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The Belt and Road Initiative and its Implications for Global Renewable Energy Development

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Abstract

Purpose of Review This article first demonstrates the natural potential of renewable energy development in BRI countries; second, the Rising Power Framework is introduced to investigate the improvement brought by BRI for renewable energy development in host countries. Finally, the political and economic challenges as well as those caused by the COVID-19 pandemic for renewable energy development are also identified.

Recent Findings The review shows that the BRI project indeed improved the renewable energy development in host countries, while the scale of renewable energy development, especially solar and wind energy, is heavily dependent on the amount of funding; moreover, the degree of technological improvement is determined by host countries' development needs and absorption capacity.

Summary In conclusion, this paper proposes a consideration related to the structure of energy investment under the BRI.

Keywords Belt and road initiative · Global renewable energy development · China

Introduction

The Paris Agreement emphasizes that both developed and developing countries must reduce carbon emissions in order to keep global warming well below 2 °C above pre-industrial levels [1]. However, developing economies need to consume large amounts of energy to support economic development; therefore, it has been estimated that these countries may emit more carbon dioxide than developed countries by the middle of this century [2]. Given this assumption, the way in which emerging economies will meet their energy needs is a key factor in determining whether the goal of the Paris Agreement can be successfully achieved.

The Belt and Road Initiative (BRI) is China's premier foreign policy aiming to enhance international cooperation and the development of global trade. As of January 2020, 138 countries have participated in the BRI [3]; many of them are emerging economies, whose demands for energy infrastructure are still very high in order to meet the needs of economic growth [4]. The BRI has channeled Chinese investment into infrastructure development, and China has invested heavily in the energy sectors of BRI countries [5]. However, China has come under criticism since such investments have mainly gone to oil, gas, and coal, which may promote developing countries' dependence on fossil fuels [6].

In recent years, China has adopted a more assertive approach for domestic environmental protection, showing its strong determination to combat pollution and climate change [7, 8]. Therefore, in response to above criticism, China has taken various measures to cut the carbon emissions in BRI host countries. China pledged to accelerate cooperation in applying clean coal technologies with host countries [9, 10]. And as a leader in renewable energy, China has continuously strengthened its cooperation with host countries to improve their clean energy development [11]. This paper reviews recent events and examines whether China is indeed promoting renewable energy development in BRI countries.

The remaining paper can be divided into three sections: "Natural Potential of Renewable Energy in Regions Covered by BRI" introduces the natural potential of renewable energy of BRI countries; "Status of Renewable Energy Cooperation" analyzes the current status of renewable energy cooperation

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between China and BRI countries by introducing the Rising Power Framework; "Challenges Faced by Future Renewable Energy Cooperation" identifies the challenges that Chinese investors may encounter in the overseas renewable energy cooperation.

Natural Potential of Renewable Energy in Regions Covered by BRI

At present, hydropower is still the world's largest source of renewable electricity [12]. Generally, regions with either high elevation or high runoff possess tremendous hydropower potential, but this potential is affected by restrictions such as developing technology, relative economic benefit, and environment protection [13]. Among the regions covered by the BRI, the largest contributor to the hydropower potential is the area around the Tibetan Plateau [14], followed by Asia Pacific [15], South America [16], and Sub-Saharan Africa [17]. Some of the BRI countries like Nepal [18] and Myanmar [19] have high hydropower potential per capita but low existing hydropower production [20].

Turning to wind energy, according to Zhou's study [21], some regions under the BRI, like Central Asia and North Africa, are endowed with high potential for onshore wind power generation. In Central Asia, given the mountainous topography, there are several BRI countries like Kazakhstan, Tajikistan, and Kyrgyzstan which have rich wind resources and are expected to develop wind power plants [22]. Endowed with 1000 km- and 724 km-long coastal lines respectively, Pakistan and Bangladesh in South Asia are ideal sites for offshore wind farms [23]. As for Africa, some of the BRI countries like South Africa, Sudan, Algeria, and Egypt have shown their promising wind power generation capacity [24].

