



CCICED
SPECIAL POLICY REPORT

Global Climate Governance and China's Role

2021

September, 2021

Member of the project group on thematic policy research *

Co-leads (surname alphabetic order)

International

Kate HAMPTON	CCICED Member, CEO, Children's Investment Fund Foundation
ZOU Ji	CCICED Special Advisor, CEO & President, Energy Foundation China

Chinese

WANG Yi	Member, Standing Committee of the National People's Congress of China; Vice President, Institutes of Science and Development, Chinese Academy of Sciences
---------	---

Core Experts (surname alphabetic order)

International

Ajay MATHUR	CCICED Member, Director General, International Solar Alliance
Lord Nicholas STERN	Chairman, the Grantham Research Institute on Climate Change and the Environmentthe London School of Economics and Political Sciences
Ana TONI	Executive Director, Instituto Clima e Sociedade (iCS) Brazil
Laurence TUBIANA	CEO, European Climate Foundation

Chinese

TAN Xianchun	Professor, Deputy Director, Institute of Sustainable Development Strategy, Institutes of Science and Development, Chinese Academy of Sciences
WANG Jinzhao	Research Fellow and Director-General, Research Department of Industrial Economy, Development Research Center of the State Council (DRC)
XU Huaqing	Director General, China National Center for Climate Change Strategy and International Cooperation
ZHANG Haibin	Associate Dean and Professor, School of International Studies, Peking University

Advisors (surname alphabetic order)

International

Athena Ronquillo	Climate Finance Director, Asia Growald Family Fund
BALLESTEROS	
Manish BAPNA	CCICED Special Advisor, President and CEO, Natural Resources Defense Council

Baroness BRYONY Jos DELBEKE	Co-Director, Quadrature Climate Foundation European University Institute's (EUI) European Investment Bank (EIB) Chair on Climate Change Policy and International Carbon Markets, former Director General Climate Action, European Commission
Adrian FERNANDEZ Alexander FISHER	Executive Director, Climate Initiative of Mexico (ICM) Program Director for Climate Change Cooperation, Environment, and Climate Friendly Urban Development, GIZ
Kelly Sims GALLAGHER	Academic Dean, The Fletcher School, Professor of Energy and Environmental Policy, Director, Climate Policy Lab and Co-Director, CIERP, Tufts University
Michael GRUBB	Professor of Energy and Climate Change, University College London
HAN Guoyi Hal HARVEY Gørild Merethe HEGGLUND Frank JOTZO	Senior Research Fellow, SEI CEO, Energy Innovation Senior Research Fellow, Fridtjof Nansen Institute Professor, Crawford School of Public Policy, Director, Centre for Climate and Energy Policy, Australian National University
Rachel KYTE Bernice LEE	Dean of The Fletcher School, Tufts University CCICED Special Advisor, Executive Director Hoffmann Centre for Sustainable Resource Economy, Chatham House
LEI Hongpeng	Director, Climate and Chief Representative, China, Children's Investment Fund Foundation
Janos PASZTOR	Senior Fellow and Executive Director, Carnegie Climate Geoengineering Governance Initiative (C2G2)
Paul SIMPSON James THORNTON Harald WINKLER Durwood ZAELKE	CEO, CDP Founding CEO, Client Earth Professor, Energy Research Centre, University of Cape Town Founder, President, Institute for Governance & Sustainable Development (IGSD)
Chinese HE Kebin	CCICED Special Advisor, Professor, School of Environment, Tsinghua University, Academician of the Chinese Academy of Engineering
KANG Yanbing	Professor, Director, Energy Sustainability Center, Energy Research Institute
WANG Pu	Associate Professor, Institutes of Science and Development, Chinese Academy of Sciences

Coordinators

ZHONG Lijin	Chief of Staff, Energy Foundation China
GU Baihe	Associate Professor, Institutes of Science and Development, Chinese Academy of Sciences
XIN Jianan	Officer, International Climate Affairs, Energy Foundation China

Team members

LIU Qiang	Director of Programmes, China, Children's Investment Fund Foundation
ZHAO Xiao	Children's Investment Fund Foundation
DONG Yue	Energy Foundation China
ZHANG Xiaohan	Energy Foundation China
ZHAO Wenbo	Energy Foundation China
LIU Yuxuan	Institutes of Science and Development, Chinese Academy of Sciences
CAI Jingjing	Energy Foundation China

* The co-leaders and members of this SPS participate in the research as individuals and do not represent the views of their organizations and CCICED.

CONTENT

Executive Summary	I
Foreword.....	VI
1. Background of the Carbon Neutral Goal	1
1.1. Green and low-carbon development has become an important direction for global economic and social development.	1
1.1.1. Climate change is an urgent global challenge in the post-epidemic era.	1
1.1.2. The international community has basically reached a consensus on carbon neutrality.	1
1.1.3. China has vowed to have carbon emissions peak before 2030 and achieve carbon neutrality before 2060.	2
1.1.4. Climate action goes hand-in-hand with sustainable development goals such as gender equality.	3
1.2. The carbon neutrality vision is compatible with China's climate policy	4
1.2.1. China has gradually established a policy system for low-carbon development.....	4
1.2.2. Public health events such as the COVID-19 epidemic have urged faster actions on climate change.	6
1.3. Green low-carbon development under the carbon neutrality vision represents an important connotation of high-quality development.....	7
2. Opportunities and Challenges	9
2.1. Opportunities.....	9
2.1.1. The 14th FYP and the 2035 vision organically integrate green low-carbon development into economic transition.	9
2.1.2. Faster green low-carbon technological transformation worldwide paves the ground for low-carbon transition.	10
2.1.3. Digital technology and digital economy drive forward green low-carbon transition.	10
2.1.4. Unique institutional and market advantages provide effective safeguards for deep emission reduction.	11
2.2. Challenges.....	12
2.2.1. Preparations are necessary, considering deep uncertainties in international political and economic landscape.	12
2.2.2. Emission reduction pathways are not actually smooth, given the short time frame for peaking carbon emissions and achieving carbon neutrality.....	13
2.2.3. China has weak basic research and development capabilities and faces competition in key low-carbon technologies.	14
2.2.4. Just transition is a prominent problem under carbon neutrality because of wide regional disparities.	14

