

Transition Towards Green and Low-carbon Energy 2024

Accelerating with New Approaches



山西派可思绿色文化中心
PEOPLE OF ASIA FOR CLIMATE SOLUTIONS

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绿动星球

March 2024

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Preface

A Bridge between China's Renewable Energy and Global Transition

(WANG, XIAOJUN)

China's strides in renewable energy are pivotal to the global energy transition, both domestically and internationally. With a rapid expansion of renewable energy sources at home and a proactive stance towards green energy cooperation abroad, China is emerging as a central player in advancing the greening of the global power system.

Domestically, recent data from the National Energy Administration underscores China's significant progress in renewable energy deployment. In 2023 alone, China added a combined new installed capacity of 292.78 GW in wind and photovoltaic power, representing nearly 60% of the world's new capacity in these sectors for the year.

China's commitment to green energy extends beyond its borders. Through its overseas energy policies, China has reaffirmed its determination to transition away from coal and promote green energy cooperation. Initiatives, such as the pledge to support developing countries in adopting low-carbon energy solutions made at the United Nations General Assembly in 2021, and the Initiative on Green Finance unveiled at the 3rd Belt and Road Forum, demonstrate China's proactive engagement in global energy transition efforts.

Since the launch of the Belt and Road Initiative, Chinese enterprises and financial institutions have been involved in the investment and construction of 268 energy projects in 67 countries, with a total installed capacity of 111GW and a total investment of US\$83 billion. Out of these energy projects, 66% are non-fossil. At the same time, China's exports of wind power and photovoltaic products have reached over 200 countries and regions. China supplies over 80% of the world's photovoltaic products and over 70% of wind power components.

With the world's largest renewable energy equipment manufacturing capacity, China has helped to significantly cut the cost of wind and solar power projects. For many developing countries with lower income and lower energy access, the cost cut means stronger competitiveness for renewable energies and stronger incentives for clean energy transition.

Consequently, and more importantly, cheaper and cleaner energy sources also mean greater opportunities for developing countries to grow their economies in a more environmental, responsible, inclusive and independent model.

COP28 in Dubai last year has set the goal of tripling the world's renewable energy generation capacity by 2030. This is an historic opportunity, as well as responsibility, for China's renewable energy industry to be further engaged with other countries to jointly battle the existential threat of climate change via fast, vast and just energy transition.

Continuous and candid dialogues and mutually designed projects are urgently needed to advance all aspects of the energy cooperation, including policy, finance, technology, and talent exchange. China's renewable energy industry needs to expand their roles as suppliers and constructors, and to bring and build in host countries important research and development capacity, manufacturing facility, and even market cultivation strategies. That is how both China and BRI partner countries together achieve climate resilience, economic independence and social prosperity.

This is precisely the goal of this report: a renewable energy bridge between China and BRI host countries to provide cleaner and stabler energy to grow economies on a large scale, but also friendlier and safer energy to protect and nurture communities on a small yet beautiful style.

As an important part of the BRIDGE (BRI Direction to Green Energy) project initiated by People of Asia for Climate Solutions, this current report is another step forward from the Transition Towards Green and Low-carbon Energy: Shared Opportunities and Challenges, 2022 report. We expect these BRIDGE serial reports to provide latest reviews on and insights into renewable energy cooperations between China and the BRI partner countries; we also expect them to continuously help to facilitate such dialogues and cooperations.

Abstract

At the moment, there is a worldwide energy revolution taking place, resulting in significant transformations across various areas such as politics, economy, technology, industry, and trade. In contrast to the previous energy revolution since the Industrial Revolution, the current wave of transformations is principally driven by the need to eliminate the utilization of fossil fuels to tackle climate crisis. Therefore, reducing carbon emissions serves as its primary target. Currently, a variety of low-carbon energy sources, such as tidal, wind, solar, nuclear, and hydro, are commonly employed as substitutes for fossil fuels. Given the availability of resources and limitations in the application of the technology, only a limited number of energy sources have the capacity to replace fossil fuels on a large scale and can be used in various territories around the world. At present, wind and solar are the most advanced and sophisticated solutions. However, the utilization of these two resources still requires significant financial and technological proficiency. Typically, it is developed or wealthy countries that are capable of properly implementing these technologies on a meaningful scale.

The primary obstacle to the energy transition in the majority of developing countries is the inability to afford the substantial up-front costs. The World Bank has highlighted in its reports¹ that low- and middle-income countries' energy transition must undergo a “positive cycle” . During the early phase, governments need to take a proactive stance in establishing a favorable policy environment and initiating the first batch of demonstration projects with concessional funds. To further advance the expansion of renewable energy on a large scale, it is crucial to attract the private sector and establish a transparent pricing and financing mechanism. This will enable continuous cost reduction and ultimately lead to the substitution of fossil fuels. However, developing countries can potentially transform the substantial up-front costs from a liability into an asset if they can process them as a means to

¹ Scaling up to phase down: Financing energy transitions in the power sector. (2023). <https://doi.org/10.1596/39689>

bolster their economies. The global energy transition, according to a report² by the International Energy Agency, will usher in an unprecedented era of opportunity, stimulate numerous technological, industrial, and commercial transformations, and foster the growth of mineral mining, equipment manufacturing, as well as operating and maintenance sectors. All countries need to explore the pathway to take advantage of the prospects of the emerging new energy economy and formulate corresponding industrial development strategies according to their unique endowments and capabilities. Compared with industrialized countries, developing countries without adequate industrial foundations should grab this opportunity to develop themselves. Hence, the energy transition in most developing countries hinges on two pivotal policy-making aspects. Firstly, the facilitation of preferential energy policy to promote a transparent market, thereby reducing overall costs. Secondly, the facilitation of industrial policy to develop associated value chains, thereby converting expenditures into prospects.

Nevertheless, developing countries continue to rely heavily on external technology and investment to build their own energy sector, particularly in the field of renewable energy(RE), which demands advanced technology and substantial investment. This reliance often leads to a challenging situation where economic development and emission reduction are difficult to reconcile. For this challenge, it is incumbent upon rich countries with large historical emissions to provide technical and financial resources to developing countries. Since the COP15 of the UNFCCC in Copenhagen in 2009, rich countries have committed to a collective goal of mobilizing USD 100 billion per year by 2020 for climate action in developing countries. This commitment is also a significant component of the Paris Agreement in 2015. Nevertheless, as per the data provided by the Organization for Economic Cooperation and Development, only about USD 90 billion was provided to developing countries in 2021. Although recent estimates show that the goal “likely” to be met as of 2022, it is still two years later than promised³. China, as the largest developing country, has put out a strong commitment to actively promote green and low-carbon energy development among other developing countries in 2021. This initiative holds promise for advancing the next stage of the energy transition in developing countries. China was once the primary recipient of technical and financial aid from rich countries. Over the past twenty years, China has emerged as one of the few developing countries to accomplish substantial growth in RE power and its associated manufacturing sectors. China shares similar development appeal with other developing countries while also possessing valuable practical insights into

² Energy Technology Perspectives 2023 – Analysis - IEA. (n.d.). IEA. <https://www.iea.org/reports/energy-technology-perspectives-2023>

³ Growth accelerated in the climate finance provided and mobilised in 2021 but developed countries remain short and must continue scaling up to reach the USD 100 billion goal. (2023, November 16). OECD. <https://www.oecd.org/environment/growth-accelerated-in-the-climate-finance-provided-and-mobilised-in-2021-but-developed-countries-remain-short.htm>

achieving balanced economic development and emission control. Therefore, the crucial factor for the global energy transition lies in how China will adapt its stance on global climate governance and effectively utilize its strengths to assist other developing countries in overcoming their predicament.

Consequently, it is essential to analyze and comprehend China's strategies and approaches to assisting developing countries in light of the current situation of RE development. Through literature research, data insights, stakeholder interviews, and case studies, we have conducted a comprehensive study of this topic. This report is dedicated to examining how China can help developing countries form a "positive cycle" of RE development and how China can give full play to its industrial advantages to support developing countries in building their green power industry. The initial chapter of the report focuses on the research background and addresses the issues of power shortages and the slow progress of RE in developing countries. The second chapter primarily presents the recent advancements made by the Chinese government and the main industrial players in the global green energy sector since 2021. This chapter takes a broader view and highlights the shifts in trends over the previous two years. The third chapter serves as the focal point of the report, delving into an extensive examination of RE in three representative regions of typical developing countries. It is centered on conducting an in-depth analysis of the political and economic landscape in the field of trans-border RE development that China encounters while supporting other developing countries. Building upon the preceding chapters, the fourth chapter provides a thorough discussion of the challenges and obstacles encountered by China in the overseas market. It extensively examines the major breakthroughs made by China, focusing on a more detailed and intricate exploration of the current core contradictions. The fifth chapter looks at potential oversights and proposes suggestions and recommendations. It provides an integrated analysis of the "Small yet Beautiful" model and presents a definition of it as well as responses to the issues faced by developing countries, as mentioned in the first chapter.

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1

Background

Developing Countries are Struggling with Energy Poverty

The power sector in developing countries still has significant potential for expansion in terms of the need for energy and electricity. However, due to global climate governance, emerging countries have been severely constrained in their ability to develop more fossil power. Consequently, numerous developing nations have modified their energy strategies and established ambitious objectives for RE. For instance, Vietnam has made revisions to its 8th energy master plan, proposing an increased proportion of wind and solar power. Nevertheless, given the dependence of developing countries on external finances and technology for the development of RE, numerous obstacles persist in attaining these objectives. In particular, the pandemic has witnessed the emergence of numerous problems and drawbacks. As the energy transition in emerging countries initiates, there is a simultaneous increase in power scarcity.



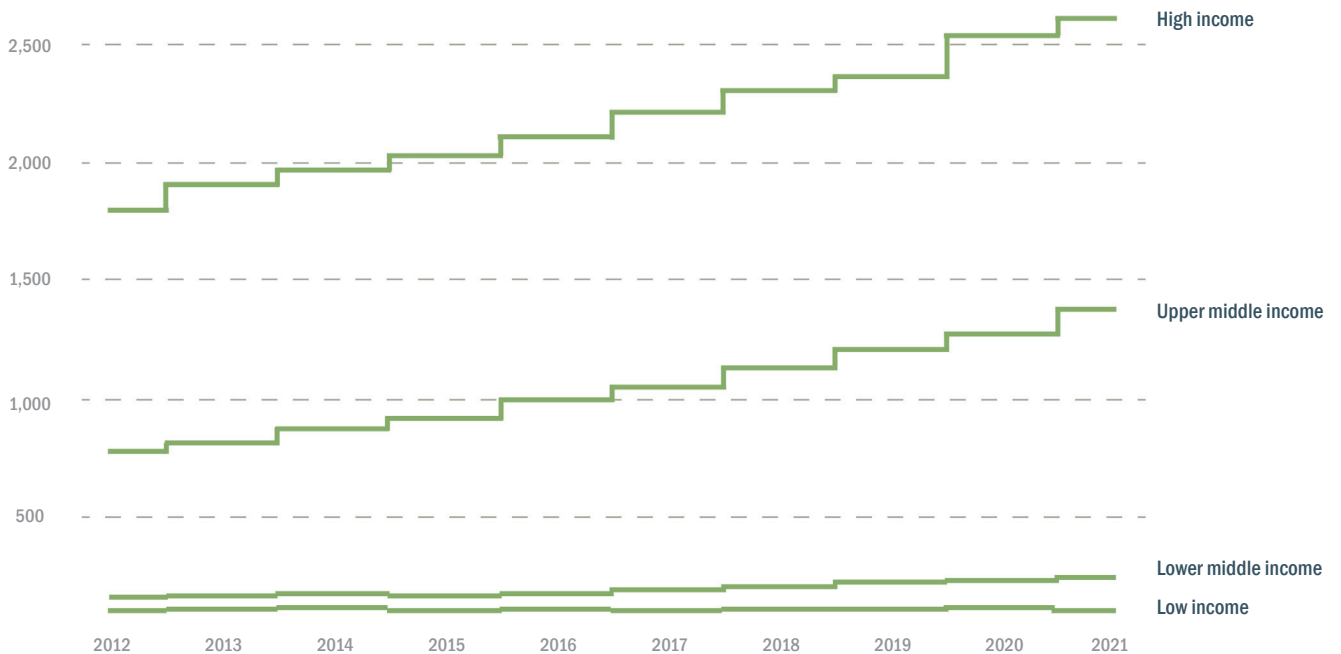
In March 2022, amid a power outage in Colombo, the capital of Sri Lanka, a little girl in the faint illumination of kerosene lamps.

The power shortfall in emerging countries is caused by several factors, such as escalating fuel prices resulting from constrained global energy supplies, frequent severe weather occurrences, and power shortages caused by rapid expansion in demand. South Africa, being the most advanced economy in Africa, has been grappling with a severe power supply crisis since 2022. Over the course of the previous year, the power supply experienced a complete failure for a total of 1,900 hours. On average, this amounted to more than 5 hours per day, with a maximum of 10 hours per day in extreme cases. The persistent power outages have had a substantial influence on the daily lives of South African people as well as the functioning of factories and businesses. In West Asia, Lebanon has repeatedly suffered nation-wide power outages. Following the shutdown of the two primary power plants due to financial difficulties, there has been a significant escalation in power shortages in the country. As a result, the majority of Lebanese citizens now experience power supply for only one to two hours per day, necessitating their reliance on costly diesel generators for the remaining duration. Southeast Asia was experiencing a severe electricity shortage too. Vietnam encountered an unusual heatwave with temperatures above 40 degrees Celsius over the period of May to June 2023, as a consequence of the El Nino phenomena. Consequently, there was a significant increase in the demand for electricity. Simultaneously, hydro power generation experienced a decline of three-quarters as a result of a severe drought, leading to the closure of 11 hydro plants, including the country's largest unit. Industrial parks in northern Vietnam have experienced frequent power outages, resulting in disruption among multiple factories. Furthermore, nations like Thailand and the Philippines, reliant on fossil fuels as their primary energy source, have encountered extensive power rationing and outages as a result of inadequate fuel supply, significantly affecting the livelihoods of their residents.

The majority of developing countries continue to depend on power systems that are predominantly fueled by fossil fuels. Over the past two years, the international energy market has experienced substantial hikes in prices of oil and gas due to the impact of the war between Russia and Ukraine. These price increases have been accompanied by unpredictable fluctuations in energy supplies. Nevertheless, as a consequence of inadequate risk mitigation instruments, developing countries encountered even more severe disruptions in the downstream power supply, necessitating the use of scarce financial resources and foreign exchange to accommodate market fluctuations. If this condition continues, poor countries would remain trapped in energy poverty, unable to undertake the initial expenditure required to develop RE power. Currently, there is a significant disparity in the progress of RE development among countries with varying wealth levels worldwide, and this disparity continues to widen. High-income nations had a RE power output per capita that was 16 times higher than that of low-income countries. While

there was no growth in RE power in low-income countries between 2012 and 2021, the disparity had increased to 23 times by 2021.

Figure 1 | RE power output per capita across countries' with different income levels(KWh)



Data source: Ember, World Bank (November 2023)

China, as the biggest developing country globally, plays a crucial role in promoting a well-organized energy transition and overcoming technological and financial obstacles that hinder the progress of RE power in other developing countries. During the 76th Session of the UN General Assembly in September 2021, Chinese President Xi declared that China will actively promote the advancement of environmentally friendly and low-carbon energy in developing countries. Additionally, China will refrain from constructing any new coal power plants beyond its borders. In March 2022, major ministries of China, including the National Development and Reform Commission, Ministry of Foreign Affairs, Ministry of Ecological and Environment, and Ministry of Commerce collectively, issued the “Opinion of Promoting the Development of Belt and Road Green Transition.” This document outlines China's commitment to fully implementing the United Nations Framework Convention on Climate Change and the Paris agreement. Specifically, China aims to enhance international cooperation in the energy sector and facilitate the transition towards green and low-carbon economy. China will encourage solar and wind enterprises to “go global” and promote multiple green energy demonstration projects. During the Third Belt and Road Forum for

International Cooperation in October 2023, President Xi declared that China will further enhance collaboration in the areas of green infrastructure, green energy, and green transportation.

Despite being a developing country, China has emerged as a prominent player in the RE sector on a worldwide scale. Its achievement could be attributed to its focus on advancing manufacturing industries and RE technology, which has been facilitated by its huge domestic market. Now, China is also providing support for other developing nations through different channels including energy diplomacy, trade, investment, training, and civil interactions.

Research Objectives and Methods

What advancements has China achieved in the previous two years in terms of bilateral and multilateral diplomacy with other developing countries?

What advancements have Chinese firms and associated industries achieved in their efforts to “go global” ?

What obstacles do developing nations face in the development of RE power? What are the characteristics of China's assistance to other developing nations?

This report aims to track the recent progress of assistance from China to other developing nations since 2021, examine the shifts in policy formulation and industrial operations, and facilitate dialogue and collaboration among policymakers, industrial participants and other stakeholders. Data insight is a crucial approach in this study, where we have gathered the most up-to-date data on the global RE sector. Our data sources encompass reputable organizations such as International Renewable Energy Agency (IRENA), the energy think tank Ember, World Bank, UN Comtrade database, China General Administration of Customs, and fDi Markets database. A model is constructed using extensive data from all sides, and essential indicators are established to support the major claims. Simultaneously, we integrated literature studies, conducted stakeholder interviews, and performed case analysis to enhance this research. This report aims to completely reconstruct the entire scope of this topic and propose recommendations for resolving the issues at hand.



2

The Latest Progress in China's Support to Other Developing Countries

2.1 The Progress of Intergovernmental Cooperation

“China will continue to deepen cooperation in areas such as green infrastructure, green energy and green transportation, and step up support for BRI International Green Development Coalition. China will continue to hold BRI Green Innovation Conference and establish dialogue and exchange mechanisms for the photovoltaic industry and a network of experts on green and low-carbon development. China will implement Green Investment Principles for the Belt and Road and provide 100 thousands training opportunities for partner countries by 2030.”

