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BRI and Carbon Pricing Mechanism

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In April 2019, Chinese and international partners officially launched the BRI International Green Development Coalition (BRIGC) at the Second Belt and Road Forums for International Cooperation. BRIGC aims to establish a policy dialogue and communication platform, an environmental knowledge and information platform, and a green technology exchange and transfer platform, so as to advance global consensus, understanding, cooperation, and action of a green Belt and Road Initiative (BRI).

The international community is actively cooperating to address climate change, and the carbon pricing mechanism is developing rapidly. It is of practical importance to study the significance and feasibility of establishing carbon markets in major countries and regions of the "Belt and Road" initiative (BRI). This study investigates in detail on the development status of the global carbon market and the status quo of major countries and regions of BRI. Based on the FASTER principle required for the carbon pricing mechanism proposed by the World Bank, 6 major indicators are selected to qualitatively analyze the feasibility of establishing carbon market in the major countries and regions of BRI. Based on the China-Global Energy Economic Model, a quantitative analysis is carried out on the impact of the construction of carbon markets on their GDP, residents' welfare, industrial development, etc. in major countries and regions of BRI. Moreover, targeted policy suggestions are proposed.

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TABLE OF CONTENTS

1. INTRODUCTION.....3

2. CHINA AND INTERNATIONAL CARBON MARKET.....3

2.1 Current status of China's national carbon market development..... 3

2.2 International Carbon Market Developments..... 5

2.3 Development of international carbon market cooperation..... 9

3. CURRENT SITUATION IN MAJOR BRI COUNTRIES AND REGIONS..... 12

3.1 Socioeconomic development and emissions in major BRI countries and regions.....12

3.2 Energy Saving Policies, Emissions Reduction Policies, and Carbon Pricing Mechanisms.. 14

4. IMPLEMENT FEASIBILITY ANALYSIS OF CARBON MARKET IN MAJOR BRI COUNTRIES AND REGIONS..... 26

4.1 Public Sector Administrative Performance and Quality.....28

4.2 Degree of corporate information disclosure..... 28

4.3 Market completeness..... 30

4.4 Degree of law-based governance..... 31

4.5 Government Willingness..... 31

4.6 Degree of Corporate Engagement..... 32

4.7 Brief summary..... 32

5. QUANTITATIVE ANALYSIS OF THE IMPACTS OF ESTABLISHING CARBON MARKETS IN MAJOR COUNTRIES AND REGIONS ALONG THE "BELT AND ROAD"..... 35

5.1 Scenario design..... 35

5.2. Result analysis.....36

6. CONCLUSIONS AND POLICY RECOMMENDATIONS..... 42

REFERENCES：.....45

Executive Summary

Faced with the unprecedented urgency of global climate change, the international community has been actively cooperating to address the climate change issue, and the carbon pricing mechanism, such as the carbon market, is developing rapidly. Therefore, it is relevant to study the significance and feasibility of establishing a carbon market in the major countries and regions of BRI (Southeast Asia, Russia, South Korea, Middle East, Africa, South Africa).

First of all, this research conducted a detailed investigation of the current development in China and the international carbon markets from different aspects likes socio-economic development, emission status, energy conservation and emission reduction policies, and carbon pricing mechanisms of major countries and regions of BRI.

Secondly, a qualitative analysis was conducted to study the feasibility of establishing carbon markets in major countries and regions of BRI. The World Bank has established the FASTER principle, namely the six principles required to establish a successful carbon pricing mechanism: fairness, consistency of policies and objectives, stability and predictability, transparency, efficiency and cost-effectiveness, and reliability and environmental integrity. This study selects six indicators for the analysis: the average value of the public sectors and institution clusters, the ease of doing business index, and the degree of corporate information disclosure index issued by the World Bank, the rule of law index issued by the "Global Justice Project", whether the policy documents in these countries mention the domestic and international carbon markets, and corporate participation released by the "Global Environmental Information Research Center". The results show that China, South Korea, the European Union, and the United States have the most developed foundation for establishing domestic carbon markets; Russia, Southeast Asia, and South Africa have relatively well-established conditions for carbon markets while the Middle East and Africa are less feasible to establish domestic carbon markets.

Finally, this study conducts a quantitative analysis of the impact of the implementation carbon markets in major countries and regions of BRI. With the 2020 to 2035 set as the target year, this study designs a reference scenario, a non-linked carbon market scenario, a BRI major country linkage carbon market scenario, and a BRI major countries linkage with Europe and the United States carbon market scenario. With these four scenarios, this study utilizes the China-Global energy-economic model to conduct a simulation analysis. Carbon prices are utilized to reflect the marginal emission reduction costs of each country, there is difference between each country's carbon emission reduction costs when meeting the NDC emission reduction commitment target. Linkage through regional carbon markets will help reduce overall global emission reduction costs but will have an asymmetrical impact on countries' GDP, residents' welfare, and industrial development. Establishing carbon market linkages is also conducive to reducing the overall emission reduction costs of BRI countries on a larger scale.

This analysis recommends: 1) China's green and low-carbon transition urgently needs acceleration of the construction of a unified national carbon market; 2) BRI countries need to join hands with China on the path of low-carbon development and take the lead in establishing a carbon market in

the power sector; 3) China need to be prudent, tighten the investment and strengthen the environmental management in coal power projects in BRI regions; 4) Establishing carbon market funds to support the establishment of carbon markets in BRI countries; 5) Promote the BRI countries' broad and in-depth cooperation on carbon market, and accelerate the construction of disciplines and training of talents related to climate change and carbon markets; 6) After the operation of China's national carbon market is relatively mature, gradually explore different types of BRI carbon market linkage and cooperation methods.

1. Introduction

The Belt and Road Initiative (BRI) is not only about economic prosperity, but also about green development. The BRI, proposed by China's President Xi Jinping in 2013, has received positive responses from all parties. As at the end of January 2020, China had entered into roughly 200 documents on BRI cooperation with 138 countries and 30 international organizations. In the construction of the Belt and Road, President Xi stated that "Using green as the base color". Under this initiative, China's Ministry of Ecology and Environment (MEE), along with its partners home and abroad, launched the International Coalition for Green Development on the Belt and Road (the Coalition), with a view to promoting the building of a consensus on green development among countries and regions along the Belt and Road as well as advancing sustainable development of these countries and regions.

Global climate change is more urgent than ever, and deep cuts in greenhouse gas (GHG) emissions brook no delay. Climate system change, mainly characterized by global warming, rising sea levels and more intense extreme weather events, is worsening, which has become one of the greatest challenges facing human survival and development. In 2018, global fossil fuel combustion CO_2 emissions reached 33.2 billion , approximately 2.4 times the 1971 level.

The international community is making concerted efforts to combat climate change, with carbon pricing mechanisms represented by carbon markets evolving rapidly. The Paris Agreement, concluded in December 2015 and entered into force in November 2016, marks a new stage of global cooperation on climate change.. According to Article 6 of the Paris Agreement, countries are encouraged to achieve their nationally determined contributions (NDCs) under the Agreement by means of international cooperation, e.g., international carbon markets. As of 2019, more than 46 countries had signed 58 carbon pricing initiatives, covering 20% of global GHG emissions, or 11GtCO_2e. With increasingly severe climate change, the scarcity of carbon emission permits is more prominent and ensuring efficient allocation of production factors emitting carbon emissions through the market mechanism for carbon trading becomes a key part of the global response to climate change and international cooperation and competition on low-carbon development.

China has always been an active participant in the global response to climate change. In terms of domestic action, China has shown to be committed to a green and low carbon transition. In September 2020, President Xi Jinping addressed the 75th United Nations General Assembly and announced that China would strengthen its nationally determined contributions (NDCs) and adopt vigorous climate policies and measures. Specifically, China aims to have its CO_2 emissions peak before 2030 and to achieve carbon neutrality before 2060. In terms of international action, China is also actively supporting other countries' efforts to address climate change through investment and technological support. Since 2011, the Chinese government has allocated more than 700 million RMB (about 100 million USD) to help developing countries address climate change through energy-saving and low-carbon projects, as well as organizing capacity-building activities. In this context, it is necessary to study both the significance and feasibility of establishing interlinked carbon markets in major Belt and Road Initiative (BRI) countries and regions (namely Southeast Asia,

Russia, South Korea, the Middle East, and Africa), which will provide China with the key infrastructure needed to support BRI countries in addressing climate change.

The Report consists of six chapters, with its research contents and structure shown in Figure 1; this Report sums up the status of socioeconomic development and carbon emissions in major BRI countries and regions, and contains both qualitative and quantitative analysis of the feasibility of establishing carbon markets in these countries and regions.

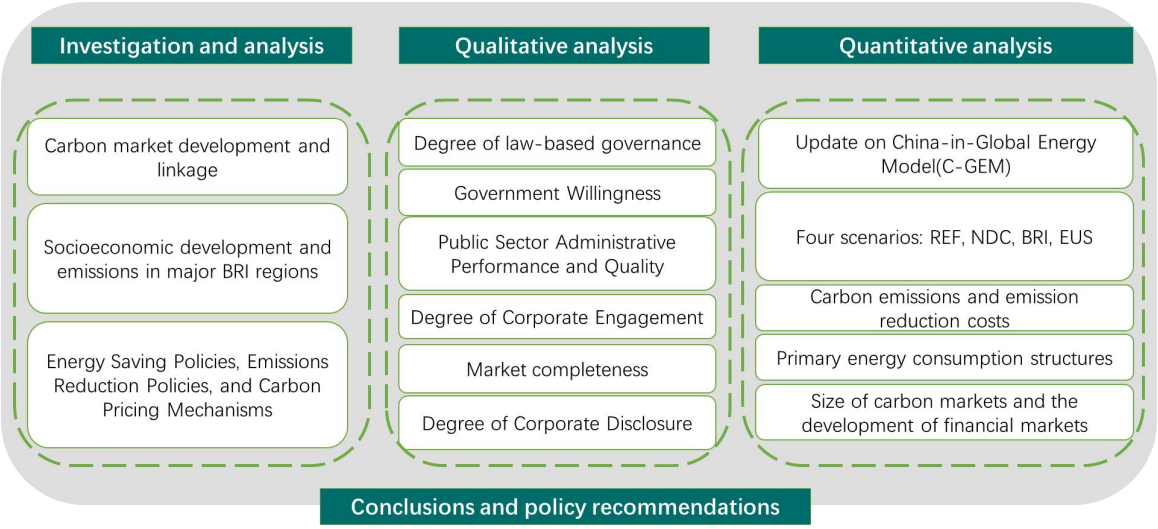


Figure 1 Research contents and structure

2. China and international carbon market

An emissions trading system (ETS), also known as a carbon market, is a market-based policy tool to achieve greenhouse gas (GHG) emission reduction targets at a minimal overall cost [1]. ETS policies are designed with a principle of "cap and trade," which means that the government shall set a “cap,” or maximum, on the total amount of carbon emissions allowed for enterprises in advance based on the government’s overall GHG reduction target. "Allowance trading" occurs based on the requirement that entities participating in the ETS must either purchase a certain amount of carbon allowances from the market to accommodate their individual emissions cap set by the government, or face a penalty. Alternatively, companies can sell their excess emission allowances on the market and earn revenue if they can cut emission below their individual cap [2]. Emissions trading can deliver long-term price signals to the market, which also helps companies conduct better planning and investment in low-carbon technologies, as well as accelerates their transition to a green and low-carbon trajectory.

2.1 Current status of China's national carbon market development

In recent years, the Chinese government has made active efforts to curtail energy consumption and reduce carbon dioxide emissions. In 2009, before the Copenhagen Climate Change Conference, China proposed cutting carbon dioxide emissions per unit of GDP by 40 to 45% by 2020 compared to 2005, with non-fossil fuel energy sources accounting for 15% of China’s total energy consumption [3]. The “12th Five-Year Plan (2011-2015) for National Economic and Social Development” proposed to reduce energy consumption per unit of GDP by 16% and carbon dioxide emissions per unit of GDP by 17% by 2015 compared to 2010 [4]. In 2014, China and the United States jointly issued the U.S.-China Joint Presidential Statement on Climate Change[5], in which China proposed to peak its carbon dioxide emissions by “around” 2030 and to aim to reach carbon peaking as soon as possible, while the proportion of energy from non-fossil fuel sources would reach 20% of China’s total energy by 2030 [5]. In 2015, China submitted its Intended Nationally Determined Contributions (INDCs) and further committed to reduce CO_2 emissions per unit of GDP by 60-65% by 2030 compared to 2005 [3].