3. China's Mid- and Long-term Climate Goals, Roadmap and Policy Guarantee System	16
3.1. Phased goals and roadmap	16
3.1.1. Near term: Early peak of carbon emissions in certain areas and sectors ...	17
3.1.2. Middle term: Early peak and steady decline of carbon emission overall ..	18
3.1.3. Long term: Construction of a carbon-neutral economic and social system	18
3.2. Transition pathways towards mid- and long-term climate goals	19
3.2.1. Adjustment of development model to build a green and low-carbon industrial structure	19
3.2.2. Implementation of energy revolution to develop a green and low-carbon energy system.....	19
3.2.3. Overall planning to promote diversified and coordinated regional low-carbon transformation and development.....	20
3.2.4. Establishment of a green modern comprehensive transportation system through both soft and hard measures	21
3.2.5. Reduction of non-CO ₂ GHG emissions	22
3.2.6. Deployment of a low-carbon technology system supporting carbon neutrality	22
3.2.7. Demand structure change to nurture the concept of low-carbon consumption	23
3.3. Policy guarantee system.....	23
3.3.1. Establishing a sound legal and regulatory system led by the climate change law	23
3.3.2. Improving the macro coordinated management mechanism on climate change	24
3.3.3. Establishing a cap-based emission reduction target system and related systems	25
3.3.4. Exploring policy synergies between local areas and various sectors in peaking carbon emissions	26
3.3.5. Accelerating the construction of market mechanisms represented by the national carbon market.....	26
3.3.6. Improving the policy system for climate investment and finance	27
3.3.7. Strengthening the coordinated governance of climate change and air pollution	28
4. A Market Mechanism Centered on Carbon Pricing	30
4.1. About carbon pricing	30
4.2. Carbon pricing has been continuously practiced worldwide	31
4.2.1. Development of the carbon pricing mechanism globally	31
4.2.2. Development of the carbon pricing mechanism in typical countries and regions.....	33
4.2.3. Challenges for the carbon pricing mechanism in practice	35

4.3. Progress and problems of China's carbon pricing mechanism.....	36
4.3.1. Carbon pricing as an important policy tool for China to achieve carbon neutrality	36
4.3.2. Progress of carbon pricing in China.....	36
4.3.3. Problems and challenges facing China's carbon pricing mechanism.....	38
4.4. Suggestions for promoting the gradual improvement of China's carbon pricing system	39
5. Global Climate Cooperation in the New Era and China's Role	42
5.1. State of global climate cooperation after the pandemic.....	42
5.1.1. Overall situation of international cooperation in global climate governance	42
5.1.2. Practical demand for international cooperation on green recovery and low-carbon transition.....	43
5.2. Suggestions for strengthening international climate cooperation	45
6. Gender Equality Analysis	49
6.1. Gender and climate as cross sectoral issues would rely much on multi-ministerial efforts	49
6.2. Women's participation in the carbon-neutral job market	50
6.3. Women's safety and transportation	51
7. Policy Recommendations.....	52
7.1. Gradually establish and improve an absolute carbon emission cap under the guidance of the carbon peaking and carbon neutrality goals.....	52
7.2. Achieve both economic recovery and low-carbon development by actively carrying out deep decarbonization efforts in key industries	53
7.3. Build a new power generation paradigm with low-carbon energy at its core, accelerate coal control and the large-scale deployment of renewable energy	53
7.4. Accelerate the development of carbon pricing, carbon market and carbon finance mechanisms and promote green finance	55
7.5. Strengthen international exchanges and extensively participate and lead the global climate governance and implemen the Paris Agreement.....	55
Acknowledgement	57
References	58

Executive Summary

The Special Policy Study (SPS) on Global Climate Governance and China's Role (2018-2021) is one of the research topics of the Task Force on Global Governance and Ecological Civilization set up by the China Council for International Cooperation on Environment and Development (CCICED). The research focuses for 2020–2021, which is the closing year of this research topic in CCICED Phase VI, include China's mid- and long-term climate goals, roadmap and policy system, as well as the new pattern of global climate governance and China's role.

Since September 2020, Chinese President Xi Jinping has stressed on many international and domestic occasions China's intention to peak carbon emissions before 2030 and achieve carbon neutrality before 2060 (hereinafter referred to as the Dual Carbon Goals). The CPC Central Committee and the State Council have attached great importance to the Dual Carbon Goals as a "systemic reform for the economy and society", and required its integration into the overall layout of the building of the ecological civilization. Carbon neutrality exerts a profound impact on China's conceptual framework, pathways and policies of economic and social development. Its realization requires a fundamental change in development model and mindset, putting higher requirements for China's economic restructuring, technological innovation, capital investment, consumption pattern change, as well as institutional framework and policy system. In view of new changes undergoing in the global political and economic landscape, the vision of carbon neutrality will also bring new opportunities and challenges to the future international climate cooperation model.

This report reviews the international and domestic background and realistic foundation of China's carbon neutrality vision, analyzes the opportunities and challenges for achieving this vision, and on this basis, proposes phased goals for carbon neutrality vision and transition pathways to mid- and long-term climate goals. With an in-depth focus on carbon pricing mechanisms, the report examines international experience, current progress and problems, and offers suggestions to promote the gradual improvement of China's carbon pricing system. Then, the report provides recommendations for stepping up global climate cooperation, taking into account the overall situation and needs. The report also examines the important aspects to consider when pursuing carbon neutrality from the perspective of gender equality. Finally, policy recommendations are provided for pursuing China's carbon neutrality vision and related goals and promoting international climate cooperation.

The main findings and conclusions are as follows:

1. There are both opportunities and challenges for China to achieve its Dual Carbon Goals

Opportunities: 1) The 14th Five-Year Plan (FYP) and the 2035 Vision organically integrates green low-carbon development into economic transition, laying an important foundation for nurturing green and low-carbon ways of production and life, and promoting the early peaking of carbon emissions and a steady decline afterwards towards carbon neutrality. 2) Faster green and low-carbon technological transformation worldwide paves the way for low-carbon transition. The development of green technologies and industries fundamentally addresses the problems of environmental pollution and ecological damage associated with the solidification of traditional industrial structure and energy mix, while injecting new impetus to the economy. 3) Progressing digital technology and digital economy drives forward green and low-carbon transition. Green and digital transition are the common choice of all countries for post-epidemic economic recovery plans. Digital technology can play an important role in further improving the efficiency of resource and energy utilization, driving the development and utilization of renewable energy, raising the efficiency of the whole society, and reducing energy demand. 4) Unique governance and market advantages provide a powerful facilitator for deep emission reduction. Institutional advantages, coupled with huge market and active stakeholder participation, will provide strong support and guarantee for the realization of the carbon neutrality vision.

Challenges. 1) Uncertainties in international political and economic landscape might create barriers to the low-carbon transition. Although the Biden administration has brought the United States back to the Paris Agreement, the ongoing and severe impact of the pandemic on developing countries and the complexities of the international situation threaten to undermine the momentum of global efforts to combat climate change. 2) China's emission reduction pathway is very steep, given the short time frame for peaking carbon emissions and achieving carbon neutrality. China's transition pathways will be expedited as only about 30 years are left for the transition between carbon peaking and carbon neutrality, which is much shorter than the time Europe and the US take to reach the neutral target from peaking plateau. This puts stronger requirements for energy restructuring, technology innovation and capital investment. 3) China has weak research & development capabilities and faces competition in key low-carbon technologies. Challenges in this regard include insufficient original scientific and technological outcomes, institutional obstacles to the transformation of scientific and technological results, inefficient allocation of innovative resources, and small number and low quality of innovative talents. 4) Just transition is a prominent problem under the carbon neutrality vision because of wide regional disparities. High-carbon industries will suffer tremendous impacts during the zero-carbon transition, especially in areas where economic development and employment are heavily reliant on coal, hence the imperative to develop systematic socio-economic solutions.

II. Staged goals and roadmap towards China's carbon neutrality vision.

Phased targets for each milestone of emission reduction and development. In the near term, carbon emissions shall peak as early as possible in certain regions and sectors.