President Xi's speech at the opening ceremony of the Third Belt and Road Forum for International Cooperation

In order to tackle the challenges of climate change and ensure energy security, China has formulated a series of documents and assertions regarding RE with other developing regions and countries. These efforts aim to support the global south by prioritizing the shift to low-carbon energy and promoting the development of related industries. Regarding the target regions, China has made notable progress with Southeast Asia, Africa, and Central Asia. Several significant events and agreements took place between China and those regions, such as the Summit to Commemorate the 30th Anniversary of China-ASEAN in November 2021, the Forum on China-Africa Cooperation in November 2021, and the China-Central Asia Summit in May 2023. In addition, China has pursued bilateral diplomacy by establishing memorandums of understanding in regard to RE with Kazakhstan, Uzbekistan, South Africa, Azerbaijan, and Cuba. China's commitment to global collaboration in RE and its partnership with other emerging nations to promote RE development clearly demonstrate those instances.

A major policy shift that has occurred in the past two years is the heightened emphasis on the "Small yet Beautiful" approach. President Xi advocated it while attending the third symposium on the development of the Belt and Road Initiative (BRI) in November 2021, saying that foreign cooperation

should prioritize "Small yet Beautiful" projects. China announced its intention to simultaneously advance "Small yet Beautiful" livelihood initiatives and landmark projects at the Third Belt and Road Forum for International Cooperation in Beijing in October 2023. The objective is to implement 1000 small-scale livelihood aid programs and accomplish the "Small yet Beautiful" development of the BRI, with a focus on the imperative of maintaining a balance between social and economic impacts. Although China's previous international assistance primarily focused on the effects of large projects, these projects often entail complicated implementation processes, posing difficulties in meeting the pressing energy needs of developing countries. On the contrary, small-scale energy projects, despite being quickly deployable due to lower funding and permitting barriers, also wield significantly stronger social influence.

Mechanisms

The international cooperation mechanism established by China serves as a tangible manifestation of China's commitment to assisting other developing nations. When BRI is set to reach its tenth anniversary in 2023, the Third Belt and Road Forum for International Cooperation took place in October. On the forum, the Green Investment and Finance Partnership was launched by the BRI International Green Development Coalition and its collaborating partners. China has committed to providing an extra USD \$100 billion in funding to tackle the investment and financing difficulties associated with the construction of the Green BRI⁴. China will create a communication and collaboration platform to provide practical solutions. China subsequently released a comprehensive ten-year assessment of the BRI, entitled "Vision and Actions for Promoting the High-quality Development of the Belt and Road Initiative-The Development Outlook for the Belt and Road Initiative in the Next Decade". The review emphasizes China's dedication to promoting the environmentally sustainable development of the BRI. The primary objective is to build a platform for communication and collaboration within the photovoltaic sector, as well as a network of experts in green and low-carbon technologies. On the other hand, the remarkable growth of the BRICS cooperation mechanism

⁴ 南华早报：中国通过“一带一路”绿色发展投融资合作伙伴关系加大全球气候治理力度。2023. http://www.briic.net/xwzx/dtzx/lmdt/202310/t20231024_132817.html

has created a conducive atmosphere for sustainable energy development among its members. During the 15th BRICS Summit, it was emphasized that in order to establish a clean energy value chain primarily led by developing countries, the BRICS countries must actively exploit their clean energy resources and enhance collaboration in terms of investment, joint research and development, technical application, and standardization within the energy transition supply chain. In addition, the Regional Comprehensive Economic Partnership (RCEP), which includes the largest economy and population in the world, has played a vital role in promoting cooperation among participants. In 2023, China witnessed a significant increase in its exports of RE equipment and components to members of the RCEP. The emergence of RE sectors among all RCEP partners was significantly aided by the trading among RCEP countries, which presented ample prospects for further collaboration.

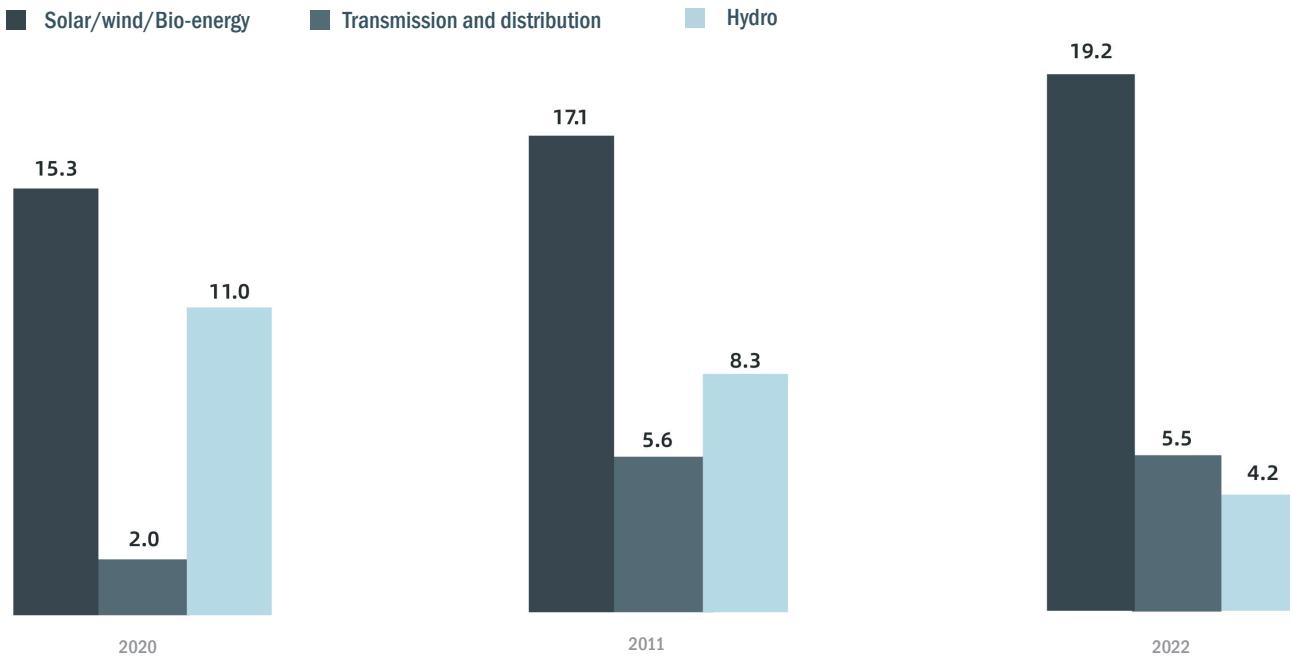
Platforms

Constructing a platform is a crucial element in enhancing and fortifying the level of collaboration. China is effectively discharging its duty as a conscientious and influential country to advance the global energy transition. In order to expedite the shift towards RE, China has built multiple international cooperation platforms. These platforms have enabled extensive collaboration between China and governmental agencies from other nations, international organizations, as well as the private sectors. Belt and Road Energy Cooperation Network is an essential platform for China to promote energy cooperation that eases the exchange of expertise and resources. It promotes the growth of low-carbon energy in the Belt and Road countries by stimulating energy collaboration and the exchange of technological knowledge. BRI International Green Development Coalition is to advance environmentally friendly and sustainable growth among Belt and Road countries. This platform, spearheaded by China, has attracted the participation of governments, enterprises, and research institutes from diverse countries. This platform has provided assistance for the formation of the High-level Forum on Green Development during the Third Belt and Road Forum. This platform has constantly strengthened global agreement and cooperative endeavors in environmentally friendly development through dialogue, exchange of information, joint research, spread of skills, and collaboration in the industries. Belt and Road Environmental Technology Exchange and Transfer

2.2 The Progress of the “Going Global” Industry

During the last four decades, China has experienced fast economic growth and has developed the world's largest and most cost-efficient power engineering and construction industries, as well as equipment manufacturing industries, by leveraging on its extensive domestic market. Since the 1990s, Chinese engineering and construction companies have experienced significant growth in the overseas market, consistently surpassing previous records. In 2023, 81 Chinese enterprises were chosen as the annual World's Top 250 International Contractors⁵. Notably, the power sector list included Power China, China Energy Engineering Group, China National Machinery Industry Corporation, Shanghai Electric, and many other companies from China. China's commitment to refrain from constructing new coal power plants in 2021 has placed Chinese power engineering firms in a position where they must undergo transformation. Nevertheless, due to the recent rapid pace of the global energy transition, there is now a widespread consensus that the RE sector is the best option, which is becoming the

Figure 3 | Contract value of the overseas power projects(billion USD)



Data source: China Mechanical and Electrical Products Export Association (November 2023)

⁵ Engineering News-Record: ENR 2023 Top 400 Contractors 1-100. 2023. <https://www.enr.com/toplists/2023-Top-400-Contractors-1-preview>

primary focus for Chinese power engineering firms in overseas market. Based on the data from the China Mechanical and Electrical Products Export Association, their overseas contract value in aggregate solar, wind and bio-energy showed a consistent increase in 2021 and 2022, with an annual growth rate of 13%. Simultaneously, the contract value from power transmission and transformation projects also saw a significant jump. Nevertheless, it is highlighted that there has been a substantial decrease in hydro, experiencing a reduction of over 50% in 2022. Undoubtedly, China's power engineering firms have embraced relatively small-scale RE as their primary focus in this new stage.

China has consistently upheld the principle of independent development in power technologies, and China has achieved global leadership in the power equipment's industrial chain via persistent and dedicated efforts, demonstrating significant competitive advantages. Over the last 20 years, Chinese firms have also achieved significant advancements in the RE sector and have emerged as the global leader. Data shows that Chinese enterprises will dominate the global photovoltaic industry in 2022, with 8 out of the top 10 companies being Chinese⁷. Additionally, Chinese wind enterprises accounted for 10 out of the top 15 companies in terms of global new wind power installations⁸. China possesses a significant competitive edge not only in wind and photovoltaic equipment but also in the essential equipment to develop RE-based power system, defined as green power equipment (GPE)⁹ in this report. Based on data from the General Administration of Customs of China, there has been a significant increase in the export of GPE products since 2021. Notably, photovoltaic modules, lithium batteries, and electric vehicles have emerged as leading exports, known as “The New Top Three.”

The international market has always been an important vane for China Energy Engineering Group in the practice of “going global” . At present, building a new pattern in international energy cooperation dominated by green and clean energy has become the global trend. China Energy Engineering Group will be deeply integrated into the global value chain, industrial chain, and supply chain, strengthen investment in green energy, and join hands with countries around the world to create a better future for sustainable development⁶ .

Song Hailiang, Chairman of China
Energy Engineering Group

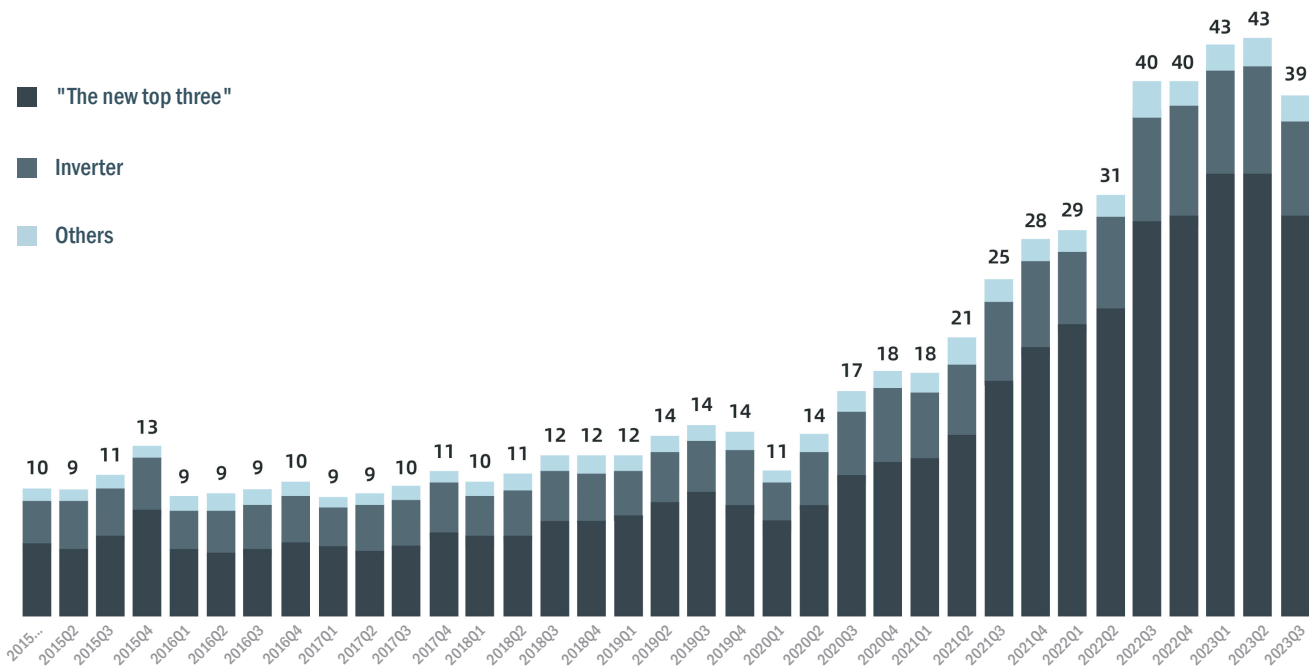
⁶ 中国能源报：中国能建党委书记、董事长 宋海良：全力谱写“一带一路”绿色能源崭新篇章 . 2023. <http://www.rmlt.com.cn/2023/1016/685085.shtml>

⁷ PV-Tech: 2022 年全球 Top10 光伏组件供应商排名 . 2023. https://www.pv-tech.cn/market_briefings/top-10-pv-module-suppliers-in-2022-shipped-245gw

⁸ Mackenzie, W. (2023, May 8). Global wind turbine OEMs 2022 historical market shares. Wood Mackenzie. <https://www.woodmac.com/reports/power-markets-global-wind-turbine-oems-2022-historical-market-shares-150122914/>

⁹ Refer to Appendix 2 for a comprehensive list of GPE

Figure 4 | Exports of Green Power Equipment (billion USD)



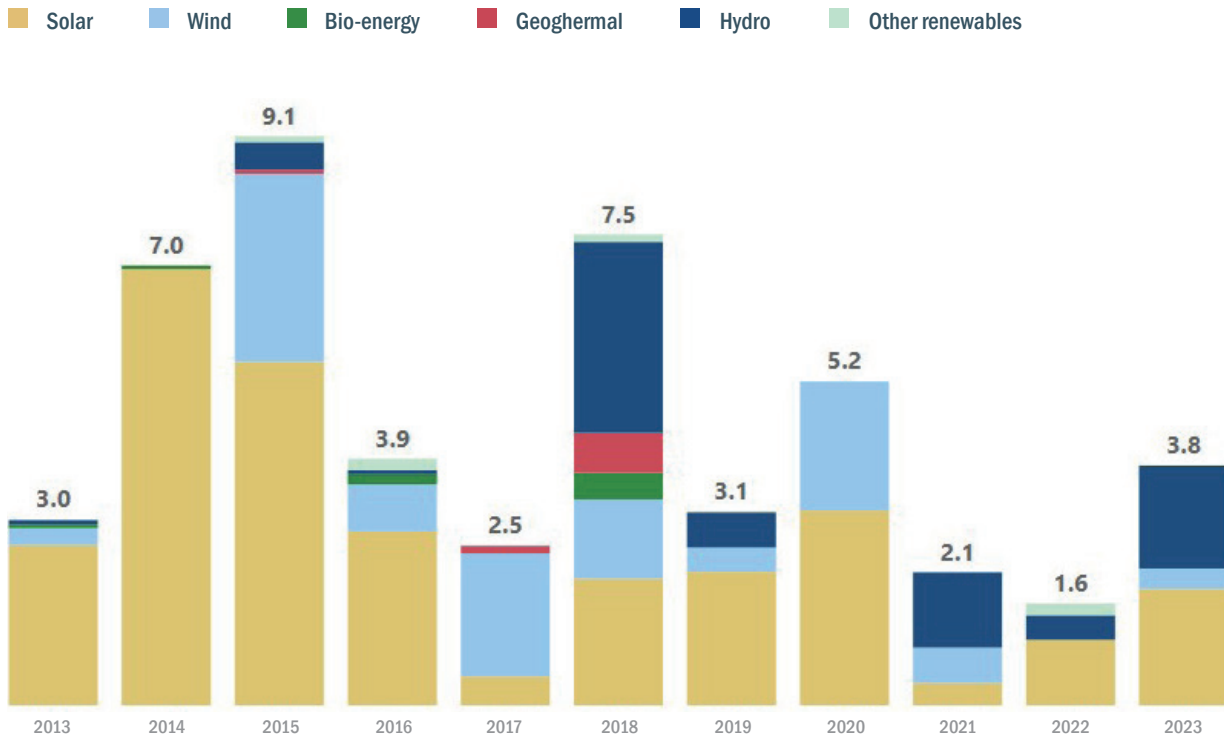
Data source: General Administration of Customs of the People's Republic of China (November 2023)

In the first half of this year, the total export of "The new top three" products, namely electric vehicles, lithium batteries and photovoltaic cells, increased by 61.6%, driving the overall export growth by 1.8%. Green industry has shown strong momentum¹⁰.

Lu Daliang, spokesman of the General Administration of Customs of China

Chinese companies' trans-border investment in RE projects has experienced draft volatility in the past ten years. Over the past three years, it has significantly drew back in adverse causes, including the COVID-19 pandemic, the global security environment, and the outbreak of the debt crisis. During the epidemic, Chinese investors in overseas RE sector has seen a somewhat subdued phase for the past three years. Yet, by 2023, the trend had reversed and China's RE project investment had experienced a substantial resurgence. The total RE project investment amount had surpassed the aggregate prior two years by the third quarter of 2023. All of these invested projects are located in countries along the Belt and Road, and the investors include China Southern Power Grid, Power China, China Energy Engineering Corporation, Znshine Solar, and China General Nuclear Power Group, etc. Solar projects constitute the majority of investments, comprising approximately 50%.

