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Sino-Thai Energy Collaboration: A Chinese Perspective on the Present State, Emerging Challenges, and Prospective Trajectories

Qian Wang[1] and Xiaolong Zou[2]

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Abstract

China-Thailand energy cooperation has made significant progress in recent years, positively contributing to the economic development and energy security of both countries. The purpose of this article is to discuss the current situation, challenges, and prospects of energy cooperation between China and Thailand. Firstly, the article reviews the history and development trends of China-Thailand energy cooperation, emphasizing the collaborative projects between the two countries in oil, natural gas, renewable energy, and electricity. Second, the article analyzes the main challenges facing Sino-Thai energy cooperation, including energy price volatility, ecological concerns, and environmental protection in sustainable development. The article then explores potential opportunities for future Sino-Thai energy cooperation, including the prospects for promoting innovation in clean energy technology and strengthening regional cooperation through energy connectivity. Finally, the article summarizes the significance of energy cooperation between China and Thailand, emphasizing that collaboration in the energy sector will positively impact regional and global energy security.

Keywords Energy Cooperation, Energy Security, Challenges, Sustainable Development, Clean Energy

[1] Research Assistant, School of International and Public Affairs, Jilin University, Changchun, China. E-mail: wangqian9922@mails.jlu.edu.cn
[2] Associate Professor, Ph.D., School of International and Public Affairs, Jilin University, Changchun, China. E-mail: zou_xl@jlu.edu.cn

1. Introduction

In the contemporary global landscape, it is widely acknowledged that the cultivation and sustenance of positive diplomatic relations are pivotal to the attainment of enduring national interests (Guo & Wang, 2017). Thailand, situated in the central region of the Indochinese Peninsula, is a close and friendly neighbor of China and an important link for China to enhance its energy cooperation with ASEAN. Since establishing diplomatic relations between China and Thailand in 1975, the two countries have been good neighbors and friendly, with steady progress and fruitful results in bilateral cooperation. In 1993, China became a net importer of refined oil products. In the same year, China's energy sector began the era of "going out", active participation in global energy cooperation (Xu, 2017). After the financial crisis 2008, China's initiative for energy cooperation with the outside world has been strengthened. China and Thailand signed the Memorandum of Understanding between the Government of the People's Republic of China and the Government of the Kingdom of Thailand on Cooperation in Sustainable Development in Bangkok on 22 December 2011. They collaborated on cleaner and renewable alternatives for the economy, as well as research and development on energy efficiency 2012, China and Thailand reached a consensus and signed the "China-Thailand Joint Action Plan on Strategic Cooperation 2012-2016," which established a comprehensive strategic partnership and further promoted cooperation between the two countries in the fields of sustainable development and energy efficiency. In 2019, Thailand officially became a part of the "Belt and Road" energy partnership, marking the beginning of a new phase in China-Thailand energy cooperation. In 2021, China will become the second-largest source of foreign investment in Thailand. The Thai Chinese Rayong Industrial Park (RIP) is not only a flagship of China's outbound investment but also a typical example of China-Thailand cooperation. In 2022, marking the 10th year of the strategic partnership between China and Thailand, General Secretary Xi Jinping described the relationship between the two countries as "China and Thailand are one family." He also signed the "China-Thailand Joint Action Plan on Strategic Energy Cooperation" and the "China-Thailand Cooperation Plan on Jointly Promoting the Construction of BRI. "The Thai side is also willing to take this opportunity to build a more prosperous, stable, and closer Thailand-China community of destiny."

As the Russia-Ukraine crisis intensifies, global energy prices are fluctuating dramatically, posing a severe challenge to the energy security of all countries. In the contemporary geopolitical milieu, China has been at the forefront of advocating for a paradigm of sustainable security cooperation with nations situated along the Belt and Road Initiative's (BRI) expansive network. This initiative is underpinned by an integrative approach that harmonizes the imperatives of security with those of development, thereby creating a synergistic framework that is conducive to positive bilateral engagements (Guo & Liao,

2019). In 2022, Thailand's power generation capacity was 180.4 gigawatt-hours (GWh), marking a 2.3% increase from the previous year. The breakdown of power generation sources is as follows: oil accounted for 1.7 GWh, natural gas for 114.6 GWh, coal for 35.5 GWh, and renewable energy for 28.5 GWh (BP, 2023). Thailand continues to rely on natural gas as the primary source of energy for power generation. This reliance means that significant fluctuations in the global price of natural gas can have a profound impact on its energy security. Simultaneously, the gradual recovery of Thailand's domestic economy is leading to an increased demand for energy, widening the gap between energy supply and demand. Therefore, securing energy supply and promoting sustainable socio-economic development through energy transition is an urgent need for Thailand. Globally, 151 countries have proposed carbon neutrality targets, encompassing 92% of the world's GDP, 89% of the world's population, and 88% of the world's emissions (Xu, 2023). Electricity Generating Authority of Thailand (2023), in its 2022 Sustainability Report, aims to achieve carbon neutrality by 2050. The report emphasizes a significant effort towards power transformation and a 30% reduction in carbon emissions by 2030 compared to 2021 (EGAT, 2023). In 2020, China proposed for the first time at the UN General Assembly a "dual carbon" goal, stating that it would be "carbon neutral" by 2060 and "peak carbon emissions" by 2030. Both China and Thailand share the vision and goal of developing renewable energy and promoting a low-carbon energy transition to achieve sustainable development.