Carbon emissions should enter a plateau period during the 14th FYP period (2021–2025). Carbon emissions will peak first in some economically developed eastern and western/southwestern provinces and cities with good renewable energy endowments, and in high-carbon industries such as power generation, steel and cement. In 2025–2030, China will push for early peaking of carbon emissions as a whole. China's energy mix continues to improve and primary energy consumption is expected to enter a plateau period as the energy structure will continuously optimize, to the stage where it is dominated by coal, oil and gas, and renewable energy, while end-use power consumption will increase significantly. In 2035–2050, an energy supply and consumption system based on renewable energy will be built while accelerating the exit of fossil energy. In 2050–2060, China will move towards carbon neutrality.

Pathways towards carbon neutrality. 1) The development model will be adjusted to foster a green and low-carbon industrial structure and establish an economic system for green, low-carbon and circular development. 2) The energy revolution will be implemented to cultivate a green and low-carbon energy system. This involves formulating a roadmap for the orderly exit of coal, greatly raising the level of electrification of end-use energy, building a supply system with a high proportion of renewable energy, accelerating the research & development and application of energy storage, hydrogen energy and smart grid technologies, and establishing and implementing a sound guarantee mechanism for the integration of renewable energy power on the grid. 3) A coordinated national plan for low-carbon transition will be established taking into account regional diversities. On the basis of the existing share of emissions, differentiated regional low-carbon development goals will be established, while paying attention to issues of fairness and justice that may arise in the transition process. 4) Both incentives and regulatory measures will be combined to build a green and comprehensive modern transportation system. Transportation systems and services will be transformed in a systematic manner, and an efficient and low carbon model of transportation will be fostered. 5) Non-CO₂ GHG emissions will be reduced by setting overall GHG emission reduction targets covering all economic sectors and advancing the implementation of the Kigali Amendment. 6) Support for carbon neutral technologies will be deployed. In alignment with the needs of carbon neutrality, mid- and long-term low-carbon technological innovation plans will be formulated as soon as possible to accelerate the research & development and application of key carbon neutral technologies and facilitate the deep integration of next-generation information technologies and advanced low-carbon technologies. 7) A low-carbon consumption mindset will be cultivated and change the demand structure. The supply of green and low-carbon products and services will be expanded while encouraging the extensive participation and active action of the public and grassroots groups.

III. It is necessary to gradually improve China's carbon pricing system.

Carbon pricing mechanisms continues to spread on a global scale. Carbon pricing mechanism has been adopted by many countries and continues to become mainstream

in global climate governance policies. In order to strengthen climate commitments, many countries and regions have expanded the coverage and intensity of carbon pricing mechanism. More and more enterprises have begun to use internal carbon pricing to encourage more aggressive emission reduction

For China, carbon pricing is an important policy instrument to achieve the carbon neutrality vision. The national carbon market has been officially launched, first in the thermal power generation sector. This has played a positive role in stimulating low-carbon innovation of enterprises, strengthening capacity building and improving regulatory capability, and contributed to the improvement of China's influence in the field of global climate governance. However, carbon pricing in China lacks a solid legal foundation and an appropriate linkage to the overall climate targets. Other problems include unclear carbon market property rights and inactive market entities. As a result, carbon pricing mechanisms fail to realize the due function of price discovery. Also, as long as the property rights around carbon pricing is not solved, the risk price inefficiency will remain.

To this end, **it is suggested to gradually improve China's carbon pricing system by:** 1) establishing a cap-based carbon emission reduction system to pave an institutional foundation for carbon emissions trading; 2) steadily accelerating the construction of the national carbon emissions trading system, and forming a hybrid carbon pricing system with both carbon tax and carbon market as appropriate; 3) gradually introducing carbon financial tools to stimulate market vitality and accelerate low-carbon transition; 4) improving basic carbon emissions accounting capabilities and making carbon pricing mechanisms more transparent; and 5) driving forward negotiations on the carbon market mechanisms of the Paris Agreement to prevent carbon leakage and promote fair trade.

IV. International cooperation on climate change should be strengthened.

As the world is undergoing major changes unseen in a century amid the Covid-19 pandemic, the green recovery of various countries demands a more effective cooperation mechanism at the global level. The pathways to low-carbon transition and jointly fighting climate change also require more extensive international technology cooperation. China should play an active role in international climate cooperation by 1) actively assuming the responsibility of a major country and drive global green and low-carbon development; 2) building a more fair and reasonable mechanism for international cooperation; 3) creating a favorable cooperation pattern in the trilateral game between China, the United States and the European Union; 4) expanding international exchanges on green and low-carbon technologies; 5) pushing forward regional cooperation in climate change; and 6) stepping up third-party market cooperation in key developing countries in Southeast Asia, Africa, and Central Asia.

V. Without gender equality, there can be no truly sustainable human development.

Gender equality is an important issue that cannot be ignored to tackle global climate change. China should mainstream gender equality awareness and action into climate policies, in order to ensure the implementation and realization of coordinated efforts and shared benefits in climate action and low-carbon transition, as well as gender equality and women's development. It is also necessary to ensure that men and women have equal access to new job opportunities in emerging green industries. Improving women's personal safety in public places, especially in the field of public transportation, can encourage women to choose more shared and lower-carbon transportation services.

VI. Policy recommendations are offered for achieving China's carbon neutrality and related goals and promoting international climate cooperation

These policy recommendations are summarized as follows: 1) gradually establishing and improving an absolute carbon emission cap under the guidance of the carbon peaking and carbon neutrality goals; 2) achieving both economic recovery and low-carbon development by actively carrying out deep decarbonization efforts in key industries; 3) building a new power generation paradigm with low-carbon energy at its core, accelerate coal control and the large-scale deployment of renewable energy. 4) Accelerating the development of carbon pricing, carbon market and carbon finance mechanisms and promote green finance; 5) strengthening international exchanges and extensively participating and leading the global climate governance and implementing the Paris Agreement

Foreword

The Special Policy Study on Global Climate Governance and China's Role, under the research umbrella of the CCICED Task Force on Global Governance and Ecological Civilization, was launched in July 2018 and will last for three and a half years. It has four primary research focuses: 1) impacts of Chinese cabinet restructuring on climate policy and governance and recommendations; 2) China's contribution and leadership in the global climate governance system and China's overall mid- and long-term strategy and roadmap for combating climate change; 3) green investment in infrastructure, and climate investment and finance in the context of the Belt and Road Initiative; and 4) experiences and lessons for improving the effectiveness of carbon pricing policies.

In 2020–2021, the research team carried out research on China's mid- and long-term strategy for addressing climate change, carbon neutrality roadmap and policy guarantee system, taking into account the needs of post-epidemic economic recovery and the mid-century strategy for low-carbon transition, so as to provide suggestions on China's mid- and long-term climate strategy and policy adjustment. Meanwhile, carbon pricing policy research was conducted to produce policy recommendations for improving carbon pricing. Research on global climate governance was also advanced, clarifying China's role in global climate governance so that China can lead the international climate cooperation.