To further reduce emissions, China has adopted a series of policy measures in the areas of energy efficiency, energy conservation and utilization, energy structure optimization, and low-carbon pilot projects. In this process, China has gradually shifted from primarily using “command and control” policies to using more market-based policy tools, and actively explored using a carbon market to help achieve its domestic carbon emissions control targets and international emissions mitigation commitments. The "gradual establishment of a carbon emissions trading market" was first proposed in the 12th Five-Year Plan. In the “Outline of the 12th Five-Year Plan for National Economic and Social Development” that was released in March 2011, it was further specified that China would establish a comprehensive GHG emission verification and accounting system, as well as gradually develop a carbon emissions trading market. In the latter half of 2011, the proposal of "launching carbon emissions trading pilot projects, establishing a voluntary emissions reduction mechanism, and promoting the construction of a carbon emissions trading market" was formally

announced, and the first five cities and two provinces to carry out pilot projects were identified, namely Beijing, Shanghai, Tianjin, Chongqing, Guangdong, Hubei, and Shenzhen. These local pilot projects aimed to accumulate practical experience and build a foundation for the construction and implementation of a national carbon emissions trading system. In 2013, the Third Plenary Session of the 18th the Communist Party of China central committee (CPC) passed the “Decision of the Central Committee of the Communist Party of China on Some Major Issues Concerning Comprehensively Deepening the Reform” The construction of a national carbon market became one of the key tasks of deepening reform, marking the official launch of the design of the national carbon market. In June 2013, the Shenzhen carbon trading pilot project was officially launched, becoming the first carbon emissions trading platform in China. After the launch of Chongqing's carbon trading pilot in June 2014, seven regional pilot trading platforms were established within the following year, and preparations for constructing the national carbon emissions trading system have also been launched successively. In December 2014, the National Development and Reform Commission (NDRC) issued the “China publishes two major policy drafts for national ETS,” laying a regulatory foundation for establishing a national carbon emissions trading system. In September 2015, China and the U.S. issued the U.S.-China Joint Presidential Statement on Climate Change, announcing that China would launch a national carbon emissions trading system in 2017.

Based on lessons learned from the design and operation of international carbon emissions trading systems, the seven pilot carbon emissions trading systems in China have each established their own legal foundations, clarified the system’s scope of coverage, determined the total amount of emission allowances in the system, formulated allowance allocation methods, and established emissions data accounting, reporting, and verification systems. Each element was designed based on the respective region's level of economic development, industrial and economic characteristics, statistical and accounting capacity, and other practical considerations, which has helped to continuously improve the design and operation of the systems.

In December 2017, China's national carbon emissions trading system were officially launched. It is predicted to become the world's largest carbon market. The Chinese government released the "The progress of China’s Carbon Market (Power Generation Industry)," which features the power generation industry as the starting point for carbon trading, and thus is expected to cover more than 1,700 enterprises and more than 3 billion of carbon dioxide emissions. According to the “Working Plan,” China’s national ETS will gradually include key emission entities from the petrochemicals, chemicals, building materials, steel, nonferrous metals, paper, and aviation industries with an energy consumption of more than 10,000 of standard coal (or an emissions total of more than 26,000 of carbon dioxide equivalent) in the future [6].

In 2018, the Department of Climate Change was placed under the Ministry of Ecology and Environment’s (MEE) supervision, and the responsibility for carbon market construction was also transferred from the National Development and Reform Commission (NDRC) to the MEE's Department of Climate Change. Since then, China's efforts to address climate change and environmental protection have been accelerated. This restructuring has also strengthened the legal foundation for carbon trading, relevant institutional rules, the system’s data management and

infrastructure, and initiatives for capacity building. In October 2019, the MEE organized a series of training courses on carbon market allowance allocation and management, while also adding special trainings to the curriculum on the interpretation of allowance allocation schemes, the operation of trading and registration systems, and compliance rules for key emission entities. The MEE also facilitated simulations for allowance calculation and carbon trading among the covered enterprises.

2.2 International Carbon Market Developments

As of April 2020, there are 28 emissions trading systems in operation worldwide, including those for one supranational organization, seven countries, and 28 localities such as cities, provinces, and states. The number of countries covered by the EU ETS is 31, with the EU as a supranational body. Aside from this, 3 jurisdictions are also currently planning to implement carbon markets: China, Germany, and Virginia. In addition, 17 other governments at different levels are considering implementing carbon markets as an important part of their climate policy, including Japan; Vietnam; Indonesia; Taiwan; Turkey; Ukraine; Chile, São Paulo and Rio de Janeiro in Brazil; Montenegro; Colombia; Manitoba, Ontario, and New Brunswick in Canada; and Oregon and Pennsylvania in the United States, as well as the Transportation and Climate Initiative (TCI), which is composed of nine U.S. states and Washington, D.C.

Global carbon markets have progressed rapidly over the past decade. Since the EU's ETS launch in 2005, GHG emissions covered by the ETS have grown from 2.1 billion of CO_2-eq. in 2005 to about 9 billion of CO_2-eq., roughly tripling from 5% to 17% of total global emissions [7].

In terms of the covered types of GHGs and included sectors, each region's ETS varies greatly. Emissions trading systems that cover the most sectors overall generally include power generation, manufacturing, construction, transportation, aviation, waste management, and forestry; systems that cover the least sectors overall generally only include power generation and/or manufacturing. All systems cover CO_2 as a greenhouse gas, but some systems cover up to seven greenhouse gas types (CO_2, CH4, N2O, HFCs, PFCs, SF6, and NF3). The features of major global carbon markets are shown in Table 1

.

Table 1: Comparison of major international carbon markets

Country/Region	Covered Industries	Types of Gases Covered	Total Emissions	Allowance Allocation	Offset Restrictions
European Union (EU) [8]	Power, Industrial, Aviation	CO_2、CH4、N2O、HFCs、PFCs、SF6	Phase I/II: Cap based on total NAP for each member country. Phase III/IV: Uniform cap setting applicable to the EU.	Phase I/II: Primarily free distribution based on grandfathering, with very few auctions. Phase III/IV: Mix of free and auction, gradually increasing proportion of auctions, free allowances are allocated by baseline method.	Phase I: No eligible offset credits. Phases II/III: Eligible to ERUs and CERs, limited to less than 50% of the total emission reductions (1.6 billion tonnes equivalent) during 2008-2020.
Switzerland [9]	Industrial	CO_2、N2O、PFCs	2008-2012: voluntary emission reductions. 2013-2020: 5.63 million tonnes in 2012 to 4.9 million tonnes in 2020, an annual decline of 1.74%.	Mix of free and auction, free allowances are allocated by baseline method.	Most projects are limited to credits originating from least developed countries (LDCs) or other countries, or from emission reductions achieved under the ERU mechanism prior to January 1, 2013.
California, United States [10]	Power, Industrial, Construction, Transportation	CO_2、CH4、N2O、HFCs、PFCs、SF6、NF3	2013: 163 million tonnes. 2014: 160 million tonnes, declining linearly at a rate of about 2%. 2015: 395 million tonnes. 2015-2020: Declining at a	Mix of free and auction, Large and growing percentage of auctions. Free allocation: Based on Output-based allocation (OBA), based on long-term procurement plans (power industry), based on historical data (natural gas industry).	The number of offset credits is generally limited to less than 8 % of the covered entity's total compliance; The number of industry-based offset credits is limited to less than 2% of total compliance by 2017 and less than 4%

			rate of about 3% per year.		between 2018 and 2020.
Quebec, Canada [9]	Power, Industrial, Construction, Transportation	CO_2、CH4、N2O、HFCs、PFCs、SF6、NF3	2013-2014: 23.2 million tonnes (per year). 2015: 65.3 million tonnes; 2016: 63.19 million tonnes; 2017: 61.08 million tonnes. 2018: 58.96 million tonnes; 2019: 56.85 million tonnes; 2020: 54.74 million tonnes.	Mix of free and auction, most allowances are allocated by auction and are increasing over time. Free allowances are allocated by baseline method.	The number of offset credits (domestic and international) is limited to less than 8% of each company's total compliance.
Regional Greenhouse Gas Initiative (RGGI) [11]	Power	CO_2	2009: 150 million tonnes (165 million short tonnes). 2014: 82.6 million tonnes (91 million short tonnes), with the 2012 initiative reform program revising the total to decline linearly at a rate of 2.5% per year.	Auction	Up to 3.3% of the total compliance of each company, although to date the system has not generated offset credits.
New Zealand [7]	Power, Industrial, Construction, Transportation, Aviation, Waste, Forestry	CO_2、CH4、N2O、HFCs、PFCs、SF6	2008–2015：Adopted emission cap based on Kyoto Protocol, no cap is set for domestic emission trading system	Mix of free and auction. However, the percentage of auctions is small; free allowances are allocated based on a baseline method.	Non-accepted; CERs and ERUs generated from nuclear projects; Long-term CERs; temporary CERs, etc.

South Korea [10]	Power, Industrial, Construction, Transportation, Aviation, Waste,	CO_2、CH4、N2O、HFCs、PFCs、SF6	2015: 573 million tonnes, with the total declining approximately 2% by 2017.	Free allocation: Grandfathering (applied to most industries), Baseline method (applied to cement industry, oil refining industry, domestic aviation industry).	Limited to less than 10%; Up to 50% of international offset credit
Saitama, Japan [7]	Industrial, Construction	CO_2	2011-2014: The total cap is set at the facility level and then added up to the Saitama-wide total, 6-8% reduction in each fiscal year compared to the baseline year. 2015-2019: 15-20% reduction compared to the baseline year.	Free allocation, Grandfathering	In general, there is no limit to the use of offset credits.
Tokyo, Japan [7]	Industrial, Construction	CO_2	2010-2014: The total cap is set at the facility level and then added up to the Tokyo-wide total, 6-8% reduction in each fiscal year compared to the baseline year. 2015-2019: 15-17% reduction compared to the baseline year.	Free allocation, Grandfathering	In general, there is no limit to the use of offset credits.

2.3 Development of international carbon market cooperation

Actions to reduce GHG emissions require both efforts from individual countries and international cooperation to improve their efficiency. As global carbon markets expand across continents, many countries show increasing interest in implementing carbon market linkages as a form of cooperation. Linking carbon markets is a potentially critical trend for future international cooperation on carbon emissions reduction.

There are three main types of links between carbon markets: one-way links, two-way links, and indirect links; one-way and two-way links are both considered direct links [12]. As shown in Figure 2, a one-way link means that an entity in Carbon Market A can purchase emissions allowances from Carbon Market B, but an entity in Carbon Market B cannot purchase emission allowances from Carbon Market A for its compliance purposes. Conversely, a two-way link allows entities in Carbon Market A and Carbon Market B to purchase each other's allowances. In an indirect link, both Carbon Market A and Carbon Market B are connected to System C, and thus indirectly linked. System C can also represent a unified type of carbon offset project that is usable in both Carbon Market A and Carbon Market B.

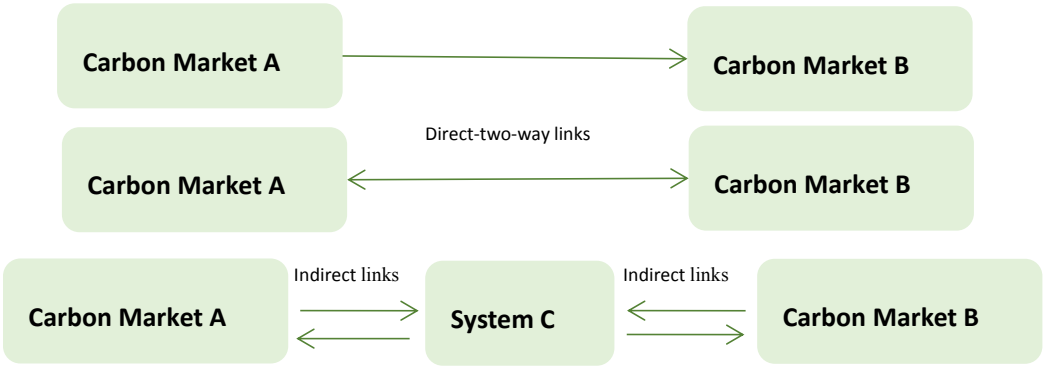


Figure 2: Types of carbon market linkage

Multiple jurisdictions are currently working on carbon market linkages, and several examples of different types of linkages have been realized in international carbon markets (see Figure 3). For example, Norway established a domestic carbon emissions trading system in 2005 with a one-way link to the EU's ETS. This means that Norwegian entities can buy emissions allowances from the EU, but EU entities cannot buy Norwegian emissions allowances. Norway, Iceland and Liechtenstein were also included in the EU ETS in 2008. The emissions trading systems in Tokyo and Saitama Prefecture, Japan were bidirectionally linked in 2011, and have similar design features. The two-way link between the carbon markets in California, United States, and Quebec, Canada was introduced in 2014, and it is currently the most successful international link. At the outset of the California-Quebec carbon markets' development, it was proposed to eventually link the respective systems, and both parties adopted similar policies and frameworks from their design to implementation, ultimately completing the integration according to their previous plans. On January 1, 2018, Ontario, Canada's cap-and-trade system was linked to the California-Quebec carbon market, creating the third largest carbon market in the world after China's forthcoming

market and the EU's existing one. At the end of 2017, Switzerland signed an agreement with the EU for a two-way linkage between the two jurisdictions' carbon markets, which will be formalized in 2020. This carbon market cooperation is a win-win situation for both Switzerland and the EU: the Swiss carbon market is small with low liquidity, and the price of allowances is much higher than the EU's. By linking up with the EU's carbon market, Swiss companies in Switzerland's national ETS will see boosted competitiveness. For the EU, such linkage would increase its political leverage. Australia also proposed in 2012 to link its carbon markets with the EU, starting with a one-way link in 2015 that featured Australia as the exclusive buyer, and shifting to a two-way link in 2018, with the EU and Australia both able to exchange allowances. However, following a government reshuffle, Australia scrapped its carbon pricing mechanism in 2014, and negotiations on ETS linkage were put on hold.