2. Literature Review

Against the backdrop of the growing significance of global energy security and environmental protection, energy cooperation among countries has made significant progress. China's strategic positioning and cooperation mechanisms in the international energy transition are examined through a SWOT analysis. This analysis is used to assess the advantages and disadvantages of China, as a non-Arctic country, in carrying out energy projects in the Arctic region. The study systematically examines the cooperation on oil and gas resources between China and North and Central Asian countries, focusing on the supply and demand characteristics, interdependence, and cooperation prospects of the two sides based on relevant data from 2016-2021 (Duan & Duan, 2023). Energy collaboration between China and ASEAN within the Belt and Road framework is being systematically pursued, focusing on electricity cooperation. The discussion involves exploring opportunities, complementary advantages, and pathways for electricity cooperation between China and ASEAN (Fen, Gong, & Guo, 2020). However, energy cooperation under the Belt and Road framework is still unsustainable. Energy projects are not in line with ASEAN's green policies, and China's renewable energy achievements have not benefited its energy cooperation

with neighboring countries. This presents a trilemma of security of energy supply, energy justice, and environmental sustainability. Nevertheless, Yang, Huang, and Wang (2023) propose that energy cooperation between China and Thailand is sustainable. China's foreign energy cooperation projects are growing rapidly. However, there is a noticeable lack of research on energy cooperation between China and Thailand. Many Chinese scholars tend to focus on typical countries' energy cooperation within the context of regional energy cooperation between China and ASEAN. As a result, studies on energy cooperation between China and Thailand are often overshadowed by regional studies. This paper will further explore fossil energy cooperation and renewable energy cooperation between China and Thailand in greater detail, building on the existing foundation.

Thailand's future energy strategy and guidelines prioritize reducing fuel consumption and increasing the utilization of renewable energy sources. This gradual shift aims to reduce the country's over-reliance on natural gas and enhance national energy security (Shoram, Hirunlabh, Kasayapanand, Amornkitbamrung, Teekasap, & Khedari, 2018).

In terms of renewable energy, there is a growing emphasis in Thailand. Thailand's energy demand has gradually increased over the past few decades, but energy efficiency has been limited by the structure of the domestic economy (Tip Pichai, 2022). With the implementation of the Alternative Energy Plan, Thailand has boosted the utilization of renewable energy within the country. This includes promoting the production and consumption of renewable energy, as well as estimating the marginal abatement cost of subsidized renewable energy generation (Muangjai et al., 2022). Thailand's heavy reliance on fossil fuels has led to high greenhouse gas (GHG) emissions. Scholars have increasingly emphasized the crucial role of hydrogen in achieving net-zero GHG emissions, leading to discussions of scenarios involving low and high hydrogen use (Pradhan, Limmeechokchai, Chaichaloempreecha, & Rajbhandari, 2024). Despite China's significant investment in the construction of various renewable energy projects in Thailand, there is a dearth of literature addressing the current status of renewable energy development in Thailand as a whole. This gap fails to provide a comprehensive summary of the collaborative energy projects undertaken by China and Thailand in the sector.

Nuclear energy is characterized by its high level of cleanliness and stability, and it has gradually become part of the energy transition plans in Asian countries. As early as 2013, some scholars proposed the construction of a nuclear power plant in Thailand to generate clean and safe electricity by harnessing heat energy from nuclear reactors. The establishment of nuclear power plants plays a crucial role in ensuring Thailand's energy security. However, due to concerns about the potential threats posed by nuclear power plants and public opinion, the Thai government decided to postpone the construction plan for nuclear power plants (Pongsoi & Wongwises, 2013). Nuclear power has significant advantages,

but modern nuclear reactors are prone to accidents and failures. Additionally, there may be an imminent shortage of high-quality uranium, and the thermoelectric fuel cycle of nuclear power plants consumes and degrades large amounts of water. The use of nuclear energy should be limited during the transition to alternative energy sources (Sovacool, 2010). However, this section of the article only addresses the feasibility and potential threats of constructing nuclear power plants as an alternative energy source in Thailand. It does not delve into the potential for cooperation between China and Thailand to build nuclear power plants.

Currently, there is insufficient research on energy cooperation between China and Thailand. Southeast Asia's energy cooperation is deeply influenced by the strategic rivalry between the U.S. and China. As China's global influence grows, the U.S. has heightened its competitive stance, impacting regional energy collaborations (Luo & Chen, 2022; Yang, 2022). China's Belt and Road Initiative promotes economic integration, while the U.S. champions democratic values and a rules-based order. Southeast Asian nations must navigate this complex dynamic, with decisions potentially reshaping domestic and regional energy landscapes.

Energy cooperation between China and Thailand only exists as a case study within the broader context of energy cooperation between China and ASEAN, and it lacks a separate and detailed study. This paper aims to analyze the current status of fossil fuels and renewable resources in Thailand. Additionally, it examines the existing energy projects between China and Thailand, presenting the status of energy cooperation between the two countries. The current situation highlights the challenges of energy cooperation between the two countries and provides insight into the prospects for future collaboration.

The remainder of this paper is divided into four sections. The following section provides a detailed overview of the current status of natural gas, hydroelectric, wind, solar, biomass, and nuclear energy in Thailand, along with energy cooperation projects between the two countries. The article discusses the challenges of energy cooperation between China and Thailand in terms of energy security and sustainable development. The final section of the article discusses the opportunities and significance of energy cooperation between China and Thailand at the bilateral, regional, and international levels. The conclusion summarizes the paper.