There are two conventional ways of using solar energy: collecting the sun's heat through thermal systems and using photovoltaic (PV) panels to convert solar energy into electricity. Concentrated solar power plant (CSP) is one type of thermal energy generating power station. Considering Africa as an example, the total theoretical CSP potential of the entire continent is estimated to be 470 PWh, of which Eastern Africa has the largest potential, followed by Southern and Northern Africa [25]. Due to the relatively low altitude and suitability of their land areas, Egypt, Iran, and Saudi Arabia are very rich in solar radiation; it is estimated that their respective electricity generation potential could exceed 30 PWh [26]. With a large land area suitable for photovoltaic installations, Southeast Asia is also estimated to have abundant solar photovoltaic potential, totaling 430 Twh; specifically, parts of Myanmar and Thailand are identified as the best regions for PV installation [27].

Status of Renewable Energy Cooperation

By quantifying the renewable energy commitments contained in the Nationally Determined Contributions (NDCs) and comparing them with China's actual investment in renewable energy projects in BRI countries, previous studies argued that the BRI has not yet acted as the catalyst for low-carbon development in host countries [6]. Based on previous research and secondary materials, this paper selects some cases of renewable energy cooperation between China and BRI countries to investigate the extent to which the BRI has promoted the development of renewable energy in BRI countries.

The Asian Drivers Framework was developed to examine the channels (trade, investment, aid, and so on) through which China interacts with other developing countries as well as the complementary and competitive impacts of these interactions [28]. This framework was further developed later by Urban et al., who added the dimensions of motive, actor, and beneficiaries to understand the impact of different interactions between China and low- to middle-income countries [29]. In this study, three branches are added under the actor dimension—namely companies, financiers, and the government—to analyze the renewable energy cooperation between China and BRI countries (Table 1).

Hydropower

Hydropower is the field in which China is most involved in global renewable energy cooperation. China's current participation in overseas hydropower projects can be divided into four categories: investment (involves ownership), construction contracting, foreign aid, and equipment supply [30]. These are theoretical categories; however, in practice, one project can involve more than one category.

For example (Table 2), the Batang Toru hydropower project in Indonesia is an overseas hydropower project which has investments by Chinese entities. Although the largest shareholder of the project is PT NSHE (an Indonesian company), the loan providers behind it are Chinese financiers, including the Bank of China, Zhefu Holding Group Ltd., and Sinosure [31]. Zhefu Company is an enterprise engaged in the development, production, and sales of hydroelectric generator sets, its main motive being to expand overseas markets for its hydropower equipment [32].

In another example (Table 2), the construction contract of Isimba hydropower plant in Uganda was awarded to the China International Water & Electric Corporation (CWE), a large state–owned enterprise. Since 85% of the project's funding came from concessional loans of the Export-Import Bank of China, this project can be classified as a Chinese aid project [39]. From an economic point of view, China's motivation is to relocate its vast foreign exchange reserve and to open up new overseas markets [40]. Additionally, according to Le's

Table 1 The Rising Power Framework

Cooperation modes	Motives	Actors			Beneficiaries	Impacts	
		Companies	Financiers	Government		Positive	Negative
Trade Investment Aid Others	1. Economic motives 2. Political motives; etc.	1. Chinese manufacturers 2. Chinese constructors; etc.	1. Chinese policy banks 2.Chinese companies; etc.	1. The Chinese government 2. The BRI countries' government.	1. China 2. Chinese companies; 3. BRI countries; etc.	1. Political impacts 2.Economic impacts 3.Environmental impacts; etc.	1. Political impacts 2. Economic impacts 3. Environmental impacts; etc.

analysis [41], China's motive for providing concessional loans to Uganda seems to be related to the country's oil reserves.

For accessing electricity or implementing their NDC commitments, there is still an urgent need for China to build hydropower projects in some emerging economies in Africa and Asia. While financial institutions like the Asian Development Bank or the World Bank may decline to fund large-scale hydropower projects due to environmental or social concerns [42], and China is more open to doing so. Under the BRI, contractors and developers of hydropower plants not only can obtain sufficient funds, but the financing process is relatively fast and efficient. Also, China has proposed a "non-intervention" principle, which means that China will not participate in the internal affairs of BRI countries, which can be an incentive to some foreign partners. However, the environmental and social costs of these projects are often sidelined as they are not the priority of investment recipients. Furthermore, the "software" that determines the sustainable development of hydropower—the knowledge and skills for planning, building, managing, and operating hydropower plants—has not been effectively transferred to BRI countries through these cooperative ventures, due to the limited capacity of host countries to absorb these technologies [43].

