

INDIA-CHINA RENEWABLE ENERGY COOPERATION: AN OVERVIEW

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Abstract

In order to find the India and China renewable energy cooperation, the study looks into how renewable energy cooperation between the two most populated countries, India and China face significant energy challenges in meeting their growing demands while variation climate change. The potential for India and China to work together on renewable energy is expanding, but the partnership is still mostly in its infancy. Instead of direct bilateral initiatives, existing cooperation frequently concentrates on third-country energy assets. India may use China's strong technology and manufacturing capabilities, especially in solar energy, to completely replace its energy infrastructure and promote sustainable growth. Although both countries are major players in renewable energy, deeper cooperation is now delayed by geopolitical conflict and domestic policy disagreements, even if there are chances for mutual gains in sectors like low-carbon manufacturing and green energy production. In order to understand their roles and interests in fostering collaboration, it is recommended that important investors be identified, including government agencies, commercial businesses, and civil society organizations.

INTRODUCTION

The world's two most populous countries, India and China, are facing vital energy tasks as their economic countries grow and their populations increasingly demand access to dependable and clean energy. As major emitters of greenhouse gases, both countries have devoted themselves to reducing their carbon footprint and transitioning to a low-carbon economy. Renewable energy offers a promising solution to meet the growing energy demands of both countries, however justifying climate change. India and China have set ambitious renewable energy targets, with India aiming to generate 40% of its power from non-fossil fuels by 2030 and China

targeting 35% of its electricity from non-fossil fuels by 2030.

This cooperation can also foster greater understanding and trust between the two nations, promoting a more stable and secure regional atmosphere. To reduce greenhouse gas emissions and improve air quality, economic benefit, technology transfer, and the trade system. (Prashant V, 2016).

Literature Review

As the economies and energy needs of the BRICS countries (Brazil, Russia, India, China, and South Africa) rise, potential energy development becomes

more and more important. This essay examines how these nations have worked together to produce breakthroughs and technology related to sustainable energy. China is an innovator in solar and wind energy, India has huge solar projects, and Brazil has advanced biofuels. Each of the BRICS countries has its own capabilities. The study explores the ways in which these advantages can be combined to tackle the world's energy problems. Key findings show the important obstacles, such as economic inequality, uneven policies, and geopolitical tensions, as well as the spreads gained through collaborative efforts. Although BRICS can spearhead global sustainable energy transitions, the report finds that overcoming these obstacles is key to achieving this objective and leading by example. (T Freze,2024).

Improving financial development, enhancing energy access, expanding access to energy, and reducing climate change are the main goals of India's renewable energy deployment. Sustainable development is made possible by the use of sustainable energy and by making sure that everyone has access to modern, cheap, dependable, and sustainable energy. Strong rule backing and an increasingly favorable economic climate have made India one of the world's most desirable markets for renewable energy. The administration has created laws, initiatives, and a welcoming atmosphere to draw in foreign capital and quickly expand the nation's renewable energy market. Many home jobs are expected to be created by the renewable energy sector in the years to come. Presenting notable results, opportunities, predictions, and electricity generation, as well as obstacles, investment, and job opportunities as a result of India's renewable energy development is the goal of this study. The numerous challenges that the renewable energy industry faces have been noted in this charge. Legislators, innovators, project developers, investors, industries, related departments and stakeholders, scholars, and experts will find value in the references derived from the review results. (Majid, 2020).

The alliance between Brazil and India on renewable energy is examined in the book. It is based on a study that looked at both countries' energy sectors. It talks about the energy-related agreements between the two nations as well as the policies for renewable energy that have been formed over the past forty years. To

identify the gaps and areas for collaboration in renewable energy, a quick competitiveness analysis, a scientific and technological drawing, and primary research were conducted. (Miranda,2021).

