frontiers in Energy Research

MINI REVIEW
published: 30 July 2021
doi: 10.3389/fenrg.2021.724892

A Critical Survey on Renewable Energy Applications in the Philippines and China: Present Challenges and Perspectives

*Xin Li, Haizhi Wang, Yuanru Lu and Wanlin Li**

Law School, Kunming University of Science and Technology, Kunming, China

China's Belt and Road (B&R) initiative provides new ideas and opportunities for international cooperation. Renewable energy plays a crucial role not only in the national sustainable development framework of China and the Philippines but also in bilateral cooperation between them. However, some obstacles still need to be addressed because renewable energy cooperation between China and the Philippines has not been thoroughly and comprehensively studied to date. Based on an in-depth analysis of current renewable energy cooperation between China and the Philippines, this paper employs PESTEL analysis to fully investigate the cooperative advantages and disadvantages by considering politics (P), economy (E), society (S), technology (T), environment (E), and legislation (L) and proposes several constructive suggestions. The ultimate purpose was to design feasible schemes to ensure the sufficient utilization of renewable energy and the construction of integrated power grid systems to meet shortages of electricity supply especially in the isolated small islands in the Philippines through cooperation with China. In particular, it offers valuable advice concerning the U.S.-China trade war and COVID- 19 pandemic, outlining how cooperation in the exploitation of potential renewable energy is vital.

Keywords: the belt and road, the Philippines-China cooperation, renewable energy, PESTEL analysis, renewable energy cooperation

OPEN ACCESS

Edited by:
Yaxing Ren,
University of Warwick,
United Kingdom

Reviewed by:
Si Chen,
University of Glasgow,
United Kingdom
Youcai Liang,
South China University of Technology,
China

****Correspondence:***
Wanlin Li
karen_lee_lx@126.com

Specialty section:
This article was submitted to Sustainable Energy Systems and Policies, a section of the journal Frontiers in Energy Research

Received: *15 June 2021*
Accepted: *19 July 2021*
Published: *30 July 2021*

Citation:
Li X, Wang H, Lu Y and Li W (2021) A Critical Survey on Renewable Energy Applications in the Philippines and China: Present Challenges and Perspectives. Front. Energy Res. 9:724892. doi: 10.3389/fenrg.2021.724892

INTRODUCTION

In response to the advantages of renewable energy (Gullberg et al., 2014), many countries and regional organizations have entered into cooperative targeted renewable energy initiatives (Anand et al., 2021; Mohan, 2021; Sasmita and Sidhartha, 2021). Existing research on renewable cooperation (Feng et al., 2020) is mainly focused on a comprehensive analysis of the renewable energy cooperative mechanism between two countries (Suryanarayana and Saumendra, 2020), a country and regional organizations (Mehdi and Mehdi, 2020), and regional organizations (Indeo, 2019), by forecasting the potentiality of cooperation and undertaking analysis *via* a mathematical model (Satish and Vinod, 2020). However, three existing gaps need to be overcome.

- Most previous studies fail to comprehensively analyze the advantages and disadvantages of renewable energy cooperation between specific countries under B & R.
- Specific suggestions based on the effective factors of cooperation such as politics, economy, society, technology, environment, and legislation have not been proposed.

TABLE 1 | The Philippine installed capacity mix (MW) (The Department of Energy, 2019).

Fuel type time	Coal	Oil based	Nature gas	Renewable energy (share)	Geothermal	Hydro	Win d	Biomass	Solar	Total
2017	8,049	4,153	3,447	7,079 (31.1%)	1,916	3,618	427	224	885	22,728
2018	8,844	4,292	3,453	7,227 (30.3%)	1,944	3,701	427	258	896	23,815
2019	10,417	4,262	3,453	7,399 (28.9%)	1,928	3,760	427	363	921	25,531

- The latest factors, including the COVID-19 pandemic and the United States-China trade war, have not been addressed.

This paper focuses on the exploitation of renewable energy cooperation between China and the Philippines, proposing a new perspective in response to this new context and undertakes a comprehensive investigation of a cooperative scheme between two countries. Based on a systematic overview of renewable energy systems in China and the Philippines, including the current situation, existing problems, policies, and plans, the basis and challenges for further cooperation between the two countries are explored (*Renewable Energy Development in the Philippines* and *Renewable Energy Development Status in China* Sections).

The background informing this topic and existing renewable energy cooperation projects between China and the Philippines are addressed, and a Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) analysis is adopted to illustrate the advantages and disadvantages of those factors in cooperation (*The Philippines—China Renewable Energy Cooperation Under Political, Economic, Social, Technological, Environmental, and Legal Analysis* Section);

Finally, some feasible and promising suggestions are proposed to deal with emerging problems and opportunities in renewable cooperation between China and the Philippines under B&R (*Political, Economic, Social, Technological, Environmental, and Legal Recommendations* Section).