On September 22, 2020, Chinese President Xi Jinping announced at the 75th Session of United Nations General Assembly that China would scale up its nationally determined contributions (NDCs) by adopting more vigorous policies and measures and aim to peak carbon emissions before 2030 and achieve carbon neutrality before 2060. This move has boosted global confidence in responding to climate change. Since then, he has emphasized the Dual Carbon Goals on more than ten important occasions. The Dual Carbon Goals have since been incorporated into the overall layout of economic and social development and the construction of the ecological civilization. While China's long-term vision for addressing climate change is set, questions remain to be answered on organically integrating the carbon neutrality vision with the targets of the 14th Five-Year Plan and the goals of realizing China's modernization by 2035 and a fully modern socialist country by 2050, as well as harmonizing the interests of all parties and making up for policy gaps.

In addition, the world political and economic landscape continues to undergo new changes. China-US frictions remain prominent. China and the European Union compete in certain areas while maintaining cooperative partnerships. There is also a prevailing trend of populism and anti-globalization. In this context, it is necessary to correctly understand the new trend of global climate governance, and make, in a timely manner, new strategic deployments in response to emerging problems and challenges. We should strengthen multilateral and bilateral cooperation, promote global consensus

on climate change and green and low-carbon development, and establish a fair, reasonable, and win-win global climate governance system.

This report consists of seven chapters. Chapter I describes the background of China's carbon neutrality vision. Chapter II analyzes the opportunities and challenges for achieving the carbon neutrality vision. Chapter III proposes a sequenced set of goals for carbon neutrality and the transition pathways to mid- and long-term climate targets. Chapter IV reviews international experience and progress, and investigates the problems of China's carbon pricing mechanisms, followed by suggestions for gradual improvement thereof. Chapter V summarizes the overall situation and needs of global climate cooperation, and provides suggestions for strengthening international climate cooperation. Chapter VI examines some issues surrounding pursuing carbon neutrality from the perspective of gender equality. Chapter VII comes up with policy recommendations to implement China's carbon neutrality vision and related goals and promote international climate cooperation.

1. Background of the Carbon Neutral Goal

1.1. Green and low-carbon development has become an important direction for global economic and social development.

1.1.1. Climate change is an urgent global challenge in the post-epidemic era.

The United Nations Environment Programme (UNEP) has assessed the impacts of the Intended Nationally Determined Contributions (INDCs) submitted prior to October 1, 2015 (by 146 countries, approximately accounting for 90% of global emissions), and concluded that these INDCs are far from sufficient to achieve the 2°C target (UNEP, 2015). The goals of limiting global warming under the Paris Agreement requires more stringent emission reduction commitments in the INDCs updated in 2020. In the remarks to the Climate Ambition Summit on December 12, 2020, the United Nations Secretary-General Guterres called on all countries to declare a State of Climate Emergency, noting that the current commitments fall far short of the Paris Agreement goals. He announced that the central objective of the United Nations for 2021 is to build a truly Global Coalition for Carbon Neutrality by the middle of the century (Guterres, 2020).

The emission reduction situation worldwide has been increasingly grim since the Paris Agreement pledged to limit global warming well below 2°C. Impacts from global warming of 1.5°C have already been observed, but they are smaller than those from higher magnitude of warming, according to the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C (IPCC, 2018). Studies suggested that to limit global warming to below 1.5°C, carbon emissions must drop rapidly to 25 gigatons of carbon dioxide equivalent (CO₂e) by 2030. However, the challenge is that based on the emission reduction commitments under the Paris Agreement, emissions are on track to reach 56 gigatons CO₂e by 2030, almost twice what they should be (UNEP, 2019). Contribution of Working Group I to the Sixth Assessment Report of IPCC released on August 9, 2021 emphasized again without immediate, rapid and large-scale reductions in emissions, curbing global warming to either 1.5C or even 2C above pre-industrial levels by 2100 would be beyond reach¹.

1.1.2. The international community has basically reached a consensus on carbon neutrality.

To achieve the 1.5°C target, global anthropogenic CO₂ emissions should be reduced to net zero around 2050, according to the 2018 IPCC Special Report on Global Warming

¹ Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

of 1.5°C. As of December 2020, totally 126 countries² have prepared to commit or have committed to carbon neutrality², covering 75% of global gross domestic product (GDP), 53% of global population and 63% of global emissions. Among them, Suriname and Bhutan have realized net zero greenhouse gas (GHG) emissions; 25 countries have incorporated clear carbon neutral targets into national laws (or proposed legislation) and policies, such as China, Japan, Germany, Canada, the United Kingdom and South Korea among the world's top ten emitting countries; and 99 countries have pledged carbon neutrality verbally without providing detailed information. These commitments include all GHG emissions for 28 countries and clear medium-term targets for 29 countries.

The target date is 2050 for carbon neutrality in the above-mentioned 99 countries, with the exception of Uruguay, which aims to become carbon neutral by 2030. GHG coverage and mid-term targets in roadmap towards carbon neutrality are unclear in most countries as the relevant plans are still under preparation. US President Biden has included climate change into the basic policy agenda and committed to carbon neutrality by 2050. In December 2020, the European Parliament and the Council of the European Union reached an interim agreement on the key elements of the European Climate Law, setting for the EU to further reduce its greenhouse gas emissions from 40% to at least 55% below 1990 levels, and to achieve climate neutrality by 2050, and strive to achieve negative emissions afterwards. At the Leaders' Summit on Climate held on April 22, 2021, many countries took more ambitious climate commitments. The United States pledged to reduce greenhouse gas emissions by 50-52% below 2005 by 2030 compared to the previous target of 26-28%, Japan pledged to reduce its greenhouse gas emissions by 46% by 2030 compared to the 2013 level, and Canada has committed to reduced its GHG emissions by 45% by 2030 below 2005, compared to 30% previously. Though without official announcements, Italy, Argentina, and the Netherlands have all aimed for carbon neutrality by 2050 and declared their respective mid-term targets.

1.1.3. China has vowed to have carbon emissions peak before 2030 and achieve carbon neutrality before 2060.

China has always been a strong supporter and powerful advocate of global climate governance and environmental protection. Among the indicators for INDCs submitted by China in June 2015, four have met or even exceeded the 2020 targets. For example, CO₂ emissions per unit of GDP in 2018 declined by 45.8% from the 2005 level, reaching the 2020 target of 40–45% 2 years ahead of schedule. As a responsible large country, China has made strategic decisions while taking both international and domestic situations into consideration. In the statement at the General Debate of the

² Energy and Climate Intelligence Unit. 2020. Net zero tracker. [https://eciu.net/netzerotracker\[2020-12-31\]](https://eciu.net/netzerotracker[2020-12-31]).