In response to the growing demand for energy and the need for low-carbon growth, China is working hard to fulfill international renewable energy cooperation aimed at preserving economic and energy security. On the other hand, energy issues have grown more significant in many nations, and the main barrier to cooperation is the absence of a multilateral cooperation device. A rapid analysis of the participants is then provided. This paper first examines the current state of global cooperation on renewable energy in China and then proposes the creation of three devices for cooperation: the regional device, the developing countries mechanism, and the developed-developing countries mechanism. In addition to discussing the concepts and procedures of creating mechanisms and the cooperation institution for their process, some policy proposals regarding cooperation techniques will be made. (Yisheng,2011).

One of the multipolar world's biggest global issues is the power of finite energy resources. Brazil, India, China, and South Africa are important growing powers that are discussed in the contribution in relation to the EU's energy governance. It focuses exactly on the bilateral energy discussions about energy cooperation that take place within strategic alliances. What is the relationship between the EU and the developing powers? Who are the key players? What are the functions of non-state actors? In the conversation, how do they view others and themselves? How is the energy conversation framed? A worldwide, multidisciplinary project's quantitative and qualitative data served as the foundation for the empirical study. The contribution shows how the four energy dialogues are very different from one another in terms of how actors interact, how they perform, how they perceive one another, how energy policy is framed (sustainability, effectiveness, and supply security), and how much fame the discourses have gained in the EU overall, thanks to the cooperation of the emerging powers. (Maupin,2022).

States that are competitors, if not in conflicts, in other contexts, like China and India, must form

alliances in order to collaborate on climate change issues. One of the main structures of the new multipolar order is the simultaneous nature of competition and collaboration, which ought to be the focus of both study and policy. The primary issue facing the next ten years is climate change, which calls for collaboration among the biggest emitters in the areas of mitigation, adaptation, climate finance, and energy supply carbonization. By itself, no state will be able to take suitable climate action. In the increasingly multipolar global order, geopolitical and geo-economic conflicts between these actors are also increasing, as seen on the Indo-Chinese border as well as in the most prominent case of today, Ukraine. Foreign participation in China's development of renewable energy has grown significantly during the past few decades. This is a result of the government's plan to unclear the part that conventional fossil fuels play in the energy mix and the huge energy demand. The worldwide teamwork in the field of renewable energy with different partners in the new century was critically examined in this article. Each partner has a different collaborative style. According to the findings, China has gained from international collaboration on renewable energy in a number of ways, including improved policy frameworks, developed human resources for renewable energy, and access to urban technology and financing. Important topics related to global collaboration are also covered. (P H Miriam, 2002).

Everyone on the planet is hoping for a cleaner, better environment in order to raise living standards in the current situation. According to the Practical Development Report of 2021, China is still ranked higher than India, even though India is the second most settled country in the world. The researcher's objective in this work is to compare China and India with regard to renewable energy sources. The difficulties with renewable energy sources are covered in further detail, along with the measures taken by the two nations to address these difficulties. The paper will give scholars and policymakers insights into the future of renewable energy and offer suggestions for overcoming the problems to the widespread use of renewable energy sources. (G Zillante, 2011).

Coal and fossil fuels, the main conventional energy sources used to generate the majority of India's electricity, are major contributors to greenhouse gas emissions and global warming. For example, as interest in generating electricity from diverse renewable energy sources spreads throughout the country, the Indian power industry is transforming. It is becoming more widely acknowledged that electricity generation from renewable sources is crucial to achieving many main and minor energy policy goals, including increased energy supply diversity and security, a decrease in local pollutants and global greenhouse gas emissions, regional and rural development, and the utilization of opportunities to promote social cohesion, value addition, and job creation at the local and regional levels. This concentrates on the prudent use of plentiful renewable energy sources, including geothermal, biomass, solar, wind, and ocean tidal energy, in order to address the energy issue. Given the feeding, production, and supply of power, this article examines India's renewable energy situation and projects future changes. India has been actively engaged in research, development, production, and demonstration for the past thirty years in an effort to find a workable solution to the ongoing issue of power deficit. India has successfully implemented a range of renewable energy technologies for use in various industries. Numerous prospects exist due to good geology and topography, a sizable client base, and a growing imbalance between supply and demand. Technological innovation, suitable legislation, tax advantages, and efficiency gains from research and development will enable the quick and economical exploitation of these large, clean resource bases. These are the only ways to save energy and the environment. Intending to determine whether India can sustain its growth and society using renewable resources, this paper provides an overview of the potential renewable energy resources in the Indian context while analyzing the current situation, the nation's energy demand, and consumption and production forecasts. (T kumari ,2022).