RENEWABLE ENERGY DEVELOPMENT IN THE PHILIPPINES

Current Status

The Philippines stores rich renewable energy which also plays an important role in the energy supply of the country. As **Table 1** shows, although the proportion of renewable energy in the total amount of installed capacity is only about 30% and there has been a slight downward trend in the last 3 years, the quantity produced is still steadily growing.

Geothermal Energy

The Philippines is located in a tropical low-latitude area at the junction of Asia, Europe, and the Pacific plate, which means the country has rich geothermal energy resources. After many years of development, the installed capacity of geothermal power reached 1,944 MW in 2018, accounting for 13% of the world's total, and ranking third after the United States and Indonesia (Ratio et al., 2020).

Hydropower Energy

The Philippines has 421 rivers, numerous mountains, rugged terrain, and a rainy climate, which create abundant hydropower resources that contribute the largest portion of installed capacity generated by renewable energy. Although the Philippines already has some large-scale hydropower plants and has made achievements in the development of hydropower infrastructure, there is still 13,097 MW of undeveloped hydropower generation capacity remaining, according to an assessment by the Philippine Department of Energy (The Department of Energy, 2019).

Solar Energy

With solar radiation of 4.0–6.0 kWh/m2/day, the Philippines has abundant solar energy resources which evenly distribute across the country and vary between 10 and 20% every month (Sharma and Kolhe, 2020). Due to the continuous improvement of technology and efficiency of solar photovoltaic (PV) modules, the solar energy industry has achieved scale development and significantly reduced the costs of solar power generation (Sharma and Kolhe, 2020). More and more residents and industrial sectors in the Philippines have started to use small-scale solar PV production.

Problem and Causes

The continuous economic expansion of the Philippines has brought serious problems in the form of insufficient energy supply (Mondal et al., 2018). The Philippines' GDP in 2018 grew by 6.2%, exceeding 6% for the seventh consecutive year (GPD, 2019). However, more than 11% of the population has no electricity, and a higher proportion suffers from unreliable electricity supply (Bertheau et al., 2020).

Huge reserves and the potential of renewable energy resources have not achieved a satisfying development in the Philippines.

The main reasons for the insufficient utilization of renewable energy, include the fact that the development of renewable energy requires high prepayment and technology costs (Zafar et al., 2019). Moreover, hydropower and geothermal energy, which generate the most electricity, have a very long development cycle (Barroco and Herrera, 2019). Moreover, the Philippines is unable to form an integrated power grid system, which impacts the sufficient transmission of electricity generated by renewable energy. The Philippine power supply system is also divided into "on-grid" and "off-grid" areas. The on-grid is supplied by two separate main power grids which lack a connection with each other. The off-grid covers these areas but suffers from insufficient power or even no power supply at all (Bertheau et al., 2020).

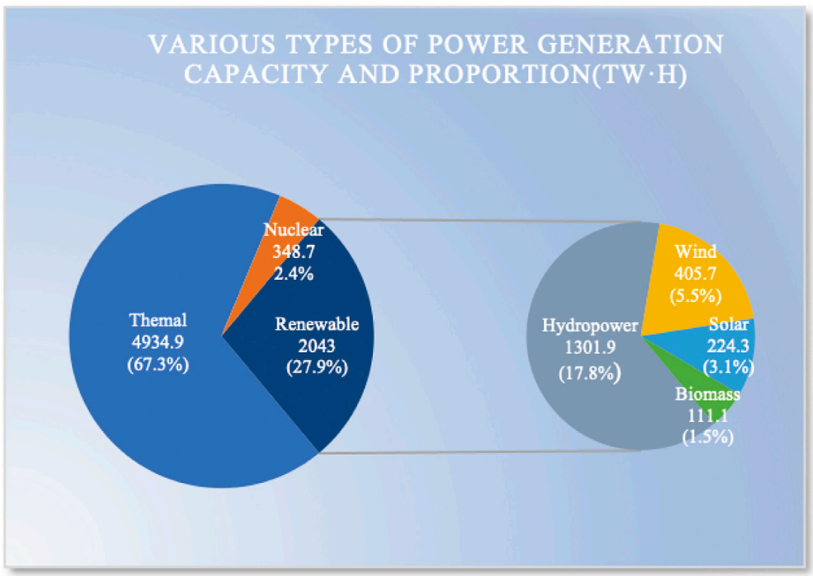

FIGURE 1 | Various types of power generation **(A)** installed capacity, and **(B)** proportion.

Policies and Plans

The Philippine government has realized the importance of developing renewable energy and has formulated several policies and plans based on the focuses: 1) ensuring energy security, 2) achieving optimal energy pricing, 3) diversifying fuel sources, and 4) developing sustainable energy systems (The Department of Energy, 2017). The National Renewable Energy Program (2011–2030) anticipates that the generation capacity of renewable energy will triple by 2030 (Wang et al., 2020) This has lead to the development of policies including carbon taxes, the improvement of energy efficiency in both generation and consumption, diversification of the energy supply-mix (Cabalu et al., 2015). Those policies and plans not only ensure energy security and reduced reliance on fossil energy they are also milestones in building a greener Philippines.