3. Methodology

Qualitative analysis, as an esteemed research methodology, is distinguished by its emphasis on elucidating the intrinsic qualities of social phenomena, encompassing their contextual nuances, underlying processes, and the profound significance of human conduct. In contradistinction to quantitative methodologies, which are predicated on the empirical measurement and statistical inference of

numerical data, qualitative analysis delves into the subject matter by amassing non-numerical data. This approach affords a deeper exploration of the subject's internal logic and the multifaceted dimensions of complexity it embodies.

Within the purview of the present scholarly work, a qualitative analytical framework is embraced to facilitate an inquiry into the dynamics of energy cooperation. The study's purview encompasses China and Thailand, selected for their pivotal roles in regional energy diplomacy. The research endeavors to synthesize an overview of the bilateral energy collaboration by critically examining a compendium of data sources, including the authoritative BP Statistical Yearbook of World Energy 2023, Thailand's strategic energy development plan as articulated by its Ministry of Energy, and the pertinent energy policy directives emanating from China's Ministry of Energy. Through this qualitative lens, the paper aims to offer a nuanced interpretation of the energy partnership's trajectory, challenges, and potential avenues for future synergy.

4. Current Situation of China-Thailand Energy Cooperation

Although the energy cooperation between China and Thailand began relatively late, the outcomes of the collaboration should not be underestimated. With the extensive promotion of the "Belt and Road" initiative, energy cooperation between China and Thailand has reached a new level. Chinese enterprises are actively expanding their presence in Thailand, focusing on technical cooperation, engineering contracting, and market expansion. Currently, collaboration in the sectors of oil, natural gas, and renewable energy, including hydro energy, wind energy, solar energy, biomass energy, and nuclear energy, is beginning to materialize.

Petroleum Cooperation

Thailand had 300 million barrels of proven oil reserves as of 2020, representing 0.1 percent of global reserves in that year. The growth rate of oil production from 2012 to 2022 is -3.5%, while the growth rate of Thailand's domestic oil consumption is 1.3%, leading to a significant disparity between oil supply and demand (BP, 2023). China is the world's second-largest oil consumer after the United States, but it is also the world's largest oil importer. Chinese oil companies actively respond to the "going out" policy and have formed important cooperation and development partnerships with many oil-rich countries around the world. China and Thailand have been collaborating in the petroleum industry, focusing on extraction technology, industry skills training, infrastructure construction, and market expansion.

Firstly, China and Thailand have enhanced technical cooperation in oil exploration. In 1993, the China National Petroleum Corporation (CNPC) was granted the right to explore and develop the Bangya Block in Thailand, marking the first time China had been granted such rights to explore and develop oil

overseas. The GW80 team of Great Wall Drilling International has been operating in Thailand for 19 years, completing a total of 743 wells and drilling over 1.99 million meters. Their efforts have been acknowledged by Thailand's largest onshore oil company, PPTEP (Su & Yang, 2023).

Secondly, the two countries have also enhanced their collaboration on skills training in the oil industry. In 2020, SINOPEC and Thailand's Ministry of Labour collaborated to "develop skills training for the oil, gas, and chemical industry," to enhance the professional skills of Thai local employees, addressing the shortage of high-level talent in Thailand's oil and gas industry, and boosting the overall international competitiveness of the industry (Zhao, 2020). The petroleum industry also emphasizes infrastructure development. The construction of the refined oil products pipeline in northeastern Thailand, undertaken by the PetroChina Pipeline Bureau, was completed in 2022. This project is a strategic energy initiative for Thailand. The successful completion of the pipeline will not only contribute to local economic and social development, but also enhance Thailand's connectivity with Myanmar, Laos, Vietnam, and other countries, and strengthen energy cooperation within ASEAN countries (Sun 2022a).

Thirdly, in the context of oil market expansion, Sinopec (Hong Kong) Limited signed an equity acquisition agreement with Susco Refined Oil and Jet Fuel Sales Company in Thailand to acquire 49% of its wholly-owned subsidiary, Susco Dealers Company Limited, in 2022. This collaboration will leverage Sinopec's strengths in resources and branding, as well as Susco's advantages in terms of network. The collaboration will expand the terminal network, continuously increase the sales of refined oil products, actively explore new energy and low-carbon environmental protection-related businesses, and jointly develop refined oil and new energy markets in Thailand and Southeast Asia (Liu & Li, 2022).

Cooperation on natural gas

As of the end of 2022, Thailand had 46,588.77 billion cubic meters of proven natural gas reserves (Ministry of Energy, 2023), which are relatively abundant. In 2022, 25.6 billion cubic meters of natural gas were produced. Over the decade from 2012 drive for natural gas pipelines. These achievements have technology, as well as in China has made significant advancements in research and development (BP, 2023). According to 2022, the annual growth rate of natural gas production was only -2.4%, with natural gas production declining year by year (BP, 2023). According to Thailand's Ministry of Commerce, natural gas imports accounted for 22.3% of Thailand's total energy imports in 2023. China has made significant advancements in the research and development of natural gas exploration technology, as well as major technology and equipment for natural gas pipelines. These achievements have continued to drive independent innovation, further enhancing China's capacity for independent innovation, as

stated in the China Innovation, and enhancing China's development steadily (Department of Oil and Gas, 2022). China and Thailand's collaboration on cooperation, with a focus on the construction of a natural gas pipeline. China and Thailand are collaborating on engagement capability (2022). It has the technical capability to "engage" and participate in international cooperation. China and Thailand are collaborating on natural gas cooperation, with a focus on the construction of a natural gas pipeline.