¹⁰ 光明日报：从“新三样”领跑看外贸韧性和动能。2023. https://news.gmw.cn/2023-08/10/content_36756804.htm

Figure 5 | Chinese investors' overseas RE project investments (billion USD)

Data source: fDi Markets (November 2023)

Certainly, Chinese investors are swiftly resuming their investments in RE projects in other developing nations following the epidemic.

To summarize, China's "going global" enterprises have seen swift transformation since 2021. Power engineering firms underwent a significant change in their main business, whereas manufacturing firms witnessed a notable expansion in their export volume. After the pandemic, there was a rapid revival in international investment of RE projects. China's "going global" industry has obviously transitioned into a development trajectory that predominantly prioritizes RE. This move occurred simultaneously with China's policy-making to promote green and low-carbon energy in other developing countries.

China has cooperated with more than 100 countries and regions in green energy since the 10-year that BRI is proposed, China's overseas green and low-carbon energy investments has surpassed traditional energy¹¹.

Wei Xiaowei, director of the Department of International Cooperation of the National Energy Administration

¹¹ 新华财经：中国在共建“一带一路”国家的绿色低碳能源投资已超传统能源。2023. https://www.cnfin.com/dz-lb/detail/20231030/3956301_1.html



3

RE Development in Developing Countries and China's Impact

In order to comprehensively analyze the characteristics of RE development in developing nations with the impact of China, we have selected three representative regions-Southeast Asia, Central Asia, and sub-Saharan Africa-and will evaluate them from a regional perspective. Presented here is the rationale for our choice. Firstly, many of the countries in these regions are low- and middle-income, and their energy development depends heavily on foreign financial and technical support. Furthermore, the countries within these regions exhibit similarities in their energy development models, including comparable industrial structures and energy resources, strong economic ties within the regions, and a significant level of interdependence in their power grid. By employing a regionally focused approach, we attempt to understand the major gaps in the overall region. Lastly, the countries in these regions are mostly the participants in the BRI that have tight economic ties with China.

This chapter commences by describing the progress of inter-governmental collaboration between China and the regions, providing readers with an overview. Then, this chapter examines the installed RE capacity in the region during the previous decade, the share of RE power in their power system, and the upcoming RE project pipelines. It aims to describe a pathway of the past, the present, and the future developments of the region's RE sector. Next, we proceed with examining the value chain of the GPE in the region, introducing Comparative Advantage Index and China Trade Relationship Index . The objective is to evaluate the present condition of the GPE value chain in the region and the influence exerted by China. Lastly, this chapter examines the status of international RE investors in the region, with a comparison with Chinese investors. It evaluates the background and investment strategies of Chinese firms to reveal their investing orientation and competitiveness in the region.

This chapter offers an extensive examination of the political and economic environment, growth trajectory, GPE value chain, and international RE investment in the representative regions. It especially highlights the features pertaining to China in each of these aspects. This chapter aims to comprehensively demonstrate the impact of China on the region' s RE development and lay the groundwork for the subsequent chapters' discussion.



Box 1 | Comparative Advantage Index and China Trade Relations Index

Comparative Advantage Index

Comparative Advantage Index measures the international market competitiveness of a nation's industries or products. Its objective is to provide a quantitative description of the comparative export performance of a country's specific industry or product groups. The comparative advantage index enables the identification of sectors within a nation that possess greater export competitiveness, thereby disclosing the nation's comparative advantage in global trade.

The Comparative Advantage Index $ij = (X_{ij}/X_{tj}) \div (X_{iW}/X_{tW})$

X_{ij} = the values of country j 's exports of product i

X_{tj} = the country j 's total exports

X_{iW} = the world exports of product i

X_{tW} = the world total exports

To facilitate comprehension, the Comparative Advantage Index has been transformed into a five-point assessment table, with the conversion criteria detailed in Appendix 1.

China Trade Relationship Index

China Trade Relationship Index quantifies the degree of trade links between a country's products or industries with China. It seeks to determine the performance of each industry or product groups in a country or region in terms of imports and exports to China over imports and exports to the rest of the world. The China Trade Relationship Index can be used to identify which industries in a country or region have stronger trade ties with China.

The China Trade Relations Index $ij = (IC_{ij} + EC_{ij}) \div (I_{ij} + E_{ij})$

IC_{ij} = the value of product i imported from China by country j

EC_{ij} = the value of product i exported by country j to China

I_{ij} = the value of country j 's global imports of product i

E_{ij} = the value of country j 's exports of product i to the world

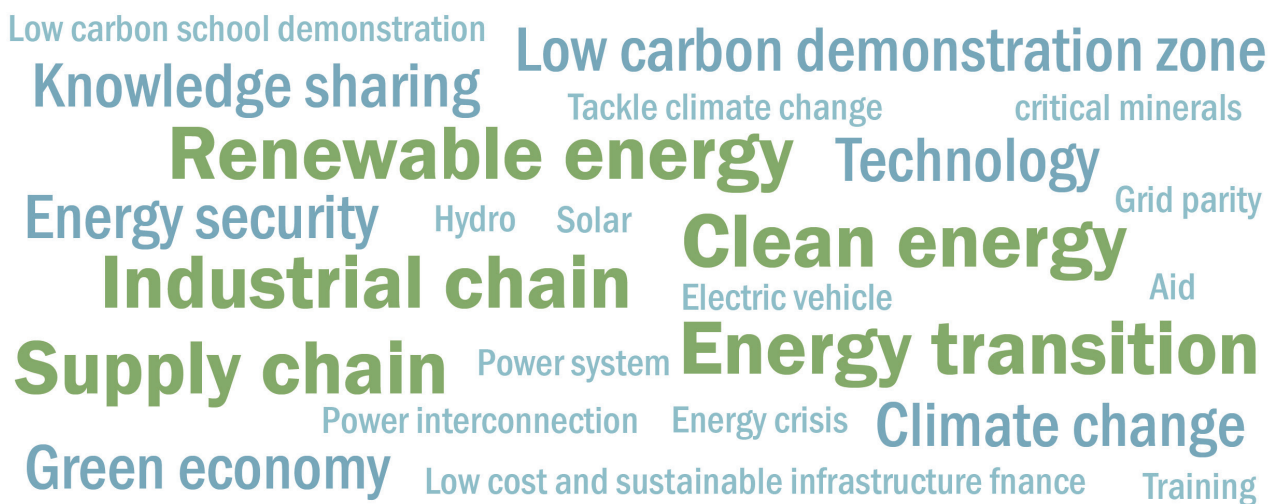
To facilitate comprehension, the China Trade Relationship Index has been transformed into a five-point assessment table, with the conversion criteria detailed in Appendix 1.

3.1 Southeast Asia

Intergovernmental Cooperation between China and Southeast Asia

China and the Association of Southeast Asian Nations (ASEAN) are experiencing rapid development in multiple aspects of clean energy cooperation. They are progressively establishing a comprehensive strategic partnership focused on extensive energy cooperation. The Lancang-Mekong Cooperation Mechanism, a sub-regional cooperation framework that China and five ASEAN nations created, has had a significant impact. “Joint Statement on Enhancing Sustainable Development Cooperation of the Lancang-Mekong Countries,” released in June 2021, suggests assisting in improving water infrastructure construction¹². During the 7th Lancang-Mekong Cooperation Foreign Ministers' Meeting in July 2022, there was a strong emphasis on the need to enhance exchanges of environmental policies across different sectors. It was also highlighted that it is important to establish platforms for sharing knowledge on green, low-carbon, and sustainable infrastructure in the Lancang-Mekong region. Additionally, there was a call to strengthen capacity-building efforts in areas such as climate change, biodiversity, energy transition, and sustainable infrastructure. Furthermore, it has also

Figure 6 | Keywords of clean energy diplomacy between China and Southeast Asia from 2021 to 2023



Data source: Belt and Road Energy Cooperation Network (November 2023)

¹² 新华社：关于加强澜沧江 - 湄公河国家可持续发展合作的联合声明 . 2021. https://www.gov.cn/xinwen/2021-06/09/content_5616341.html

committed to enhancing the collaborative development of the green economic model and advancing technology and innovative solutions. During the Special Summit to Commemorate the 30th Anniversary of the ASEAN-China Dialogue, both parties expressed their intention to collaborate on regional energy transition. They discussed the possibility of establishing a clean energy cooperation center, enhancing the exchange of RE technologies, strengthening cooperation in green finance and investment, and offering assistance for regional low-carbon sustainable development. The Regional Comprehensive Economic Partnership Agreement (RCEP), which took effect in 2022, aims to enhance extensive and profound trade between China and ASEAN, including the RE sector. It offers a fresh opportunity and initiates a new phase for the development and integration of the associated RE industry. On one hand, it facilitates the effective use of a larger market size by both parties, fosters the smooth integration of the RE supply chain, enhances the comparative advantages of countries, encourages the expansion of the industrial chain within the region, and drives down the overall cost of regional efforts to develop RE. Furthermore, streamlining control measures such as visas and work permits will allow the movement of qualified professionals and technical experts, as well as boost the training of labor skills in the Southeast Asia. This, in turn, will contribute to the advancement of RE technologies and their widespread implementation.

China and ASEAN countries have established extensive collaboration in the RE supply chain and industrial chain. The China-Cambodia Low Carbon Demonstration Zone and China-Laos Low Carbon Demonstration Zone have been created as instances of intergovernmental collaboration. Collaboration in the RE industry has also produced substantial results. Chinese solar manufacturing companies predominantly select ASEAN countries as their primary destinations for expanding their operations abroad. Thailand, Malaysia, Vietnam, Cambodia, and other nations have established further solar manufacturing capabilities, leading to a total module output capacity of more than 40 GW¹³. Chinese firms have promoted the ASEAN photovoltaic industrial chain in a way that has transformed the region into a prominent global manufacturing hub for photostatic products. It now holds the second position worldwide, just behind China. The region is currently reaping the advantages of the global low-carbon transition dividend.

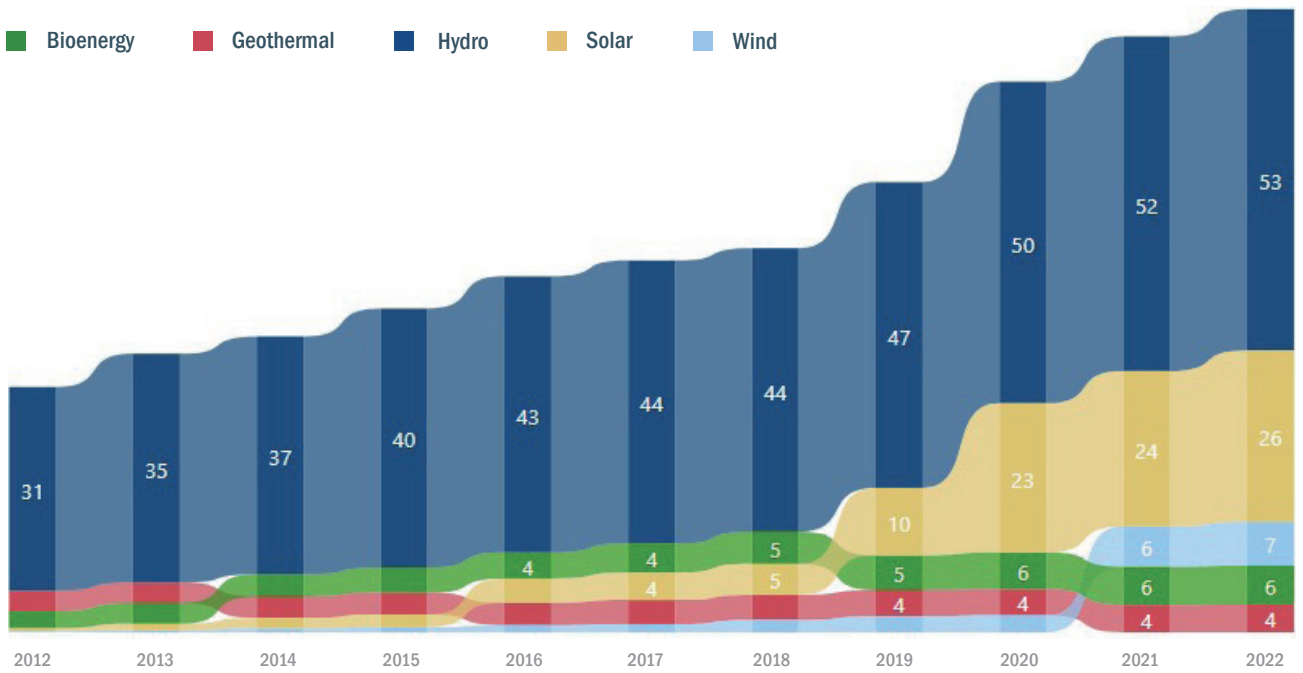
¹³ The data is collected from multiple public sources

The Development of RE in Southeast Asia

Over the past decade, ASEAN countries, which are among the rapidly expanding economies worldwide, have witnessed a significant increase in their power demand. Simultaneously, the growth of RE has also accelerated swiftly. Over the past decade, hydro power has been consistently growing, with an annual addition of more than 2 GW of new capacity. Since 2018, solar has undergone a period of rapid growth, demonstrated by the yearly addition of more than 5 GW of new capacity. Wind has made significant progress since 2020, with the installation of 7 GW of built capacity in the past two years. As of 2021, RE generation accounts for 25% of the overall power generation in Southeast Asia, with each person generating an average of 430 KWh of RE electricity every year. Although there is still a gap when compared to the worldwide average of 29%, if the current rate of progress continues, the gap will be eliminated in the near future. Countries with abundant RE resources, such as Laos, offer a more viable opportunity for the development of large-scale RE projects. The rate of change has been relatively slower in countries that are abundant with fossil fuels, such as Indonesia and Thailand. The RE project pipelines in Southeast Asia have achieved significant progress, with a planned capacity of 216 GW, about double the existing installed capacity. The most are wind projects, then hydro and solar. Geothermal and biomass are also significantly represented. Considering the current slowdown in the expansion of solar energy projects, wind power will become the main priority for regional development in the upcoming phase.

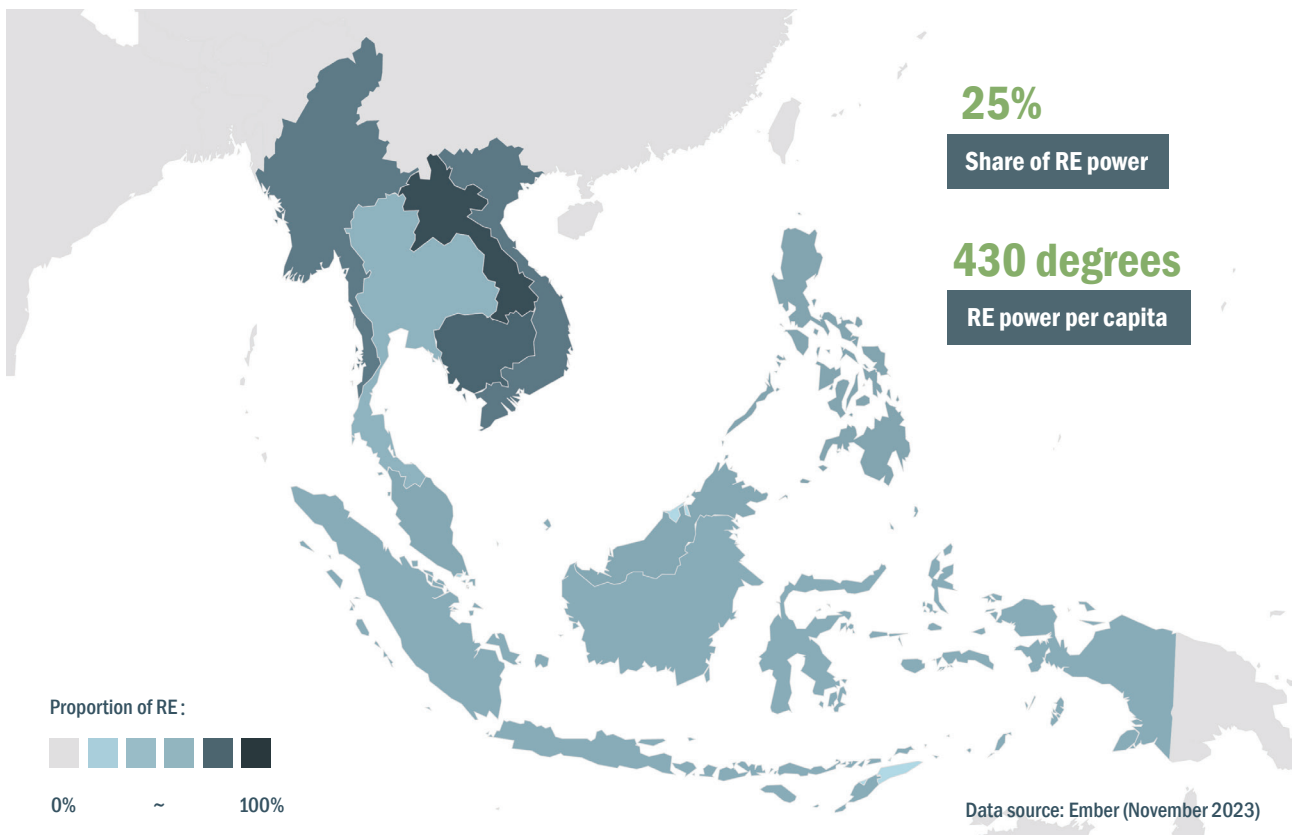


Figure 7 | Installed RE capacity in Southeast Asia (GW)