The primary driver of any nation's economic growth is energy. Lack of energy acts as a growth impediment in developing nations like India. India's energy consumption has been rising at a

comparatively rapid pace in recent years as a result of both economic and population growth. Electric power is in high demand due to India's rapid growth. Coal power plants currently provide the majority of the electricity needed, which puts pressure on fossil fuels. Greenhouse gas releases that contribute to climate change and poverty protection at the local and regional levels are characteristics of coal-based power generation. Thus, in addition to lowering greenhouse gas emissions, energy security must be improved. One environmentally beneficial energy source is renewable energy. In the current energy landscape, effectively utilizing renewable potential is becoming essential in order to ensure a sustainable power supply and lessen the detrimental conservation effects of fossil fuels. (CB Tripathi, 2016).

The main benefit of renewable energy is that it doesn't produce carbon emissions or direct pollution. There are significant regulatory edges to boost the penetration of renewable energy sources due to concerns about global warming brought on by carbon emissions. This paper aims to describe and assess the difficulties brought about by the growing use of renewable energy sources for electricity production. Solar and wind are the main sources of these generation sources, and they are expanding quickly. Then, they are relatively new to the grid, and the effects of significant penetrations are not entirely known. Given their inherent characteristics, solar and wind power are probably going to provide more systemic issues than "conventional" sources. Those obstacles can be surmounted, but only at a price. To determine a range of such costs, at least as they are anticipated by academics assisting in the preparation of ambitious plans for grids to receive high percentages (30–50%) of their kilowatt hours from mostly solar and wind power, several sources will be referred in later portions of the paper. Issues with energy poverty are described and linked to concerns about the cost of renewable energy. (Bruce N. Stram, 2016).

Electricity generation that is economical, ecologically friendly, and sustainable relies heavily on renewable energy (RE). According to an International Energy Agency (IEA) report, the need for fossil fuels to produce electricity has begun to decline since 2019, as renewable energy sources (RE)

have become more popular in order to meet the world's energy needs. To improve the performance of RE generation, particularly in terms of energy conversion efficiency, research on RE technologies is regularly expanding. Understanding and further researching the existing renewable energy technologies, such as solar, hydro, wind, bio, geothermal, and hydrogen, is the goal of this review paper. To increase the overall effectiveness of RE in producing power, several hybrid RE technologies have also been investigated and contrasted. Finally, recommendations are made to address and review the technical, financial, and energy conversion efficiency issues and limits of RE technologies. (P. Natarajan, 2022).

The majority of India's electricity is produced using traditional energy sources, the main ones being coal and fossil fuels, which significantly increase greenhouse gas emissions and contribute to global warming. With the country enthralled with the prospect of generating electricity from a variety of renewable energy sources, the Indian power industry is transforming. A growing number of primary and secondary energy policy goals, including increased energy security and diversity, lowering local pollution and global GHG emissions, regional and rural development, and taking advantage of opportunities to promote social cohesion, value addition, and job creation at the local and regional levels, are acknowledged to be significantly aided by the production of electricity from renewable sources. In order to address the energy crisis, this emphasizes the prudent use of a wealth of renewable energy sources, including geothermal, biomass, solar, wind, and ocean tidal energy. Given the consumption, production, and supply of power, this article examines India's renewable energy situation and projects future changes. For the past thirty years, India has been actively engaged in research, development, production, and demonstration in an effort to find a workable solution to the ongoing issue of power deficit. Numerous renewable energy technologies have been applied in India for use in various industries. Due to the excellent geology and geography, a large customer base, and the growing imbalance between supply and demand, there are several prospects. There are only a few ways to conserve energy and the environment, and

technological advancement, appropriate regulations, tax breaks, and efficiency gains as a result of R&D activities will guarantee that these vast, clean resource bases are used as efficiently and economically as feasible. Intending to determine whether India can sustain its growth and society using renewable resources, this paper provides an overview of the potential renewable energy resources in the Indian context while analyzing the current situation, the nation's energy demand, and consumption and production forecasts. (D Sourav,2016).