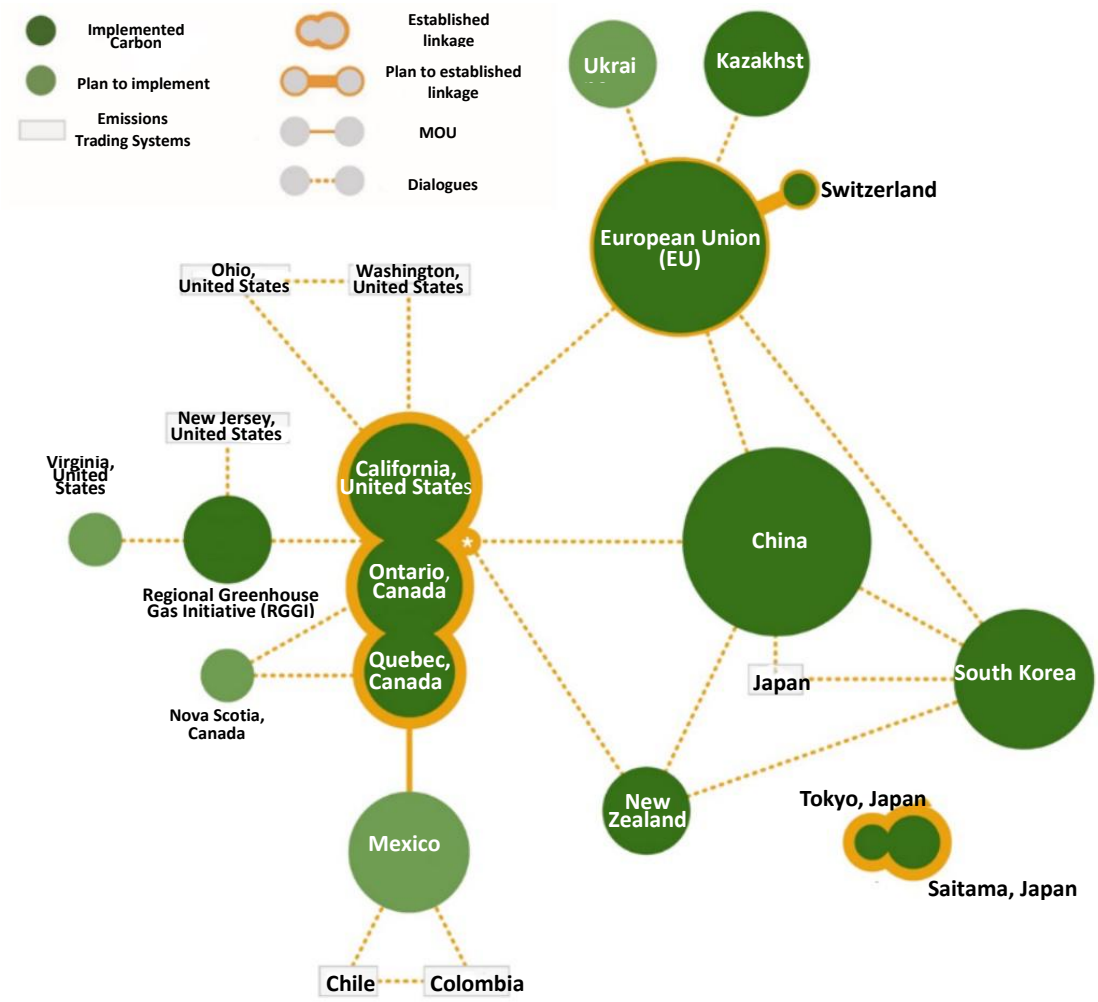


Figure 3. Status of International Carbon Market Linkages (2018)[7]

[Note: The proximity and strength of the connecting lines indicate the level of cooperation, while

the bubble size approximately corresponds to the size of the respective market volume.]

Theoretically, global carbon market linkages could minimize the overall cost of emission reductions worldwide. The sooner global carbon markets are established, the greater the savings in emissions reduction costs and the greater the chances of increasing global climate ambition in the short term [13]. Article 6 of the Paris Agreement also recognizes the option of international cooperation in helping countries achieve their NDC targets.

3. Current situation in major BRI countries and regions

3.1 Socioeconomic development and emissions in major BRI countries and regions

As the level of development varies from country to country along the Belt and Road, only after the status of socioeconomic development and emissions in these countries is effectively identified can reasonable projections of their ways forward be made and the impacts of establishing carbon markets on their socioeconomic development and emissions be analyzed. As shown in Figure 4, this chapter analyzes socioeconomic development, energy consumption, emission status quo and trends in major BRI countries through the following indicators.

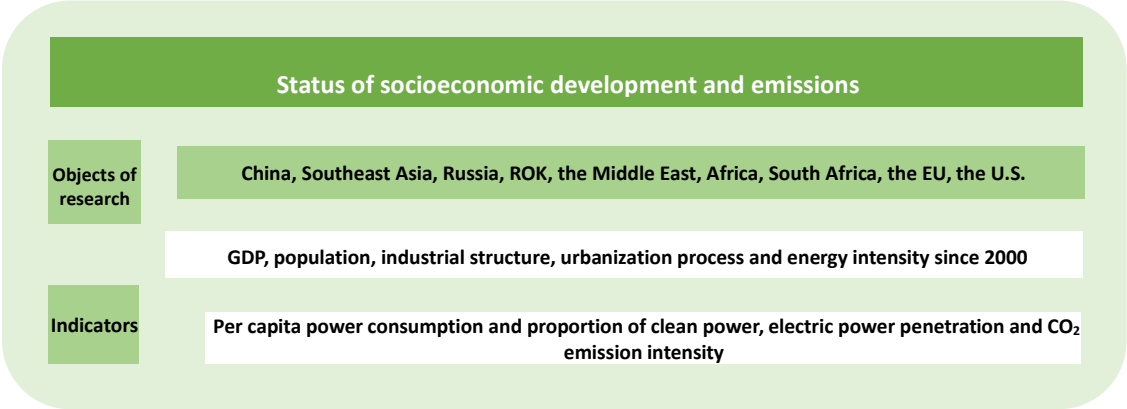


Figure 4 Objects of research and indicators

Table 2 suggests in 2018, the largest economy and population in China; the highest proportion of urban population in ROK, which registered 82% and the lowest in Africa, being 42%; the highest proportion of value added of the service sector in South Africa, which reached 61% and the lowest in the rest of Africa, which was 43%; the highest proportion of industrial value added in ROK, hitting 44%, and the lowest in South Africa, being 37%; the highest energy intensity in Russia, i.e., 0.39 kgoe/U.S. dollar, and the lowest in Africa, 0.15 kg CO_2e/U.S. dollar; the highest carbon intensity of 0.95 kgCO_2e/U.S. dollar in South Africa and the lowest of 0.36kgCO_2e/U.S. dollar in the rest of Africa; the highest per capita power consumption in ROK, amounting to 10,900 kWh, while the lowest in Africa, only 673 kWh; the highest proportion of power from renewable energy in China, reaching 26%, of which 8% came from wind and solar energy, and the lowest in the Middle East, being just 2%; the highest GDP growth rate over the past 18 years and over the past 5 years in China, registering 9.2% and 6.7% respectively, and GDP growth over the past 5 years in Russia (0.4%) and South Africa (0.9%) are less growth rate.

Table 2 Status of social development and energy emissions in major BRI countries and regions in 2018

	China	Southeast Asia	Russia	ROK	Middle East	South Africa	Africa (excluding South Africa)
GDP in 2018 (trillion USD)	**11.6**	3.2	1.8	1.5	2.9	0.5	2.2
Population in 2018 (10^8)	**13.9**	6.6	1.4	0.5	2.5	0.6	12
Proportion of urban in 2018	59%	49%	74%	**82%**	73%	66%	42%
Proportion of service value-added in 2018	52%	51%	54%	54%	58%	**61%**	43%
Proportion of industry value-added in 2018	41%	39%	43%	**44%**	41%	37%	41%
Energy intensity in 2018 (kgoe/ USD)	0.25	0.17	**0.39**	0.21	0.26	0.27	0.15
Carbon intensity in 2018 ($kgCO_2$/ USD)	0.91	0.51	0.92	0.49	0.76	**0.95**	0.36
Power consumption per capita in 2018 (kWh)	5120	1598	7495	**10900**	4763	4420	673
Proportion of power from renewable energy in 2018	**26%** (Wind and PV power: 8%)	24% (Hydropower: 18%; wind and PV power: 1%)	18% (Hydropower: 17%)	21% (Biomass and garbage power: 17%; wind and PV power: 3%)	2%	5%	19% (Hydropower: 16%)
Annual GDP growth rate from 2000 to 2018	**9.2%**	5.1%	3.4%	3.8%	3.7%	2.7%	4.6%
Annual GDP growth rate from 2014 to 2018	**6.7%**	4.9%	0.4%	2.9%	2.5%	0.9%	3.0%

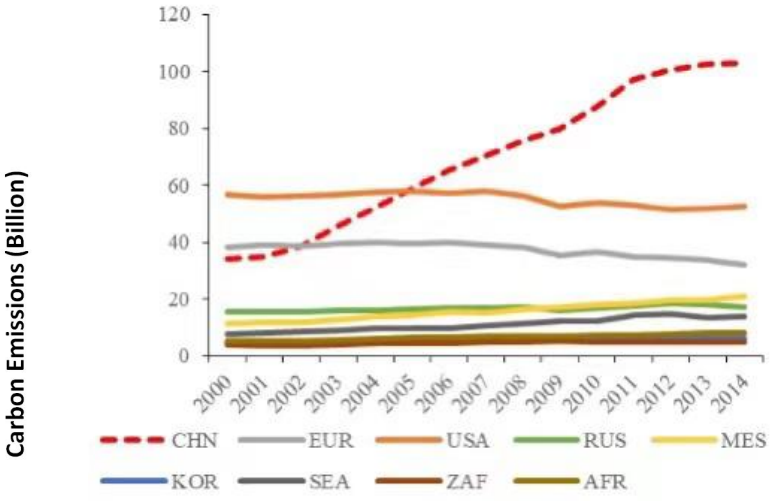


Figure 5. Cumulative and annual emissions by country

3.2 Energy Saving Policies, Emissions Reduction Policies, and Carbon Pricing Mechanisms

The Paris Agreement, which was adopted at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), established a new goal for addressing climate change, specifically by setting the long-term goal of keeping the global average temperature rise below 2°C, while striving to limit it to 1.5°C [14]. Each signatory country will take actions to reduce emissions based on its NDCs to in turn achieve "bottom-up" emissions reductions. This section mainly introduces the NDCs and carbon pricing mechanisms proposed by major countries and regions along the Belt and Road [15] [16].

China, Russia, South Africa, and South Korea have all proposed unconditional emissions reduction targets for 2030, but none have proposed conditional goals (see Table 3). China's target focuses on reductions in carbon intensity, Russia and South Africa's are absolute emissions reduction targets, and South Korea has proposed a reduction target relative to the business as usual (BAU) scenario.

In terms of carbon pricing mechanisms, China and South Africa have proposed and used domestic carbon pricing mechanisms to promote emissions reductions, while South Korea established a domestic carbon market in 2015 and proposes to establish an international carbon pricing mechanism.

Since 2013, China has launched pilot carbon markets in eight cities and provinces, including Beijing and Shenzhen, which cover 3 Gt eq, and account for about 33% of China's own carbon emissions and 5.9% of global emissions. As of 2019, the carbon price in Shenzhen and Chongqing is about $1 per tonne ($CO_2$-Eq.); in Tianjin and Fujian, the price is about $2 per tonne; in Guangdong, the price is about $3 per tonne; in Shanghai and Hubei, the price is about $4 per tonne; and in Beijing the price is about $11 per tonne.