RENEWABLE ENERGY DEVELOPMENT STATUS IN CHINA

Current Status

As the second-largest economy in the world, China has abundant renewable energy storage. By the end of 2019, the installed capacity of renewable energy in China was as high as 794.88 GW and has increased by 8.7% since 2018 (Si et al., 2021). The current power generation capacity of each renewable energy source is shown in **Figure 1**, and the current situation of China's renewable energy is shown in **Table 2** (China Renewable Energy Engineering Institute, 2019). In 2013, China proposed the B&R initiative, which covers 65 countries in Asia, Africa, and Europe (Wang et al., 2020). More importantly, promoting the green and low-carbon transformation of the energy structure of countries along the B&R is a core content of green construction in the area and a significant measure in improving the ecological environment and supporting global sustainable development (Yang et al., 2021). As a key country along the Maritime Silk Road, the Philippines has also joined the Asian Infrastructure Investment Bank initiated by the Chinese government.

Advantages

After decades of efforts, China has developed innovative approaches to energy and shared these experiences with other countries through the green cooperation of B&R to eliminate dependence on high-carbon growth models.

The advantages of the Chinese approach stem from it being a strong financial power. China has promoted the vigorous development of renewable energy, and in 2018 China became the world's largest investor in renewable energy for the seventh consecutive year, an investment that accounts for almost one-third of the world's total, reaching US $91.2 billion (Si et al., 2021). Moreover, China's renewable energy technology, manufacturing level, and high-quality production capacity have significantly improved in recent years, and a complete industrial chain with international advanced levels has been constructed in the renewable energy sector. This huge renewable energy product market has also contributed to the development of renewable energy worldwide.

Policies and Plans

In 2005, China enacted the Renewable Energy Law, quickly followed by more than 100 policies, regulating grid subsidies and special fund management measures, including guidance on promoting renewable energy consumption and other aspects as shown in **Figure 2** (China Renewable Energy Engineering Institute, 2019). The most important renewable energy plan of China is the 14th Five-year Plan (2021–2025). The key tasks of which include giving priority to the development of renewable energy based on

TABLE 2 | Status of types of renewable energy in China.

Category	Status
Conventional	1. From 2016 to 2019, the newly added production reached 26.9 GW, and the newly started construction reached 34 GW, which was 68.1 and 56.7% of the planned target respectively 2. By the end of 2019, online monitoring data access for 273 hydropower stations had been completed, with a total installed capacity of 189 GW
Pumped	1. At present, the installed capacity of pumped storage sites included in the national plan is about 120 GW 2. From 2016 to 2019, 31.83 GW of new construction was started
Wind	1. The total grid- connected installed capacity reached 210 GW, accounting for 10.4% of the total installed capacity, of which onshore wind power was 204 GW and offshore wind power was 5.93 GW 2. The hoisting capacity increased by 27 GW. Among the world's top 10 onshore wind. Turbine manufacturers, the total share of Chinese enterprises accounted for 38%
Solar	1. New and cumulative installed capacity of PV generation ranks first in the world 2. In 2019, the electricity price of PV subsidy bidding projects dropped significantly
Biomass	China has put into operation 14 commercial biological natural gas projects, with an annual gas capacity of about 127.75 million m^3, an annual output of organic fertilizer of 1.056 million ton, and an annual output of 4 million ton of biological liquid fuel