Wind Energy

A decade ago, the Chinese government was determined to decarbonize its economy through the development of renewable energy and issued many policies to accomplish this goal [43]. During this period, a number of leading wind turbine manufacturers with strong manufacturing capacity and professional technology mushroomed in China. After nearly 10 years of rapid development, the wind turbine market in China has become saturated, resulting in the government slowing down the utilization of wind farms [44]. Therefore, these manufacturers have set their sights on foreign markets, hoping to resolve the problem of domestic overcapacity through trade and investment in overseas wind farms (Table 3). For the BRI countries that desire cleaner and cheaper energy, or the improvement of the local wind industry, Chinese wind turbine manufacturers are welcomed due to their competitive products and carried funding [52].

Chinese entities have indeed promoted the technical development of wind energy industry in BRI countries. Chinese equipment suppliers have been found to improve the wind industry in BRI countries through imparting skills and technology to the local employees about operating and managing wind power plants, even though their efficiency remains unknown as of now.

However, the scale of these optimistic collaborations has been questioned. As renewable energy projects are highly capital-intensive and require large-scale upfront investment,

Table 2 Modes of China's hydropower cooperation with BRI countries

Cooperation modes	Case projects	Motives	Main actors			Beneficiaries	Impacts	
			Companies	Financiers	Government		Positive	Negative
Investment (with trade of hydro equipment)	Batang Toru hydropower project in Indonesia (2018)	Zhefu Holdings: find a new market for its hydro equipment [33] Indonesia: 1. Improve electricity access; 2. Reduce reliance on fossil fuel	Zhefu Holding Group Ltd.; (as sponsor) Sinohydro (as constructor)	Zhefu Holding Group Ltd.; Bank of China; Sinosure	China: issue supporting policies Indonesia: implement environmental impact assessment (EIA) [34]	Zhefu Holding Group Ltd.; Constructor; Indonesia	Zhefu Holding Group Ltd: access to Indonesian market Constructor: gain profits Indonesia: diversify the energy source	China's financial institution: gain a bad reputation concerning environmental issue [35] Indonesia: threaten an orangutan specie with extinction
Overseas contraction (with aid)	Isimba hydropower project in Uganda (2014)	China: 1. Relocate exchange reserves 2. Increase Beijing's influence on global governance 3. Exchange for natural resources Uganda: improve electricity access (only 20.4% of the population had access to electricity until 2014 [37])	China International Water & Electric Corporation (as constructor)	China EximBank (85%, also the loan is concessional); Government of Uganda (15%) [36]	China: 1. Issue supporting policies 2. Operate on non-intervention principle Uganda: Implement environmental impact assessment (EIA) [42]	China; Constructor; Uganda	China: 1. Rebalance country's balance of payments 2. Strengthen the relationship with Uganda Constructor: Gain profits Uganda: access to electricity at speed	Uganda: 1. Heavy debts 2. Raise fears for local ecological environment

Source: [33, 35–38]

Table 3 Modes of China's wind power cooperation with BRI countries

Cooperation mode	Case projects	Motives	Main actors			Beneficiaries	Impacts	
			Companies	Financiers	Government		Positive	Negative
Trade Regular trade	ACT project Phase II in Pakistan (2020)	Goldwind: avoid saturated domestic market Pakistan [45]: 1. Improve electricity access 2. Improve energy security	Goldwind (wind turbines supplier)	-	China: issue supporting policies Pakistan [46••]: 1. Set renewable energy targets 2. Tax incentive	Goldwind; Pakistan	Goldwind: gain profits Pakistan [47]: 1.Access to clean energy 2. Local labors have received professional training	Still unknown
Trade with O&M services	Yucel project in Turkey (2020)	Goldwind: develop new cooperation modes Turkey [49]: 1. Meeting energy demand 2. Develop local technology 3. Achieve the clean energy strategy of Europe	Goldwind (provide turbines and O&M services)	Unknown	China: issue supporting policies Turkey [49]: 1.Set renewable energy targets 2. Issue supporting policies to distributed wind power	Goldwind; owner of the project	Goldwind: 1. Gain profits 2. Set a new cooperation mode in global market Owner of the project [48]: 1. Energy self-sufficiency 2. Lower electricity costs	Still unknown
Investment (acquisition)	Penonome I Wind Project in Panama (2014)	Goldwind: explore new market for its wind power products Panama [50]: 1. Meet electricity and energy demand 2. Decarbonize the energy system	Goldwind acquired the wind farm from Union Eolica Panamena (UEP) [51]	Unknown	China: issue supporting policies; Panama: set renewable energy targets [50]	Goldwind; Panama	Goldwind: gain profits Panama: strengthen local renewable energy matrix	Still unknown