South Africa is the first country in Africa to implement a carbon tax on fossil fuels, which started in

June 1, 2019 and covers 0.4 Gt of CO2 eq; this number is about 80% of South Africa's own carbon emissions and about 0.8% of global carbon emissions. The carbon price in South Africa was about R120 per tonne of CO2 eq ($8 per ton) in 2019, and through 2022, the carbon tax rate's increase is set to 2% on top of the annual increase for inflation adjustment. After 2022, the only adjustment is expected to be for inflation. In 2020, the carbon tax rate is R127 per tonne, which is about $9 per tonne (the nominal price in US dollars as of February 1, 2020).

South Korea's carbon market was launched in 2015, and South Korea was also the first country in East Asia to launch a national carbon market. Its carbon market, which entered its second phase on January 1, 2018, will come into full effect by October 1, 2020, covering sectors such as heavy industry, power generation, aviation, construction, and waste management. It covers 548 Mt CO_2 eq, accounting for about 70% of the country's carbon emissions and about 0.9% of global carbon emissions, with a carbon price of $22 per tonne (nominal price in US dollars as of April 1, 2019).

Table 3. Nationally Determined Contributions in Major Belt and Road Countries

Country	Unconditional Goals	Conditional Targets	Use of carbon pricing mechanisms	Type of Unconditional Targets
China	60-65% reduction in carbon intensity from 2005 levels by 2030	-	Domestic	Emission intensity reduction
Russia	Reduce carbon emissions by 25-30% by 2030 compared to 1990.	-	None	Absolute Emission Reduction
South Africa	South Africa's emissions will peak between 2020 and 2025, plateau for about 10 years, and decline in absolute terms afterwards.	-	Domestic	Absolute Emission Reduction
South Korea	37% below BAU by 2030	-	International and Domestic	Relative reduction to BAU

Except for the Philippines, all countries in Southeast Asia (see Table 4) have put forward an unconditional NDC plan. Singapore and Malaysia have proposed unconditional carbon intensity reduction targets; Cambodia, Indonesia, Thailand, and Vietnam have proposed unconditional reduction targets relative to their BAU scenarios; the Philippines has proposed conditional reduction targets relative to its BAU scenario; Brunei, Laos, Myanmar, and Timor-Leste have proposed partial sectoral measures or targets.

In terms of carbon pricing mechanisms, Singapore has implemented a carbon tax and has proposed to use an international carbon pricing mechanism to promote further emissions reductions. Thailand, Cambodia, Indonesia, Vietnam, and Laos have also proposed to use international carbon pricing mechanisms to promote emissions reductions.

Starting from January 1, 2019, Singapore will implement a carbon tax on all industry and power sector facilities that emit more than 25 $ktCO_2e$ of GHGs annually; this covers 40 $MtCO_2e$ of carbon emissions, which is about 80% of the country's carbon emissions and about 0.08% of global carbon emissions. For the first five years, the carbon tax rate will be set at S$5 per tonne of CO_2 equivalent (which is about US$4 per tonne of CO_2 equivalent). The government will review the tax rate by 2023 and plans to raise it to S$10-15 per tonne (US$7-11 per tonne) by 2030.

Table 4. Nationally Determined Contributions in Southeast Asia Countries

Country	Unconditional Goals	Conditional Targets	Use of carbon pricing mechanisms	Type of Unconditional Targets
Singapore	Will reduce 36% of carbon intensity by 2030	-	International	Emission intensity reduction
Malaysia	Reduce 35% GDP emissions intensity compared to 2005 by 2030.	Additional 10% is conditional	None	Emission intensity reduction
Cambodia	20% below BAU by 2030	Additional 10% need international support	International	Relative reduction to BAU
Indonesia	29% below BAU by 2030	Additional 12% is conditional	International	Relative reduction to BAU
Thailand	20% below BAU by 2030	Additional 5% is conditional	International	Relative reduction to BAU
Vietnam	8% below BAU by 2030	Another 17% are subject to international cooperation and cooperation mechanisms.	International	Relative reduction to BAU
Philippines	-	70% below BAU by 2030	None	Conditional target for relative reduction to BAU
Brunei	NDC sets three sectors goals	-	None	Partial measures or targets
Laos	NDC has developed a number of sectoral initiatives	-	International	Partial measures or targets
Burma	NDC has developed a number of sectoral initiatives	-	None	Partial measures or targets
Timor-Leste	No emission targets, but rather an overview of the activities to be undertaken by each sector.	-	None	Partial measures or targets

Except for Oman, Syria, and Palestine, all countries in the Middle East (see Table 5) have put forward unconditional NDCs, with Saudi Arabia and Israel putting forward unconditional, absolute emissions reduction targets. Iran, Iraq, Lebanon, Yemen, and Jordan have proposed unconditional emissions reduction targets relative to their BAU scenarios. The UAE, Bahrain, Kuwait, and Qatar have proposed partial sectoral measures or targets for their emissions reductions. Oman has proposed a conditional reduction target relative to its BAU scenario; Syria and Palestine have not yet proposed their own NDC plans. Only Jordan has proposed that it would use international carbon pricing mechanisms to further reduce emissions.

Table 5. Nationally Determined Contributions in Middle East Countries

Country	Unconditional Goals	Conditional Targets	Use of carbon pricing mechanisms	Type of Unconditional Targets
Saudi Arabia	NDC aims to avoid up to 130 million tonnes of CO_2 per year by 2030		None	Absolute emission reduction
Israel	26% below 2005 levels by 2030		None	Absolute emission reduction
Iran	4% below BAU by 2030 (unconditional)	Additional 8% is conditional	None	Relative reduction to BAU
Iraq	1% below BAU by 2035	Additional 13% is conditional	None	Relative reduction to BAU
Lebanon	15% below BAU by 2030 (unconditional)	Additional 15% is conditional	None	Relative reduction to BAU
Yemen	1% below BAU by 2030 (unconditional)	Additional 13% is conditional	None	Relative reduction to BAU
Jordan	1.5% below BAU by 2030	Additional 12.5% is Conditional	International	Relative reduction to BAU
UAE	NDC has established several sector initiatives, including a 24% clean energy goal by 2021.	-	None	Partial measures or targets
Bahrain	NDC lists a number of sectoral initiatives without setting targets	-	None	Partial measures or targets
Kuwait	NDC lists several measures	-	None	Partial measures or targets
Qatar	NDC lists a number of sectoral initiatives without setting targets	-	None	Partial measures or targets
Oman	-	2% below BAU by 2030	None	Partial measures or targets
Syria, Palestine	-	-	None	-

Among African countries other than South Africa, (see Table 6) 29 countries or regions including the Democratic Republic of the Congo, the Central African Republic, and Nigeria have put forward unconditional NDC plans. Of these, seven countries, including the Democratic Republic of the Congo, proposed unconditional, absolute emissions reduction targets, while Tunisia proposed a carbon intensity reduction target. Seventeen countries, including Algeria, the Central African Republic, and Nigeria, have proposed unconditional reduction targets relative to their BAU scenarios. Benin, Cape Verde, Malawi, and Somalia proposed partial sectoral measures or targets.

18 African countries or regions, including the Republic of the Congo and Ethiopia (see Table 7), put forward only conditional NDC plans. Twelve of these countries, including the Republic of Congo and Zimbabwe, have proposed emissions reduction targets relative to their BAU scenarios. Three countries, Mozambique, Sierra Leone, and Sao Tome and Principe have proposed absolute emissions reduction targets. Sudan and Guinea-Bissau have proposed partial sectoral measures or targets. Rwanda has proposed a plan to use international carbon market mechanisms to reduce emissions, but it has not put forward a formal NDC plan, and Libya and seven other countries have not yet put forward an NDC plan.

In terms of carbon pricing mechanisms, 30 African countries, including Botswana and Cameroon, have proposed to use international carbon pricing mechanisms to promote emissions reductions, while Gabon has proposed to consider establishing a domestic carbon pricing mechanism.

Table 6. Nationally Determined Contributions in African Countries (excluding South Africa) (Unconditional target has been proposed)

Country	Unconditional Goals	Conditional Targets	Use of carbon pricing mechanisms	Type of Unconditional Targets
Botswana	15% below 2010 levels by 2030	-	International	Absolute emission reduction
Cameroon	32% below 2010 levels by 2035	-	International	Absolute emission reduction
Republic of Chad	18.2% below the 2010 level	Additional 52.8 % is conditional	International	Absolute emission reduction
Democratic Republic of Congo	17% below 2000 values	-	None	Absolute emission reduction
Djibouti	40% below 2010 levels by 2030	Additional 20% is conditional	None	Absolute emission reduction
Equatorial Guinea	20% below 2010 levels in 2030		International	Absolute emission reduction
Gambia	44.4% reduction in 2025 and 45.4% reduction in 2030 relative to 2010 levels.	-	International	Absolute emission reduction
Tunisia	13 % reduction in carbon intensity by 2030	Additional 28% is conditional	International	Emission intensity reduction
Algeria	7% below BAU by 2030	Additional 15% conditional emission reduction	None	Relative reduction to BAU
Angola	35% reduction from BAU levels by 2030 (unconditional)	Additional 15% is conditional	None	Relative reduction to BAU
Burkina Faso	6.6% reduction from BAU levels by 2030	Additional 5% is conditional	International	Relative reduction to BAU
Burundi	3% reduction from BAU levels by 2030 (unconditional)	Additional 17% is conditional	None	Relative reduction to BAU
Central African	5% below BAU by 2030	-	International	Relative reduction to

Republic				BAU
Eritrea	39.2% reduction from BAU levels by 2030 (unconditional)	Additional 41.6 % is conditional	-	Relative reduction to BAU
Gabon	At least a 50% reduction in emissions compared to the reference scenario by 2025	-	Domestic	Relative reduction to BAU
Ghana	15% reduction from BAU levels by 2030	Additional 30% is conditional	International	Relative reduction to BAU
Lesotho	Unconditional target of 10% of BAU baseline by 2030	Additional 25% is conditional	International	Relative reduction to BAU
Mauritania	22.3% below BAU by 2030	Additional 65.7 % is conditional	None	Relative reduction to BAU
Morocco	17% reduction from BAU by 2030, with 4% from AFOLU actions; without AFOLU actions, the reduction target is 13%.	Additional reduction of 25% (21% without AFOLU) is conditional	International	Relative reduction to BAU
Namibia	79% reduction from BAU levels by 2030	Additional 10% is conditional	International	Relative reduction to BAU
Niger	2.5% reduction by 2020 and 3.5% reduction by 2030 compared to BAU levels	Additional 22.5 % in 2020 and 31.1 % in 2030 are conditional.	International	Relative reduction to BAU
Nigeria	20% unconditional reduction from BAU levels by 2030	Additional 25% is conditional	International	Relative reduction to BAU
Senegal	5% unconditional reduction from BAU levels by 2030	Additional 16% is conditional	None	Relative reduction to BAU
Togo	11.14% reduction from BAU levels by 2030	Additional 20% is conditional	International	Relative reduction to BAU
Zambia	25% reduction from BAU levels by 2030	Additional 22% is conditional	International	Relative reduction to BAU

Benin	NDC proposed unconditional targets for each sector: 3.63% overall, 1.98% for Energy, 5.8% for Agriculture, and 23.4% for Land Use Change and Forestry	NDC set conditional targets for each sector: 12.55% overall, 9.53% for Energy, 25.3% for Agriculture, and 76.6% for Land Use Change and Forestry	None	Partial measures or targets
Cape Verde	30% Renewable Energy Target by 2025	With international support, 100% renewable energy by 2025	International	Partial measures or targets
Malawi	NDC has developed a number of sectoral initiatives	NDC has developed a number of sectoral initiatives	None	Partial measures or targets
Somalia	NDC has developed a number of sectoral initiatives	-	None	Partial measures or targets

Table 7. Nationally Determined Contributions in African Countries (excluding South Africa)

(No unconditional targets were proposed)

Country	Conditional Goals	Use of carbon pricing mechanisms	Type of conditional Targets
Republic of Congo	48% below BAU levels by 2025 and 55% by 2030	None	Relative reduction to BAU
Ethiopia	64% compared to BAU projections by 2030.	International	Relative reduction to BAU
Guinea	13% reduction from BAU by 2030	International	Relative reduction to BAU
Liberia	15% reduction from BAU levels by 2030	International	Relative reduction to BAU
Kenya	30% reduction from BAU by 2030	International	Relative reduction to BAU
Madagascar	14% reduction from BAU by 2030 is conditional	None	Relative reduction to BAU
Mauritius	30% reduction from the BAU levels by 2030	None	Relative reduction to BAU
Mali	9% reduction in agriculture, 31% reduction in energy, and 21% reduction in forest and land-use change compared to BAU.	International	Relative reduction to BAU
Seychelles	21.4% reduction in 2025 and 29% reduction in 2030, compared to BAU levels.	None	Relative reduction to BAU
Tanzania	10-20% lower than the BAU emissions by 2030	None	Relative reduction to BAU
Uganda	22% reduction from BAU by 2030	International	Relative reduction to BAU
Zimbabwe	Carbon intensity will be 33% below BAU levels by 2030.	International	Relative reduction to BAU
Mozambique	76.5 $MTCO_2e$ reduction by 2030	International	Absolute emission reduction
Sierra Leone	Emissions will not exceed 7.58 $MtCO_2$ by 2035 and will be carbon neutral by 2050.	International	Absolute emission reduction
Sao Tome and Principe	24% reduction from 2005 emission levels in 2030	International	Absolute emission reduction

Guinea-Bissau	According to 2006 data, Guinea-Bissau is an absolute sink of GHG and therefore has no GHG reduction targets. However, it will implement new policies to combat deforestation in the country.	International	Partial measures or targets
Sudan	NDC has developed a number of sectoral initiatives	International	Partial measures or targets
Rwanda	Estimates of emission reductions are in progress.	International	-
Libya, Western Sahara, Eswatini, Saint Helena, Comoros, Mayotte, Côte d'Ivoire			-

4. Implement feasibility analysis of carbon market in major BRI countries and regions

A carbon emissions trading scheme (ETS) is designed for the trading of GHG emission allowances or credits with the purpose of controlling GHG emissions. In this sense, carbon markets, as policy-based markets, require a powerful national administrative system to safeguard the stability, transparency and consistency of policies, as well as effective disclosure of information such as enterprises' emissions and energy use to ensure data reliability, and also a relatively perfect market environment to guarantee reasonable trade order and pricing.