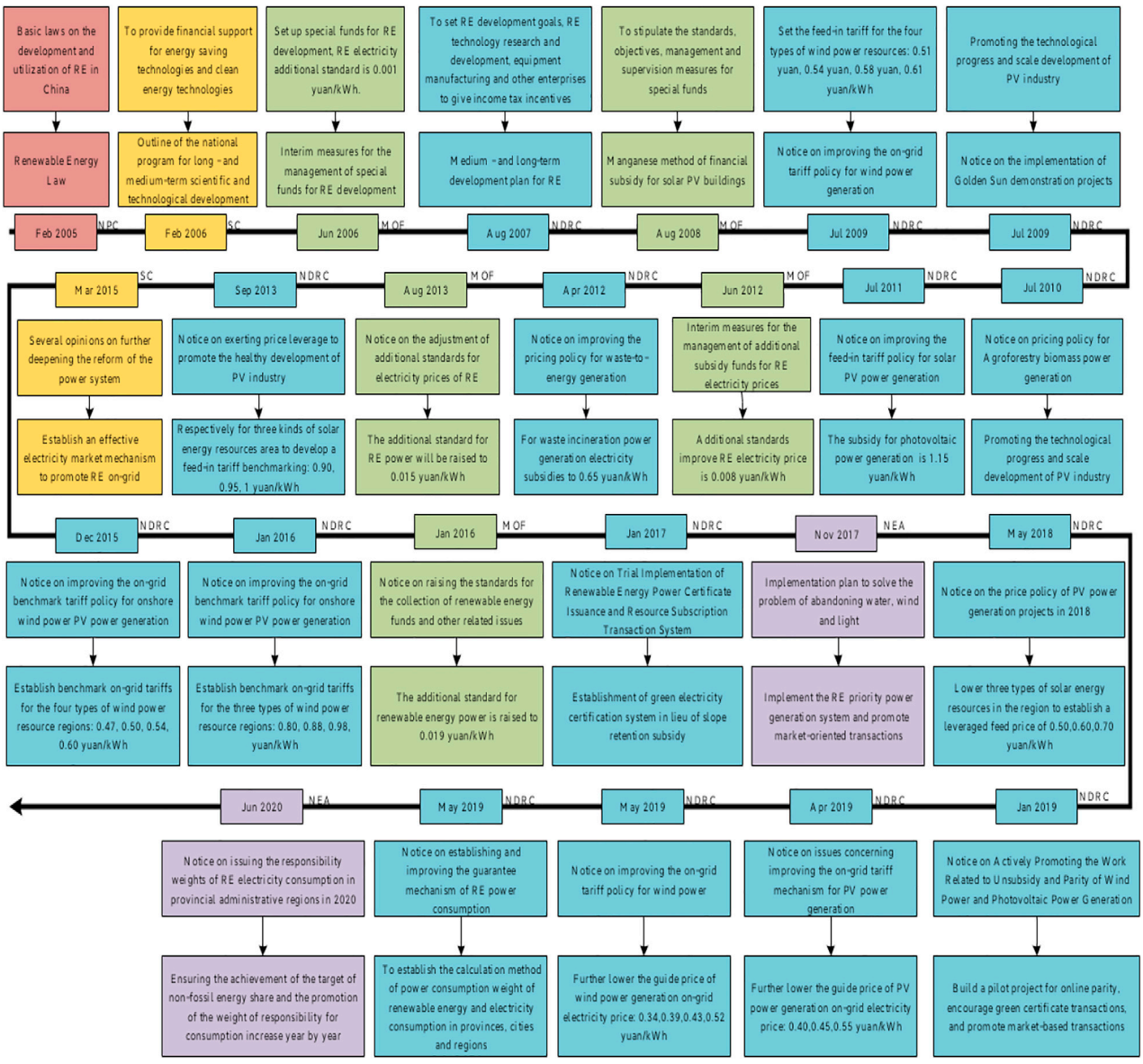

FIGURE 2 | Renewable energy policy roadmap in China (China Renewable Energy Engineering Institute, 2019). Abbreviations: National People's Congress (NPC); State Council (SC); Renewable Energy (RE); Ministry of Finance (MOF); National Development and Reform Commission (NDRC); National Energy Administration (NEA); Exchange rate: 100 (CNY) = 15.4400 (USD) (Date: January 22, 2021).

TABLE 3 | The Philippines—China renewable energy corporation projects.

No	Name of Power Station	Installed Capacity (MW)	Location	Type of Station	Date	Corporation Unit
1	Liangan	11.9	Bacolod	Hydropower	2016	China
2	Kapuan	60	Baguio	Hydropower	2016	China
3	Agus VI	69	Quezon	Hydropower	2017	China
4	Pulangi	250	Miandanao	Hydropower	2017	China
5	Sacasun	58.98	San Carlos	PV	2016	China
6	Garcia	20	Currimao	PV	2016	China
7	Leyte	30	Leyte	PV	2015	China

market forces and low costs, systematically evaluating the development conditions and goals of various renewable energy resources, promoting renewable energy technologies and equipment to develop a relative industrial system, etc., (Liu, 2019). In addition to the macro level, specific plans for different types of renewable energy exist that are international and jointly promote the construction of clean energy (Liu, 2019).

THE PHILIPPINES—CHINA RENEWABLE ENERGY COOPERATION UNDER POLITICAL, ECONOMIC, SOCIAL, TECHNOLOGICAL, ENVIRONMENTAL, AND LEGAL ANALYSIS

Existing Cooperation

China and the Philippines have a history of extensive cooperation in renewable energy, including hydropower, PV, biomass energy, and wind energy, as shown in **Table 3**. This includes both the supply of existing equipment and Engineering Procurement Construction (EPC). This has greatly improved the utilization of hydroelectric and PV in the Philippines, and has made up for power shortages in some areas.

Hydropower cooperation is the focus of the China-Philippines renewable energy cooperation agreement. Cooperative projects are mainly large-scale hydropower plants with an installed capacity of over 10 MW. Solar energy has now become the fastest-growing type of renewable energy in the Philippines, which has attracted many Chinese enterprises.

As one of the listed companies affiliated with the State Grid of China, the NARI Group owns several EPC projects of PV power stations in the Philippines. The Hengshun Group, a private company in China, signed an EPC contract of wind power and PV integration with Energy Logics Philippines, Inc. in 2016: the largest PV integration project to date in the Philippines.

Political, Economic, Social, Technological, Environmental, and Legal Analysis of Renewable Energy Cooperation

Under the intensifying forces of globalization and competition, PESTEL has recently evolved from PEST analysis, to consider the environmental and legal factors, with increased potential impact on businesses (Thakur, 2021). The PESTEL analysis model is an effective tool for macro-environmental analysis that can not only analyze the external environment but also identify all forces that have an impact on the organization. This analysis mode mainly analyzes the investment environment of enterprises.