China and Thailand's collaboration on natural gas is steadily deepening. Over the past decade, PetroChina Pipeline Bureau has constructed over 1,500 kilometers of pipelines in Thailand, representing more than 60% of the total length of Thailand's long-distance oil and gas pipeline network. In a single decisive move, CNPC Pipeline Bureau Asia Pacific successfully secured the turnkey project for Thailand's seventh gas treatment plant and interconnecting pipeline in 2021. This achievement, marking the largest project undertaken by Chinese-funded enterprises in Thailand, effectively disrupts the longstanding monopoly held by Japan and South Korea over the natural gas market in the country. With an annual processing capacity of 5 billion cubic meters, the project is designed to replace Thailand's No. 1 gas treatment plant, which has been operational for over 30 years. This will lay the foundation for entering the high-end oil and gas market in Thailand (Li, 2021). In the natural gas power generation sector, natural gas is projected to account for 63.5 percent of Thailand's total power generation in 2022 (BP, 2023). PetroChina Pipeline Bureau Engineering Co., Ltd.'s Thailand branch has been awarded the contract to supply natural gas for the Sun Gang Power Plant gas pipeline project in Ratchaburi province, Thailand. Once completed, the project will meet the demand for clean energy in Ratchaburi province and the west-central region of Thailand (Sun, 2022b).

Cooperation on renewable energy

Thailand is situated in the tropics and possesses ample reserves of renewable energy, including hydro, wind, solar, and biomass. The installed capacity for renewable energy power generation is 3,119.62 megawatts (EGAT, 2023), and renewable energy has been developed to a significant degree. During the 13th Five-Year Plan period, China's renewable energy development has achieved remarkable results. By the end of 2020, China's installed renewable energy power generation capacity accounted for 42% of the total installed power generation capacity, totaling 934 million kilowatts, which ranked first in the world for many consecutive years. China plans to vigorously develop renewable energy in its 14th Five-Year Plan, to adapt to the global energy revolution trend and continue to participate in the construction of the global green low-carbon energy system. The focus will be on constructing a new type of power system and deepening the promotion of energy technology and production capacity cooperation (NDRC, 2023). With the deepening of China-Thailand cooperation

under the "Belt and Road" initiative, an increasing number of Chinese enterprises are investing in Thailand's renewable energy sector through engineering contracting, technical cooperation, and capacity produced. Currently, cooperation between China and Thailand in the field of renewable energy has developed in the areas of hydro energy, wind energy, solar energy, biomass energy, and nuclear energy.

Hydro Energy Cooperation

As of August 2023, Thailand's installed hydropower capacity is 3,038.13 MW (EGAT 2023), and hydropower has been developed to a greater extent than other renewable energy sources. Since 2014, China has held the top position in the world for installed hydropower capacity and power generation. This has given the country a significant competitive edge in international hydropower development. Under the "Belt and Road" initiative, Chinese enterprises have emerged as significant partners in Thailand's hydropower development, leveraging their financial and technological advantages.

China-Thailand hydropower cooperation primarily involves engineering contracting. On January 18, 2023, the EPC project for Thailand's Pachu 2*7 MW hydropower plant, awarded to Sinohydro (Thailand) and entrusted to Jiangxi Hydropower Company, was fully handed over. As the largest hydropower project invested in and constructed by the National Electricity Authority of Thailand in recent years, the Phachu Hydropower Station has an average annual power generation capacity of 91.26 million kWh. This capacity plays a crucial role in promoting the development of sustainable green power in Thailand (Li & Zeng, 2023). The successful handover of this project marks significant progress in the collaboration between China and Thailand in the field of hydro energy and establishes a strong foundation for future cooperation.

Wind Energy Cooperation

Thailand is abundant in wind energy resources because of tropical monsoons and cyclones, but the average wind speed is low and primarily concentrated in the southern region of the country. Thailand's wind power generation has increased by 69.8 percent from 2012 to 2022, with a wind power generation capacity of 3.4 MW in 2022 (BP, 2023). Thailand aims to generate 3.4 MW of wind power by 2036 (BP, 2023). Thailand's wind power generation capacity is expected to reach 3.4 gigawatts by 2026 (BP, 2023). Thailand aims to achieve 3,000 MW of wind energy by 2036 (Ministry of Energy, 2016) and increase the country's wind energy target to 7 GW by 2037 (Ministry of Energy, 2020). In 2023, the Thai Wind Energy Association and the Wind Energy Professional Committee of the Chinese Renewable Energy Society signed a Memorandum of Understanding (MOU) on China-Thailand cooperation in the field of wind energy, with the expectation of strengthening their cooperation in the future. China is the world's largest producer of wind power. Low-speed wind

power has become the primary source of new domestic installed capacity, and the technology for low-speed wind power continues to mature and advance. China and Thailand have strong technical expertise in the field of wind power.

Firstly, onshore wind power development cooperation is progressing steadily. Thailand's EGCO's inaugural wind power project, THEPPANA wind farm, is situated in Chaiyaphum Province, northeast of Bangkok, Thailand. The project marks the first commercially operated wind farm in Thailand to be connected to the national PEA grid. The wind turbines, supplied by China's Goldwind, include the largest single-capacity wind turbine installed in Thailand to date. Since its grid connection and operation in 2016, the project has not experienced any safety accidents, and the units have operated with high reliability (Song & Guo, 2022a).