75th Session of United Nations General Assembly, Chinese President Xi Jinping announced that China would scale up its INDCs, with goals to peak carbon emissions before 2030 and achieve carbon neutrality before 2060. This undoubtedly embodies the determination to take responsibilities as a great power and make greater contributions to the Paris Agreement targets. The move also strongly boosts global confidence in responding to climate change. At the 9th meeting of the Central Finance and Economics Committee on March 15, 2021, in order to reinforce the implementation of the carbon peaking and carbon neutrality goals, they have been incorporated into the overall framework of the construction of the ecological civilization. On April 16, 2021, during a trilateral video summit with French and German leaders, President Xi Jinping announced that China will accept the "Kigali Amendment". In parallel, China's special envoy for climate change, Xie Zhenhua, and US President's special envoy for climate issues, John Kerry, held talks in Shanghai on April 15-16, 2021, which led to the issuance of the "Sino-US Joint Statement Addressing the Climate Crisis". On May 27, 2021, Vice-Premier Han Zheng presided over the first plenary meeting of the Carbon Peaking and Carbon Neutrality Work Leading Group, demanding that the construction of ecological civilization be solidly promoted to ensure that the carbon peaking and carbon neutrality goals are achieved on schedule. The Ministry of Ecology and Environment also issued the "Guiding Opinions on Coordinating and Strengthening the Work Related to Climate Change and Ecological and Environment Protection" on January 11, 2021, requiring unwavering implementation of the national strategy to actively respond to climate change. The third series of the second round of the central ecological and environmental protection inspectors was started in April 2021.

China's target date for carbon neutrality is about ten years later than pledged by most developed countries. Nevertheless, it should be noted that developed countries generally have a transition period of 50–70 years moving from carbon emission peaking to carbon neutrality, but China has only about 30 years. This requires China, as a large developing country, to increase the pace and intensity of efforts in the transformation of energy structure and development pattern and reduction of CO₂ and GHG emissions, compared with developed countries, which is also much more difficult.

1.1.4. Climate action goes hand-in-hand with sustainable development goals such as gender equality.

Climate action is not a standalone topic. It is one of the 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States. Among the SDGs there is also SDG 5 – gender equality, and all other strategies which must go hand-in-hand for building a shared blueprint for peace and prosperity for the planet.

Climate change is not a gender neutral process. It impacts men and women differently, largely due to their gender-differentiated relative powers, roles, and responsibilities at the household and community levels. Disparities in economic opportunities and access to productive resources also render women more vulnerable to climate change because

they are often poorer, receive less education, and are not involved in political, community and household decision-making processes that affect their lives.³

As part of this work, we view gender equality as an important cross-cutting issue and we believe that gender equality considerations (and the rights of other vulnerable groups) should be mainstreamed into all climate change policies, strategies and programs. Given the speed and massive socio-economic impact nature of the low-carbon transformation, the inclusion of gender equality and in general considerations of the fight against inequalities needs be imbedded in policies and planning since their inception. While we recognize that more work must be done in this area, we hope that what we have provided within this paper can provide the grounds for future work.

1.2. The carbon neutrality vision is compatible with China's climate policy

1.2.1. China has gradually established a policy system for low-carbon development.

In 2012, the Report of the 18th National Congress of the Communist Party of China (CPC) proposed to build an ecological civilization by incorporating ecological progress into a five-sphere integrated plan. It also put forward for the first time the concept of "beautiful China", emphasizing that we must give high priority to making ecological progress and integrate it into all aspects and the whole process of advancing economic, political, cultural, and social progress⁴. Since 2013, the CPC Central Committee and the State Council have issued a raft of important documents, such as the Decision of the CPC Central Committee on Several Major Issues Concerning Comprehensively Deepening the Reform, Opinions of the CPC Central Committee and the State Council on Accelerating the Construction of Ecological Civilization, and Integrated Reform Plan for Promoting Ecological Progress, and adopted more than 40 important systems with respect to ecological progress. These have formed Xi Jinping's systematic thought on ecological civilization that provide the fundamental principles for building an ecological civilization.

During the 12th Five-Year Plan (FYP) period (2011–2015), China began to tackle climate change in a systematic manner. The Outline of the 12th Five-Year Plan for National Economic and Social Development included for the first time carbon intensity as a binding target. A system of targets in climate change has therefore taken shape, including energy intensity, carbon intensity and total energy consumption. In terms of multilateral and bilateral cooperation, China and the United States issued successive joint statements on climate change in Beijing and Washington in November 2014 and September 2015. This directly facilitated the conclusion of the Paris Agreement,

³ Habtezion, Senay. "Gender and climate change: Overview of linkages between gender and climate change." New York: United Nations Development Programme (2016).

⁴ Hu Jintao's report at the 18th CPC National Congress.

http://www.xinhuanet.com//18cpcnc/2012-11/17/c_113711665_9.htm [2020-9-11].

making important contributions to the improvement of global climate governance system. On June 30, 2015, China submitted the Enhanced Actions on Climate Change – China's Intended Nationally Determined Contributions, which contains the INDCs targets by 2030.

During the 13th FYP period (2016–2020), China further deepened its goals and actions on climate change. The Outline of the 13th Five-Year Plan for National Economic and Social Development carried forward the multi-dimensional system of targets in energy and climate change from the previous period and stepped up the control of energy intensity and total energy consumption, referred to as dual control. With regard to the low-carbon transition of energy sector, the Energy Supply and Consumption Revolution Strategy (2016–2030) was unveiled in December 2016 with China's energy vision for 2050. In terms of market mechanisms, the Plan for Building a National Carbon Emissions Trading Market (Power Generation Industry) was released in 2017, marking the official launch of the national carbon market. At the same time, focusing on green and low-carbon development and financial policies to address climate change, China has explored the systems and practices related to climate investment and finance. The Guiding Opinions on Promoting Climate Investment and Finance was issued on October 20, 2020 as a preliminary exploration of the cap system for carbon emissions. In addition, China and the United States issued the third joint statement on climate change—China-US Joint Presidential Statement on Climate Change in March 2016, which has played a key role in the signing and entry into force of the Paris Agreement. Domestically, the Department of Climate Change was transferred to MEE in 2018 to strengthen the coordinated governance of climate change, air pollution and other ecological and environmental issues.

Peaking carbon emissions and achieving carbon neutrality is an extensive and profound systemic reform of the economy and society and should be integrated into the overall layout for building an ecological civilization, underscored the Ninth Meeting of the Central Committee for Financial and Economic Affairs on March 15, 2021. This implies that China has established the strategic direction of green development and will systematically put into practice the philosophy of green development.

China's proactive policies and actions on climate change have yielded remarkable results. As of the end of 2019, the carbon intensity was cut by 48.1% compared with 2005, while the share of non-fossil energy in primary energy consumption was raised to 15.3%. The average annual growth of energy consumption and CO₂ emissions dropped from 6.0% and 5.4% during 2005–2013 to 2.2% and 0.8% during 2013–2018 respectively. China has not only gradually decoupled economic development from carbon emissions, but also fulfilled its international commitments for 2020 ahead of schedule.

1.2.2. Public health events such as the COVID-19 epidemic have urged faster actions on climate change.

The outbreak of COVID-19 epidemic in 2020 has seriously affected the world in many aspects. The COVID-19 effects can be persistent, leading to many possible scenarios and uncertainties in future development⁵. Amid the global COVID-19 spread, people have come to realize for the first time that problems in non-traditional security fields are gradually escalating. Therefore, it is necessary to pay great attention to non-traditional security issues such as ecological environment and climate change, as well as public emergencies.