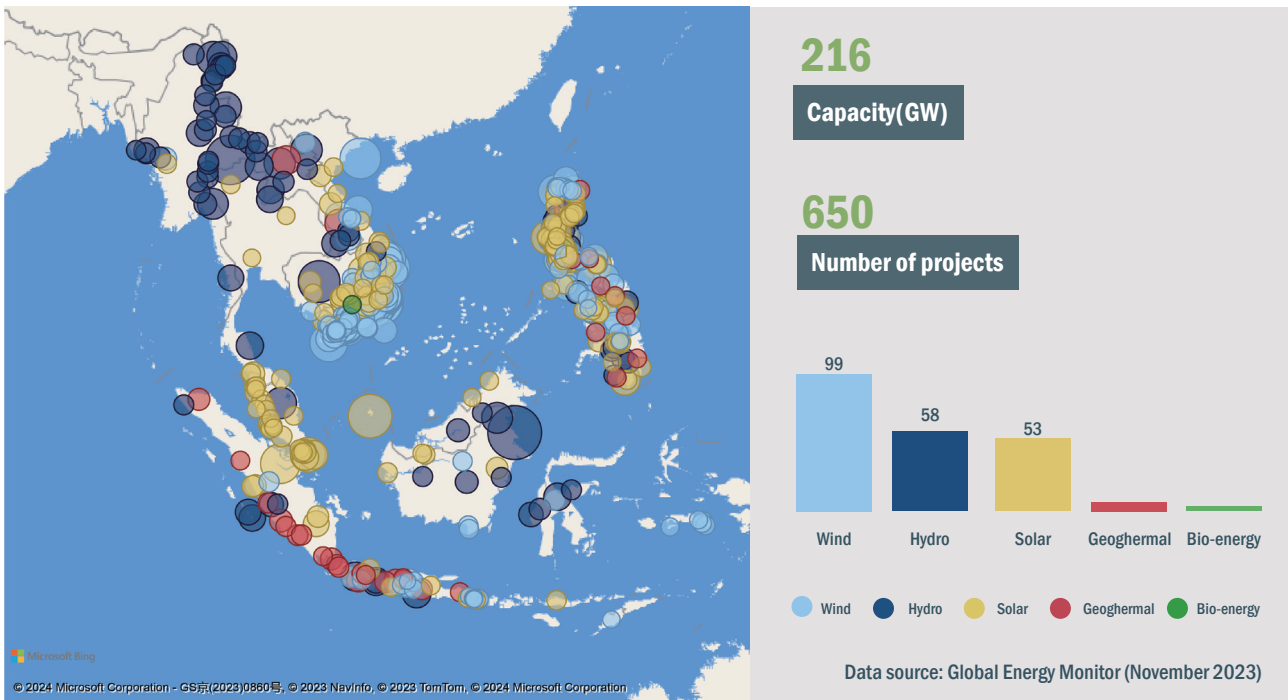
Data source: IRENA (November 2023)

Figure 8 | RE power supply in Southeast Asia in 2021 (%)



Data source: Ember (November 2023)

Figure 9 | RE project pipelines in Southeast Asia



The GPE Value Chain in Southeast Asia

Southeast Asian countries have significant competitive advantages in many parts of the GPE value chain. These advantages encompass upstream resources like nickel, copper, and cobalt found in critical mineral sectors, as well as downstream manufacturing of photostatic modules, inverters, transmission and transformation equipment, and lithium batteries. It is rare that developing nations have this level of competitive advantage, which plays a significant role in promoting RE deployment in the region. China have robust inter-connectivity throughout multiple segments of the GPE value chain with the region. China is the main country that receives key mineral exports from Southeast Asia. On the other hand, China is the main source of GPE imports for the region, including wind, lithium batteries, and hydro equipment . The use of Chinese technology and equipment is pivotal in facilitating the growth and development of RE in the region.

Table 1 | GPE value chain in Southeast Asia

Product	Comparative Advantage (Score from 0 to 5)	Net Export/Import to China	Trade Relationship with China (Score from 0 to 5)
Copper	● ● ● ○ ○	Net Export	● ● ○ ○ ○
Lithium	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Cobalt	● ○ ○ ○ ○	Net Export	● ● ● ● ○
Nickel	● ○ ○ ○ ○	Net Export	● ● ● ● ●
Wind	○ ○ ○ ○ ○	Net Import	● ● ● ● ○
Solar	● ● ● ○ ○	Net Import	● ○ ○ ○ ○
Inverter	● ● ● ○ ○	Net Import	● ● ○ ○ ○
Hydro	○ ○ ○ ○ ○	Net Import	● ● ● ○ ○
Lithium Battery	● ○ ○ ○ ○	Net Import	● ● ● ○ ○
Transformer	● ● ○ ○ ○	Net Import	● ● ○ ○ ○
Transmission	● ● ○ ○ ○	Net Import	● ● ○ ○ ○
Electric Vehicle	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Heat Pump	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Electrolysis	● ● ○ ○ ○	Net Import	● ● ○ ○ ○

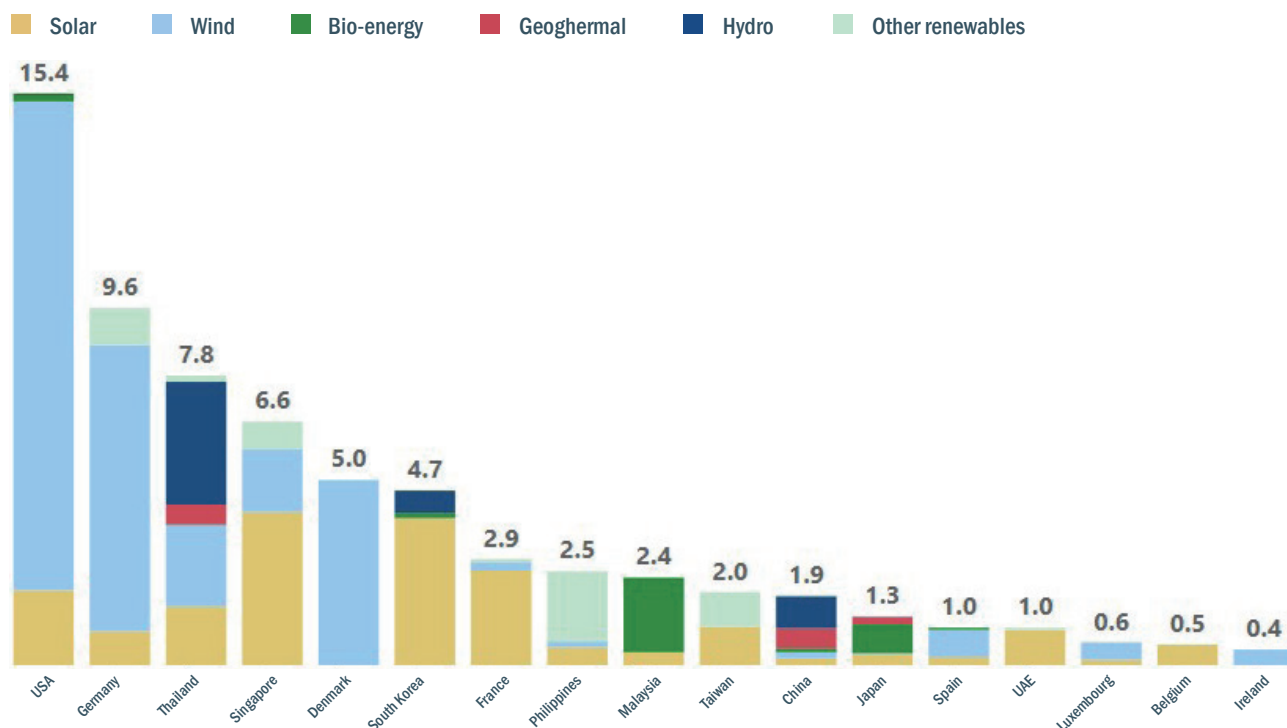
Data source: UN Comtrade database (November 2023)

International RE Investors in Southeast Asia

United States, Germany, Thailand, Singapore, and Denmark are the primary contributors to RE investment in Southeast Asia. There has been a significant increase in RE investment in recent years, amid frequent mutual investments among countries within the region. Thai investors have made significant investments in Vietnam, Cambodia, Laos, etc. For Chinese investors, they seemed to prioritize hydro as the primary investment focus. In addition, they have also made investments in wind, solar, geothermal, and biomass. Chinese investors comprise power firms such as China Three Gorges Corporation and China General Nuclear Power Corporation, engineering firms including China Gezhouba Group and China National Electric Engineering Corporation, and China Everbright Group, an enterprise specializing in waste management. These companies have extensive expertise in overseeing RE projects and possess strong technical capabilities. However, there is still a

significant disparity in the amount of investment between Chinese investors and other international investors. Chinese investors, on average, have only undertaken one or two projects as they await the establishment of a crucial competitive advantage in Southeast Asia.

Figure 10 | International RE investments in Southeast Asia from 2013 to 2023 (billion USD)



Data source: fDi Markets (November 2023), the data for 2023 is up until the end of the third quarter.

Table 2 | International RE investors in Southeast Asia from 2013 to 2023

Investor	Country	Number of Project (2013-2023)	Project Technology
Global			
WPD	Germany	9	Wind, Other renewables
AC Energy	Philippines	8	Wind, Solar, Other renewables
Enfinity	Belgium	8	Solar
Total Energies	France	7	Solar
BayWa	Germany	6	Wind, Solar
Electricity Generating Public Company	Thailand	5	Geothermal, Hydro, Other renewables

BlueFloat Energy	Spain	4	Wind
Mainstream Renewable Power	Ireland	4	Wind
Scatec AS	Norway	4	Solar
Super Energy Corporation	Thailand	4	Solar

China

China Three Gorges Corporation	China	2	Wind,Hydro
China Everbright Group	China	1	Bioenergy
China General Nuclear Power Corporation	China	1	Solar
China Gezhouba Group	China	1	Hydro
China National Electric Engineering	China	1	Hydro

Data source: fDi Markets (November 2023), the data for 2023 is up until the end of the third quarter.

3.2 Central Asia

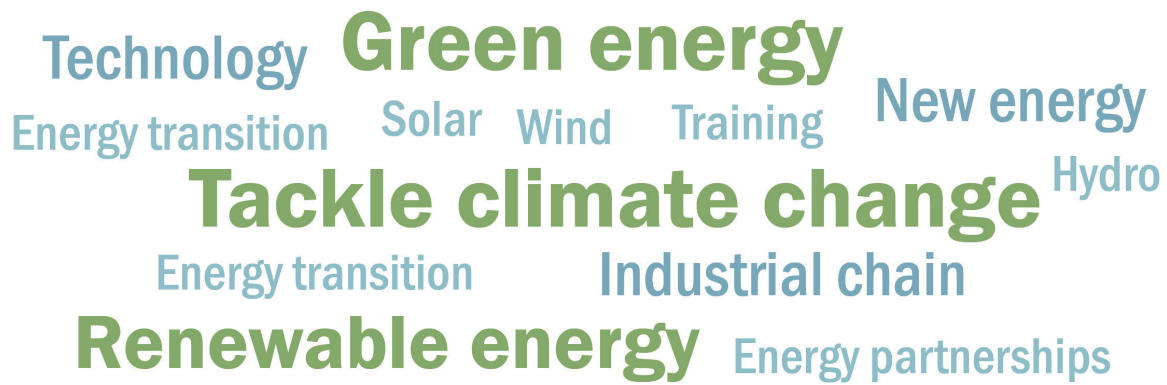
Intergovernmental Cooperation between between China and Central Asia

Central Asia has a significant impact on China's energy security with its geopolitical position. The collaboration between China and Central Asia has strengthened in the period following the epidemic, particularly in the aftermath of the war between Ukraine and Russia. In addition, it is essential for the Central Asian nations to prioritize the improvement of their geosecurity and the ensure the stability of energy trade. Due to their mutual reliance, Central Asian nations and China have identified clean energy as a key area of cooperation. At the second China-Central Asia Foreign Minister Conference in May 2021, the two sides stressed the importance of working together to protect environment, achieve sustainable development, and address climate change. In addition, they also claimed to promote the use of RE power in private sectors, broadening environmentally friendly economy. At the Third China-Central Asia Foreign Minister Conference, which took place in Nursultan in June 2022, a common statement was issued to fulfill Green Silk Road Roadmap. The statement also highlighted the significance of enhancing funding for training in specialized knowledge and technical collaboration in the field of alternative energy sources, along with executing regional strategies and initiatives

pertaining to environmentally friendly technologies. “Samarkand Declaration of the Shanghai Cooperation Organization,” published in September 2022, emphasized the need to improve collaboration in the energy industry. It called for the wider implementation of cost-effective and environmentally friendly technologies, the reduction of pollution, the assurance of energy security, and the promotion of a transition to an energy-efficient economy. “Xi'an Declaration of the China-Central Asia Summit,” published in May 2023, emphasized the importance of reciprocal support in the RE industry, encompassing hydro, solar, and wind sectors.

Chinese firms exhibit notably greater interest in investing in RE projects in Central Asia compared to other regions. Furthermore, 2023 signifies a momentous year for collaboration between the two parties. During the China-Central Asia Summit held in May, Chinese companies signed agreements for RE initiatives with Kazakhstan and Kyrgyzstan. In July, China Southern Power Grid and Uzbekistan entered into an investment deal about pumped-storage power plants. Chinese firms are increasingly targeting Central Asia as a prime target of RE investment.

Figure 11 | Keywords of clean energy diplomacy between China and Central Asia from 2021 to 2023

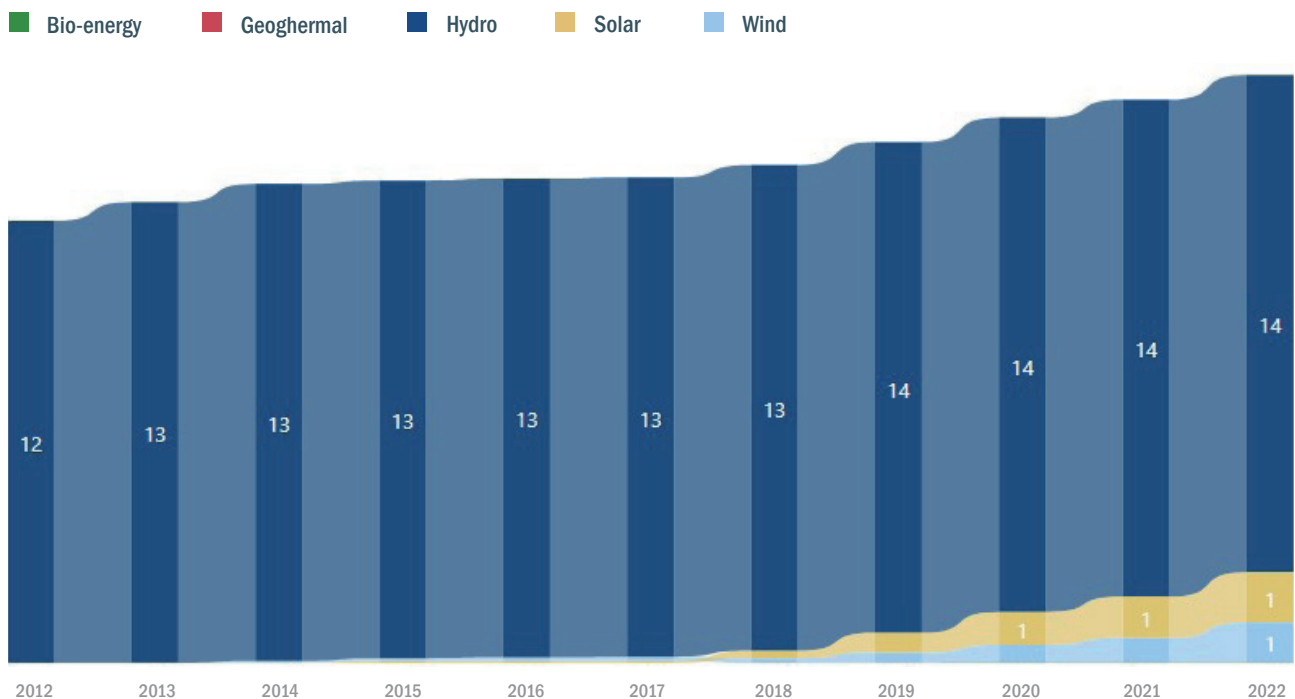


Data source: Belt and Road Energy Cooperation Network (November 2023)

The Development of RE in Central Asia

The pace of RE development in Central Asia is fairly moderate. The region's hydro power growth has faced a major hurdle in the past decade, with the addition of new capacity only reaching just over 2 GW. In the year 2018, there was a significant increase in the expansion of solar and wind, resulting in capacity exceeding 1 GW by 2022. The RE generation share of the Central Asian countries in 2021 stood at 21%, which was below the global average of 29%, and the RE electricity per capita amounted to 627 KWh. The region's RE power is predominantly derived from the hydro plants in Tajikistan and Kyrgyzstan. However, the untapped potential of RE in the region necessitates more exploration. Currently, a total of 15 GW of capacity is under development, with hydro occupying the largest portion. And the upcoming wind and solar projects are mostly located in Uzbekistan and Kazakhstan. In the future, the primary emphasis of regional energy transition will be the expansion of power infrastructure to connect and balance the unevenly distributed RE sources in this region.