Thailand's GNP wind power project is contracted by CECC Zhongnan Hospital. The project has a total installed capacity of 67.5 MW, with 33 Gamesa G114 wind turbine units installed, including 18 units of 2.0 MW and 15 units of 2.1 MW. The hub height is 153 meters, which is currently the highest onshore wind power in Asia. The project is scheduled to achieve grid connection of the entire wind farm, consisting of 33 units, on 19 October 2017, with the final handover of the project expected on 14 February 2018 (Li, 2017).

Secondly, thanks to Thailand's extensive coastline along the Gulf of Thailand, the country has favorable conditions for the development of offshore wind energy. In 2023, the Thai government plans to collaborate with China Vision Energy Group, Gunkul Engineering & Design, and the Ratch Group to develop the 260 MW Hanuman offshore wind project. The project will comprise 65 wind turbines, each with a capacity of 4 MW.

Solar energy collaboration

Statistics from the Thai Ministry of Energy show that Thailand receives an average of 18 megajoules per square meter of solar energy per day. Thailand aims to increase its installed PV capacity to around 15 GW by 2037, with half of its renewable energy generation in coming from PV (Ministry of Energy, 2020). In 2022, China's exports of PV products increased by 67.8% year-on-year. The cost of PV power generation in China decreased by more than 80% in terms of kilowatt-hours (kWh). As a result, China's PV industry has evolved into an industrial and supply chain with a competitive advantage in the global market (Liao, 2023). China-Thailand photovoltaic (PV) cooperation focuses on technical and industrial collaboration.

At the technical cooperation level, the project utilizes the hydroelectric power station at the Sirindhorn Reservoir in Ubon Province, Thailand, in combination with PV panels manufactured in China. This setup enables the provision of PV power during the daytime and hydropower at night, thereby enhancing the stability of the power supply in the region. The project has installed over 144,000 PV modules,

totaling an installed capacity of 58.5 MW. It can reduce 47,000 tonnes of carbon dioxide emissions annually, helping Thailand decrease its dependence on highly polluting thermal power generation and achieve its goal of increasing the proportion of renewable energy to 35% by 2037 (Song & Guo, 2022b).

Under the "Belt and Road" initiative, China Trina Solar Technology (Thailand) Co., Ltd. has been actively engaging in industrial cooperation. The company has invested US$200 million to establish a solar module factory in Thailand's Thai Chinese Rayong Industrial Park, with a projected annual production capacity of 700 megawatts of photovoltaic cells and 500 megawatts of photovoltaic modules. This investment has led to the creation of numerous jobs in the local area. At the same time, Trina Solar's investment project will attract a series of supporting enterprises in the industrial chain, thus forming a complete industrial cluster in the Thai market. The new energy cooperation between China and Thailand has a radiating effect on other countries in the Southeast Asian region (Li & You, 2016).

Biomass Collaboration

Thailand has a well-developed agricultural sector, with five crops (rice, sugarcane, cassava, maize, and oil palm) serving as biomass feedstocks. These crops are primarily used in the industry and produce minimal electricity. Biomass is not centrally utilized, despite a large surplus, due to high collection costs. According to the International Energy Agency (2021), Thailand's energy supply from biomass and waste was 882,462 kJ (2021). Waste-to-energy cooperation is a focus of energy in various aspects of collaboration between China and Thailand, with Chinese companies participating in Thailand's waste-to-energy initiatives.

China Electric has signed an EPC contract for the 1x12MW waste power plant project of TPIPP Songkhla in Thailand, marking another milestone in China Electric's ongoing regional development in the Thai market. CECC International Group and Pathum Rat Sugar have signed an EPC (Engineering, Procurement, and Construction) contract for an integrated comprehensive project involving a sugar mill and biomass power plant in Bangkok, the capital of Thailand. The contract is valued at USD 208 million. This is the first new type of project signed in Thailand since the establishment of the International Group. The signing of this project brings new opportunities for China Electric and International Group to develop in the Thailand market (Wang, 2022).

Nuclear Energy Cooperation

With its high energy density and low energy consumption, nuclear energy is a crucial area for the advancement of renewable energy in the future. In 2022, China is expected to have 53 commercial nuclear power units with a nuclear power generation capacity of 417.78 billion kWh, representing a 2.5% year-on-year increase. The scale of nuclear power units under construction will continue to be the largest in the world. Additionally, there will be significant achievements in

nuclear energy science and technology innovation, new developments in nuclear energy-related industries, and progress in the application of nuclear technology. Furthermore, international cooperation in nuclear energy will continue to deepen (Wang, 2022). International cooperation continues to deepen (Zhang, Li, & Bai, 2023). In 2017, China and Thailand signed an Agreement between the People's Republic of China and the Government of the Kingdom of Thailand on Cooperation in the Peaceful Uses of Nuclear Energy. The first meeting of the China-Thailand Joint Committee on Cooperation in the Peaceful Uses of Nuclear Energy was held in Beijing in 2018, reviewing the positive progress made in nuclear energy cooperation between the two countries. According to Thailand's energy development report PDP2010, the country's installed power capacity is projected to reach 70.69 million kilowatts (kW) by 2030, with 2 million kW coming from nuclear power. Thailand plans to finalize the feasibility study by 2017, complete the bidding for nuclear power projects in 2020, and construct the first nuclear power unit in 2026 (Ministry of Energy, 2010). In recent years, Thailand has strengthened its development of nuclear power plants, but the actual construction of nuclear energy has been slow. Currently, the focus of China-Thailand renewable energy cooperation remains on wind power and photovoltaic power generation. On the one hand, the development of nuclear power in Thailand was criticized by some academics and environmentalists after the Fukushima nuclear crisis in 2011. The National Energy Policy Committee postponed the 4,000 MW nuclear power generation plan it had set out in 2010 (Pongsoi & Wongwises, 2013). On the other hand, the contradiction between Thailand's domestic energy supply and demand has further increased. According to the National Energy Development Report PDP 2015, Thailand plans to achieve the target of nuclear energy contributing no less than 5 percent of the total energy supply by 2036 (Ministry of Energy, 2016). In the future, cooperation between China and Thailand in the field of nuclear energy will be an important aspect of renewable energy collaboration.