China is undergoing a critical period of transition to high-quality economic and social development. Public attention to environmental health issues and public awareness of green consumption both keep growing. The Chinese government has already recognized that from the 14th FYP and mid- to long-term perspective, green low-carbon development will offer an important opportunity for high-quality economic and social development. In this context, the 2020 Government Work Report brought forward new infrastructure and new urbanization initiatives and major transportation and water conservancy projects and called for green and low-carbon deployments for economic recovery. In the meantime, green transformation of production and consumption patterns has been advanced. The Opinions on Accelerating the Establishment of a Legal and Policy System for Green Supply and Consumption adopted on March 11, 2020 clarified the legal and policy framework for green supply and consumption, providing an institutional guarantee for green transition in economic and social development.

In September 2020, on the basis of systemic trade-offs and far-reaching plans, the CPC Central Committee made the major strategic decision to peak carbon emissions before 2030 and achieve carbon neutrality before 2060. Since then, a series of policies and actions have been intensively introduced or rapidly deployed. The Special Plan on Climate Change During the 14th FYP Period (2021–2025), which is under preparation, will set out CO₂ emission targets compatible with the new target of peaking carbon emissions. The Plan of Action to Peak Carbon Emissions, which MEE is working on to cover the 14th FYP and 15th FYP (2025–2030) periods, intends to set down the roadmap, action plan and support measures for peaking carbon emissions at local level and in key industries. At the same time, MEE will promote the inclusion of such actions into the central environmental protection inspection (this SPS also put forward this policy recommendation).

⁵ How Coronavirus Affects Global Economy.

<https://home.kpmg/cn/zh/home/social/2020/03/how-coronavirus-affects-global-economy.html> [2020-11-20].

1.3. Green low-carbon development under the carbon neutrality vision represents an important connotation of high-quality development.

China's economy has been shifting from a stage of high-speed growth to a stage of high-quality development, said the Report to the 19th CPC National Congress. High-quality development requires implementation of the principles of innovative, coordinated, green, open and shared development.⁶

Under the vision of carbon peaking and carbon neutrality, comprehensive green transition or green low-carbon development can drive high-quality development in the following aspects: 1) Accelerate the transformation of energy structure. This will guide the orderly withdrawal of fossil energy while developing an energy supply system blending high proportion of renewable energy. China will safely develop nuclear power, actively produce and utilize green hydrogen energy and foster the hydrogen energy industry. China will also improve the electrification level of the entire economic and social process, especially end-use sectors, and strengthen the integration of digital and information technologies to realize the intelligent and digital transformation of energy system; 2) Urge the optimization and upgrading of industrial structure. Through green and low-carbon industrial development, backward production capacity will be gradually eliminated. This will accelerate the green transformation of traditional industries, as well as the withdrawal of investment-inefficient and high-carbon industries. China will support the development of green strategic emerging industries, vigorously develop high-level service industry, build a green supply chain and develop a circular economy to continuously tap the potential for high-quality growth; 3) Stimulate green and low-carbon technological transformation. Low-carbon and zero-carbon technological transformation is of vital strategic significance for China's technological innovation and high-quality economic development. It will help China enhance its global leadership in the field of new technologies and nurture core competitiveness in a new climate- and eco-friendly economy in the future, thus playing an important leading role. China has already made considerable contributions to reducing the cost of wind power and solar photovoltaic technologies. It is now a global leader in investment and application of renewable energy and production and consumption of electric vehicles. While actively exploring hydrogen production and its application in industrial and transportation sectors, China has made some deployments for a flexible, safe and stable modern smart grid system, as well as negative emission technologies such as CO₂ removal. However, this is far from enough. In a prospective pattern of competition and cooperation in low-carbon and zero-carbon fields, China needs to further scale up efforts to comprehensively deploy the research & development

⁶ Xi Jinping: Secure a Decisive Victory in Building a Moderately Prosperous Society in All Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era, Delivered at the 19th CPC National Congress. http://www.gov.cn/zhuanti/2017-10/27/content_5234876.htm [2020-9-11].

and commercial application of low-carbon, zero-carbon and negative emission technologies, and continue to bring down the cost of green and low-carbon technologies by relying on its own green market and policy. As such, green and low-carbon development can inject new impetus into China's economic growth in the near future while adding more high-quality jobs to the society.

In short, carbon neutrality and carbon peaking targets do not simply put constraints on economic and social development. They provide an important opportunity of development by forcing changes in the overall patterns of economic and social development. Therefore, we must change our mindset in development, and proactively seek out endogenous growth drivers that harmonize the economy, society, energy, environment, and climate, with a view to wide-ranging green transition and high-quality sustainable development.

2. Opportunities and Challenges

2.1. Opportunities

2.1.1. The 14th FYP and the 2035 vision organically integrate green low-carbon development into economic transition.

The Outline of the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 (hereinafter referred to as the Outline), adopted on March 12, 2021, envisaged new progress in the construction of ecological civilization. In the upcoming five years, China will optimize the development and protection of territorial space, and effectively change the modes of production and lifestyle for green transformation. Energy and resources will be more appropriately allocated and more efficiently used. Energy consumption and CO₂ emissions per unit of GDP will be cut by 13.5% and 18% respectively (respectively 15% and 18% during the 13th Five-Year Plan). The total emissions of major pollutants will be continuously reduced while the forest coverage rate will be raised to 24.1%. The ecological environment will keep improving; the ecological security shields will become stronger; and urban and rural living environment will be significantly improved. By 2035, green modes of production and lifestyle will be widely seen; carbon emissions will be steadily reduced after reaching the peak; and the ecological environment will be fundamentally improved, basically attaining the goal of building a beautiful China."

The 19th CPC National Congress formulated a two-stage strategic plan for the Two Centenary Goals. In specific, by 2035, socialist modernization will be basically realized, and by 2050, China will be built into a great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious, and beautiful. The 5th Plenary Session of the 19th CPC Central Committee gave more systematic and comprehensive explanations on green development. It stressed that China would "advance green development and promote human-nature harmony". By doing so, "green modes of production and lifestyle will take shape broadly; carbon emissions will decline steadily after reaching the peak; and the ecological environment will fundamentally turn better, so the goal of building a beautiful China will be basically attained." The meeting emphasized the green transformation of economic and social development on all fronts and the organic integration of development in the response to environmental and climate challenges in the new development stage and stipulated the important characteristics and nature of future development.

A series of specific tasks have been laid down in the Outline, including strengthening legal and policy guarantees for green development; developing green finance; stimulating green technological innovation; promoting clean production; boosting environmental protection industries; advancing green transformation in key industries and major fields; urging clean, low-carbon, safe and efficient use of energy; developing

green buildings; carrying out green living activities; reducing carbon intensity; encouraging local areas to take the lead in peaking carbon emissions where appropriate; and formulating an action plan for peaking carbon emissions by 2030. The Outline draws up a comprehensive blueprint for economic and social development in 14th FYP period and even in the medium and long term, laying an important foundation for nurturing green and low-carbon modes of production and lifestyle and promoting the early peak and subsequent steady decline of carbon emissions with a view to carbon neutrality.