Political

Advantage

China and the Philippines have established diplomatic relations for 45 years. A mutual friendship formed after the election of Roberto Duterte to President of the Philippines in 2016. Building upon this preexisting relationship, China's focus on green energy cooperation among countries means that it actively seeks energy cooperation partners in different regions. The Philippines is currently pursuing a green energy development model, implementing a large number of fiscal incentives to attract foreign investment in the renewable energy sector (Cabalu et al., 2015).

Disadvantage

The relevant disputes between China and the Philippines in the South China Sea once froze the bilateral relationship. The current highly friendly relationship benefits from Duterte's policy towards China, but this might change when Duterte's term in office ends in 2022. Besides, the Philippines has serious political corruption problems and bureaucracy that may also lead to the unfair treatment of Chinese companies.

Economic

Advantage

The Philippines is one of the most dynamic economies in the East Asia Pacific region. As a beneficiary of the power industry reform of the Philippines, the State Grid Corporation of China holds 40% of the National Grid Corporation of the Philippines. Meanwhile, Chinese energy enterprises have excellent brands and performance advantages. For example, as an active partner cooperating with the Philippines, China Energy Engineering Group Company has experience in power engineering projects and formed a complete industrial chain in international cooperation (Shang et al., 2020).

Disadvantage

In 2020, COVID- 19 pandemic caused a recession in the world economy and hindered international cooperation. In addition, the United States-China trade war has seriously affected the world market and greatly increased the trade barriers between economies. These international economic factors are detrimental to the cooperation between the two countries.

The overall economic level of the Philippines is not high, and the per capita GDP ranks 123rd in the world (International Monetary Fund Philippine GDP per capita, 2019). Moreover, the industrial development level of the Philippines is relatively low, and public facilities such as transportation, electricity, and hydropower lag behind other countries. An out-of-date economy and lesser developed technical facilities make cooperation between the Philippines and other countries difficult.

Social

Advantage

China and the Philippines belong to the East Asian cultural circle and have a long history of cultural exchange. A Cultural Exchange Forum and a series of public welfare activities between the two countries were also held recently (Sina News, 2018). After the COVID- 19 pandemic, China has repeatedly donated medical materials to the Philippines to jointly fight the epidemic.

The Philippines has an abundant labor force and a very young population structure in which the working-age population aged between 15 and 65 has reached 63.6%. In addition, English is the official language of the Philippines, and the literacy rate of Philippines residents is 96.4%, ranking among the highest in Asia (Ministry of Commerce of the People's Republic of China, 2019).

Disadvantage

The domestic security situation of the Philippines is not favorable. There were 8,826 murders and 16,100 robberies in 2017, with 8.40 per 100,000 people (Ministry of Commerce of the People's Republic of China, 2019). There are also several armed rebel terrors groups.

The price levels and costs in the Philippines are also extremely high. The prices of vegetables and fruits, electricity, and hotel accommodation and meals are 3–4 times, 2–3 times, and 1–2 times higher than that of China, respectively (Ministry of Commerce of the People's Republic of China, 2019).

Technological

Advantage

China and the Philippines are technically complementary in terms of energy development and power construction. China's power technology is in the front ranks of the world and could help power development in the Philippines. For example, the advanced UHVDC power transmission technology could realize a sufficient power supply in the offshore islands, which is highly conducive to the formation of the power grid system in the Philippines. Meanwhile, China's infrastructure construction, including 5G, the internet of things, and the industrial internet are also very advanced (Yang et al., 2021). The Philippines also attaches great importance to the development of science and technology through active cooperation with technology-developed countries in engineering and scientific projects *via* higher education.

Disadvantage

Due to the limitations of technology and financial resources, the level of large-scale projects independently constructed by the Philippines is very limited. Hence, many projects have been completed with capital and technologies from other countries. Chinese enterprises may lack the most advanced technology and experience in geothermal energy cooperation due to the lack of domestic geothermal resources.

The risks affecting electricity technical standards of design and construction cannot be ignored. The Philippines mainly adopts American standards which are different from those of China and lead to the extension of design and approval time.

Environment

Advantage

China is a maritime neighbor of the Philippines, and the local time of the Philippines is consistent with Beijing time, which is convenient for cooperation and communication.

Disadvantage

Due to its fragile climate and frequent geological disasters, the Philippines is frequently affected by natural disasters resulting in a great loss of human life and property (Bollettino et al., 2020). Besides, the construction of hydropower stations could adversely affect wildlife and plants and lead to geological disasters. Local people and environmental protection organizations are very opposed to the construction of hydropower stations and the development of geothermal energy, which may greatly impact energy cooperation.

Legal

Advantage

China and the Philippines issued the "Renewable Energy Law" in 2005 and 2008, respectively, to vigorously develop renewable energy and ensure energy security and the optimization of the ecological environment. Foreign investment in biomass and garbage power generation projects had a restriction of 40% lifted in November of 2019 after an announcement by the Philippine government. It is anticipated that other renewable energy projects will be further opened to foreign investment in the future (The Department of Energy Administrative Order, 2020).