5. Challenges in China-Thailand Energy Cooperation

Although China and Thailand have made progress in the collaboration on fossil energy and renewable energy, they still encounter significant challenges. China and Thailand face challenges in energy cooperation, particularly in the areas of energy security and sustainable development. Energy security is reflected in three aspects: high external dependence, lack of energy storage facilities, and inability to control energy pricing power. Sustainable development encompasses the fields of oil, natural gas, renewable energy, and nuclear energy.

Energy security

The escalating energy prices resulting from the global energy crisis have presented a challenge to the energy security of China and Thailand. This challenge is primarily evident in the growing dependence on foreign countries for energy, the inability to ensure a stable energy supply, and the absence of a robust energy market. According to BP's 2023 statistics, energy prices surged in 2022. The price of Brent crude oil averaged $101 per barrel in 2023, reaching its highest level since 2013. Additionally, natural gas prices in Europe and Asia reached new highs (BP, 2023). In response to the increasing fuel prices, the Electricity Generating Authority of Thailand has implemented changes in fuel price management and power generation schedules to alleviate the impact of fuel price fluctuations on people's livelihoods and to uphold the security of the national power system (EGAT, 2023). Energy dependence, which refers to the extent of a country's net energy imports about its energy consumption, is a crucial indicator of energy security. According to the World Bank, Thailand's reliance on external energy sources was as high as 42 percent in 2014. Meanwhile, the price of natural gas has increased, impacting the Thai government's imports of natural gas, and leading to a decrease in energy supply. On the one hand, Thailand's domestic power development is highly reliant on natural gas, with 180.4 MWh of electricity generation in 2022, marking a 2.3 percent increase compared to the previous year. Additionally, 1.7 MWh is generated from oil, 114.6 MWh from natural gas, 35.5 MWh from coal, and 28.5 MWh from renewable energy (BP, 2023). Thailand's natural gas primarily comes from imports. According to the Organization of Petroleum Exporting Countries 2022 report, Thailand's natural gas imports of 17,131 million cubic meters are the highest in the last decade. Thailand's natural gas import infrastructure is relatively limited and vulnerable to geopolitical manipulation, and the domestic energy security situation is not promising. Thailand's energy policy is currently being adjusted in the short term to align with national interests and specific economic conditions. However, the fundamental dominance of natural gas in the country has not changed. The Electricity Generating Authority of Thailand of Thailand has emphasized in a relevant report that individuals and businesses need to conserve energy in their daily lives to address the energy crisis. On the other hand, the escalating cost of imported energy has amplified Thailand's financial burden and contributed to inflation, compelling companies to reduce production or cease operations altogether. This has diminished people's standard of living and has had an impact on the overall economic security of the country.

Although Thailand has abundant renewable resources, they can only be utilized if they are converted into electricity. While Thailand utilizes its renewable resources to some extent, the lack of transmission equipment and energy storage facilities weakens the capacity for renewable energy consumption. The wind power plant in the northeastern province of Chaiyaphum and the Sirindhorn photovoltaic-

hydroelectric power plant in the eastern province of Upon are still far from Thailand's economically developed areas. They require the construction of high-voltage transmission lines to achieve the balance of supply and demand for renewable energy. Due to the inherent variability of renewable energy sources, it is essential to construct energy storage facilities to ensure a consistent supply of electricity. Thailand's current emphasis on developing renewable energy generation projects, with fewer transmission lines and storage facilities, has resulted in a resurgence of cheaper but more carbon-intensive coal power during energy crises. In its 2022 Sustainability Report, the Electricity Generating Authority of Thailand proposes to decrease the reliance on natural gas as a fuel for power generation, postpone the scheduled decommissioning of unit 8 of the lignite-fueled Mae Moh power plant, and reintegrate unit 4, which was decommissioned in 2019, into the system (EGAT, 2023). Thailand is currently constructing numerous renewable energy projects, yet it still has high carbon emissions.

Currently, pricing power in the international energy market is still predominantly held by Western countries, led by the United States. The trend of financialization of energy has increased, exacerbating the risk of short-term price volatility. Energy cooperation between China and Thailand primarily focuses on energy-related engineering construction and technical cooperation, with less emphasis on energy trade. In the future, the energy trade will primarily involve the green power trade, with less emphasis on the fossil energy trade. It will be challenging to achieve a high level of local currency cooperation between China and Russia. The two countries have not established a robust energy market mechanism, and they are unable to control energy pricing. Additionally, Thailand's reliance on a limited number of energy import channels makes it more vulnerable to fluctuations in international energy prices.