Figure 12 | Installed RE capacity in Central Asia (GW)



Data source: IRENA (November 2023)

Figure 13 | RE power supply in Central Asia in 2021 (%)

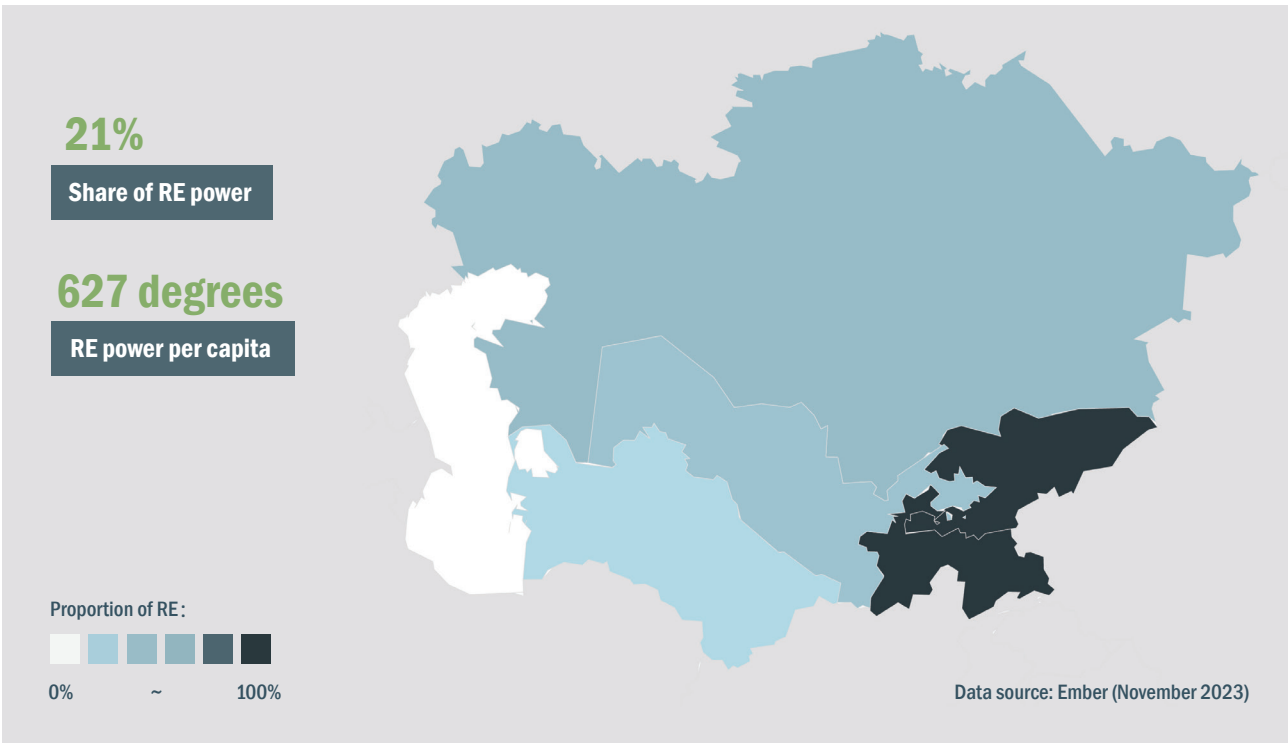
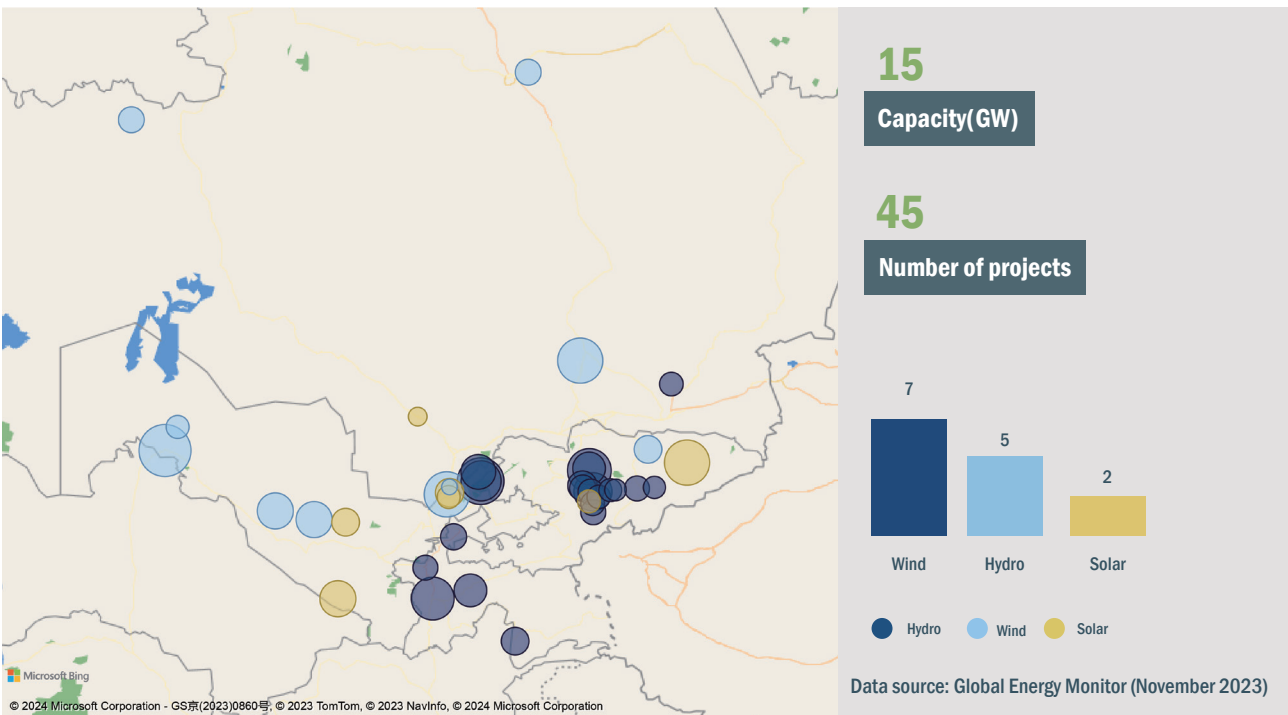


Figure 14 | RE project pipelines in Central Asia



GPE value chain in Central Asia

The region demonstrates moderate performance in the GPE value chain, primarily due to its abundant supply of key minerals, particularly copper and lithium. It possesses notable comparative advantages in transformers but lags behind in other areas. Equipment for RE development in Central Asia heavily relies on imports. The region has close ties with China across various segments of the GPE value chain, with China being the primary destination for key mineral exports and the major source of imports. Specifically, nearly all solar equipment is imported from China, while other equipment such as hydro turbines, lithium batteries, and electrolyzers also see significant imports from China. This underscores the heavy dependence of RE development in Central Asia on Chinese technology and equipment.

Table 3 | GPE Value Chain in Central Asia

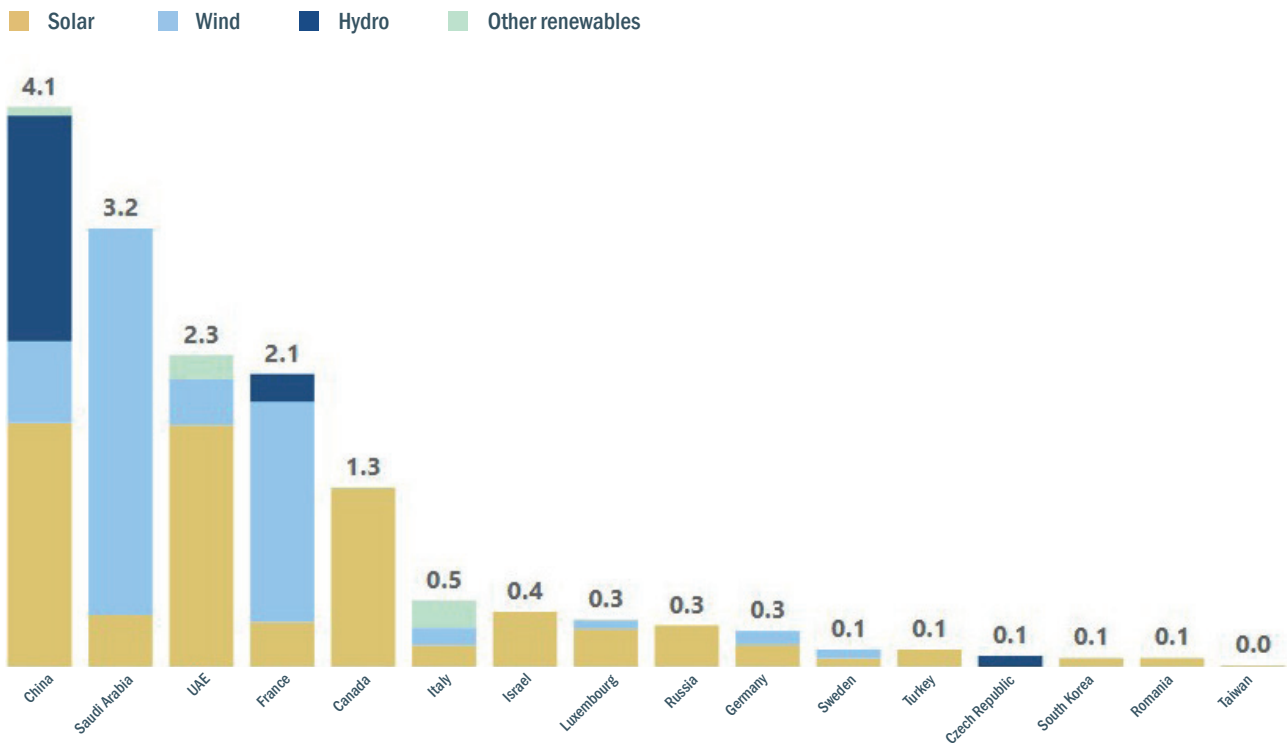
Product	Comparative Advantage (Score from 0 to 5)	Net Export/Import to China	Trade Relationship with China (Score from 0 to 5)
Copper	● ● ● ○ ○	Net Export	● ● ● ● ○
Lithium	● ○ ○ ○ ○	Net Import	○ ○ ○ ○ ○
Cobalt	○ ○ ○ ○ ○	Net Export	○ ○ ○ ○ ○
Nickel	○ ○ ○ ○ ○	Net Export	● ● ● ● ●
Wind	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Solar	○ ○ ○ ○ ○	Net Import	● ● ● ● ●
Inverter	● ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Hydro	○ ○ ○ ○ ○	Net Import	● ● ● ○ ○
Lithium Battery	○ ○ ○ ○ ○	Net Import	● ● ● ● ○
Transformer	● ● ● ○ ○	Net Import	● ● ○ ○ ○
Transmission	○ ○ ○ ○ ○	Net Import	● ○ ○ ○ ○
Electric Vehicle	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Heat Pump	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Electrolysis	○ ○ ○ ○ ○	Net Import	● ● ● ○ ○

Data source: UN Comtrade database (November 2023)

International RE Investors in Central Asia

China is the primary contributor to RE investment in Central Asia, with Saudi Arabia, the UAE, France, and Canada following as the top five sources of investment in the region. Apart from China, investors from West Asia and Europe also play significant roles in the region. In 2023, China Southern Power Grid, Znshine Solar, and Power Construction Corporation of China notably ramped up their investment in this region. While Chinese investment as a whole have shown fast growing momentum, the investors individually still lags behind Masdar and ACWA Power. These two companies have gained strong competitive edge due to their early presence in Central Asia, establishing a formidable competition for Chinese enterprises.

Figure 15 | International RE investments in Central Asia from 2013 to 2023 (billion USD)



Data source: fDi Markets (November 2023), the data for 2023 is current up until the end of the third quarter.

Table 4 | International RE investors in Central Asia from 2013 to 2023

Investor	Country	Number of Project (2013-2023)	Project Technology
Global			
Masdar	UAE	10	Wind,Solar,Other renewables
ACWA Power	Saudi Arabia	6	Wind,Solar
SkyPower	Canada	6	Solar
Hevel	Russia	5	Solar
Eren Groupe	Luxembourg	4	Wind,Solar
Eni SpA	Italy	3	Wind,Other renewables
Svevind	Switzerland	2	Wind,Solar
Voltaia	France	2	Wind,Solar
Arm Wind	Italy	1	Solar
Building Energy	Italy	1	Other renewables
China			
China Southern Power Grid	China	3	Hydro
Risen Energy	China	3	Solar
Jiangsu Zhenfa Holding Group	China	2	Wind,Solar
Power Construction Corporation of China	China	2	Solar
China Longyuan Power Group	China	1	Wind
Data source: fDi Markets (November 2023), the data for 2023 is current up until the end of the third quarter.			

3.3 Sub-Saharan Africa

— Intergovernmental Cooperation between China and Sub-Saharan Africa

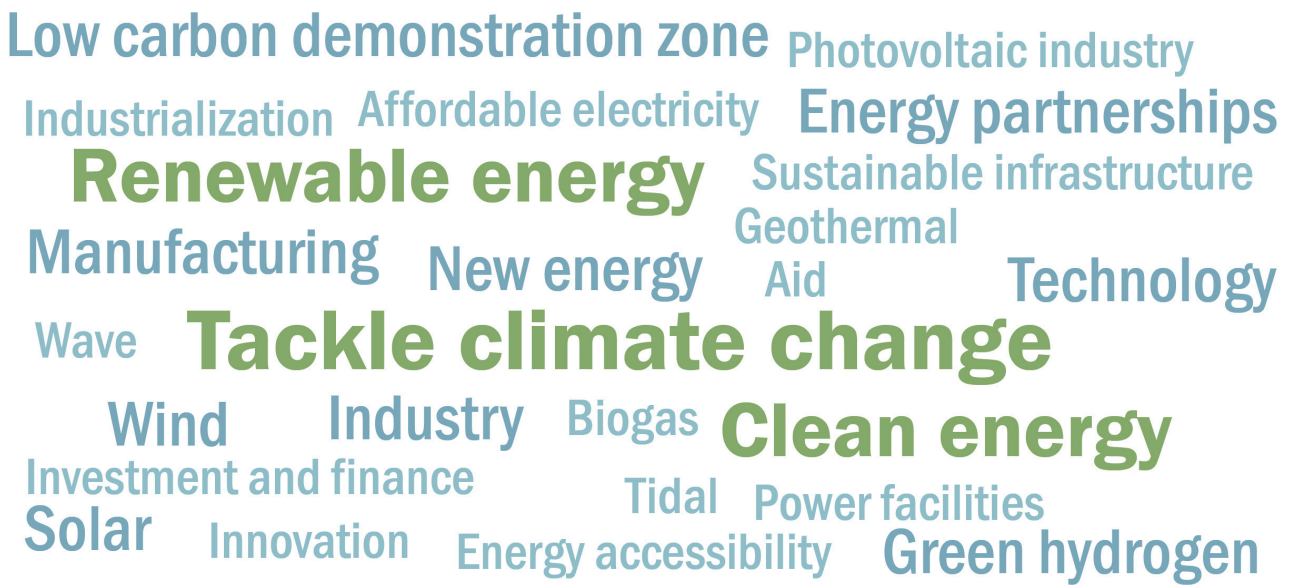
Sub-Saharan Africa has historically experienced the most severe energy poverty in the world. Forecasts indicate that by 2030, over 660 million people globally will continue to lack access to

electricity, with the majority residing in sub-Saharan Africa¹⁴. Despite the abundance of RE resources in the region, the inadequate industrial capabilities of local countries complicate RE deployment. Therefore, the region's governments have opted for China's assistance and cooperation as a crucial strategic choice. The 8th Ministerial Conference of the Forum on China-Africa Cooperation in 2021 included the green development program among the "Nine Programs." China will undertake 10 environmental protection and climate action projects, support the development of the "Green Great Wall," and build low-carbon demonstration zones and climate adaptation demonstration zones. In November 2021, the Forum on China-Africa Cooperation put forth a clear proposition in promoting green and low-carbon initiatives and moving forward with RE such as solar and wind. "Dakar Declaration, the China-Africa Cooperation Vision 2035," "Declaration on China-Africa Cooperation on Combating Climate Change," and "Dakar Action Plan 2022-2024," adopted at the conference, had proposed action points such as effectively enhance the share of RE consumption and build more RE projects. In August 2023, President Xi delivered a keynote speech entitled "Joining Hands to Advance Modernization and Create a Great Future for China and Africa," launching the Initiative on Supporting Africa's Industrialization. In that, China will better harness its resources to support Africa in growing its manufacturing sector and realizing industrialization.

China has employed its advantages in green technology to develop multiple "Small yet Beautiful" distributed energy projects throughout sub-Saharan Africa. China supported the Abuja Solar Traffic Signal Project by installing solar-powered signal lights at all 172 traffic crossroads in Nigeria's capital city. This allowed the signals to function independently without human monitoring. China has provided support to the Seychelles in the establishment of a low-carbon demonstration zone and the donation of RE equipment, including solar LED lighting, photovoltaic vehicle shelters, off-grid photovoltaic energy storage systems, and electric bikes. In addition, China has created industrial parks across Africa, enticing Chinese companies to extend local operations, which will serve as the groundwork for the region's RE manufacturing industry.