Disadvantage

According to Philippine law, foreign investors are prohibited from buying land (The Department of Energy Administrative Order, 2020). In addition, the Philippines has strict controls over work visas for Chinese, which is not conducive to management and technical personnel traveling there from China. Furthermore, as the main form of contracted projects between Chinese enterprises and the Philippines, government projects can only be established after being approved by the Philippine National Economic Development Agency.

POLITICAL, ECONOMIC, SOCIAL, TECHNOLOGICAL, ENVIRONMENTAL, AND LEGAL RECOMMENDATIONS

Political

First, the Philippines and China should make the most of the existing mutual friendly diplomatic relationship to actively develop cooperation. The B&R and the China-ASEAN Free

Trade Area have brought more opportunities and favorable conditions for renewable energy cooperation between the two countries. In terms of disputes in the South China Sea, it is the consensus and commitment of China and the Philippines to settle through negotiation and properly manage their relevant dispute.

Secondly, the renewable energy development strategy could be deepened in the two countries respectively. China should consider renewable energy as a new orientation of developing export trade and investment outward, and actively guide and support overseas cooperation. The Philippines could absorb advanced foreign renewable energy technologies in grid construction while mobilizing domestic resources to develop renewable energy.

Economic

With the guidance of the B&R initiative and the help from the Asian Infrastructure Investment Bank, the Philippines could actively carry out infrastructure construction to improve the business environment. In terms of offshore islands, the construction of renewable energy power plants and grids would solve electricity shortages.

Hydropower and geothermal power generation are the main areas of international cooperation in the Philippines. The EPC mode could be an ideal choice in cooperation, which is relatively fixed, and the implementation period is not long. Chinese companies could integrate the upstream and downstream of the industrial chain systematically to achieve sufficient cooperation and expand the scale and benefits of collaboration.

Social

The two countries could continue to carry out cultural exchange under the background of B&R and promote non-government exchange. In addition, China and the Philippines always adhere to the coexistence of diversified culture, mutual learning, and cooperation for shared benefits. Therefore, Chinese companies participating in cooperation should pay attention to local cultural differences, and respect the local customs, religions, and living habits of the Philippines. Besides, the Philippine government needs to increase public security management through the reduction of crime rate, strictly control the possession of guns, and standardize its application administrative procedures.

Technological

Firstly, China is an advantageous partner in assisting the Philippines to form a complete power grid that especially aims to increase the power supply of offshore islands. To reduce the technical risk, research and exploitation in major technology should be strengthened. Making good use of a contract to constraint risk, promoting project supervision and construction quality should be the focus of project management.

Secondly, great attention should also be paid to the integration of power standards with international standards. Due to the different situations in each country, integration should not aim to achieve the unity of technical standards but to learn from the international advanced technical standards and increase public knowledge of China's working practices to continuously optimize and update standards.

Environment

Due to the frequent occurrence of natural disasters and tropical epidemic diseases in the Philippines, contractors should pay close attention to local news and take preventive measures to prevent personnel and property losses.

Actively fulfilling social responsibility and strengthening environmental awareness is of great significance, because they develop the local economy and improve local people's livelihoods. Through appropriate publicity in a local area, the public could be told more about the cooperative project, and gain an understanding of the fact that they will directly experience an improvement in quality of life quality from these projects. This would improve the enterprise's local popularity and form a positive corporate image.

Legal

On the governmental level, an agreement focused on the strategic cooperation of renewable energy and based on the national strategy and security of both two countries could be reached, which may include investment, technology cooperation, grid construction, and trade. Furthermore, governments of China and the Philippines could establish a unified and effective platform to share renewable cooperative information, corresponding policies, and administrative procedures to solve the difficulty of information collection and nontransparent policies faced by potential cooperators or contractors.

In terms of enterprises, Chinese organizations need to fully understand Philippine laws and regulations to ensure they operate legally, including visas, environmental protection, land, and localized employment regulations. Moreover, the restriction of the foreign investment ratio of renewable energy projects should be studied seriously to maximize the profit of the enterprises in accordance with the laws of the Philippines.

CONCLUSION

This paper is the first to undertake a systematic study of renewable energy cooperation between China and the Philippines under B&R, and draws the following crucial conclusions:

Firstly, the cooperation between China and the Philippines in renewable energy is a mthod of building a greener Philippines and protecting the environment. The coexistence of abundant but undeveloped renewable energy resources and the shortage of electricity supply, especially in the offshore islands, requires deep cooperation with China, as it has superior technological and extensive experience in grid construction. Among various renewable energy, hydropower and geothermal powers are major cooperative areas, in terms of the status of the Philippines. How to explore and utilize renewable energy more economically and efficiently, and realize a sufficient electricity supply are important factors in alleviating dependence on imported fossil fuel energy, a will form a top priority of any cooperative agreement. In addition, the two countries can use the opportunity of renewable energy cooperation to promote cooperation in other industries and achieve mutual benefit and win-win results between the two countries.