Sustainable Development

The Thai Cabinet adopted the draft 13th Five-Year Plan in 2021, which emphasizes four principles and concepts: the idea of a self-sufficient economy, self-healing capacity, the UNDAF Sustainable Development Goals, and the BCG economic model (Bioeconomy, Circular Economy, and Green Economy). The plan aims to create a socio-economic environment with equal opportunities to safeguard natural resources and the environment. socio-economic environment plays a crucial role in ensuring the sustainable development of natural resources and the environment (Zhou, 2022). Currently, Thailand's energy is still predominantly derived from fossil fuels, leading to carbon dioxide emissions of 275.3 million tonnes, the second highest among ASEAN countries after Indonesia (BP, 2023). As a consequence of the global energy crisis, Thailand has reactivated several coal-fired power stations. While China and Thailand are collaborating in the energy sector, they still face varying levels of sustainability challenges in the oil and gas sector, renewable energy, and nuclear energy.

Thailand is a prime example of a country that has achieved high socio-economic growth through the excessive depletion of environmental resources. However, in recent years, the Thai government and people have shown considerable attention to environmental protection in the country. Although Thailand has developed numerous policy plans to promote renewable energy, the dominance of natural gas will not be easily disrupted. Additionally, the resurgence of coal-powered stations will lead to an increase in carbon emissions, posing a threat to the carbon neutrality target. According to BP 2022, Thailand's carbon dioxide emissions from gas venting and flaring in 2022 were 200 million cubic meters, accounting for 0.2% of the world's total emissions (BP, 2023). The Thai government is currently taking active measures to improve energy efficiency and strengthen carbon sequestration efforts. In the field of renewable energy, the challenge to sustainable development is the alteration of the local ecological environment caused by the construction of energy projects. The construction of water conservancy dams will inevitably alter the dynamic between nature and society within the watershed, impacting fish migration and spawning as well as local biodiversity. Similarly, the establishment of onshore wind power installations can lead to the degradation of land resources and the disruption of local flora and fauna due to turbine operation noise. Additionally, the proper disposal of solid waste generated during the installation process poses a significant challenge. Meanwhile, some developers fail to comprehend the environmental protection laws in Thailand before construction, leading to both economic and environmental losses. In the global energy transition process, the advancement of renewable energy is essential. Both developers and target countries need to conduct thorough environmental assessments in advance, engage in timely communication and exchange with residents, and consider residents' perspectives when enhancing operation and maintenance.

The sustainable development of nuclear power may be a current concern, as Thailand halted its nuclear power plant preparatory program in 2011 following the Fukushima nuclear leakage incident in Japan. Nuclear power plants are a cleaner source of energy and complement renewable energy generation, but the risk of leakage is indisputable. Dealing with nuclear waste is an important aspect of the sustainable development of nuclear power. Currently, Thailand only has plans to develop nuclear power plants and lacks relevant construction experience and infrastructure for nuclear power development personnel. To achieve sustainable development of nuclear power, it is essential to focus on preliminary preparatory work and educate the public about the necessity of nuclear power construction to reduce social opposition. Adequate funding should be ensured, and nuclear waste should be promptly disposed of to minimize damage to the ecosystem.

Opportunities and Importance of China-Thailand Energy Cooperation
Possibilities for collaborating on energy abound, from pioneering clean energy technologies to fostering regional partnerships built on interconnectedness.

This year marks the 10th anniversary of China's "Belt and Road" initiative. Over the past decade, China and Thailand have upheld the principle of "joint construction and sharing" to advance the comprehensive development of energy cooperation between the two countries. The future energy collaboration between China and Thailand will be centered on interconnection to facilitate the exchange of innovative clean energy technologies and regional cooperation.

China and Thailand are collaborating on energy initiatives to advance clean energy technology innovation. In recent years, China has made remarkable achievements in the field of renewable energy development, and its scale of clean energy development and utilization ranks first in the world. In addition, China has made significant advancements in clean energy technology and equipment. It boasts the world's largest megawatt hydropower turbine design and manufacturing capacity in the hydropower sector. Its low-speed wind power technology is among the world's leading, and its photovoltaic power generation technology continues to improve. China has repeatedly set new world records for battery conversion efficiency, and its nuclear energy technology has matured significantly. These achievements demonstrate China's robust influence and strength in the renewable energy sector, as well as its unwavering determination and proactive approach to developing clean energy. Thailand is rich in natural resources and has a high energy demand. However, its renewable energy technology is relatively underdeveloped, making it challenging to independently increase installed power generation capacity. Therefore, it needs to collaborate with other countries to advance the country's energy transformation and upgrade its technology. Currently, cooperation between China and Thailand is thriving, with significant progress in wind and solar energy. The focal point of future collaboration between the two countries may be in the area of nuclear energy. China has advanced nuclear power generation technology, and Thailand has expressed strong interest in developing nuclear power generation capacity.

China and Thailand are actively enhancing their energy diplomacy as part of the "Belt and Road" initiative. They are relying on the China-ASEAN Energy Community of Destiny, the "Belt and Road" Energy Partnership, and other energy cooperation platforms to bolster their energy policy. Through the China-ASEAN Energy Community of Destiny, the "Belt and Road" Energy Partnership, and other energy cooperation platforms, China and Thailand have intensified policy consultations in the energy sector, built consensus on cooperation, facilitated project agreements, and actively advanced the deepening of their energy collaboration. Firstly, China and Thailand are collaborating through project contracting, technical cooperation, infrastructure construction, and EPC (Engineering, Procurement, and Construction). Secondly, China is conducting global energy diplomacy as part of

the "Belt and Road" initiative, aiming to provide international public goods to stabilize the global energy supply, ensure energy transport security, address obstacles and challenges in energy cooperation, and foster energy interconnection among countries. China's Guangxi Zhuang Autonomous Region aims to establish a national comprehensive energy base for ASEAN by 2030. China and Thailand can utilize this energy base as a foundation to enhance energy interconnection and facilitate the expansion of energy cooperation between the two countries in the domains of energy storage, energy transportation, and energy trade.