A vital pillar of both social and economic advancement is energy. As the economy grows and human society's energy needs increase, the depletion of fossil fuels and their environmental contamination have led to a growing conflict between energy supply, environmental preservation, and economic growth. Renewable energy will become a viable and realistic option to ensure the world's continued development due to its renewable nature and lack of pollution. China's solar energy is currently mostly used for home energy use in both urban and rural areas, as well as for powering remote locations. Different stages of development are experienced by the solar water heater, photovoltaic cell, solar furnace, and passive sunlight house. Direct burning, gasification, liquefaction, and biological chemical transition are all methods of using biomass energy in China. (Li Xinrong, 2011).

In this article, China's strategic alliances with India, the European Union (EU), and Russia are examined. The majority of it is devoted to a thorough investigation of the strategic alliance between China and Russia. China's strategic alliances with the EU and India are also examined. It is evident from a comparative analysis that these alliances are motivated by China's and the other three superpowers' shared political commitment to preserving an interaction pattern in their relations that benefits both parties. Even if these dyads are competitive, China's partnership diplomacy has demonstrated its ability to successfully reshape great power politics in a way that makes the global climate generally conducive to its ascent. (Yong Deng,2007). A wide variety of businesses from many industries collaborate informally to create both internal and external associations in the wind power sector,

which is a complex industry. Being a complex system, it is essential to identify the locations of the many industry components, their operational traits, and the different connections among the numerous wind power industry sectors. This research builds a wind power industry chain model and analyzes the industry's working processes using the broad industry chain theory. As a result, three viewpoints for the wind power industry are established: the value chain model, the supply chain model, and the technology chain model. These perspectives, in turn, represent the value generation, technology transfer, and supply-demand relationship of wind power-related industries. It is possible to use the models to examine the distribution of resources, the links between supply and demand and production among linked firms, the necessary technology systems, and the wind power industry's value-adding process. This study examines the wind power industry in China using the following methods: the supply chain analyzes the wind power industry's construction, tools supply, and on-grid connection; the technology chain assesses the industry's technical status from the standpoint of its level of technology, its source, and its standards; and the value chain examines the value distribution of the wind power industry in China. According to the findings, China's wind power industry expansion is hampered mostly by overloading, a lack of core technologies, and an inadequate follow-up service system. The models serve as a useful tool for measuring and analyzing the state of development of the wind power sector in various nations and validating the idea of creating a sustainable growth plan. (Z George, 2014).

Research Methodology

The approach used in the study is qualitative. The analytical technique is used to carry out this research, and the data is gathered from the secondary sources. Texts, books, and other sources found in libraries and online are used to conduct this study. The purpose of the study on India-China renewable energy cooperation and energy is a growing area of interest, driven by both countries' commitment to decreasing carbon emissions and promoting sustainable development. This study also analyzes specific instances of India-China cooperation in renewable energy projects, such as

joint ventures or technology sharing. Examining the impact of policies and agreements on India-China renewable energy cooperation. To identify key stakeholders, including government agencies, private companies, and civil society organizations, and to understand their roles and interests in promoting cooperation. (Smith, Jeff M, 2019).