Source: [46••, 47–51]

Table 4 Modes of China's solar power cooperation with BRI countries

Cooperation mode	Case projects	Motives	Main actors			Beneficiaries	Impacts	
			Companies	Financiers	Government		Positive	Negative
Trade	Thuan Nam solar project in Vietnam (2020)	Jinko Solar: declined demand in EU and US Vietnam [58]: 1. Access to cheaper and cleaner energy 2. Energy security 3. Job creation	Jinko Solar (PV modules supplier [57])	-	China: issue supporting policies Vietnam [59]: 1. Set renewable energy targets 2. Announce both financial and non-financial incentives to attract developers	Jinko Solar; Vietnam	Jinko Solar: gain profits Vietnam: access to cleaner energy	Still unknown
Investment (greenfield)	PV cell and module manufacturing facility in Malaysia (2015)	Jinko Solar: 1. Reduce production cost 2. Low tariffs on products exported to EU and US Malaysia: improve the PV industry to support the Economic Transformation Program (ETP [55])	Jinko Solar (investor [60])	Unknown	China: issue supporting policies Malaysia: announce both financial and non-financial incentives to attract investors [56]	Jinko Solar; Malaysia; importers of the products from Malaysia	Jinko Solar: gain profits Malaysia: 1. Improve clean power generation 2. Improve local PV industry 3. Solve unemployment problem Foreign importers: access to solar power with less pollution	Malaysia: may endure the chemical pollution from PV manufacturing facility [61]

Source: [55, 57–61]

wind energy development in BRI countries usually requires sovereign or corporate clients to raise funds through financial institutions. Since many Asian and African countries still tend to raise money for fossil fuel to meet their energy needs, renewable energy projects are rarely given priority [46••]. From the companies' perspective, unlike hydropower, the main Chinese entities participating in overseas wind energy cooperation are privately owned enterprises (PoEs), the internal financial resources of which are more limited than those of state-owned enterprises (SoEs). Furthermore, it is more difficult for PoEs to obtain bank loans when making overseas investments than it is for SoEs [6].

Solar Energy

From 2003 to 2006, the EU countries that announced the introduction of feed-in tariff schemes to support PV adoption experienced a surging demand for photovoltaic products, which triggered the development of photovoltaic manufacturing in China [52••]. With the Chinese government's supportive policies, many leading Chinese PV manufacturers were established in this period by acquiring PV technology from abroad [53]. However, due to anti-dumping and countervailing investigations since 2011, the orders received by Chinese PV manufacturers from the traditional EU and US markets have shrunk significantly [54], leading to even more serious domestic overcapacity than that of the wind power industry. In order to prevent bankruptcy, Chinese PV manufacturers are striving to find new markets and to reduce costs by establishing overseas manufacturing facilities. BRI countries also have strong motivation to cooperate with China. Besides obtaining cleaner and cheaper energy, some countries also look forward to solving unemployment problems and improving the local PV industry, relying on foreign investment and advanced technology (Table 4).

The "push" from China and the "pull" from BRI countries have contributed to improving the solar industry in BRI countries. A successful case is the PV cell and module manufacturing facility invested in by Jinko in Penang, Malaysia; this investment has brought Malaysia's PV industry a significant improvement. There are several reasons for this success: Malaysia's determination to identify the PV industry as a key pillar of the domestic economy, its attractive incentive for investors, and the relatively mature supporting industries and skilled employees for PV manufacturers [55].

Although China has launched a guiding policy to support PV manufacturers' overseas activities [56], these privately owned manufacturers have discovered the same problem as that encountered by wind turbine suppliers: they still have limited opportunities to improve solar energy development on a large scale without substantial subsidies.

Challenges Faced by Future Renewable Energy Cooperation

According to existing research [62], political and economic factors present significant challenges to China's overseas renewable energy investment. Moreover, the COVID-19 outbreak, causing changes in renewable energy industries will also have an impact on the Chinese renewable energy investment after 2020.