This chapter first identifies key factors influencing different links of carbon market operation by analyzing the rationale and participants of an ETS, then selects specific indicators that can reflect these key factors through data research and screening to evaluate the development status in different countries and identify the countries that are able to establish a carbon market or link their markets to others.

The FASTER principles for successful carbon pricing established by the World Bank (WB) include fairness, alignment of policies and objectives, stability and predictability, transparency, efficiency and cost-effectiveness, reliability and environmental integrity.

Specifically, "fairness" means that successful carbon pricing policies should reflect the "polluter pays" principle and contribute to distributing costs and benefits equitably, avoiding disproportionate burdens on vulnerable groups.

"Alignment of policies and objectives" means that successful carbon pricing policies are part of a suite of measures that facilitate competition and openness, ensure equal opportunities for low-carbon alternatives, and interact with a broader set of climate and non-climate policies.

"Stability and predictability" means that successful carbon prices are part of a stable policy framework that gives a consistent, credible and strong investment signals, the intensity of which should increase over time.

"Transparency" means successful carbon pricing policies are clear in design and implementation. This implies the need for open communication with affected stakeholders about the rationale of policies in the policy making process and inclusion of their feedbacks in policy design and implementation; and the need for the establishment of independent public censorship and systems that effectively monitor and verify emissions, and the reporting of results, which are critical for public trust in carbon pricing efforts.

"Efficiency and cost-effectiveness" means that successful carbon pricing improves economic efficiency and reduces the costs of emission reduction. This tells that a country should have in place a relatively perfect market environment to ensure effective carbon pricing, increase economic efficiency and reduce emission reduction costs, and provide consistent, credible and strong investment signals.

"Reliability and environmental integrity" means that successful carbon pricing schemes result in a measurable reduction in environmentally harmful behavior. This requires a certain degree of transparency, normal channels of administrative accountability and lower levels of corruption in the public sector to ensure equitable policy making; moreover, the public sector should also maintain quality public administration to develop a suite of reliable measures in line with emission reduction targets; further, the public sector should carry out rule-based governance to ensure policy implementation and environmental integrity.

To sum up, the feasibility of establishing carbon markets in major BRI countries and regions can be analyzed qualitatively from six indicators, namely degree of law-based governance, government willingness, administrative ability and quality of the public sector (government), enterprises' enthusiasm for participation, market completeness and degree of information disclosure by enterprises ("Government, Enterprise and Municipal Law" for short). Through research and data selection, this study identifies six key indicators for analysis: the Country Policy and Institutional Assessment (CPIA) public sector management and institutions cluster average, the ease of doing business index, the Corporate information disclosure index, the World Justice Project law-based governance Index, each country's specific references to domestic and international carbon markets in their policy documents, and corporate engagement information published by the Carbon Disclosure Project (CDP).

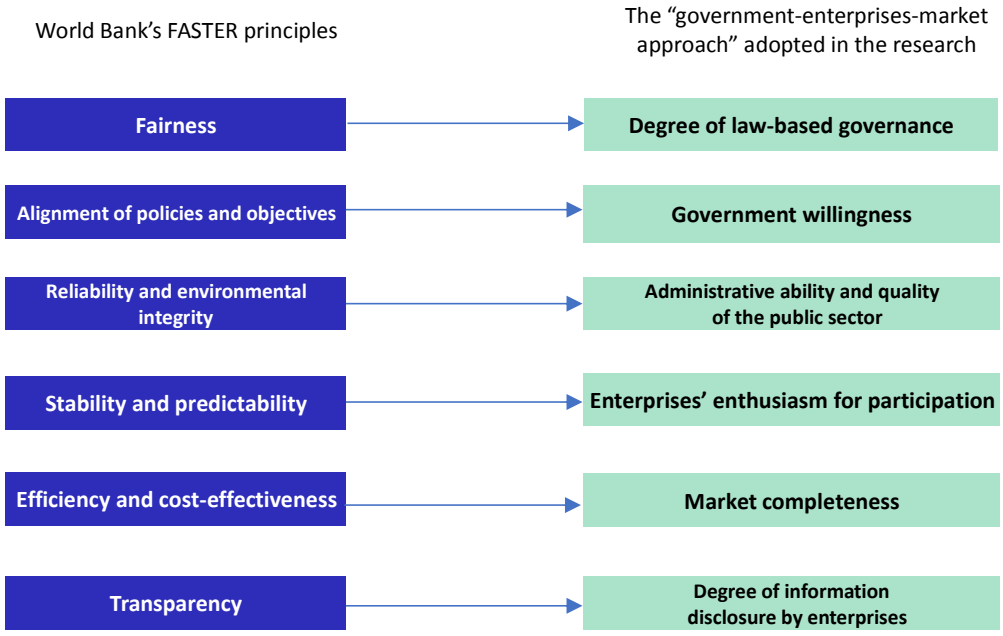


Figure 6 Prerequisites for successful carbon markets: the "government-enterprises-market approach"

4.1 Public Sector Administrative Performance and Quality

The performance and quality of public sector administrative bodies are assessed using the World Bank's CPIA averages for the public sector and institutional clusters from 2005 to 2018 (values range from 1 to 6, with higher values indicating better performance and quality).

Data show that, excluding high-income countries, Europe and Central Asia, as well as East Asia and the Pacific region, have comparatively strong public sector administrative capacity and high administrative quality which is above the world average; In terms of administrative performance and quality, they are in a strong position to implement a carbon market. Southern Africa's public sector administrative capacity and quality are close to the world average, and the region has some capacity to implement a carbon trading market. However, the Middle East and North Africa region continues averaging below low-income countries and has shown a clear downward trend in recent years, making it more difficult to implement carbon trading markets from the perspective of public sector administrative capacity and quality.

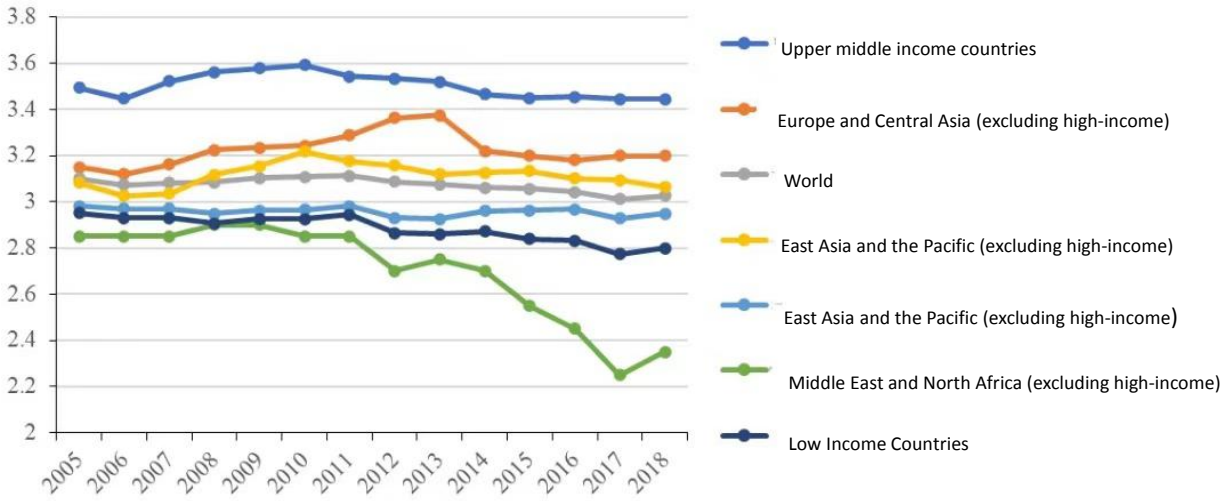


Figure 7. Country Policy and Institutional Assessment (CPIA) averages for the public sector and institutional clusters

4.2 Degree of corporate information disclosure

To ensure the transparency and reliability of data on areas such as carbon emissions, covered entities need to disclose as much information as possible about their business. The World Bank's corporate information disclosure index is used to measure information disclosure. The index measures the extent to which investors are protected by disclosing information such as ownership status and financials. The index provides a range from 0-10, with higher values indicating a higher degree of disclosure. The chart below shows the 2019 corporate information disclosure index for China, major Belt and Road countries and regions, the European Union, and the United States.

In 2019, Chinese companies had the highest level of disclosure, with an index rating of 10; this was followed by South Korea and South Africa, both of which had a corporate disclosure index rating of 8. The United States and Southeast Asia received a corporate disclosure index rating of 7.4. The

European Union, the Middle East and Russia all received corporate disclosure index ratings of 6. The level of corporate disclosure is relatively low in Africa, with an average index rating of 5. As the EU has the world's largest carbon emissions trading market, it can be assumed that companies and countries with a level of corporate disclosure at or near EU levels have sufficient corporate disclosure to ensure data transparency and reliability in their carbon markets. Therefore, aside from countries like South Korea and China that have worked to establish carbon markets, South Africa, Southeast Asia, the Middle East, Russia, and other Belt and Road countries and regions may have the ability to establish carbon markets from the corporate disclosure perspective.

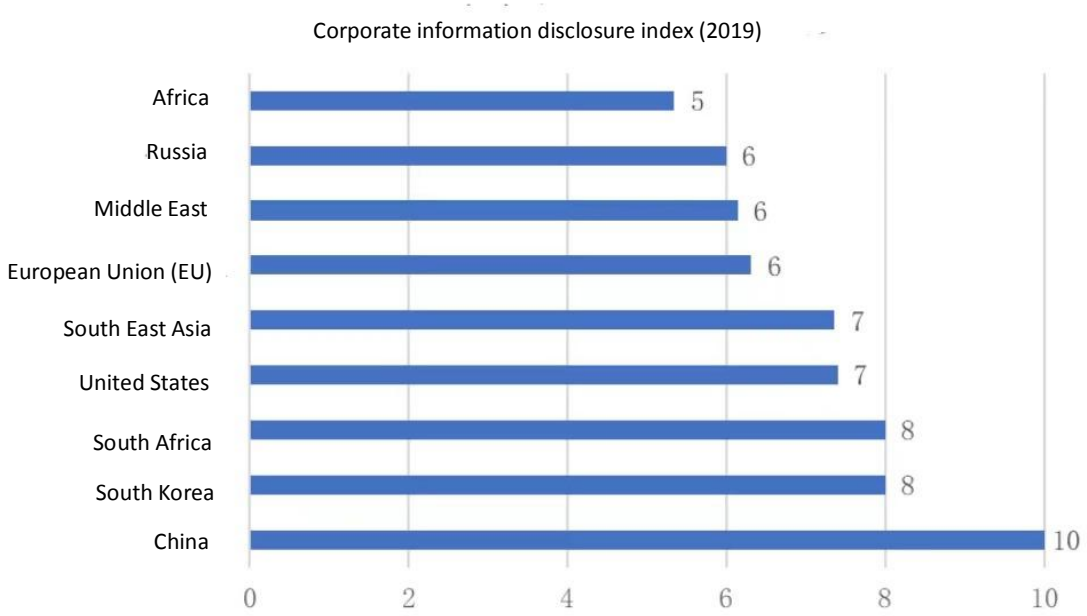


Figure 8. 2019 Corporate information disclosure index for Major Countries and Regions

4.3 Market completeness

The World Bank's ease of doing business index reflects the ease, efficiency, cost, and fairness of the market environment for doing business in a specific country. The ease of doing business index ranks economies from 1 to 190, with the first place being the best; a higher ranking indicates a more favorable regulatory environment for doing business and a more sophisticated market. The index uses the simple average of each country's percentage ratings across the ten areas covered by the World Bank's "Doing Business" program. Figure 9 shows the 2019 ease of doing business index ratings for major countries and regions.