Secondly, renewable energy cooperation is the focus of energy cooperation in any B&R initiative. Moreover, a Regional Comprehensive Economic Partnership was established in 2020 and has eliminated trade barriers between Asia-Pacific countries and ASEAN countries. The combination of these initiatives and agreements presents an unprecedented opportunity for China and the Philippines to develop renewable energy cooperation. However, the outbreak of the United States-China trade war and the ongoing COVID- 19 pandemic have brought unprecedented challenges to such potential cooperation initiatives. In response to opportunities and challenges and to achieve a win-win situation, China and the Philippines need to strengthen political and economic cooperation and promote corresponding policies.

Thirdly, a cooperative agreement focused on strategic cooperation concerning renewable energy that is based on national strategy and the security of both two countries may include investment, technology cooperation, grid construction, and trade for renewable energy infrastructure. Furthermore, the Chinese and the Philippine governments could establish a unified and effective platform to share renewable cooperative information, corresponding policies, and administrative procedures to solve the difficulties of collecting information and nontransparent policies faced by potential cooperators or contractors.

Finally, although the disputes between China and the Philippines in the South China Sea once impacted this bilateral relationship seriously, the current friendly relationship has lasted 5 years, creating a positive and timely opportunity for cooperation between the two countries.

AUTHOR CONTRIBUTIONS

XL: Conceptualization, Writing- Reviewing and Editing. HW: Writing- Original draft preparation, Investigation. YL: Writing-Reviewing and Editing. WL: Supervision, Resources.

ACKNOWLEDGMENTS

The authors acknowledge the support of the Talents Training Program of Kunming University of Science and Technology (KKZ3201524007).

REFERENCES

Anand, K., Md Nishat, A., and Shekhar, K. (2021). Sliding Mode Controller Design for Frequency Regulation in an Interconnected Power System. *Prot. Control. Mod. Power Syst.* 6 (1), 77–88. doi:10.1186/s41601-021-00183-1

Barroco, J., and Herrera, M. (2019). Clearing Barriers to Project Finance for Renewable Energy in Developing Countries: A Philippines Case Study. *Energy Policy.* 135, 111008. doi:10.1016/j.enpol.2019.111008

Bertheau, P., Dionisio, J., Jütte, C., and Aquino, C. (2020). Challenges for Implementing Renewable Energy in a Cooperative Driven off- Grid System in the Philippines. *Environ. Innovation and Soci. Trans.* 35, 333–345. doi:10.1016/j.eist.2019.03.002

Bollettino, V., Alcayna-Stevens, T., Sharma, M., Dy, P., Pham, P., and Vinck, P. (2020). Public Perception of Climate Change and Disaster Preparedness: Evidence From the Philippines. *Clim. Risk Management.* 30, 100250. doi:10.1016/j.crm.2020.100250

Cabalu, H., Koshy, P., Corong, E., Rodriguez, U.-P. E., and Endriga, B. A. (2015). Modelling the Impact of Energy Policies on the Philippine Economy: Carbon Tax, Energy Efficiency, and Changes in the Energy Mix. *Econ. Anal. Pol.* 48, 222–237. doi:10.1016/j.eap.2015.11.014

China Renewable Energy Engineering Institute (2019). China Renewable Energy Development Report. Available at: http://www.creei.cn/portal/article/index/id/25365.html. 2020 (Accessed November 26, 2020).

Feng, T. T., Gong, X. L., Guo, Y. H., Yang, Y. S., Pan, B. B., Li, S. P., et al. (2020). Electricity Cooperation Strategy Between China and ASEAN Countries Under' the Belt and Road'. *Energy Strategy Reviews.* 30, 100512. doi:10.1016/j.esr.2020.100512

GPD (2019). *GDP (Current US$) – Philippine GDP*. World Development Indicators database. Available at: https://www.worldbank.org/cn/country/Philippine (Accessed November 19, 2020).

Gullberg, A. T., Ohlhorst, D., and Schreurs, M. (2014). Towards a Low Carbon Energy Future - Renewable Energy Cooperation between Germany and Norway. *Renew. Energ.* 68, 216–222. doi:10.1016/j.renene.2014.02.001

Indeo, F. (2019). ASEAN- EU Energy Cooperation: Sharing Best Practices to Implement Renewable Energy Sources in Regional Energy Grids. *Global Energy Interconnection.* 5 (2), 393–401.

International Monetary Fund Philippine GDP per capita (2019). International Monetary Fund Philippine GDP Per Capita. Available at: https://www.imf.org/external/index.htm (Accessed December 20, 2020).

Liu, J. (2019). China's Renewable Energy Law and Policy: A Critical Review. *Renew. Sustainable Energ. Rev.* 99, 212–219. doi:10.1016/j.rser.2018.10.007

Marquardt, J., and Delina, L. L. (2019). Reimagining Energy Futures: Contributions From Community Sustainable Energy Transitions in Thailand and the Philippines. *Energ. Res. Soc. Sci.* 49, 91–102. doi:10.1016/j.erss.2018.10.028

Mehdi, T., and Mehdi, N. (2020). Human Reliability Analysis in Maintenance Team of Power Transmission System protection. *Prot. Control. Mod. Power Syst.* 5 (4), 270–282.