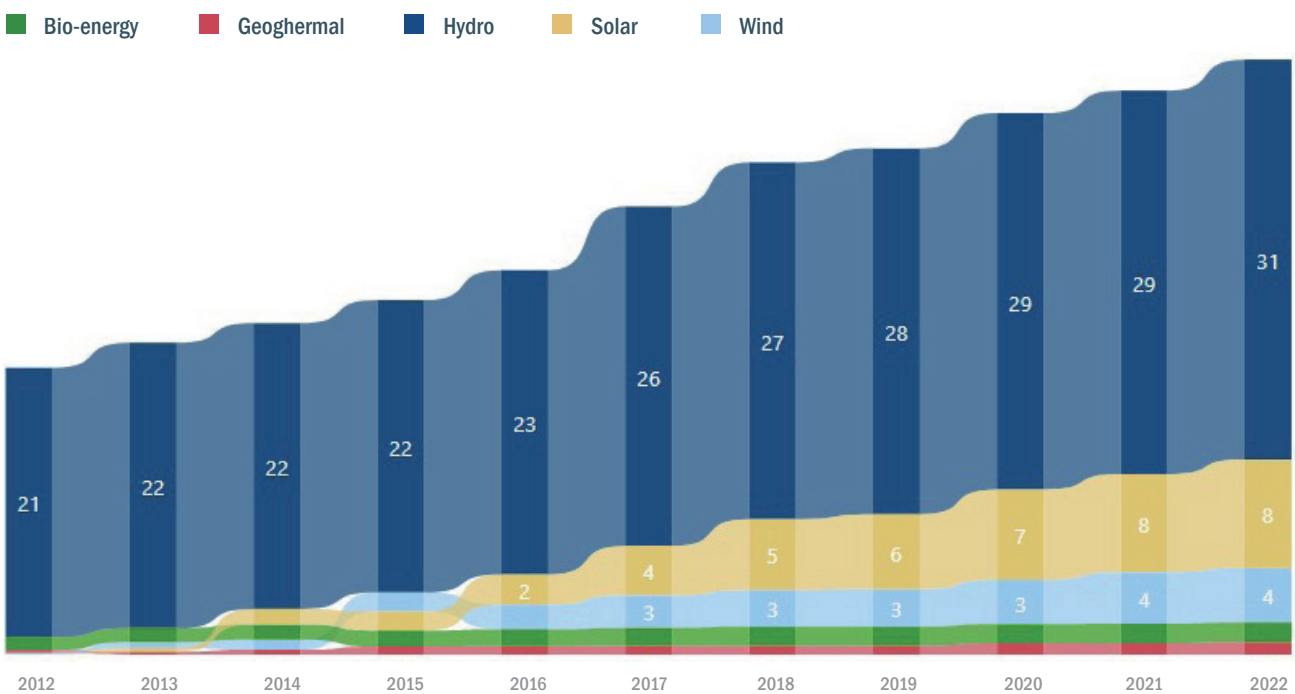
¹⁴ 新华社：中非清洁能源合作助推非洲绿色发展。 https://www.gov.cn/xinwen/2022-04/15/content_5685439.htm

Figure 16 | Keywords of clean energy diplomacy between China and Africa from 2021 to 2023



Data source: Belt and Road Energy Cooperation Network (November 2023)

Figure 17 | Installed RE capacity in sub-Saharan Africa (GW)



Data source: IRENA (November 2023)

Figure 18 | RE power supply in of sub-Saharan Africa in 2021 (%)

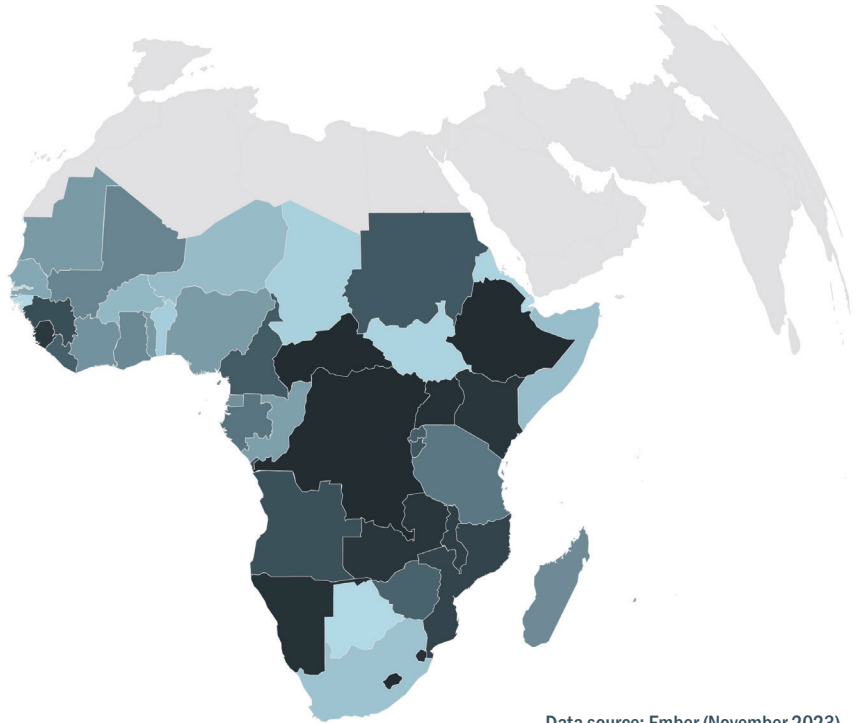
34%

Share of RE power

135 degrees

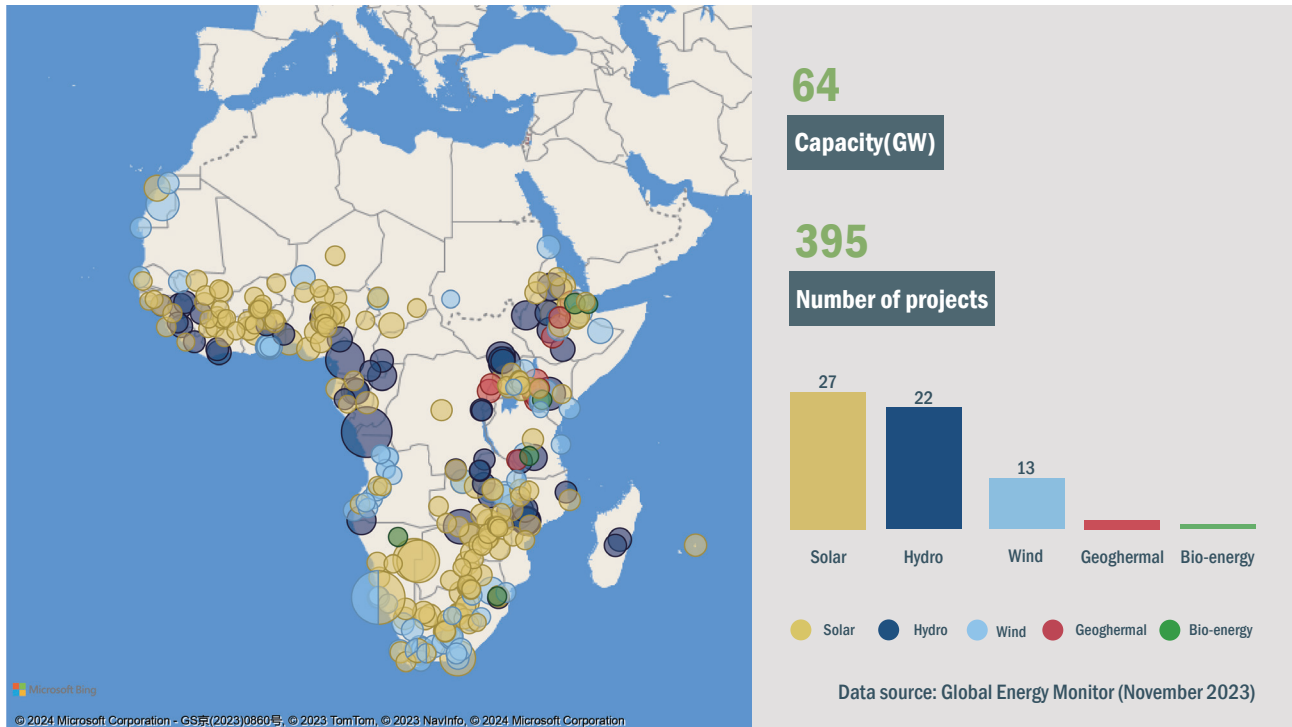
RE power per capita

Proportion of RE:



Data source: Ember (November 2023)

Figure 19 | RE project pipelines in sub-Saharan Africa



The Development of RE in Sub-Saharan Africa

In the face of a significant energy deficit, the region has witnessed rapid expansion in power capacity over the past decade, largely driven by the annual addition of 1 GW of newly commissioned hydro plants. Following 2013, there was a significant surge in the development of solar and wind, resulting in the establishment of over 12 GW of operational plants since then. By 2021, the share of RE power in sub-Saharan African nations had reached 34%, surpassing the global average of 29%. However, the per capita RE power remained low at 135 kWh, the lowest globally. The region's cumulative RE project pipeline stands at 64 GW, with solar comprising the largest share, followed by hydro and wind. Solar, in particular, has consistently demonstrated robust growth in recent years, with many solar projects reaching advanced development stages. Hence, solar energy is poised to take precedence in the near future for this region.



The GPE Value Chain in Sub-Saharan Africa

Sub-Saharan Africa possesses a notable advantage in key minerals, particularly copper, cobalt, and nickel. While there are some relative advantages in power transmission and transformation equipment, most other areas remain underdeveloped. As a result, further development of RE in the region heavily relies on imported equipment. China maintains a robust partnership with sub-Saharan Africa across almost all aspects of the GPE value chain. The region exports significant quantities of key minerals to China, while equipment such as inverters, lithium batteries, solar panels, and wind turbines are primarily imported from China. Chinese equipment has played a crucial role in accelerating the region's RE development.

Table 5 | GPE Value Chain in sub-Saharan Africa

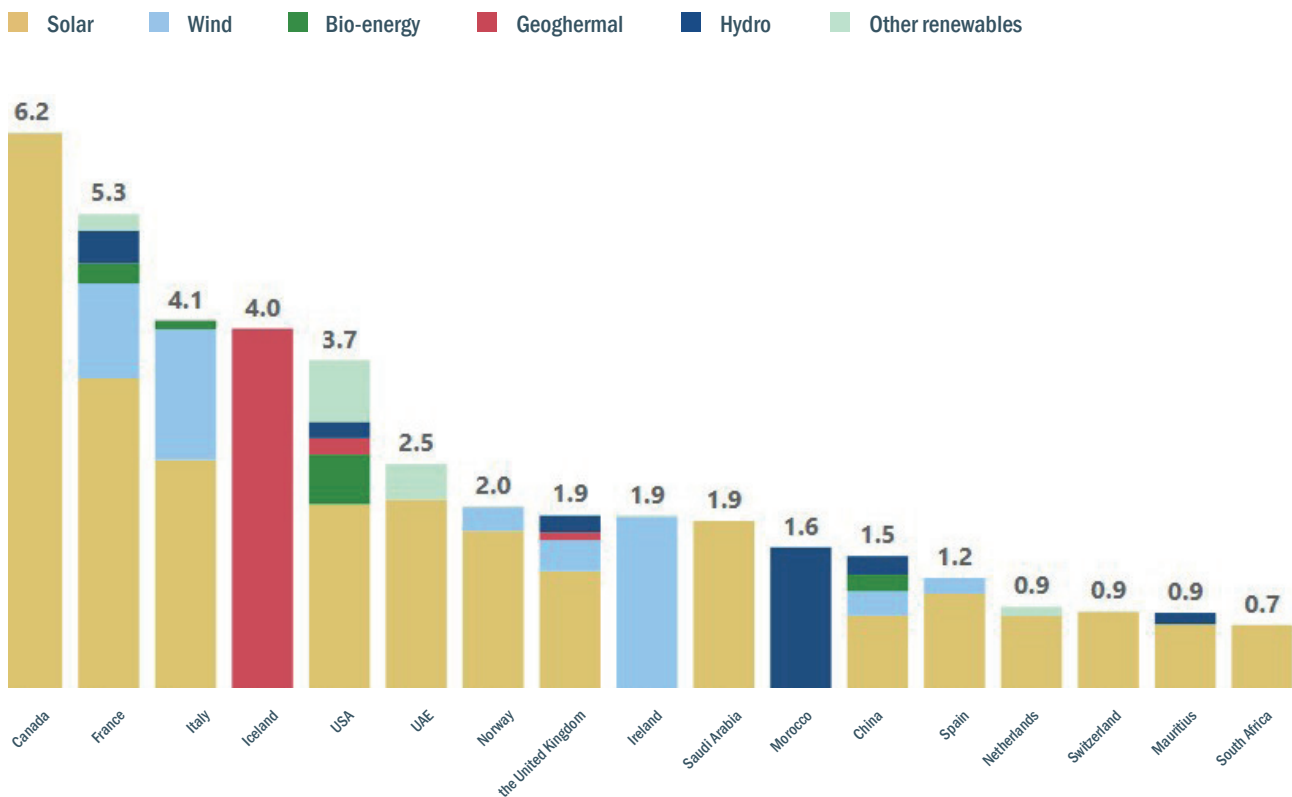
Product	Comparative Advantage (Score from 0 to 5)	Net Export/Import to China	Trade Relationship with China (Score from 0 to 5)
Copper	● ● ● ○ ○	Net Export	● ● ○ ○ ○
Lithium	○ ○ ○ ○ ○	Net Export	● ● ● ● ●
Cobalt	● ● ● ● ●	Net Export	● ● ○ ○ ○
Nickel	● ● ● ● ●	Net Export	○ ○ ○ ○ ○
Wind	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Solar	○ ○ ○ ○ ○	Net Import	● ● ● ● ○
Inverter	○ ○ ○ ○ ○	Net Import	● ● ● ○ ○
Hydro	○ ○ ○ ○ ○	Net Import	● ● ● ○ ○
Lithium Battery	○ ○ ○ ○ ○	Net Import	● ● ● ● ○
Transformer	● ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Transmission	● ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Electric Vehicle	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Heat Pump	○ ○ ○ ○ ○	Net Import	● ● ○ ○ ○
Electrolysis	● ○ ○ ○ ○	Net Import	● ● ● ○ ○

Data source: UN Comtrade database (November 2023)

International RE Investors in Sub-Saharan Africa

The majority of RE investments in sub-Saharan Africa originate from Western developed nations, with Canada, France, Italy, Iceland, and United States on the top five. There was totally USD 1.5 billion investment from China to nine RE projects in the region. The Chinese investors are manufacturing companies Xiaocheng Technology, power companies China Longyuan Power Group, and engineering firms Power Construction Corporation of China, China Energy Engineering Corporation, and China National Complete Plant Import & Export Corporation. Chinese companies lag well behind their Western counterparts in terms of both the quantity and variety of projects.

Figure 20 | International RE investments in sub-Saharan Africa from 2013 to 2023 (billion USD)



Data source: fDi Markets (November 2023), the data for 2023 is current up until the end of the third quarter.

Table 6 | International RE investors in sub-Saharan Africa from 2013 to 2023

Investor	Country	Number of Project (2013-2023)	Project Technology
Global			
Mainstream Renewable Power	Norway	17	Wind,Solar
Enel Green Power	Italy	14	Wind,Solar
Access Power MEA	UAE	7	Solar
Cummins	United States	6	Bioenergy
Electricite de France	France	6	Wind,Solar
General Electric	United States	6	Solar,Other renewables
Gigawatt Global	Netherlands	6	Solar,Other renewables
Scatec AS	Norway	6	Solar
AMEA Power	UAE	5	Solar
Building Energy	Italy	5	Solar,Bioenergy
China			
Power Construction Corporation of China	China	3	Solar
Beijing Fuxing Xiaocheng Electronic Technology Stock	China	1	Solar
China Energy Engineering	China	1	Wind
China National Complete Plant Import & Export Corporation	China	1	Bioenergy
China Longyuan Power Group	China	1	Wind
Data source: fDi Markets (November 2023), the data for 2023 is current up until the end of the third quarter.			

Since 2021, the energy cooperation between China and other developing countries has progressively escalated across several sectors, such as industrial chains, supply networks, low-carbon demonstration zones, manufacturing, and industrialization. The level of cooperation varies across different regions. China and Southeast Asia prioritize collaboration in the supply chain and the industrial chain. In Central Asia, Chinese corporations are presently making substantial RE investment. In sub-Saharan Africa, China is actively tackling the energy poverty crisis by offering tangible aid to

address the urgent issue of power shortages as well as fostering the growth of industrialization and manufacturing sectors to seek sustainable solutions for achieving self-reliance in long-term.

Developing nations have predominantly relied on hydro power as their primary RE source. However, there are signs of a deceleration in the growth of hydro power in certain regions. The cost-effectiveness of hydro power offers a definitive answer to address the energy deficit in emerging nations for a long time. Unfortunately, the prolonged duration of construction and significant environmental risks associated with hydro power impede its ability to further scale-up. Over the last five years, there has been substantial expansion in solar and wind power, with solar experiencing the most rapid growth. The photovoltaic industry in Southeast Asia has developed distinct competitive strengths, leading to notable progress in the implementation of solar projects. Although different regions varies in RE development mode and preferable technologies, all the three regions in this chapter have large-scale wind and solar project pipelines waiting for construction.

GPE value chain is still mostly underdeveloped in developing countries. The majority of developing nations are constrained to exporting raw materials, whereas their RE power is strongly dependent on foreign technology and equipment. China has strong connections with nearly all developing countries throughout the GPE value chain, and Chinese equipment plays a crucial role in promoting the RE development in these countries. In regard to international RE investment, Chinese investors demonstrate a heightened enthusiasm to invest in locations characterized by a better level of political mutual trust. Nevertheless, there exists a noticeable discrepancy between Chinese and other international investors, and they must be prepared to face fierce rivalry in particular regions.



4

The Breakthroughs in China's Assistance to Other Developing Countries

The third chapter emphasizes China's crucial contribution to the advancement of RE to assist other developing nations. China's robust industrial chain and production capability has provided a solid foundation for the contribution. Nevertheless, there are still challenges that need to be addressed in order to make this industrial chain fully functional.

Firstly, the intricacy of efficient and synchronized communication between upstream and downstream sectors in the industrial chain poses a considerable challenge as for its complexity. Secondly, RE technology and manufacturing have been a substantial hindrance for many developing nations. As a result, developing countries depend largely on the foreign equipment, with a large part of the import from China. On the other side, China also places a high priority on facilitating the transfer of technology to assist other developing nations, as an important part of its energy diplomacy endeavors. Aligning China's willingness with the expectations of developing countries is another major challenge. Thirdly, while Chinese investors have emerged as major participants in trans-border RE investment, Chinese investors still lag behind their international counterparts in the number and diversity of investment. Chinese investors need to further improve internationalization efforts and brand influence in order to ensure their success in cross-border RE investment.

In summary, China's industrial firms and related institutions, as members of the key players involved in RE sector in other developing countries, have strong potential to modify and overcome those challenges, which will further help to facilitate the energy transition in developing countries. So the question is what breakthroughs has China made since 2021 in response to the challenges? This chapter will thoroughly analyze each of these breakthroughs.