South Korea, China, and Russia have relatively strong market conditions as defined by the ease of doing business index; they are followed by South Africa, Southeast Asia, and the Middle East, while the rest of Africa has relatively weak market conditions. In terms of market conditions, apart from China and South Korea, which have already established carbon markets, Russia, South Africa, seven countries in Southeast Asia, nine countries in the Middle East, and six countries in Africa should be relatively well equipped to establish carbon markets based on this index. However, it is likely more difficult to implement carbon trading markets in the rest of Africa, Southeast Asia, and the Middle East.

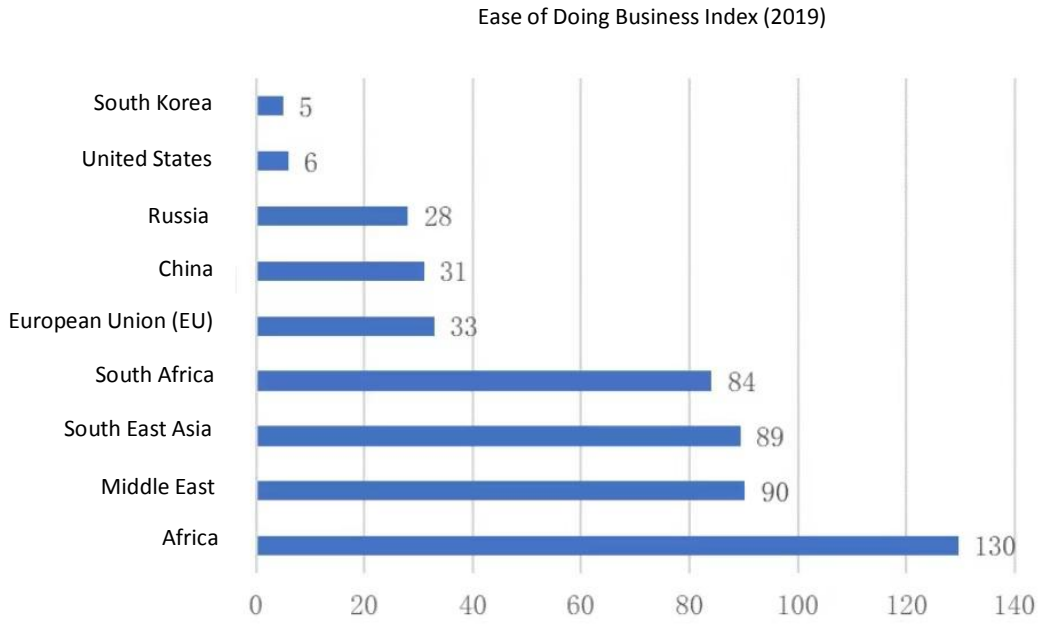


Figure 9. 2019 Ease of Doing Business Index for Major Countries and Regions

4.4 Degree of law-based governance

The establishment of carbon markets requires a well-developed national legal environment and a strong law-based governance. This section is therefore measured by the law-based governance Index results as published by the World Justice Project in 2020. Based on a quantitative assessment methodology, the law-based governance Index provides a detailed and comprehensive overview of the degree to which countries adhere to the law-based governance in practice, resulting in a comprehensive ranking scale with a score of 1 being the best and 0 being the worst. South Korea, South Africa, China, Russia, parts of the Middle East, parts of Southeast Asia, and parts of Africa all have the basic level of the law-based governance that is necessary to establish carbon markets.

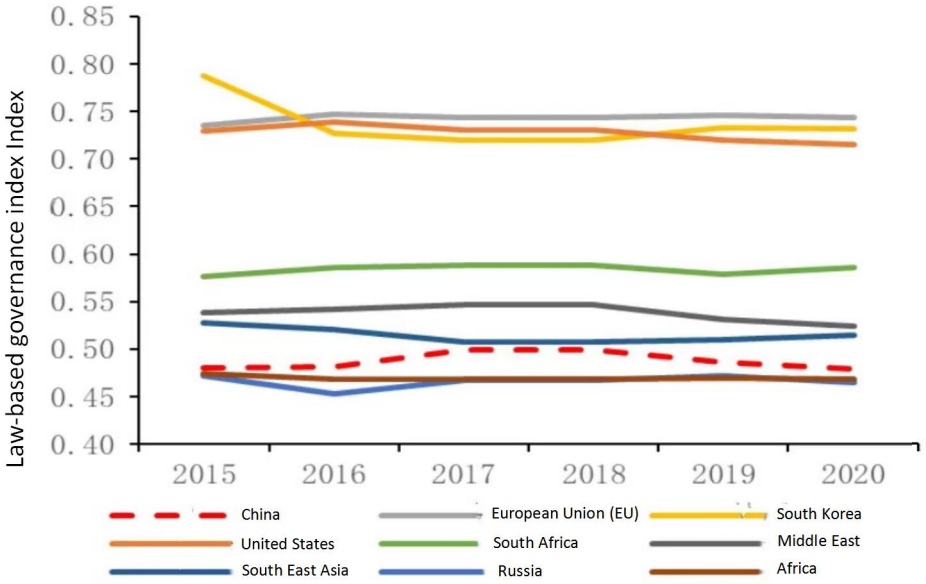


Figure 10. Law-based governance Index for Major Countries and Regions, 2015-2020

4.5 Government Willingness

In addition to strong public sector administrative capacity and quality, corporate disclosure, and market completeness, government willingness is critical to the establishment of carbon markets. Currently, carbon pricing policy instruments mainly include carbon markets and carbon taxes. For countries that have implemented carbon markets and for those that plan to implement carbon markets, it can be assumed that there is a strong willingness for the government to establish carbon markets. Conversely, for countries that plan to or have implemented carbon tax policies, there is recognition and support for carbon pricing practices, although no carbon market is in place. If international pressure to reduce domestic GHG emissions increases in the future, it is more likely that the country will use international carbon market linkages to reduce emissions, thereby creating the possibility for the country to adjust its domestic carbon tax policy and shift to a carbon market aligned with an international market. Therefore, the government's willingness to establish a carbon market in these countries can be seen as moderate. For countries that have not yet mentioned carbon markets or carbon pricing policy instruments such as carbon taxes in their NDC plans, it can

be assumed that their governments are less willing to establish carbon markets.

4.6 Degree of Corporate Engagement

The measurement for corporate engagement used in this report is derived from the number of companies that have disclosed their performance on climate change from each respective country, as published on the CDP website. In 2019, more than 8,400 companies in over 90 countries disclosed their environmental performance through CDP [17], which includes 8,361 companies that disclosed their performance in addressing climate change. In China, CDP invited nearly 1,800 companies, of which about 1,100 responded to the CDP questionnaire; this number includes 48 listed companies that were invited to participate by investors, as well as 1,038 supplier companies.

According to CDP's 2019 data, 482 companies in China disclosed their environmental and climate performance through the CDP platform. By comparison, about 960 companies disclosed this information in the United States, while 222 did in South Korea, 107 did in South Africa, and 62 did in Russia. In the EU, more than 200 companies from Germany, about 260 from France, 90 from Italy, and 66 from Belgium participated in CDP's disclosure initiative. CDP also currently discloses five Southeast Asian countries' corporate environmental performance information, which specifically includes Singapore, Indonesia, Malaysia, Thailand, and the Philippines. 38 companies in Singapore disclosed their environmental and climate change performance through CDP. 50 disclosed this information in Indonesia, as did 48 in Malaysia, 46 in Thailand, and 25 in the Philippines. In the Middle East, 12 companies in the UAE disclosed their performance on environmental issues and climate change through CDP. Furthermore, 13 companies disclosed this information in Israel, 8 did in Saudi Arabia, and 1 did in Iran. For African countries aside from South Africa, one Algerian company disclosed its environment and climate change performance through the CDP platform. There are also 7 that disclosed this information in Egypt, as well as 1 in Gabon, 2 in Kenya, and 2 in Nigeria.

This shows that companies in China, South Korea, South Africa, Russia, Southeast Asia, the United States, and the European Union have been more active in addressing climate change, while companies in the Middle East and Africa were only moderately engaged.

4.7 Brief summary

To ensure the comparability of indicators, the six indicators for each country or region are rated on a four-point scale (see Table 8), and 1 represents the weak degree, 2 represents the moderate degree, 3 represents the relative strong degree, and 4 represents the strong degree.

Table 8 Carbon market feasibility indexes of major countries and regions

	Public sector administrative performance and quality	Degree of corporate information disclosure	Market completeness	Degree of law-based governance	Government willingness		Corporate engagement	Average
					Willingness to build a domestic carbon market	Whether linkage to international markets mentioned in policy documents issued		
China	4	4	4	3	4	-	3	3.7
ROK	4	4	4	4	4	Yes	3	3.8
Russia	4	3	4	3	2	-	3	3.2
South Africa	4	4	3	3	2	-	3	3.2
Southeast Asia	4	4	3	3	3	Mentioned by Singapore, Thailand, Indonesia, Vietnam, Laos and Cambodia	3	3.3
Middle East	2	3	3	3	1	Mentioned only by Jordan	2	2.3
Rest of Africa	3	2	1	3	2	Mentioned by 30 countries including Botswana and Cameroon	2	2.2
U.S.	4	3	4	4	3	Yes	4	3.7
EU	4	3	4	4	4	Yes	3	3.7

Data shows that conditions in China, ROK, the EU and the U.S. are already ripe for establishing a domestic carbon market, and ROK and the EU have expressed willingness to establish an international carbon market; with relatively ripe conditions, Russia, Southeast Asia and South Africa can find it feasible to establish a domestic carbon market; it is less feasible for the Middle East and Africa to build a carbon market at home.

In Southeast Asia, Singapore, Malaysia, Thailand, Indonesia and Vietnam have comparatively sufficient conditions of establishing a domestic carbon market, indicating relatively high feasibility of doing so in the near future.

In the Middle East, the United Arab Emirates (UAE), Israel and Saudi Arabia meet the objective

requirements to establish a carbon market at home, among which Saudi Arabia has a relatively strong will to establish a carbon market, so it is feasible for the country to do so in the near future.

In the rest of Africa, Rwanda, Morocco, Kenya and Tunisia are qualified and willing to establish a carbon market, so it is feasible for the four countries to do so in the near term.

5. Quantitative analysis of the impacts of establishing carbon markets in major countries and regions along the "Belt and Road"

5.1 Scenario design

Taking into account the progress in the construction of major countries and regions along the "Belt and Road" and deadlines of their committed emission reduction targets and policy paths, this research targets BRI countries that have submitted explicit emission reduction targets and paths, with years of 2020, 2025, 2030 and 2035 as target years, and designs the following four scenarios for analysis with the China-Global Energy Economic Model, hereinafter as C-GEM.

(1) The reference scenario (REF). In this scenario, rather than carbon tax and carbon markets, countries or regions such as China, ROK, Russia, South Africa, Southeast Asia, the U.S. and the EU adopt other energy conservation and new energy policies in their respective emission reduction paths. It is the reference scenario for other scenarios containing carbon market policies.

(2) The scenario of non-linked carbon markets (NDC). This scenario assumes that countries deliver their committed emission reductions for 2020-2030 by establishing nationwide carbon markets on the basis of that they have implemented emission reduction measures through energy conservation and new energy, and that carbon constraints for 2035 continue the carbon intensity constraints for 2020-2030. As the U.S. has withdrawn from the Paris Agreement and submitted no NDCs, this research considers the carbon emissions estimated by the IEA's World Energy Outlook 2019 in the U.S. commitment policy scenario as U.S. emission reduction target. In this scenario, countries build independent carbon markets at the national level in the light of their committed emission reduction targets for 2020 and 2030 as the design basis of emission allowance caps, in comparison to the analysis of the impacts of linking carbon markets across regions.