Ministry of Commerce of the People's Republic of China (2019). Guide for Foreign Investment and Cooperation Countries (Regions)- Philippines. Available at: http://www.mofcom.gov.cn/mofcom/typt.shtml (Accessed December 25, 2020).

Mohan, M. (2021). A Comprehensive Review of DC Fault protection Methods in HVDC Transmission Systems. *Prot. Control. Mod. Power Syst.* 6 (1), 1–20.

Mondal, M. A. H., Rosegrant, M., Ringler, C., Pradesha, A., and Valmonte-Santos, R. (2018). The Philippines Energy Future and Low-Carbon Development Strategies. *Energy.* 147, 142–154. doi:10.1016/j.energy.2018.01.039

Ratio, M. A., Gabo- Ratio, J. A., and Fujimitsu, Y. (2020). Exploring Public Engagement and Social Acceptability of Geothermal Energy in the Philippines: A Case Study on the Makiling- Banahaw Geothermal Complex. *Geothermics.* 85, 101774. doi:10.1016/j.geothermics.2019.101774

Sasmita, P., and Sidhartha, P. (2021). Application of a Simplified Grey Wolf Optimization Technique for Adaptive Fuzzy PID Controller Design for Frequency Regulation of a Distributed Power Generation System. *Prot. Control. Mod. Power Syst.* 6 (1), 21–36.

Satish, K. I., and Vinod, K. T. (2020). Optimal Integration of DGs into Radial Distribution Network in the Presence of Plug- in Electric Vehicles to Minimize Daily Active Power Losses and to Improve the Voltage Profile of the System Using Bioinspired Optimization Algorithms. *Prot. Control Mod. Power Syst.* 5 (1), 21–35.

Shang, T., Liu, P., and Guo, J. (2020). How to Allocate Energy-Saving Benefit for Guaranteed Savings EPC Projects? A Case of China. *Energy.* 191, 116499. doi:10.1016/j.energy.2019.116499

Sharma, A., and Kolhe, M. (2020). Techno- Economic Evaluation of PV Based Institutional Smart Microgrid under Energy Pricing Dynamics. *J. Clean. Prod.* 264, 121486. doi:10.1016/j.jclepro.2020.121486

Si, S., Lyu, M., Lin Lawell, C.-Y. C., and Chen, S. (2021). The Effects of Environmental Policies in China on GDP, Output, and Profits. *Energ. Econ.* 94, 105082. doi:10.1016/j.eneco.2020.105082

Sina News (2018). The Largest Non- Governmental Cultural Exchange Event in the History of China and the Philippines Former Philippine President: Thank You China!. Available at: http://k.sina.com.cn/article_3974550866_ece6d55200100bv9g.html (Accessed December 22, 2020).

Suryanarayana, G., and Saumendra, S. (2020). A Novel Complex Current Ratio-Based Technique for Transmission Line protection. *Prot. Control. Mod. Power Syst.* 5 (3), 239–247.

Thakur, V. (2021). Framework for PESTEL Dimensions of Sustainable Healthcare Waste Management: Learnings From CO VID- 19 Outbreak. *J. Clean. Prod.* 287, 125562. doi:10.1016/j.jclepro.2020.125562

The Department of Energy Administrative Order (2020). The Department of Energy Administrative Order. Available at: https://www.doe.gov.ph/laws- and-issuances/administrative- order (Accessed November 05, 2020).

The Department of Energy (2017). Draft National Renewable Energy Program Overview. Available at: https://www.doe.gov.ph/presentations (Accessed November 05, 2020).

The Department of Energy (2019). Biomass Sector Roadmap. Available at: https://www.doe.gov.ph/presentations (Accessed November 05, 2020).

Wang, C., Wood, J., Geng, X. R., Wang, Y. L., Q iao, C. Y., and Long, X. L. (2020). Transportation CO2 Emission Decoupling: Empirical Evidence from Countries along the belt and Road. *J. Clean. Prod.* 263, 121450. doi:10.1016/j.jclepro.2020.121450

Yang, B., Swe, T., Chen, Y., Zeng, C., Shu, H., Li, X., et al. (2021). Energy Cooperation between Myanmar and China under One Belt One Road: Current State, Challenges and Perspectives. *Energy.* 215, 119130. doi:10.1016/j.energy.2020.119130

Zafar, M. W., Shahbaz, M., Hou, F., Sinha, A., and Sinha, A. (2019). From Nonrenewable to Renewable Energy and its Impact on Economic Growth: The Role of Research & Development Expenditures in Asia-Pacific Economic Cooperation Countries. *J. Clean. Prod.* 212, 1166–1178. doi:10.1016/j.jclepro.2018.12.081

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2021 Li, Wang, Lu and Li. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.