Renewable Energy Cooperation

As their economies expand and their populations' needs for clean, dependable energy grow, the two most crowded nations in the world, China and India, are confronted with critical energy challenges. Both nations have committed to lowering their carbon footprints and moving toward a low-carbon economy. China has set ambitious renewable energy targets, with China aiming to create 40% of its electricity from non-fossil fuels by 2030 and India aiming to generate 35% of its electricity from non-fossil fuels by the same year. Renewable energy offers a promising solution to meet both countries' growing energy demands while addressing climate change. This collaboration may also develop more consideration and trust between the two nations, promoting a more constant and safer regional environment. To reduce greenhouse gas emissions and improve air quality, economic benefit, technology transfer, and the trade system. This study is grounded in the following conceptual frameworks: neoliberal institutionalism, energy security, and sustainable development. (T Takahashi, 2024).

This framework highlights the significance of international organizations and collaboration in fostering mutual interest and resolving problems. Transfer, deregulation, consumer choice, globalization, free trade, and budget cuts are some of the economic liberalization policies that are frequently linked to neoliberalism. In order to satisfy a nation's economic and social demands, energy sources must be dependable and continuously available. With the support of Energy Security Protection, our energy system is more dependable, affordable, and feasible. Creating motivations to provide economic energy savings, lower peak demand, and boost green hydrogen generation accomplishes this. This framework examines China-India strategic exchanges in relation to teamwork on renewable energy. These goals cover a wide range of

issues, including poverty, hunger, health, education, sex equality, climate action, and sustainable intake and production. (Miranda Mousinho,2021).

Game Theory: This framework examines China-India strategic exchanges in relation to collaboration on renewable energy. By working together, both countries can achieve mutually beneficial outcomes, such as increased bargaining power, improved energy security, and Environmental benefits. A dynamic game also significant role in understanding game theory, and can also be used to study the cooperation relationship between India and China renewable energy trade. This model takes into account the strategic interactions between the two countries, such as competition for resources and cooperation in renewables. (J Jie, 2010).

Potential Areas of Cooperation

Some potential areas of cooperation between India and China in renewable energy include Joint research and development, investment in renewable energy projects, and energy swaps and trading. Collaborative research in renewable energy technologies, such as solar and wind power, can help both countries develop new technologies and reduce costs. China can invest in India's renewable energy sector, which is expected to offer investment opportunities of \$30 billion every year for the next decade. (W. Xingwu,2014). China and India can explore energy swaps and trading arrangements to reduce transportation costs and enhance energy security. To face many challenges to cooperation between India and China in renewable energy, such as economic and political tensions, and strategic concerns. Overall, game theory provides a useful framework for exploring the strategic dealings between India and China in renewable energy cooperation. By thoughtfully considering the reasons and challenges to cooperation, both countries can work towards mutually beneficial outcomes in the renewable energy sector. (An Athwal, 2007).

China is a global leader in solar panel production, while India aims to become a major solar hub. Chinese companies like LONGI Solar have established manufacturing plants in India, and there's scope for further investment and technology

transfer. Both countries can collaborate on wind turbine technology and joint projects to enhance efficiency and reduce costs. India and China can work together on green hydrogen production, a promising clean energy source. China can invest in India's renewable energy sector, which is expected to offer \$30 billion in investment opportunities annually for the next decade. India-China cooperation in renewable energy can drive growth, sustainability, to a cleaner and more secure energy future. (R Mizo, 2016).

Economic Growth

It identifies the need for economic growth but argues that it can be decoupled from environmental degradation through advances and policy. Cooperation in renewable energy can create new opportunities for economic growth, job creation, and reduced dependence on fossil fuels. China's investments in renewable energy have helped cut green costs worldwide, making sustainable energy solutions more accessible. Both countries play a crucial role in achieving role in global climate targets, with their renewable energy growth contributing to a low-carbon future. Renewable energy cooperation can create new investment opportunities, jobs, and industries. Collaborative efforts can accelerate the transition to clean energy, reducing dependence on fossil fuels, contributing to global climate goals, and promoting a sustainable future. (S Yamada, 2016).

Challenges and Opportunities

India and China have made significant strides in renewable energy, with both countries setting ambitious targets to reduce their reliance on fossil fuels. Cooperation between the two nations in this sector presents both opportunities and challenges.

