to below 1.5°C.

Against this backdrop, this book throws light on the renewable energy policies and strategies of two of the most prominent developing countries—Brazil and India. The book deserves great attention from policymakers, the research community, academia, and industry, for unveiling the

finer nuances of strategies of these countries in relentlessly promoting the renewable energy sector. While Brazil has been a pioneer in the development of alternative energy sources since the formation of the Pro-alcohol policy following the first oil shock, India too has been promoting distributed energy development for decades. The policy initiatives of these two countries have gained further momentum.

By exploring the policies, politics, and economic structures in Brazil and India that shape renewable energy development, Dr. Mousinho has been able to present an extremely well-informed discussion on various aspects specific to the energy transition. In-depth data analyses supported by rich qualitative information collected by the author through expert interviews and policy reviews make this book invaluable to the academic debates on the role of renewable energy collaboration. The author's familiarity and knowledge of the political and socioeconomic context of India and Brazil have indisputably helped in strengthening the findings in the book. Dr. Mousinho's book is essential reading for industry representatives, academicians, practitioners, and members of the research community who are focusing on topics of renewable energy as well as India–Brazil cooperation. I believe, this book will also play a great role in strengthening the future bilateral engagements between the two leading developing nations from the Global West and Global East- Brazil and India.

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Foreword by Leonardo Ananda Gomes

"Let the future tell the truth and evaluate each one according to their work and their achievements". I could not begin the preface of this work without mentioning one of my favorite quotes from the great Nikola Tesla. That leads me now to explain what motivated me to remember this incredible statement, in addition to the "free and infinite energy" advocated by this genius.

Firstly, Tesla received important influences and inspirations from our beloved India, which, of course, also happened to our author. The fact is that Nikola Tesla had the opportunity to live with one of the greatest teachers ever born in India: Swamiji Vivekananda, who after their first meeting wrote in a letter dated February 13th, 1896: "Mr. Tesla was delighted to hear about Vedanta's prana and akasha and kalpas. He thinks he can demonstrate mathematically that force and matter are reducible to potential energy. I must go see him next week to get this mathematical proof. In that case, Vedic cosmology will be placed on the most secure foundations. I clearly see its perfect union with modern science and the elucidation of one will be followed by the other".

With this extract, I can elucidate the second reason for choosing to quote Tesla. As well as Nikola Tesla, the author also shows an interesting boldness to be a precursor in the publication of a study on a topic that is still truly little explored and widespread in the scientific, academic, or even corporate environment.

The third reason is at the heart of Nikola's words. In my opinion, the inventor was very assertive in making such a statement, because it is known that many works, achievements, and discoveries are only recognized after being covered by the cloaks of wisdom of time, that is, fair merit belongs to the future, and I think that is what will also happen with this work.

The author, inspired by the winds from the east, decided to be bold and unveil information that is still dormant about the enormous potential of the India–Brazil relationship in the energy sector. I can affirm that because I talked about this topic with Maria Cândida, that one of her main challenges in writing this book was the scarcity of recognized and reliable sources that could support the arguments and facts that were very well selected and developed by her.

I explain that the recognition of such a work will happen in the future not due to the lack of relevance of the theme nowadays, quite the contrary. The timeliness of the theme proposed here is inexorable and it is almost frightening how this book could not have been written at a better time. However, the recognition to which I refer will be related to the reference that this book will become to several other works that will follow it in the future.

Nonetheless, before commenting on the importance of this theme for the India–Brazil relations and consequently for humanity, I cannot fail to mention my recognition and admiration for Maria Cândida not only because of her academic preparation, acquired during her doctorate in Science, Energy and Environment but also because of her ability to organize her ideas in an objective, practical, and accessible way for all types of audience that might be interested in this book. In addition, my most sincere admiration rests on the passion shown by the author in all phases of the elaboration of the present work. Talk to her for five minutes about her creation, and you will realize that she has not only a broad mastery of the content and methodology used, but, above all, a real devotion to this beautiful work.

This book aims to discuss the importance of international cooperation and development, with reference to renewable energy. Thus, the bilateral interaction between India and Brazil was very well analyzed regarding the joint effort to promote the generation of renewable energy, elucidating how important it is to solidify the path for cooperation in this segment and the creation of mechanisms that make this agenda is increasingly present in the political dialogue between the Indian and Brazilian nations.

Moreover, as I also qualify myself as a great lover of the India Brazil relationship, I would also like to briefly discuss how it is opportune to count on the publication of a work that consolidates facts, information, events, and perspectives from one of the areas with the greatest potential in the India Brazil relationship.

India figures as one of the most attractive markets in the renewable energy segment in the world today. The installed capacity for renewable energy generation shows growth prospects considering the large influx of foreign investments in recent years. The issue of increasing renewable energy production in India is extremely relevant in strategic terms for maintaining the pace of growth in the Indian economy and sustaining the country's economic activities. This is because India still shows a high level of dependence on non-renewable energies, considering that the nation imports about 80% of its oil and gas needs. Such dependence motivated a great technological development in the search for these alternative energies and smart nations will be able to take advantage of these important gains experienced by Indians in recent years.

In contrast, Brazil, on a complementary basis, has expertise in the use of renewable energy sources. Currently, 83% of the Brazilian electric matrix is originated from these energy sources, led by hydroelectric (63.8%), followed by wind (9.3%), biomass and biogas (8.9%), and centralized solar (1, 4%) according to the Ministry of Mines and Energy. In addition, when it comes to renewable energy in Brazil, it is also essential to mention the production of ethanol. In the 2019/2020 harvest, the country reached a record in the production of ethanol from sugar cane and corn, with 35.6 billion liters, according to data provided by the National Supply Company (Conab). Thus, it is notable that Brazil demonstrates an apparatus increasingly focused on the generation of renewable energy, signaling positively to the issues of energy security in the country.