(3) The scenario of linking carbon markets in major BRI countries (BRI). As indicated by the analysis in the previous chapter, China, ROK, Russia, South Africa and Southeast Asia are all BRI countries or regions qualified to establish a carbon trading market. Hence, this scenario assumes that on the basis of the SEP scenario, carbon markets in the five major BRI countries or regions will be further linked in 2025, with initial carbon allowances of these countries or regions in each year being carbon emissions in the NDC scenario. This scenario, which is an ideal one, is designed to analyze the development and impact of a multi-player carbon market with extensive participation in the future.

(4) The scenario of linking carbon markets in major BRI countries to those in Europe and America (EUS). So far, the EU has established the world's largest carbon emissions trading market, and the U.S. has introduced carbon markets in sub-national administrative regions including California and Massachusetts. The EU and the U.S. are two major carbon emitters and spend heavily on carbon emission reduction, so their participation in BRI carbon markets will contribute to maximizing the benefits of emission reduction in BRI countries. Therefore, this scenario assumes that, on the basis

of the BRI scenario, the EU and the U.S. will be further linked to carbon markets in the five major BRI countries or regions in 2025, with initial carbon allowances of these countries or regions in each year being carbon emissions in the NDC scenario. In this scenario, carbon trading markets in these countries can be considered absolute cap market.

5.2. Result analysis

5.2.1. Carbon emissions and emission reduction costs under current policies of different countries

Further analyzing the impacts of establishing domestic and international carbon markets in major BRI countries and regions necessitates the effective identification of their carbon emission paths (including emissions from industrial processes and from fossil fuel burning) and emission reduction costs required to achieve their NDCs (for the U.S., the current policy target). As shown in Figure 11, China will peak its carbon emissions in 2030, at 12.1 billion tonnes of CO_2, which will then fall to 11.7 billion tonnes. The U.S. will peak its carbon emissions in 2020, at 5 billion tonnes, and then gradually reduce them to 4.2 billion tonnes in 2035. The EU has witnessed a decline in its carbon emissions since 2014 (3.3 billion tonnes), which will further drop to 2 billion tonnes in 2035. In Southeast Asia, carbon emissions will increase from 1.4 billion tonnes in 2014 to 2.6 billion tonnes in 2035. ROK has already peaked its total carbon emissions, which will slowly fall from 0.73 billion tonnes in 2018 to 0.52 billion tonnes in 2035. South Africa will peak its carbon emissions in 2025, at 0.45 billion tonnes, which will then slowly decrease to 0.42 billion tonnes in 2035.

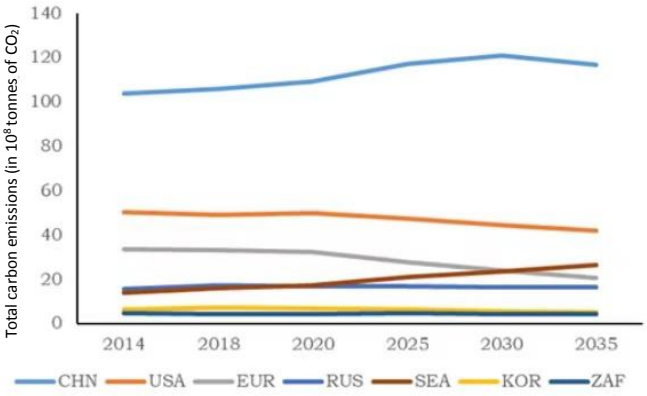


Figure 11 Carbon emissions of different countries during 2014-2035 in the NDC scenario

In the NDC scenario, marginal costs of emission reduction in major countries will increase with the tightening of carbon restrictions (see Figures 12). Marginal costs of emission reduction in China will rise from USD 6.8/tonne in 2020 to USD 20/tonne in 2035. Southeast Asia and Russia are second to China in terms of size of the economy, carbon intensity reduction target and emission reduction costs. In Southeast Asia, marginal costs of emission reduction will gradually grow from USD 3.3/tonne in 2020 to in USD 15.3/tonne 2035. Similar to Southeast Asia in respect of emission reduction costs, Russia will see an increase in marginal costs of its emission reduction from USD 3.4/tonne in 2020 to USD 12.5/tonne in 2030 and then to USD 15.5/tonne in 2035. Despite with a higher carbon intensity than China, the Republic of South Africa has to pay more for emission

reduction as a result of slow progress in the improvement of renewable energy technologies and energy efficiency, with such payment to increase from USD 12/tonne in 2020 to USD 19.2/tonne in 2035 and further to USD 24.2/tonne in 2035. Emission reduction costs are high in ROK, the EU and the U.S., which will increase from USD 20.2/tonne in 2020 to USD 50.2/tonne in ROK; although the EU has a lower carbon intensity than the U.S., it performs better in renewable energy and other low-carbon technologies, and pays mildly less for emission reduction, with such payment to grow from USD 24.2/tonne in 2020 to USD 60.2/tonne in 2035; in the U.S., the costs will increase from USD 28.4/tonne in 2020 to USD 64.8/tonne in 2035.

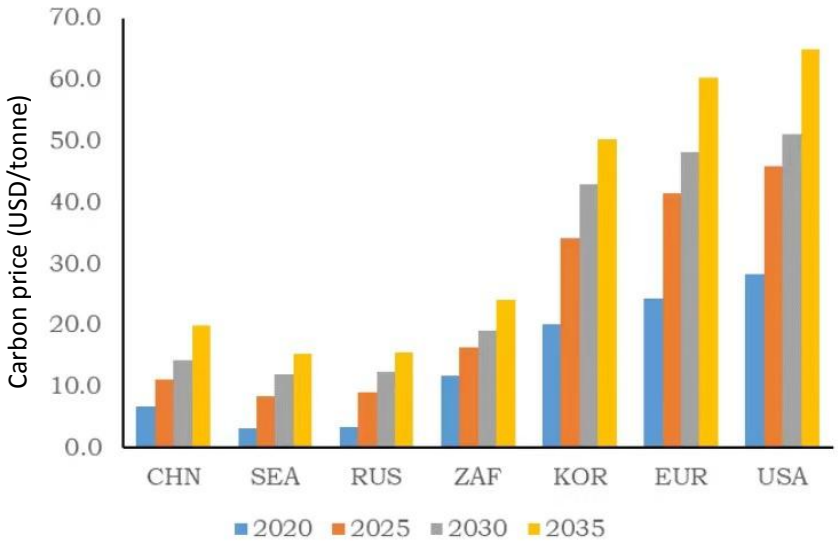


Figure 12 Carbon emission reduction costs of different countries during 2020-2035 in the NDC scenario

5.2.2. Primary energy consumption structures of different countries under current policies

In the NDC scenario, China's total primary energy consumption will continue to grow, from 4.28 billion tce in 2014 to 6.25 billion tce in 2035. Coal is currently dominating in China's energy structure.

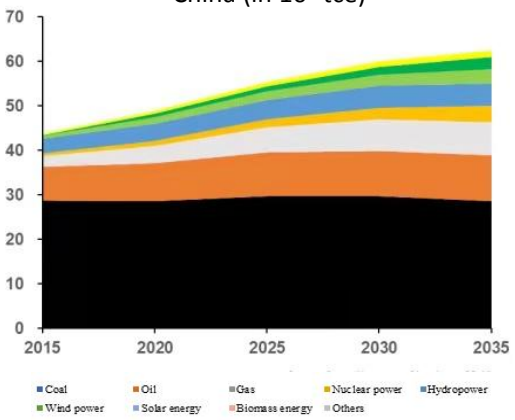
During 2014-2035, Russia's primary energy consumption is expected to stay at 1-1.1 billion tce, and natural gas will prevail in the country's energy structure. In Southeast Asia, total primary energy consumption is expected to double from 0.69 billion tce in 2014 to 1.33 billion tce in 2035, without regard to biomass energy used in traditional ways, and oil products will dominate. ROK's primary energy consumption is expected to peak during 2020-2025 and then gradually decline to 0.42 billion tce in 2035, with the share of oil in the primary energy consumption to drop from 48% in 2018 to 42% in 2035. The primary energy consumption in South Africa is expected to be 0.18-0.19 billion tce, which will be dominated by coal but continue to fall in the future.

EU is expected to peak its primary energy consumption in 2020, at 2.25 billion tce, which will then

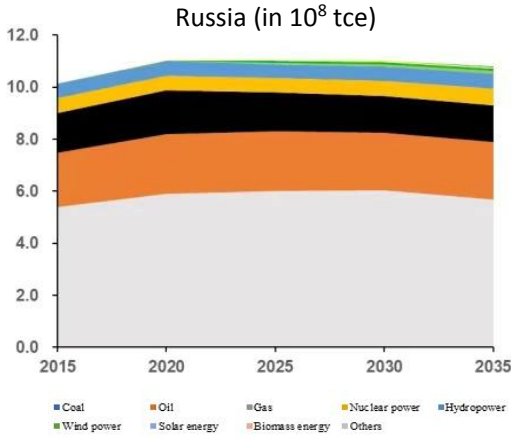
slowly decline to 1.88 billion tce in 2035. Oil and gas consumption is expected to peak in 2020, with the share of oil to fall from 34% in 2020 to 28% in 2035 and that of gas from 25% to 23%.

The U.S. is expected to see an increase in its primary energy consumption from 3.07 billion tce in 2014 to 3.2 billion tce in 2018, which will then stay relatively stable. Currently, oil and gas dominate in the U.S. primary energy consumption.

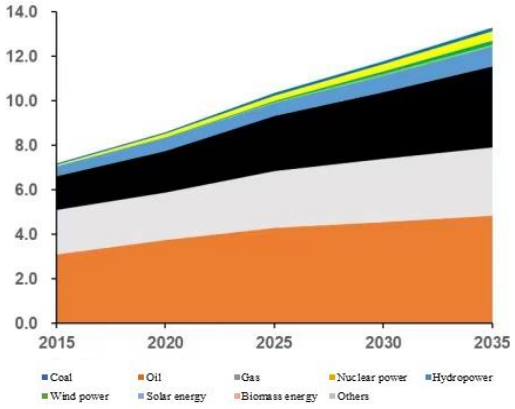
China (in 10^8 tce)



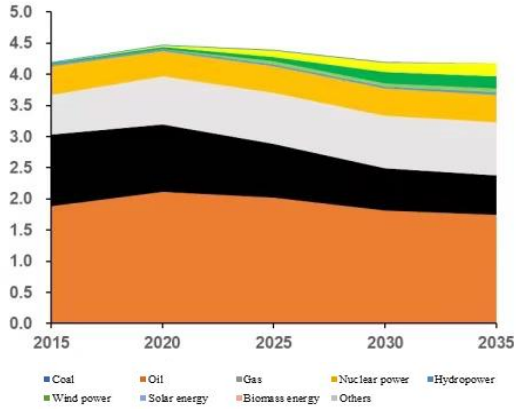
Russia (in 10^8 tce)



Southeast Asia (in 10^8 tce)



ROK (in 10^8 tce)