2.1.2. Faster green low-carbon technological transformation worldwide paves the ground for low-carbon transition.

At present, a new wave of technological revolution and energy revolution is unfolding worldwide, driving the green reconstruction of global industrial chain. Digital technology becomes deeply integrated with the economy and society, while costs continue to fall rapidly for solar energy, wind energy and energy storage technologies, paving the way to green and low-carbon growth. In the context of tough recovery and deep adjustment of global economy, all countries are trying hard to advocate and pursue a green economic recovery. With the rapid development of high-tech fields such as digital technology, information technology and artificial intelligence, the energy technology system is faced with the challenge of phasing out traditional fossil fuels and quickly switching to cleaner, safer and cheaper renewable energy sources. New technologies provide more economically feasible conditions and support for this transition. Inevitably, the economic development model that matches the above-mentioned transition will quickly turn to the path of sustainable development instead of the old path of resource-, energy- and pollution-intensive growth. Green technologies and industries themselves are conducive to improving the utilization efficiency of natural resources and creating new drivers of economic growth (Jiang et al., 2020). They also help to fundamentally solve environmental pollution and ecological destruction associated with fixed industrial structure and energy structure (Zhu et al., 2019), thereby improving public health (von der Goltz et al., 2020). In addition, green technologies and industries can also effectively stimulate employment. According to a 2018 report of the International Labor Organization (ILO), 24 million jobs will be created by emerging innovative industries such as electric vehicles, clean energy and green finance by 2030, while only 6 million jobs will be lost in high-carbon industries such as coal and oil exploration (ILO, 2018).

2.1.3. Digital technology and digital economy drive forward green low-carbon transition.

Countries around the world have increasingly turned to green and digital development in their post-epidemic economic recovery plans. While lending a heavy blow to the real economy, the COVID-19 epidemic has brought new opportunities for green low-carbon development and the digital economy. Green low-carbon ways of work and life such as

remote office, video conferencing and online procurement have become more popular. Especially in the process of economic recovery, the digital and intelligent transformation of industries such as low-carbon energy, low-carbon buildings, low-carbon transportation, and energy conservation and environmental protection have been significantly accelerated.

Digital technology can play an important role in improving the utilization efficiency of resources and energy, promoting the development and utilization of renewable energy, increasing the efficiency of production, sales and use of products and services in the whole society, or reducing the demand for energy and raw materials through the dematerialization of human activities and exchanges. Research showed that digital technology could already help reduce global carbon emissions by up to 15% through solutions in energy, manufacturing, agriculture and land use, buildings, services, transportation and traffic management (Falk et Al., 2020). A study completed by the German Digital Association, the Borderstep Institute and the University of Zurich in 2020 suggested that digital technology can save up to 20% of global GHG emissions, with the greatest potential in the sectors of energy, transportation and agriculture. With the help of digital technology, it will be possible for Germany to avoid the emissions of up to 290 megatons CO₂e in 2030, corresponding to about 37% of the forecast GHG emissions (Bitkom, 2020). Seizing the opportunity, the digital economy integrating green low-carbon development will help strengthen the driving force of innovation and unleash new momentum.

2.1.4. Unique institutional and market advantages provide effective safeguards for deep emission reduction.

Carbon emission is a typical behavior of economic externalities. The existence of externalities is generally considered as one of the defects of market price mechanisms in resource allocation. In other words, when externalities exist, market price mechanisms alone are often unable to ensure the optimal allocation of resources and the maximization of social welfare. Therefore, on the one hand, the government should fully play the due role; on the other hand, the market should be organically combined with the government to provide new governance tools. New tools such as the Emission Trading Scheme, allowing to internalize the carbon externality, will play a significant role. Other emission capping, carbon pricing (either the ETS or a carbon tax according to the sector), carbon footprint accounting and reporting mechanisms would also contribute to measure climate risks and costs for the economy. The 2060 carbon neutrality target sends a strong positive signal for addressing climate change, but it is enormously challenging and hardly achievable by relying on a single market. China's institutional advantages can play an important role exactly in emission reduction, as proved by the outstanding performance in the fight against the COVID-19 epidemic. These advantages are mainly reflected in the coordination of all efforts to complete key national undertakings; the capability and efficiency of coping with major risks and challenges in complex situations; and the effective transmission, continuity and

stability of systems and policies.

The carbon neutrality vision is a far-reaching plan made in the context of the current complex and volatile international situation and the deep domestic economic and social transformation. It not only meets the requirements of domestic high-quality development, but also conforms to the direction of future world development. However, there is still certain uncertainty in the pathways. On the one hand, we need to leverage superior resources to support industrial transformation and upgrading, technology research & development and application, and capital system guarantee. On the other hand, we need to promote consensus among all parties, and send clear and stable long-term policy and price signals by policy and market means. Only in this way will industrial transformation be clearly guided. Local governments will act seriously and the market will respond positively, to channel funds to low-carbon projects, purchase and adopt appropriate technologies, and tap the mitigation potential, thus gradually fostering a trend that the whole society advocates green low-carbon ways of production and lifestyle. At the same time, China has begun to operate the world's largest carbon market. The continuous improvement of market mechanisms will more effectively drive the progress toward carbon neutrality. Institutional advantages, huge domestic market and active shareholder engagement will provide strong support and guarantee for the carbon neutrality goal.

2.2. Challenges

2.2.1. Preparations are necessary, considering deep uncertainties in international political and economic landscape.

The COVID-19 epidemic has been impacting the global economy and society in all-around way. According to the “2021 World Economic Situation and Prospects” by the UN Department of Economic and Social Affairs, the global economy has contracted by 4.3% in 2020, which represents more than twice and a half times the recession of the 2009 financial crisis.. The international geopolitical pattern and strategic landscape on climate change are also undergoing profound changes. All countries must intensify climate cooperation to promote the global fight against the environmental and climate crises.

After President Biden was sworn into office, his administration has brought the United States back into the Paris Agreement, has exerted climate leadership on a multilateral platform, and promoted the US-led global climate cooperation framework. It is expected that in the short term, competition will outweigh cooperation between China and the United States, even in the fields of little divergence such as climate change. Since the United States joins the Paris Agreement via presidential executive order instead of federal legislation, the US attitude to multilateral cooperation in climate change still remains uncertain.

The unstable factors of global climate governance still exist. The Covid pandemic has caused a severe and long-lasting impact on the global scale, especially in developing countries. Developing countries will make the pandemic response and the economic and social recovery their political priority, which in turn might weaken the importance given to climate action. In response to the epidemic, the G7 summit held in June 2021 committed to stop overseas public investments in unabated coal power. It proposed to eliminate inefficient fossil fuel subsidies by 2025 but lacked substantial progress on the latter. In terms of climate financing, other countries have failed to commit to increasing the supply of climate funds like Germany.

At present, there is an increasing voice of creating green barriers on the grounds of climate issues, leading to the rising protectionism that urges the use of carbon tariffs to increase trade barriers. The European Union has made it clear in 2021 to establish a carbon border adjustment mechanism. China needs to be fully prepared to deal with such uncertainties.