Breakthrough 1

Consulting Service “Going Global” -Establishing Soft Power in Overseas Markets

Chinese companies have significant expertise in construction and equipment manufacturing, allowing them to develop a strong ability to carry out projects effectively, which is the hard power. However, China demonstrates shortcomings in areas of soft power, including legal services, accounting services, technical services, and conflict settlement. These areas are equally crucial for the effective implementation of projects. Let's examine the scenario of RE development, where the significant impact of soft power is crucial. RE power equipment, such as wind turbines, solar panels, and batteries, must comply with equipment certification and product access procedures in accordance with local regulations. Moreover, RE projects are widely dispersed throughout geographical regions, aligning with the habitats of local animals and the areas where people live and work. Hence, there is a potential for societal discord. Furthermore, the financial stability of RE projects depends on commercial power purchase agreements and does not have a sovereign guarantee, rendering it susceptible to legal disputes. RE projects operation is contingent upon various external factors, such as power grid design and electricity market regulations, which exert simultaneous influence. Hence, it is crucial to regularly oversee changes in pertinent legislation and regulations in the host nation. In order to tackle the aforementioned concerns, it is imperative to build a strong and comprehensive support system for soft power that can efficiently assess and mitigate any potential hazards.

The policy-making departments in China have taken action about this issue. “The Notice on Promoting the High-quality Development of Design and Consulting Services for Overseas Projects,” jointly issued by the Ministry of Commerce and eighteen other ministries under the State Council in early 2021, has created opportunities for the growth of design and consulting services. In the following years, Chinese businesses and research institutions in relevant fields took action, and in 2023, multiple research were made public. These achievements generally relate to the advancement of the international power sectors and the strategic management of power systems. This has greatly enhanced the development of large-scale construction businesses in China and facilitated the smooth

integration of upstream and downstream enterprises in the power industry chain.

The provision of legal services relating to foreign affairs has experienced substantial growth. The BRI Lawyer Alliance, founded by China Lawyers Association, now encompasses 54 areas and countries. Chinese law firms currently have 63 branches operating in 24 Belt and Road countries, which represents a significant increase of 47.5% compared to the number of branches five years ago¹⁵. However, the progress of financial services is slower in comparison, and the repercussions of foreign competition on offshore accounting services for Chinese firms are more pronounced. Although Chinese accounting firms have a strong desire to grow their presence internationally, but the offshore business model is still in the exploratory stage¹⁶.

Table 7 | Overseas Power Research by Chinese Consulting Institutions

Release Time	Consulting Institutions	Research Content
October 2021	China Electric Power Planning & Engineering Institute	Report on China-Southeast Asia Energy Cooperation
January 2023	China Electric Power Planning & Engineering Institute	Report on China-Central Asia Energy Cooperation
May 2023	China Energy Engineering Group China Power Engineering Consulting Group	Research on Electric Power Development in 74 Overseas Countries
May 2023	China Electric Power Planning & Engineering Institute	Green Power System Planning Toolbox for the Belt and Road Countries
May 2023	Global Energy Interconnection Development and Cooperation Organization	Research on Clean Energy and Power Cooperation Mechanism of Belt and Road Initiative
October 2023	China Electric Power Planning & Engineering Institute	Research on the Planning of the National Power System of Uzbekistan ¹⁷

¹⁵ 中国新闻网：司法部：“一带一路”律师联盟已覆盖 54 个国家和地区。2013. https://m.gmw.cn/2023-11/23/content_1303579803.htm

¹⁶ 中国经营网：鼓励创新允许试错 中国本土会计师事务所积极探索最佳适配的“走出去”模式。2023. <http://www.cb.com.cn/index/show/kx/cv/135348811551>

¹⁷ 电力头条：电规总院承担的乌兹别克斯坦国家电力系统规划研究工作启动。2023. <https://www.chinapower.org.cn/detail/413437.html>

Box 2 | Green Power System Planning Toolbox for Belt and Road Countries**Green Power System Planning Toolbox for Belt and Road Countries**

The toolbox consists of four modules: resource assessment, economic assessment, stability verification, and comprehensive energy analysis for new energy development. The new energy resource assessment module utilizes advanced analytical methodologies from the fields of economics, population dynamics, meteorology, environmental studies, and other relevant disciplines. Based on the analytic hierarchy process and multivariate analysis, it assists Belt and Road countries in obtaining more accurate key information such as the total amount of resource development, the amount of technology that can be developed, the layout of development, and the cost of power generation, as well as recommending appropriate areas and priorities for new energy development. The green power system production simulation and power market analysis module can systematically evaluate the rate of wind and solar power curtailment, the fluctuation in electricity prices, and the alteration in the operational mode of traditional units under various scenarios, and additionally obtain quantitative indicators to provide comprehensive decision-making guidance. The green power system security and stability analysis module fully considers the physical characteristics and control model of new energy. It performs power flow calculation, electromechanical transient analysis, and electromagnetic transient analysis for numerous scenarios of the power system, identifies the vulnerable points of the power system, and proposes relevant measures to ensure the safe and stable operation of the green power system when the new energy is connected to the grid on a large scale. Based on the open environment and multi-physical modeling, the integrated energy system's multi-physical modeling and simulation analysis module can accurately evaluate the dynamic process and economy of the integrated energy system, along with forming the scientific certification of the major integrated energy composition in power planning.

¹⁷ 电力头条：电规总院承担的乌兹别克斯坦国家电力系统规划研究工作启动。2023. <https://www.chinapower.org.cn/detail/413437.html>

Breakthrough 2

Low-carbon Demonstration Zone —Establishing Channels for Technology Diffusion

In the global industrial system, most developing countries largely function as suppliers of raw materials. The third chapter reveals that developing countries tend to prioritize the key minerals in the GPE value chain. Moreover, the one-way industrial structure of these nations obstructs the incorporation of low-carbon economy into their overall economic growth, ultimately preventing them from acquiring the necessary skills to independently develop RE. China has been a crucial contributor in supporting the development of manufacturing and RE technology in developing nations, leveraging its advantages in this field. In 2015, China introduced the "Ten-Hundred-Thousand" Initiative for China South-South Climate Cooperation. This effort comprises 10 low-carbon demonstration zones, 100 climate change mitigation and adaptation programs in developing countries, and 1000 climate training programs for representatives from developing nations. It is known as the "China's Solution" and aims to support other developing countries. The low-carbon demonstration zones is a crucial platform for the transfer and spread of technology to the host country. It will demonstrate Chinese technology while also stimulate the growth of the related industrial chain. It also can effectively stimulate the growth of the GPE application and manufacturing in the host country. By the end of 2023, China has established four low-carbon demonstration zones in various locations¹⁸, such as Africa and Southeast Asia. The demonstration zones have effectively adopted RE technology from China, while also fostering GPE manufacturing sector. This advancement has successfully facilitated the regional growth of the green economy.

The establishment of low-carbon demonstration zones offers China an opportunity to synchronize its dedication to fulfilling the demand from other developing countries. The primary objective of this program is to facilitate structured cooperation between the government and private sectors, using the China-Laos Vientiane Saysettha Development Zone as a model. This project, backed by the

¹⁸ 生态环境部网站：生态环境部举行 10 月例行新闻发布会。2023. http://www.scio.gov.cn/xwfb/bwxwfb/gbwfbh/sthjbj/202310/t20231030_777046.html

governments of China and Laos. is executed by a joint venture between Yunnan Construction and Investment Group and the Laos Vientiane Municipal Government, who contribute shared financing for the project. Yunnan Development and Investment Group is a state-owned company located in Yunnan Province, China. It specializes in the development of industrial parks and has a strong regional presence. After completing its construction, Solarspace, a Chinese firm specializing in photostatic module, decided to establish its factory in the demonstration zone. The company intends to build high-efficiency modules with a total capacity of 7GW. The implementation of low-carbon demonstration zones in Laos has successfully catalyzed the expansion of low-carbon businesses, leading to a significant ripple effect.

Box 3 | China-Laos Vientiane Saysettha Comprehensive Development Zone

China-Laos Vientiane Saysettha Comprehensive Development Zone



China has provided Laos with new energy buses.
Photo credit: Vientiane Saysettha Development Zone

The construction of low-carbon demonstration zones was officially initiated by the Ministry of Ecology and Environment of China and the Ministry of Natural Resources and Environment of Laos in July 2020. During the previous two years, the Chinese and Lao teams collaborated to overcome the negative impacts of the COVID-19 pandemic. They successfully devised and executed a comprehensive plan for the low-carbon demonstration zone, while also proposing recommendations for the development objectives,

strategies, primary tasks, and key projects in the low-carbon demonstration zone. All 12 newly acquired energy buses, 8 energy trucks, and 8 environmental law enforcement vehicles donated by China to Laos have been successfully installed and delivered to Laos, fully prepared for immediate use. Three new fixed bus routes were formally launched in Vientiane City, contributing to the city's efforts to create a low-carbon urban setting.

Table 8 | Low-carbon demonstration zones

Cooperating Countries	Name of Low-carbon Demonstration Zone	Construction Status	Demonstration Technology	Types of Green Power Equipment Industry Being Introduced
Laos	Vientiane Saysettha Development Zone	Completed	New energy bus, new energy truck, photovoltaic lighting	High Efficiency Battery Project with a Capacity of 7 GW by Solarspace ¹⁹
Cambodia	Low-carbon Demonstration Zone in Sihanoukville Province	Completed	Photovoltaic power generation, photovoltaic lighting, electric motorcycle	Solar Long PV Tech ²⁰
Seychelles	Low-carbon Demonstration Zone in Seychelles	Under construction	Photovoltaic power generation, building energy conservation, photovoltaic lighting, photovoltaic car shed, photovoltaic storage system, electric bicycle	-
Papua New Guinea	Tarim Low Carbon Demonstration Zone	In planning	Photovoltaic storage system, photovoltaic lighting	-

Breakthrough 3

Green Panda Bonds

-Breaking the Bottlenecks of International Investments

International investments in RE projects frequently span the spectrum from tens to hundreds of millions of US dollars, or tens to hundreds of megawatts on average. Although this type of undertaking

¹⁹ 云南省国资委：合作标杆！万象赛色塔综合开发区开创老挝多个第一。2023. <http://www.sasac.gov.cn/n2588025/n2588129/c27749761/content.html>
²⁰ 中国新闻网广西：柬埔寨副首相考察西港特区建设：欢迎世界各国投资者。2023. <http://www.gx.chinanews.com.cn/dmjj/2023-09-12/detail-ihctaqav0074646.shtml>

may not be as big as a traditional energy endeavor, it nonetheless necessitates a significant infusion of financial resources. Obtaining cheap financing sources is critical for the project's implementation. However, Chinese RE investor have historically encountered obstacles when attempting for project investments on account of constraints in their financial channels. Chinese financial institutions, such as the Industrial and Commercial Bank of China, Export-Import Bank of China, and the China Development Bank, comprise the majority of the funding sources. However, the stringent requirements for obtaining concession loans with lower financing costs pose a significant challenge, in regard to the assessment and authorization procedure. On the other hand, other Chinese commercial banks face significant challenges in obtaining foreign currency, and as a result, they charge interest rates 1% to 2% higher than those provided by their international rivals²¹. Currency exchange risk is another major risk in cross-border RE investments. Although several nations have implemented the strategy of pricing RE power in USD or Euro to attract foreign investment, RMB pricing is uncommon. This poses a substantial challenge for Chinese investors, as they predominantly depend on RMB for international investments.

The accelerated growth of the Panda Bond over the previous two years has marked a turning point. International multilateral financial institutions, sovereign governments, and overseas development enterprises have issued panda bonds with sustainable labels, with a significant portion of the proceeds going to RE projects. The issuing of green panda bonds would not only lower the cost of financing but also spark the appetite of Chinese investors. For instance, China Power International Development Limited, a Hong Kong-listed power company and an international low-carbon energy investment platform of its parent company China Power Investment Group (one of China's five major power groups), has issued two panda bonds since 2023, all of which are used for clean energy projects overseas. Over the past two years, the company has been extremely active in the overseas RE investments, with deals in Bangladesh, Kazakhstan and Hungary etc.

²¹ 中国发展观察：政策性开发性金融促进构建双循环新发展格局的机理与路径。2022. <https://cdo.developpress.com/?p=13531>

Table 9 | Green panda bonds issued in China

Issue Time	Issuer	Amount/Coupon Rate	Sustainable Label	Use of fund
May 2022	New Development Bank	RMB 8.5 billion/2.70%	-	For financing infrastructure and sustainable development projects in member countries, including RE
November 2022	Hungary	RMB 2 billion/3.75%	Green bond	For eligible green expenditures under the Hungarian Green Bond Framework, including RE
February 2023	China Power International Development Limited	RMB 800 million/3.29%	Green bond	For the Kazakhstan's Clean Energy Project
November 2023	Egypt	RMB 3.5 billion/-	Sustainability-linked Bond	For supporting Egypt's inclusive growth and green development goals, including RE
November 2023	China Power International Development Limited	RMB 1.2 billion/2.99%	Green bond	For overseas clean energy projects

Box 4 | Panda Bonds**Panda Bonds**

Panda Bonds are RMB priced bonds and issued by foreign institutions in China. Panda Bond issuers are classified into four categories, foreign governments, international development institutions, overseas financial institutions, and overseas non-financial enterprises. Statistics indicate that as of November 2023, a total of 90 panda bonds were issued, amounting to 149.55 billion yuan. This represents an impressive rise of approximately 76% compared to the corresponding period in 2022, or roughly 1.75 times the size of the issuance from the previous year. Panda bonds can be categorized into three main types based on their various applications: green bonds, BRI construction bonds, and general panda bonds. The funds generated through the issuance of Green Panda Bonds are allocated towards sustainable development and infrastructure initiatives as specified in the Green Bond Endorsed Project Catalogue, in adherence to the Green Bond Principles.



5

The Next Phase: "Small yet Beautiful" Approach

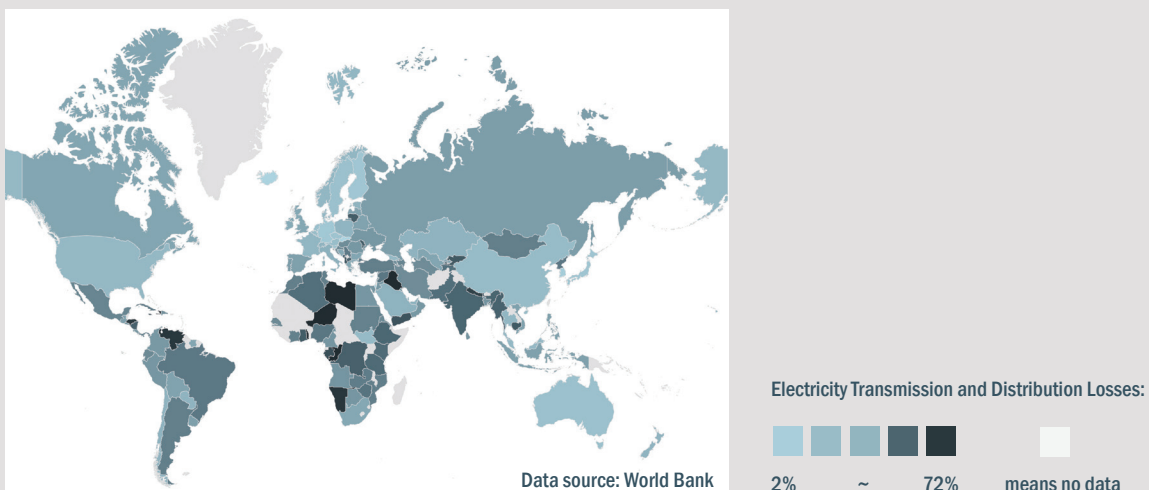
The preceding chapters discuss the RE development model that prioritizes the utility-scale projects need to be integrated into the power grid. The installed capacity of such RE projects generally varies between tens and hundreds of megawatts. Although the scale of the projects is significantly smaller in comparison with traditional

Box 5 | Electricity Transmission and Distribution Loss

Electricity Transmission and Distribution Loss

The electricity transmission and distribution loss is a crucial indicator to evaluate the stability of the power grid. The loss ranging from 5% to 7% is considered the standard range. Except for developed countries and a few industrialized countries, most developing countries have greatly surpassed this standard. This is primarily due to long-term disregard and inadequate management of their power grid. For instance, Ghana saw electricity transmission and distribution losses of up to 23%, while Iraq faced losses as high as 51%.

Figure 21 | Global power transmission and distribution loss



fossil energy, the investment and development model still adhere to the capital-intensive mode with lengthier development cycle and a greater financing barriers. Numerous developing nations struggling with substantial power shortages are unable to rely solely on this model, as it should be based on a resilient, however expensive, grid infrastructure that can effectively accommodate RE sources, especially in regards to the management of the volatile nature of wind and solar power. Huge investment need to be poured into technological improvement of power infrastructure, including some cutting edge technologies like super high-voltage transmission line, smart grid and utility-scale power storage. Unfortunately, the application of such technologies in developing countries is generally lagging behind (refer to box 4). It is unrealistic for most developing countries to independently enhance the power grid infrastructure in a short time.



5.1 "Small yet Beautiful" RE Development Model

Due to the lack of adequate power infrastructure, people in developing nations are expediting the rooftop photovoltaic systems and other small-scale RE projects to solve the urgent problem of power shortages. As a result, there has been a significant surge in the exports of such equipment from China since 2020. Recognizing this trend, Chinese policymakers have introduced a novel approach known as the "Small yet Beautiful" development mode since 2021. China made its intention at the Third Belt and Road Forum for International Cooperation in 2023 that to balance the implementation of landmark projects with "Small yet Beautiful" ones and to implement 1000 small-scale projects to enhance welfare of livelihood, It is expected that China will extend official development assistance to a greater number of small-scale RE sets in the future. It will support developing nations in their endeavor to explore a self-sufficient energy development model.