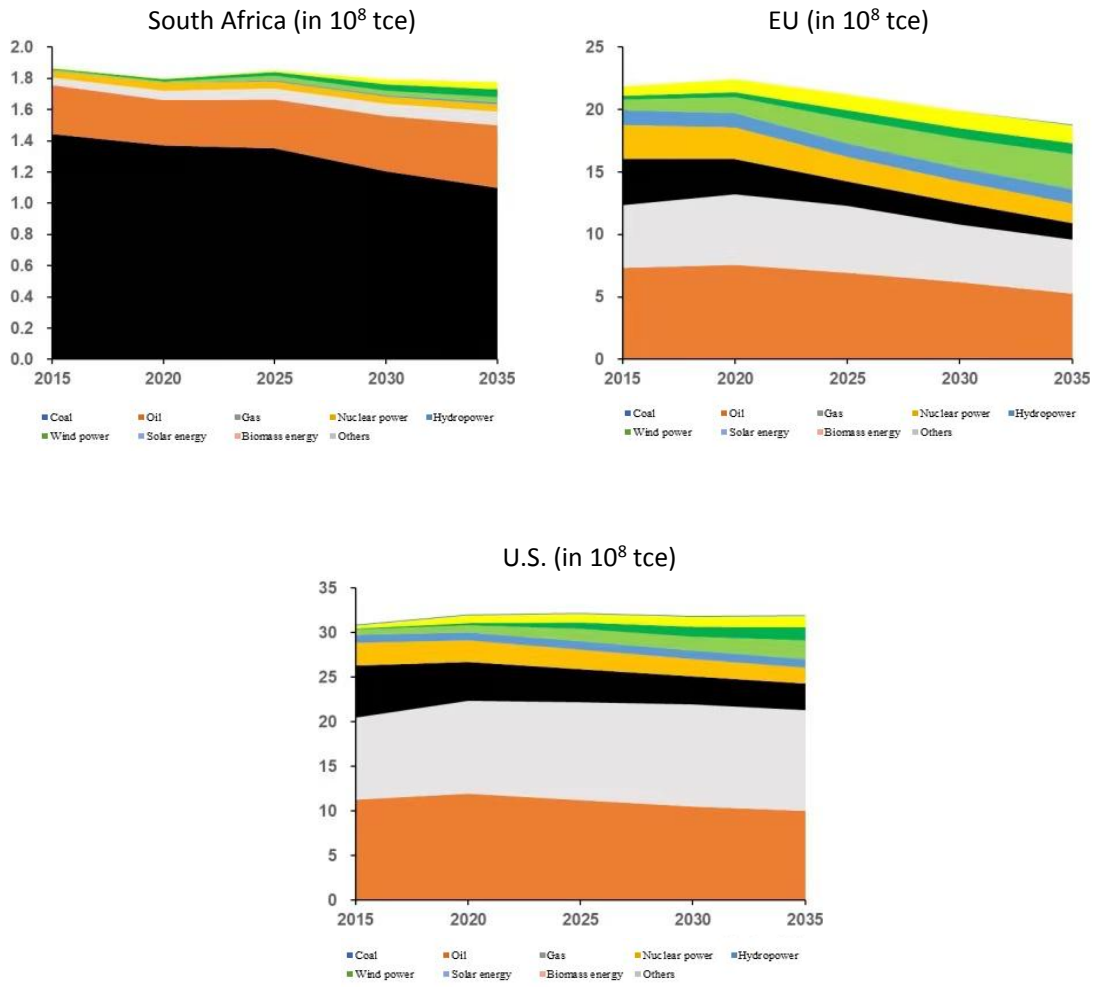


Figure 13 Primary energy consumption in major countries in the NDC scenario

5.2.3. Size of carbon markets and the development of financial markets

Research results show that establishing carbon markets contribute increasingly to emission reduction efforts of different countries, with the largest contribution taking place in China (emissions reduced by 32%-40% in the NDC scenario relative to the REF scenario), followed by ROK (23%-25%), the U.S. (20%-26%), the EU (18%-19%), South Africa (12%-13%), Russia (9%-13%) and Southeast Asia (4%-6%). With the participation of major BRI countries, trading volume in all carbon markets may total USD 192.5 billion in 2025, USD 253.3 billion in 2030 and USD 335.2 billion in 2035; if the EU and the U.S. are also included, the total trading volume will further increase, which may hit USD 525 billion in 2025, USD 596.5 billion in 2030 and USD 730.2 billion in 2035.

Table 9 implies that due to different emission reduction targets and costs, allowance trading prices vary greatly from country to country in the NDC scenario. This in essence reflects differences in emission reduction capacity, proving theoretically that linking carbon markets across regions can provide great space for optimization of these markets. However, in practice, big differences in carbon market prices in different regions will cause disagreements between carbon markets on emission reduction intensity, supply of allowances and transfer of benefits after their linkage is

created, thus adding to the difficulty of linking carbon markets.

When all major BRI countries or regions are linked to form a single carbon market, i.e., in the BRI scenario, the equilibrium carbon price will be USD 20.5/tonne in 2035 and the turnover would be USD 10.2 billion. If the EU and the U.S. join the BRI carbon market, i.e., in the EUS scenario, the carbon market will further expand, where the equilibrium carbon price will rise to USD 24.2/tonne and the turnover would be USD 54.8 billion.

Table 9 Carbon prices, trading volumes and turnovers in 2035 in the NDC, BRI and EUS scenarios

Major countries and regions	Emissions in 2035 in REF scenario ($MtCO_2$)	Emission allowances in 2035 ($MtCO_2$)	Contribution of carbon markets to emission reductions	CO_2 prices in 2035 (USD/tonne of CO_2)			Imports ($MtCO_2$) and turnovers (10^8 USD) in global carbon markets in 2035, + represents imports	
				NDC	BRI	EUS	BRI	EUS
China	19415	11677	7738	20.0	20.5	24.0	126 (25.9)	-786 (-190.2)
Russia	1852	1620	232	15.5			-125 (-25.5)	-153 (-36.9)
Southeast Asia	2753	2625	128	15.4			-124 (-25.5)	-194 (-46.9)
ROK	679	516	62	50.2			111 (22.8)	92 (22.3)
South Africa	482	420	163	24.2			11 (2.3)	-1 (-0.2)
EU	2514	2038	476	60.2	-		-	293 (70.8)
U.S.	5643	4200	1443	64.8	-		-	748 (181.1)

Cooperation on carbon market among countries can optimize the allocation of resources in different regions, raising the overall GDP. By purchasing carbon allowances to optimize their resources, allowance importers will see an increase in GDP in the BRI scenario; GDP of allowance exporters might be adversely impacted after carbon trading, and the impacts rest with revenues from carbon allowance trading and changes in emission reduction output. South Africa, for example, will experience a 0.04% decrease in GDP in 2035. For the overall, the global GDP will increase by 0.04% in 2035 after they are linked. Carbon market cooperation will increase the GDP of allowance importers, such as ROK and South Africa, which will grow by 0.3% and 0.03% respectively in 2035. For China, it will benefit relatively less from participating in the BRI carbon market (the BRI scenario), with its GDP to increase by only 0.01%, since the equilibrium carbon price in the carbon market involving the five countries will be close to China's carbon price in the NDC scenario, indicating that China will trade only a small number of carbon allowances in the BRI carbon market. If the EU and the U.S. join regional carbon trading, China may witness GDP growth by selling its

carbon allowances, which will register 0.18% in 2035. Russia, Southeast Asia and ROK are all main beneficiaries from the BRI carbon market. If the EU and the U.S. join, that is, in the EUS scenario, the regional equilibrium carbon price will be raised and Russia and Southeast Asia will gain more from sales of carbon allowances, with their GDP to further grow; while ROK, as an allowance importer, will see a smaller increase in GDP than that in the BRI scenario as importable allowances are squeezed.

Linking carbon markets plays a positive role in improving the wellbeing of people from different countries. Research results indicate that Russia, Southeast Asia and ROK are main beneficiaries from the BRI carbon market; if the EU and the U.S. join the regional carbon market, Russia and Southeast Asia will benefit more, so will the EU and the U.S.

6. Conclusions and policy recommendations

The efforts to set up carbon markets will play an effective role in reducing carbon emissions in individual nations and strictly limiting the total amount of carbon emissions. Nations should take an active part in establishing domestic carbon markets, and those that have carried out pilot carbon markets, such as China and South Korea, should share experience and policies to help others set up carbon markets as soon as possible and thereby limit the total amount of carbon emissions.

Studies show that the conditions for China, South Korea, the EU and the United States to set up carbon markets are ripe, and South Korea and the EU have signaled their intentions to be a part of the international carbon market; it is highly feasible to set up carbon markets in Russia, Southeast Asian countries and South African countries as conditions are relatively ripe; while it is less feasible to set up carbon markets in the Middle East and African countries. Among Southeast Asian countries, Singapore, Malaysia, Thailand, Indonesia and Vietnam enjoy relatively ripe conditions that make it highly feasible to set up carbon markets. In the case of the Middle East countries, UAE, Israel and Saudi Arabia meet objective conditions. Among them, Saudi Arabia shows its strong intentions, making it highly feasible to set up a carbon market in a short term. For African countries, with relative mature objective conditions and strong intentions, it is highly feasible to set up carbon markets in Rwanda, Morocco, Kenya and Tunisia.

By analyzing the China-Global Energy Model (C-GEM), it finds that carbon pricing can reflect the marginal costs for emission reduction of each individual country; in light of the varied costs for emission reduction in different countries when delivering the commitments, while facilitating the reduction of overall costs across the world, linking regional carbon markets would also have asymmetric effects on the GDP, the public welfare and industrial development of each individual country. The regional carbon market of the 5 major countries and regions along the BRI, including China, South Korea, Russia, Southeast Asia and South Africa, has less leverage over the improvement of public welfare and GDP growth in China, thanks to the proximity of the equilibrium carbon price in the region to China's independent carbon pricing. Despite China is an importer of carbon allowance, only a limited amount of allowance has been traded. Major beneficiaries of this market include Russia, Southeast Asia and South Korea. Once the EU and the United States join the BRI regional carbon market, China would turn into an exporter of carbon allowance and expect to experience a significant growth in its public welfare and GDP. At that time, the market would not only further improve the public welfare and GDP in Russia and Southeast Asia, but also contribute to the economic development of EU countries and the United States, allocating more carbon emission reduction responsibilities to those countries and regions where the reduction utility could be maximized . Therefore, when building the BRI carbon market connections, it is suggested to incorporate developed economies like the EU and the U.S., which can both cut the regional costs for emission reduction and improve the economy and public welfare of each individual country.

Considering the costs for emission reduction of each individual country, building carbon market connections could help more BRI countries cut the costs for emission reduction; on the other hand, it should be noted that building connections between countries with similar costs or between

countries whose equilibrium carbon pricing is closed to China's carbon price level would impede costs cut in China. Therefore, when designing the linkage, it is essential to target the suitable partners for international carbon market and identify proper positions, so as to ensure all countries can benefit from the BRI carbon market linkage.

Given the above, the following six policy recommendations are highlighted:

1) To promote China's low-carbon green transition, it is imperative to accelerate the establishment of a national carbon market. Chinese President Xi Jinping points out that global transition to low-carbon green growth should be guided by the Paris Agreement that marks a global commitment to address climate change. China will scale up its intended Nationally Determined Contributions and adopt more vigorous policies and measures so as to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. China's Vice Premier of the State Council Han Zheng urges to implement Xi Jinping's thought on promoting ecological civilization, put utmost effort toward the vision of CO_2 emission peaking and carbon neutrality, speed up the establishment of nationwide carbon market, and take an active part in the global climate governance.

2) Countries that have joined the BRI should work with China to seek low-carbon development, with top priority given to building carbon markets in their power sectors. China has started with the power generation industry to launch a national carbon emission trading system, cultivate market entities, improve market regulation, and expand market coverage within this system; South Korea, Thailand, Indonesia, the EU and the U.S. have also given high priority to carbon emission trading in their power sectors. Thus, it is advised to help countries that are interested in building carbon markets launch pilot projects in power sectors, especially in regions along the BRI where China has set up state-controlled power plants, promoting green development by the Belt and Road cooperation.

3) China should make prudent investment and tighten management on coal-fired power plant projects to be undertaken in regions along the BRI. Works should be done to: encourage enterprises to improve environmental protection technologies and apply stricter emission standards against global emission standards, so as to forestall environmental risks; jointly formulate relevant laws and rules and set up a standard basic database to build a decision support and government service system; introduce institutional innovation to get coal-fired power plants that China has already built overseas involved into China's carbon market; draw up project strategies based on actual local conditions and strengthen response to public opinions; give full play to the roles of the International Coalition for Green Development on the Belt and Road (the Coalition) and other multilateral cooperation platforms, rely on China Electricity Council, Global Energy Interconnection Development and Cooperation Organization and other professional institutions both at home and abroad, and make full use of Coalition partners' resources in terms of electric generation and environmental protection and exercise their influences in the industry, thus enabling them to play an active role in project information collection, solution customization and public opinion guidance.

4) The fund of carbon market should be set up to support countries along the BRI to build carbon markets. The fund can be used to provide training and guidance to countries that are willing to build carbon markets in establishing overall design and management mechanisms, so as to encourage them to enter the BRI international carbon market. Considering the ripe conditions for building carbon markets in Russia, countries in Southeast Asia including Malaysia, Thailand, Indonesia and Vietnam, countries in the Middle East including UAW, Israel and Saudi Arabia, and the African countries including Rwanda, Morocco and Tunisia. The fund of carbon market should be provided to the above mentioned countries as priority targets for conducting pilot projects and then can be extended to other countries.

5) Efforts should be intensified to promote extensive cooperation and exchanges on carbon market among countries along the BRI, so as to accelerate the establishment of relevant disciplines and cultivation of professional forces for climate action and carbon market. It is suggested to organize BRI carbon market workshops and invite representatives from governments, academic and business community of countries along the BRI to explore the necessity, feasibility and challenges of building domestic and international carbon market, in order to enhance the understanding of the carbon pricing mechanism among these countries. Besides, it is also advised to develop a systematic training program to complete the talent pool system and provide continuous supply of professionals. Lastly, assistance should be provided to technologically underdeveloped countries and regions to help them expedite the establishment of relevant disciplines and cultivation of professionals.

6) After the carbon market in China is established more systematic and more perfect, efforts should be made to explore different modes for BRI carbon market linkages and cooperation. When designing the BRI carbon market linkages, priority should be given to building double-way linkages among carbon markets of China, South Korea, the EU and the U.S. Other countries will be gradually included as their carbon markets turn mature.

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