Political Challenges

Political challenges are mainly reflected in the stability of the state's sovereignty, administrative institutions, and presence of violence [62]. Changes in the political situations of BRI partners will inevitably have a negative impact on renewable energy cooperation with the Chinese. According to the World Bank [63], there are some BRI partners which have unstable political situations (e.g., Afghanistan and Ethiopia), and investors should proceed with caution when these countries are selected as cooperative partners.

The quality and transparency of government refers to government efficiency, compliance burden, regulatory quality, accountability, and corruption control [64]. The administrative procedures of a government will affect the process of establishing a company or obtaining permits and licenses required for renewable energy projects; an efficient and incorruptible host government is extremely attractive to investors [65]. From this perspective, investment uncertainty in some BRI host countries like Sudan and Uzbekistan (with weak voices and accountability) or Myanmar and Somalia (with inefficient governments) is relatively high [63].

Macro-economic Challenges

Exchange rate volatility refers to the appreciation or devaluation of foreign currencies [66] and may affect the profitability of renewable energy investment and international trade by changing the cost of a project's investment or its equipment export and import [62, 67]. In countries without a reliable financial system, more consideration should be given to exchange rate volatility in investment and trade activities. With a developed financial system, investors can withdraw their shares from the stock market in the face of exchange rate volatility while in countries without a reliable financial system, investors may face more complicated situations [68].

COVID-19

Due to its low operating costs and prioritized access to more power systems, renewable energy has become the most resilient energy source during the lockdown period of COVID-19 [69]. However, renewable energy projects are also facing

multiple challenges brought about by the coronavirus crisis, such as administrative and social delay, the disruption of construction and the expiration of incentives from the governments for renewable energy projects [70]. For the transnational renewable energy cooperation between China and the BRI partners, the following two COVID-19 challenges may be even more severe.

First, supply chain disruptions have suspended activities at several sectors of the renewable energy industry [69]. Solar panels produced in Chinese factories account for approximately 70% of the global supply, and another 10% to 15% come from Chinese-invested manufacturers in Southeast Asia [71]. In the first quarter of 2020, due to the lockdown of key areas caused by the COVID-19 pandemic, many solar photovoltaic production lines were disrupted. The same disruption also occurred in the wind energy industry, which is even more interconnected on a global scale than solar photovoltaics [72].

Second, affected by the epidemic, the public budget pressure and fiscal deficit of some BRI partners may increase, which would lead to a decline in the government's debt solvency, thereby increasing the investment risks and pressure on funds recovery [30].

Conclusion

To achieve the ambitious goal of carbon emission control at the global scale, the contribution from emerging economies plays a decisive role. As most members of the BRI are developing countries, it is important to ask to what extent renewable energy cooperation between China and BRI partners can help emerging economies avoid high-carbon development pathways. This study analyzed renewable energy cooperation between China and its BRI partners using the Rising Power framework. As the BRI project covers most of the Asian and African continents as well as parts of Europe, Oceania, and the American continent, the diverse topography gives BRI partners different potential options for generating renewable energy. Under the domestic "push" from China and the "pull" from BRI countries, China has been significantly involved in improving renewable energy development in host countries. The results show that the scale of the development depends on the amount of funding (especially in the fields of wind and solar energy) and the extent of technological improvement determined by host countries' development needs and absorption capacity. Also, renewable energy cooperation under the BRI also faces challenges from the host country's political environment, macroeconomics and response to COVID-19.

Can the reduction of carbon emissions, in part made possible by renewable energy projects, offset the increase of carbon emissions caused by China-invested fossil fuel projects in BRI countries? In light of a recent study [6] among the energy-sector loans provided by the China Development Bank and the China Exim bank in BRI countries, the oil, gas, and petrochemical sectors still accounted for 43% of loans, followed by the coal sector with 17.9%. Because of this, the possibility of reducing carbon emissions by replacing fossil fuels with renewable energy in BRI countries is questionable. Nevertheless, the BRI is a constantly evolving project with some signs suggesting that China intends to make the BRI more environmentally sustainable. More research is needed to critically examine this green turn of the BRI and what it means for renewable energy cooperation on a global level.

Compliance with Ethical Standards

Conflict of Interest Qingge Geng declares that she has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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