How small

In contrast to large projects that require higher development barriers, small projects can be installed and managed by their energy users. These projects offer greater flexibility in design, allowing them to cater to various scenarios and promptly address the power demand of households as well as industrial and commercial users in. By assembling solar panels, inverters, and lithium batteries, individuals are able to constitute a household-level power system by themselves. Larger energy users, such as industrial parks or schools, could establish a power system contains rooftop solar, small wind, heat pumps and battery stations etc. To further apply mini-grid and hydrogen-making facilities, decentralized RE sets could be further grouped up and could provide a resilient and customized power supply for various end users. This will be a bottom-up approach of energy development driven by demand-side and it will be more feasible in developing countries without a sophisticated top-down power infrastructure.

How beautiful

Embracing the ethos of “Small yet Beautiful” development models holds the potential to yield invaluable intangible assets for societal advancement. These intangible assets serve as indispensable facilitators in the evolution of power hardware. Specifically, programs such as skill-building workshop and entrepreneurship competition will play a pivotal role to empower local communities in energy development by their own hands. Numerous civil society entities will back the hosting of such programs, with spanning media outlets, think tanks and non-governmental organizations. The impact extends beyond RE development, it will also disseminate China's unique experiences and foster deep, empathetic connections across all levels of society. These "beautiful" aspects will assist developing nations in charting their own course towards independent energy development.

The "Small yet Beautiful" model serves as not only a means for China to detect and address gaps in overseas market but also a novel approach, which emphasis the independence and self-sufficiency, for developing countries in building of their own energy systems. Furthermore, it will also promote a shift in the overall economic development paradigm. China, as the largest developing country globally, will act as the primary driving force behind this novel approach.

5.2 Suggestions for Commercializing "Small yet Beautiful" Approach

Besides official development assistance, the "Small yet Beautiful" model need to develop a profound business model. However, it remains an area that Chinese entities unwilling to explore. The biggest problem is the significant information asymmetry of "Small yet Beautiful" projects, leading to higher transaction costs than large-scale projects. To address this challenge all the stakeholders, including policymakers, financial institutions, engineering contractors, power investment enterprises, equipment manufacturing enterprises, consulting service agencies, civil society organizations, and small and medium enterprises, need to adjust their operating models and cooperate to overcome the bottlenecks of this new model. Based on the study in this report, we propose the following suggestions on the key aspects in regard to amplify “Small yet Beautiful” model:

Navigate Chinese Flagship Financial Institutions

China announced an additional \$100 billion in financing to the flagship financial institutions (FFIs), including the China Development Bank, the Export-Import Bank of China, and the Silk Road Fund, in 2023, during the third Belt and Road Forum. Throughout the past 10 years, Chinese enterprises have placed significant reliance on these FFIs as the principal sources of financing in overseas markets. As a result of these institutions' irreplaceable status, their loan policies also strongly impact the selection of projects in the early phase. Therefore, it is crucial that FFIs could incorporate provisions for "Small yet Beautiful" projects into their policies and strategies. Additionally, FFIs may also collaborate with local partners in host countries, who are capable of identifying dispersed, small-scale RE projects and target clients through the local channels. FFIs could enhance the liquidity of such assets through refinancing, which will, in turn, enhance enthusiasm of RE developers for "Small yet Beautiful" projects.

Connect with International Climate Funds

The 28th Conference of the Parties to the UNFCCC further advocated for the expansion of globe climate funds, including the Loss and Damage Fund and the Least Developed Countries Fund, which provide assistance to developing nations. Simultaneously, there is a substantial expansion of alternative climate funds that are overseen by charitable foundations, international organizations, and multilateral financial institutions. A considerable proportion of the funds are allocated towards fostering the growth of RE in developing nations, with a subset specifically designated to provide assistance for mini-grids and distributed RE in countries struggling with power scarcities (refer to Appendix 3). The suggestion for those funds is that they should open more channels for Chinese entities and work together to explore innovative technologies and business models in developing countries.

Innovate on “RE+” Solutions

At present, global RE market is full with sophisticated technical solutions and business models that have been developed predominantly for industrialized countries with firmly established power infrastructure. Nevertheless, these may not correspond with the real demands prevalent in developing nations. Consequently, manufacturers should design more modular and “RE+” solutions that are more suitable for developing countries. Examples of such solutions include solar+charging stations, solar+cold storage, solar+air conditioning, and wind+heating. These “RE+” solutions specifically target the particular demand in the scene. It is a two way street where end users and other stakeholders in the host country identify their demand, prompting upstream manufacturers to

Support Civil Entities to “Go Global”

The "Small yet Beautiful" model greatly benefits from the help of civil entities. This not only strengthens connections on energy transition issues between countries, but also enables businesses to establish close relationship with local communities, thereby mitigating potential social conflict risks when doing business. Chinese enterprises and financial institutions venturing abroad should enhance cooperation with civil groups, by providing platforms at various forums, seminars, or exhibitions, and by establishing regular communication channels with these organizations in overseas operation. These measures will help those companies better manage risks and seize more opportunities for high-quality growth in overseas market.

5.3 Examples of Chinese Civil Entities “Going Global”

In the array of "Small yet Beautiful" projects initiated by China, vocational education stands out as a significant focal point. In this area, there are both “going global” programs like Luban Workshop and “bring in” programs like Philippines Next Generation RE Students. Those vocational education programs lays the groundwork for exploring "Small yet Beautiful" model of RE development.

Additionally, this sector is drawing increased participation from small and medium-sized enterprises

and civil society organizations, resulting in positive social impacts.

Luban Workshop

Luban Workshop is a vocational education brand that local governments and vocational education institutions in China collaboratively promote. It is an international institution that implements academic education and technical training using the Sino-foreign cooperative teaching style. There are two specialized "Luban Workshops" that focus on new energy education. One is founded by the Chennai Institute of Technology in India, while the other is established by Ain Shams University in Egypt²². Chinese-funded enterprises, such as Hanergy Thin Film Power Group, located in the Suez Economic and Trade Cooperation Zone, have played an active role in developing the Luban Workshop in Egypt. They have contributed to the establishment of the talent training program and proposed employment standards. Additionally, these enterprises have signed a memorandum of cooperation between schools and Luban Workshop and have utilized their factories as training bases for students. It has provided training for local technicians and skilled workers to meet the employment requirements of Chinese-funded businesses in Egypt²³.



Experimental device for new energy at the Luban Workshop in Egypt.
Photo credit: Xinhua News Agency

²² 马思宁, 沈洁, 姚高等. 基于“鲁班工坊”建设推进新能源专业课程体系优化 [J]. 中国多媒体与网络教学学报 (中旬刊), 2020(12):60-62+65.

²³ 王娟. 埃及鲁班工坊: 打造中高职贯通体系 [J]. 中国投资 (中英文), 2021(22): 106-108.

Philippines Next Generation RE Students

People of Asia for Climate Solutions (PACS) and three other organizations have chosen 18 high school graduates from the Philippines to go to Jiuquan, China. These students will undergo a three-year training program to become RE engineers, focusing on solar and wind energy. The training program is designed to provide them with in-depth knowledge and skills in the implementation of RE technology. Upon completion of the program, candidates will enter an internship in a RE power base at Jiuquan. This internship will allow them to enhance their proficiency in the required technical operations. While studying in China, Jiuquan Vocational and Technical College will offer full scholarships, living stipends, and housing. PACS is presently engaged in consultations with other Chinese institutions to facilitate the enrollment of further students from the Philippines and other countries. The objective is to enable these students to pursue studies of RE technology in China and promote China and the Belt and Road countries to expand their pool of green talents and collaboratively advance climate solutions.



Appendix

Appendix 1: The Conversion Criteria for Comparative Advantage Index and China Trade Relations Index

The five-point conversion criteria for Comparative Advantage Index:

0 point	Comparative Advantage Index, ranges from 0 to 0.1, including 0.1
1 point	Comparative Advantage Index, ranges from 0.1 to 0.5, including 0.5
2 point	Comparative Advantage Index, ranges from 0.5 to 1, including 1
3 point	Comparative Advantage Index, ranges from 1 to 5, including 5
4 point	Comparative Advantage Index, ranges from 5 to 10, including 10
5 point	Comparative Advantage Index, exceeds 10

The five-point conversion criteria for China Trade Relations Index:

0 point	China Trade Relations Index, ranges from 0% to 5%, including 5%
1 point	China Trade Relations Index, ranges from 5% to 20%, including 20%
2 point	China Trade Relations Index, ranges from 20% to 40%, including 40%
3 point	China Trade Relations Index, ranges from 40% to 60%, including 60%
4 point	China Trade Relations Index, ranges from 60% to 80%, including 80%
5 point	China Trade Relations Index, ranges from 80% to 100%

Appendix 2: GPE Value Chain Product List

HS Code	Product
841912	Solar water heaters
854142	Photovoltaic cells not assembled in modules or made up into panels
854143	Photovoltaic cells assembled in modules or made up into panels
854140	Photovoltaic cells(this code is used before 2021)
850231	Generating sets, wind-powered
841011	Hydraulic turbines and water wheels, of a power <= 1.000 kW (excl. hydraulic power engines and motors of heading 8412)
841012	Hydraulic turbines and water wheels, of a power > 1.000 kW but <= 10.000 kW (excl. hydraulic power engines and motors of heading 8412)
841013	Hydraulic turbines and water wheels, of a power <= 1.000 kW (excl. hydraulic power engines and motors of heading 8412)
841090	Parts of hydraulic turbines and water wheels incl. regulators
850421	Liquid dielectric transformers, having a power handling capacity <= 650 kVA
850422	Liquid dielectric transformers, having a power handling capacity > 650 kVA but <= 10.000 kVA
850423	Liquid dielectric transformers, having a power handling capacity > 10.000 kVA
850431	Transformers having a power handling capacity <= 1 kVA (excl. liquid dielectric transformers)
850432	Transformers, having a power handling capacity > 1 kVA but <= 16 kVA (excl. liquid dielectric transformers)
850433	Transformers having a power handling capacity > 16 kVA but <= 500 kVA (excl. liquid dielectric transformers)
850434	Transformers having a power handling capacity > 500 kVA (excl. liquid dielectric transformers)
850760	Lithium-ion accumulators (excl. spent)
850440	Static converters
870380	Motor cars and other motor vehicles principally designed for the transport of <10 persons, incl. station wagons and racing cars, with only electric motor for propulsion (excl. vehicles for travelling on snow and other specially designed vehicles of subheading 870310)
870240	Motor vehicles for the transport of >= 10 persons, incl. driver, with only electric motor for propulsion
854330	Machines and apparatus for electroplating, electrolysis or electrophoresis
841861	Heat pumps (excl. air conditioning machines of heading 8415)
854460	Electric conductors, for a voltage > 1.000 V, insulated, n.e.s.

HS Code	Product
280410	Hydrogen
260300	Copper ores and concentrates
283691	Lithium carbonates
284190	Salts of oxometallic or peroxometallic acids (excl. chromates, dichromates, peroxochromates, manganites, manganates, permanganates, molybdates and tungstates "wolframamtes")
260500	Cobalt ores and concentrates
260400	Nickel ores and concentrates

Appendix 3: Programs of Global Climate Funds to Support Developing Countries

Program Name	Target Country	Target Technical Area	Implementation Institution	Approved Year	Fund Value (million USD)
Scaling Up Renewable Energy Program (SREP)	India	Scaling Up Renewable Energy Program (SREP)	ADB	2022	0.55
Scaling Up Renewable Energy Program (SREP)	Multi-country (India, Myanmar, Bangladesh)	TAF: Fast tracking the Global Green Recovery Agenda through institutional support for the "OSOWG" initiative - India, Myanmar, and Bangladesh	IBRD	2022	0.65
Scaling Up Renewable Energy Program (SREP)	Pakistan	Scaling Up Renewable Energy Program (SREP)	ADB	2022	0.57
Pilot Program for Climate Resilience (PPCR)	Grenada	TAF: Accelerating Renewable and Energy Efficiency Development in Grenada's Electricity Sector	IBRD	2022	0.35
Pilot Program for Climate Resilience (PPCR)	Mexico	BDRP: Battery Storage Pilot to Improve Power Grid Climate Resilience	IFC	2021	4.3
Pilot Program for Climate Resilience (PPCR)	Multi-country (Kazakhstan, Uzbekistan)	TAF: Sustainable and Inclusive Green Acceleration (SAIGA) Program - Kazakhstan, Uzbekistan	EBRD	2021	1.85
Green Climate Fund (GCF-1)	India	(FP164) Green Growth Equity Fund	FMO	2021	137
Green Climate Fund (GCF-1)	Global (Ghana, Nigeria, Tunisia, Kenya, Ethiopia, Guinea)	(FP168) Leveraging Energy Access Finance (LEAF) Framework	AfDB	2021	170.9
Green Climate Fund (GCF-1)	Global (Botswana, CAR, DRC, Kenya, Congo Rep, Mali, Namibia, Uzbekistan)	(FP163) Sustainable Renewables Risk Mitigation Initiative (SRMI) Facility	World Bank	2021	280
Global Environment Facility (GEF7)	Pakistan	Combating Climate Change through the Promotion and Application of Sustainable Biomass Energy Technologies in Pakistan (PASBET)	UNDP	2021	3.44
Global Environment Facility (GEF7)	Benin	Benin National Child Project under the GEF Africa Minigrids Program	UNDP	2021	1.33
Global Environment Facility (GEF7)	Burkina Faso	National child project under the GEF Africa Minigrids Program Burkina Faso	UNDP	2021	0.92
Global Environment Facility (GEF7)	Comoros	National child project under the GEF Africa Minigrids Program Comoros	UNDP	2021	1.27
Global Environment Facility (GEF7)	Djibouti	National child project under the GEF Africa Minigrids Program Djibouti	UNDP	2021	3.07
Global Environment Facility (GEF7)	Eswatini	National child project under the GEF Africa Minigrids Program Eswatini	UNDP	2021	0.86

Program Name	Target Country	Target Technical Area	Implementation Institution	Approved Year	Fund Value (million USD)
Global Environment Facility (GEF7)	Ethiopia	National child project under the GEF Africa Mini-grids Program Ethiopia	UNDP	2021	2.89
Global Environment Facility (GEF7)	Global	Green Hydrogen Support in Developing Countries	World Bank	2022	1.7
Global Environment Facility (GEF7)	Malawi	National child project under the GEF Africa Mini-grids Program Malawi	UNDP	2021	0.4
Global Environment Facility (GEF7)	Mali	Mali national child project under the Africa Minigrids Program	UNDP	2021	1.78
Global Environment Facility (GEF7)	Niger	Niger National Child Project under the GEF Africa Minigrids Program	UNDP	2021	1.6
Global Environment Facility (GEF7)	Nigeria	National child project under the GEF Africa Mini-grids Program Nigeria	UNDP	2021	5.91
Global Environment Facility (GEF7)	Regional - Sub-Saharan Africa	GEF-7 Africa Minigrids Program II	UNDP	2022	0.87
Global Environment Facility (GEF7)	Regional - Sub-Saharan Africa	Regional Child Project under the GEF Africa Mini-grids Program	UNDP	2021	3.53
Global Environment Facility (GEF7)	Sao Tome and Principe	São Tomé and Príncipe national child project under the Africa Minigrids Program	UNDP	2021	1.97
Global Environment Facility (GEF7)	Somalia	National child project under the GEF Africa Mini-grids Program Somalia	UNDP	2022	3.28
Global Environment Facility (GEF7)	St. Kitts and Nevis	Achieving a rapid decarbonization of the energy sector in Saint Kitts and Nevis	UNDP	2021	3.32
Global Environment Facility (GEF7)	Sudan	National child project under the GEF Africa Mini-grids Program Somalia	UNDP	2022	2.64
Global Environment Facility (GEF7)	Tuvalu	Increasing Access to Renewable Energy in Tuvalu	ADB	2021	2.75
Global Environment Facility (GEF7)	Vietnam	Accelerating low-carbon circular economy through cleantech innovation towards sustainable development in Viet Nam	UNIDO	2021	1.74
Global Environment Facility (GEF7)	Zambia	Zambia National Child Project under the GEF Africa Minigrids Program	UNDP	2022	1.36
Clean Technology Fund (CTF)	Bangladesh	GESP : Electricity Distribution Modernization Program	IBRD	2022	15.35
Clean Technology Fund (CTF)	Brazil	GESP: Battery Energy Storage Systems (BESS) to Increase the Reliability of Energy Systems in Brazil	IADB	2022	16.15
Clean Technology Fund (CTF)	Colombia	GESP: Promoting the Energy Transition from Hydrocarbons to Green Hydrogen for Power Generation and Storage	IADB	2021	9.8

Program Name	Target Country	Target Technical Area	Implementation Institution	Approved Year	Fund Value (million USD)
Clean Technology Fund (CTF)	Egypt	DPSP III Futures Window: Green Hydrogen Financing Facility	EBRD	2022	30
Clean Technology Fund (CTF)	Haiti	GESP: Battery Energy Storage System to maximize the use of surplus energy from a solar photovoltaic plant located in the Caracol Industrial Park of Haiti	IADB	2022	3.15
Clean Technology Fund (CTF)	Honduras	GESP: Innovative Energy Solutions for Health Service Delivery in Honduras	IADB	2021	0.53
Clean Technology Fund (CTF)	Honduras	GESP : Green Hydrogen Production and Commercialization Assessment in Honduras	IADB	2021	0.6
Clean Technology Fund (CTF)	Indonesia	GESP : Indonesia Sustainable Least-Cost Electrification (ISLE) Project	IBRD	2021	17
Clean Technology Fund (CTF)	Maldives	GESP: Accelerating Sustainable System Development Using Renewable Energy (ASSURE) Project	ADB	2022	15
Clean Technology Fund (CTF)	South Africa	GESP: Renewable Energy Grid Integration Program	IFC	2021	30
Clean Technology Fund (CTF)	Vietnam	GESP : Renewable Energy Accelerating Change (REACH) Project	IBRD	2021	26



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