The significance of energy cooperation between China and Thailand holds multifaceted importance in bilateral collaboration.

China and Thailand are close and friendly neighbors. Strengthening energy cooperation between the two countries is of great significance for safeguarding the energy security of both sides and promoting low-carbon energy transformation. Secondly, China and Thailand are part of the Greater Mekong River region, and Thailand is situated in the core of the ASEAN countries. Therefore, energy cooperation between the two countries holds significant importance in promoting energy interconnection within the Mekong subregion and subsequently extending it to the entire ASEAN region. This cooperation aims to strengthen energy technology collaboration, facilitate clean energy transformation and advancement, and reduce carbon emissions. Finally, energy cooperation between China and Thailand is beneficial for fostering innovation in a new international energy order in today's turbulent world energy landscape.

First, energy cooperation between China and Thailand is an important aspect of their bilateral cooperation. China and Thailand can achieve energy complementarity through bilateral cooperation in technology, capital, and resources. Strengthening energy cooperation between China and Thailand can guarantee national energy security. Renewable energy technology and financial cooperation can enhance power generation from renewable sources, reduce reliance on fossil fuels, and mitigate the impact of international energy price fluctuations on the domestic economy. On the other hand, energy cooperation between China and Thailand can facilitate the interconnection of energy sources between the two countries, expand the channels for energy import and export, and ensure the diversification of the national energy supply. The two countries will enhance communication between the "Belt and Road" initiative and the "Thailand 4.0 Strategy" as well as the "Thailand Eastern Economic Corridor Strategy". They will prioritize infrastructure "hard connectivity" and reinforce rules and regulations. With a focus on "hard connectivity" in infrastructure, "soft connectivity" in rules and regulations, and the ultimate goal of "heart connectivity" between the two peoples, China and Thailand aim to advance the "One Belt, One Road" project through energy engineering and construction, energy capital and technology cooperation, and energy market development.

Through energy project construction, energy capital and technology cooperation, and energy market development, China and Thailand will further promote high-quality collaboration under the "Belt and Road" initiative, and work together to establish a China-Thailand community of destiny (UCLG-ASPAC Committee on the Belt and Road Local Cooperation, 2022).

Secondly, energy cooperation between China and Thailand will strengthen the relationship between the Mission Hills subregion and ASEAN countries. As one of the founders of the Meilan Cooperation Mechanism, China has made significant advancements in mechanism construction, strategic planning, financial support, and practical cooperation over the past seven years since its establishment. This has infused new vitality into regional development and delivered tangible benefits to the people of all participating countries. China-Thailand energy cooperation is highly significant for enhancing the interconnection of the Mekong-Meilong Sub-region and alleviating the blockage of energy transport in neighboring countries. Under the "One Belt, One Road" initiative, Chinese enterprises have been actively expanding their operations to collaborate with the Thai government in constructing energy projects, which have become integral to numerous energy cooperation projects in the Mekong subregion. As Thailand is strategically located in the center of ASEAN, energy cooperation between China and Thailand has a significant impact on the entire ASEAN region. At present, China and Thailand are engaged in extensive cooperation in various aspects of fossil fuels and renewable energy. Through numerous projects in Thailand, we are showcasing China's advanced technology and high level of business capacity in the energy sector to ASEAN countries. This is aimed at attracting more ASEAN countries to collaborate with China, promoting the development of low-carbon energy transformation across the entire ASEAN region, and achieving ASEAN's overall emission reduction plan.

Finally, cooperation between China and Thailand in the energy sector will contribute to the establishment of a new global energy order. Energy cooperation within the "Belt and Road" framework has disrupted the longstanding dominance of Western countries in the global energy sector and shifted the unfavorable perception of energy collaboration among developing nations. China's energy cooperation is based on the concept of a community of human destiny and aims to establish cooperative partnerships with a wide range of developing countries under the principle of common development and resource sharing. Energy cooperation between China and Thailand plays a crucial role in reshaping the global energy landscape. The collaboration between the two countries has defied the inflexible demands and compulsory dispute-resolution measures typically imposed by traditional dominant nations in energy cooperation. This holds significant importance for advancing the democratization of international energy collaboration.

6. Conclusion

China and Thailand are both significant consumers of energy, and they share the common objective of transitioning to sustainable energy sources to ensure national energy security and achieve long-term energy development. China-Thailand energy cooperation is a crucial component of the energy collaboration between China and ASEAN, and it serves as a model for other ASEAN countries. This paper analyzes the current state of energy cooperation between China and Thailand in the context of the global energy crisis. It also outlines the challenges related to energy security and sustainable development that both countries are facing. The paper aims to provide recommendations for future energy cooperation between China and Thailand. The analysis concludes that the current energy cooperation between the two countries primarily revolves around engineering construction and technical collaboration, with limited trade cooperation. The level of collaboration in the nuclear power sector still needs improvement. Second, energy security is a shared challenge that both countries have long confronted. Exploring ways to enhance energy self-sufficiency and advance the development of energy storage facilities will represent a new area of cooperation between the two countries.

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