With this quick look at data and findings, it is easy to understand how timely, synergistic, and complementary the India–Brazil relationship is in this sector. It is not difficult to conclude that Brazil can contribute immensely to India's energy security, considering cooperation, mainly in biofuels, initially involving a vast transfer of technology for ethanol production in India and even the direct supply of Brazilian alcohol fuel to serve the potential high demand that will consequently arise in India, in a second moment. Likewise, India can become an important supplier of equipment and technology for the generation of solar

energy in Brazil, which currently imports those items at high costs from developed countries.

To conclude, I emphasize, as mentioned above, the pertinence and topicality of the theme proposed in this work. For instance, in the context of the last visit of the Brazilian president to India in 2020, a memorandum of understanding was signed in the bioenergy area, foreseeing the intensification of cooperation in the production of biofuels, considering the experience accumulated by the countries and through the exchange of information, technologies, scientific practices, and promotion of investments in production chains. The participation of the renewable energy sector, especially biofuels, therefore, deserves to be highlighted in the spectrum of the bilateral relationship between India and Brazil. There are positive perspectives for the continuous approximation of both countries, considering that they are extremely relevant strategic partners for the development of capacities, technologies, and efficient generation of renewable energy in the current global context. When India and Brazil get closer, great achievements materialize. And this will definitely be proven by this work, which will become an important reference for real advances in the energy sector, in the relationship between these two great nations, and how the strengthening of this bilateral relationship can contribute to the world energy matrix.

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Foreword by Dinabandu Sahoo, Ednildo Andrade Torres and Silvio A. B. Vieira de Melo

Renewable energy generation is one of the biggest challenges of our time. The dimensions of this challenge are diverse, interconnected, and complex. How to approach renewable energies without relating their positive impacts on climate change, in particular on global warming? Which renewable energies have the greatest potential to replace fossil energy when the time comes? How will the potential for generating energy from renewable resources affect global geopolitics? Will the main players and world leaders cooperate or compete? How will sustainable energy consumption affect countries' economic and social development? What is the role of population growth in this process? Will science, technology, and innovation play a relevant role in the transition to a sustainable energy society?

This book sheds light on the discussion about the challenges and opportunities that Brazil and India have ahead on the issue of renewable energies, identifying similarities and differences between their energy matrices, their respective demands as well as scientific and technological prospecting, aiming at bilateral cooperation, instead of competition, for common and shared objectives. Differences between scientific outputs and technological innovation in these countries are also critically analyzed, with special emphasis on biofuels and solar energy.

It is an essential text to understand the intricate mechanisms capable of promoting Brazil–India cooperation in renewable energies, in a multipolarized world, with diversified global interests and alliances. The contemporaneity of the theme is striking, in a way even visionary, because its main content results from the author's Doctoral Thesis in Energy and Environment, which we were very pleased to be her supervisors, concluded in 2018. Since then, the COVID-19 pandemic has put the sustainability of planet Earth in check, among other things, definitely accelerating the energy transition from a global society based on fossil energy to a new sustainable model based on renewable energies. The future became the present and projections are now the reality.

This book text, although not intended to be a didactic material, can be equally useful and appreciated by undergraduate and graduate students, as well as by experts in the subject, or even lay and curious people, which is partly due to the multidisciplinary nature of the theme, enriched by the careful and judicious way in which the author developed her approach and narrative.

April 2021

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Energy is the bridge that unites all things and the engine that propels them in the most varied possible forms. Personally, I believe that human relationships are also part of this concept: we know people who drive us to become better human beings because they contribute to broaden our horizons, our way of understanding the world, of which we are part. Simply, but with an immeasurable sense of gratitude, I want to thank all institutions and people around the world who have helped me in the process of writing this book. This is cooperation!

This book originates from my doctoral thesis published in 2018. Then I would like to thank my former advisors, Professors Ednildo Andrade Torres, Silvio Alexandre Beisl Vieira de Melo and Dinabandhu Sahoo for the decision to lead me through paths different from the ones that I once imagined to tread and for sharing with me their knowledge and experiences. My gratitude to Professors Nanda Kumar Janardhanan, Luciano Amaral Oliveira, Elsa Kraychete and Edgard Leite for all the conversations, suggestions and essential teachings for the writing of this book. I am very grateful to the consul and president of the Brazil–India Chamber of Commerce Leonardo Ananda for all the support and attention.

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I thank the public school José Prado Alves, where a six-year-old girl, who wrote books to sell, began to dream—and still does.

Contents

List of Figures

List of Tables

CHAPTER 1

Introduction

In this contemporaneity, the relationship between energy and the environment has been the object of complex debates. After all, the intensification of economic activities demands a boost in energy production, which, in turn, implies an increase in the use of natural resources. Inevitably, the conservation of the environment is threatened. It is important to note that carbon dioxide (CO_2) emissions increase with each analysis carried out and that: despite actions to be taken in the coming years to reduce countries' dependence on fossil fuels, emissions are expected to keep rising until 2040, with an obvious impact on global temperature.

However, curbing CO_2 emissions is not the only challenge. Access to energy resources is a more crucial challenge as there are still millions of households without access to basic energy services. This lack of access to modern means of energy has harmful effects on areas such as health and education. It is noteworthy that accessibility not only refers to the access to electricity or to a more sustainable means of cooking, but it is also related to *per capita* consumption when comparing countries like India with countries like Japan or the United States. In addition, taking into account the energy resources and their heterogeneous distribution in the globe, accessibility is a strategic issue.

Thus, while developing countries seek to grow economically, they are still faced with the problem of "how" such growth must happen in order that social and environmental benefits be equally generated. This is a

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