Opportunities

Technology Sharing: China's the world's largest producer of solar panels and components, can share its expertise with India, enhancing the latter's solar energy capacity. China, a global leader in solar panel production, can share its expertise with India, which aims to become a hub for solar energy. (A Lema, 2012).

Energy Security:

Cooperation in renewables can help both countries reduce dependence on imported fuels, enhancing energy security and reducing price volatility risks. Energy security is closely tied to national security, as disruptions can impact a country's stability and sovereignty.

Global Climate Goals:

Joint efforts can contribute to achieving global climate targets, promoting a sustainable future. Global climate goals aim to mitigate climate change by reducing greenhouse gas emissions and transitioning to a low-carbon economy. United Nations Sustainable Development Goal 13 focuses on taking urgent action to combat climate change and its impacts. (A Sharma, 2025).

Challenges

Competition for resources: India and China compete for scarce energy resources, which can drive up prices and reduce bargaining power. India and China's competition for resources is driven by their rapid growth and increasing energy demand. India and China compete for oil and natural gas resources globally, which has led to a strategic focus on securing resources and influencing the Indian Ocean region. (D Sourav, 2016).

Economic and Political Tensions:

Bilateral tensions, territorial disputes, and strategic concerns can delay cooperation in renewable energy. Collaborative efforts can create new investment opportunities, jobs, and industries, driving economic growth.

Financing Hurdles:

Both countries face significant financing requirements to meet their renewable energy targets, with India needing substantial investment to achieve its goal of tripling renewable energy capacity by 2030. (D. Lew, 2013).

Different Priorities:

India and China have different priorities, with India focusing on energy access and security, while China emphasizes reducing reliance on imported fossil fuels. This cooperation can influence China's

skill in renewable energy technologies and India's huge renewable energy potential. By sharing knowledge, technologies, and best practices, India and China can foster a cleaner, greener, and more bearable energy future, driving growth and prosperity for both countries (VH Hoffmann, 2020).

Recommendations

To enhance bilateral dialogue, regular high-level discussions to foster cooperation and address challenges. The two countries have agreed to promote joint research and modernization in fields like renewable energy and healthcare, shared heritage for cultural diplomacy, and enhance maritime cooperation in the Indo-Pacific region.

Technology transfer of renewable energy technologies between the two countries. India has expressed concerns about China's technological advancements and potential security risks in areas like telecom networks and artificial intelligence.

Investment in renewable projects encourages Chinese investments in India's renewable energy sector and vice versa. India and China are among the world's largest emitters of greenhouse gases. China is dominating the global market, and India is setting ambitious targets.

International cooperation on global platforms to promote renewable energy and address climate change. Both countries have made significant strides in scaling up their renewable energy capacities, with China dominating the global market in solar panel production and wind farm installations, while India aims to become a global hub for solar energy.

Conclusion

In the end, India and China have significant opportunities to drive economic growth and sustainability through cooperation in renewable energy. They can Collaborative efforts can accelerate the transition to clean energy, reducing dependence on fossil fuels. Renewable energy cooperation can create new opportunities, such as jobs and industries. Diversifying energy sources can improve energy security and reduce price volatility risks. Highlighting the key factors that promote or hinder cooperation in renewable energy. Such as Lower costs, tax breaks, and increased profit. Providing a framework for understanding the complex

relationships between India-China cooperation, energy security, sustainable development, and climate protection. Offering references for policymakers, industry leaders, and public society groups to promote cooperation and sustainable development in the renewable energy sector.

They should similarly encourage the use of solar energy, create cooperative wind energy projects, and strengthen hydro energy cooperation. In terms of money, they ought to create a joint fund for investments in renewable energy, offer financing options for renewable energy projects, and provide tax breaks for such investments. Institutionally, they ought to set up a joint renewable energy school, design a shared curriculum, and build a joint platform for exchanging knowledge about renewable energy. Lastly, they should create a collaborative internship program for renewable energy and offer training and capacity-building initiatives.

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