2.2.2. Emission reduction pathways are not actually smooth, given the short time frame for peaking carbon emissions and achieving carbon neutrality.

Compared with the European Union and the United States, China needs to redouble the efforts to achieve carbon neutrality. European countries such as the United Kingdom and France roughly see that carbon emission peaked in the 1980s and 1990s and declined slowly after a long plateau period. This gives 50–70 years for the European Union to move from peak carbon to carbon neutrality. As to China, since CO₂ emissions still exhibit an upward trend, strenuous efforts will be required to meet its set deadline of peaking carbon emissions. Even so, only about 30 years will be left for the transition to carbon neutrality, which necessitates unusually intense pathways. More drastic structural changes would occur if the plateau period fluctuated or extended due to internal and external environmental factors. In any case, China's average annual carbon emission reduction rate will reach about 8–10% from 2030 onwards, far higher than developed countries, which poses the biggest challenge to China. In fact, emission reduction pathways in different sectors are roughly the same for developed and developing countries, but China's shorter time frame entails higher requirements for economic restructuring, technological innovation and capital investment in a large country (Table 1).

Table 2-1. Comparison of transition period from carbon peaking to carbon neutrality under country commitments

No.	Country	Actual year of peaking carbon emissions ⁷	Target year for carbon neutrality ⁸	Transition period / years
1	United Kingdom	1973	2050	77
2	Hungary	1978	2050	72

⁷ IEA, CO₂ Highlights 2019.

⁸ Energy & Climate Intelligence Unit, Net zero by 2050.

3	Germany	1979	2050	71
4	France	1979	2050	71
5	Sweden	1976	2045	69
6	Denmark	1996	2050	54
7	Portugal	2002	2050	48
8	Ireland	2006	2050	44
9	Spain	2007	2050	43
10	Japan	2013	2050	37
11	Austria	2005	2040	35
12	Finland	2003	2035	32
13	South Korea	2018	2050	32
14	China	Before 2030	Before 2060	About 30

Note: China's target year for peaking carbon emissions is given in the table as the peak has not yet arrived.

2.2.3. China has weak basic research and development capabilities and faces competition in key low-carbon technologies.

Multiple major challenges hinder green low-carbon development and progress to carbon neutrality in China, including insufficient original scientific and technological outcomes, many institutional obstacles to transformation of scientific and technological achievements, inefficient allocation of innovative elements, and small number and low quality of innovative talents. In terms of low-carbon technologies, focus tends to be put on technical details, as well as the refinement and promotion of existing technologies, resulting in inadequate original innovation in and attention to disruptive technologies. China has not yet established goal-oriented mid- and long-term technological strategy and plan for emission reduction that takes into account economic, social, climate and environmental dimensions. It is still plagued by the lack of key techniques, low degree of dependence and low level of industrialization in some key low-carbon technologies, such as hydrogen fuel cell vehicles. Regarding hydrogen energy, China is the world's largest hydrogen producer. Nevertheless, green hydrogen accounts for a low proportion because coal and natural gas support 70% of hydrogen production. There is not yet substantial technical breakthrough in hydrogen production, storage and large-scale use. While technological breakthrough offers one of the core solutions for deep emission reduction, China encounters many more obstacles in technology transfer and cooperation due to the international pattern of economic interests coupled with trade protectionism. Hence, it is imperative for China to speed up the formulation of technological innovation and support plans to facilitate carbon neutrality (Huang Jing, 2020).

2.2.4. Just transition is a prominent problem under carbon neutrality because of wide regional disparities.

Economic and social development is uneven in China, generally more advanced in the east and south than in the west and north. In terms of carbon emissions, carbon emissions increase slightly in relatively developed eastern regions, with peaking already close in some areas. Despite strong emission reduction capabilities, under both pressures from the economic recovery and the carbon peaking target, the instinct often

falls back on using traditional economic stimulus methods based on carbon-intensive projects to stimulate the economy. In contrast, carbon emissions in central and western regions still have some room for expansion and are unlikely to peak in the short term, especially in fossil energy-rich provinces.

Under the carbon neutral vision, China has established the long-range direction and trend of withdrawal from coal production. Yet, the specific roadmap needs to be carefully designed in accordance with economic development stage and various capacity conditions, taking full account of the benefits and effects of low-carbon transition on different sectors, regions and groups. The traditional fossil fuel sector, especially upstream and downstream coal industries – including mining, transportation, coal power and coal chemicals, will be tremendously impacted in the zero-carbon transition. Such impacts will be more noticeable in areas where economic growth and employment heavily depend on coal. In addition, the coal sector transformation with the advancement of mechanization, elimination of backward production capacity and industrial upgrading has already put pressure on traditionally coal-producing provinces such as Henan and Shanxi. Jobs will be lost with the inevitable withdrawal from the coal sector. For this reason, systematic solutions are needed to explore new development models for these areas, which includes policy measures to support proper arrangement or re-employment of coal workers. These tasks should be carried out sooner rather than later.

On the whole, the COVID-19 epidemic has exerted a huge impact on the economic and social order, but there are opportunities in crisis. In the short term, the urgency of carbon emission reduction is compromised in the combat against the epidemic; in the medium and long term, green low-carbon development remains to be one of the strategic directions. The epidemic has brought opportunities for structural adjustment while hindering economic growth. Many traditional industries fall into crisis amid the epidemic, but emerging industries such as the information industry demonstrate strong vitality. They have greatly expanded the room for green economic growth, making it possible to pursue green development. It can be said that the epidemic has created an excellent opportunity for structural upgrading. The outbreak also prompts the whole society to reflect on the development model featuring overemphasis on speed and scale. This is undoubtedly conducive to the formation of new development philosophy that places greater emphasis on green development and harmony between human and nature within the whole society, creating favorable conditions for green transition despite the impact of the epidemic. At the same time, the slowdown in energy consumption growth during economic downturn offers an opportunity for accelerating energy transition, so that new energy demand can be more met by renewable energy. China should seize the opportunity to reshape the current economic and energy system, provide support for a carbon-neutral future, and lead the creation of a greener and more resilient world.

3. China's Mid- and Long-term Climate Goals, Roadmap and Policy

Guarantee System

3.1. Phased goals and roadmap

The 5th Plenary Session of the 19th CPC Central Committee set two-stage goals: By 2035, green modes of production and lifestyle will take shape broadly; carbon emissions will decline steadily after reaching the peak; and the ecological environment will fundamentally turn better, so the goal of building a beautiful China will be basically attained. By 2050, China will develop into a great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious and beautiful. In the meantime, China will ensure ecological security, and get actively involved and take a driver seat in international cooperation in environmental protection issues such as climate change⁹.

For the purpose of accelerating green low-carbon development and deeply reducing GHG emissions, it is necessary to conduct coordinated governance of economy, society, energy, environment and climate and promote the comprehensive green transformation of economic and social development. Internally, China will step onto the path of sustainable development for the harmony between human and nature and sustained development of the Chinese nation. Externally, China will take a driver seat in global climate governance to safeguard the ecological security of the Earth and the survival and development of the mankind.

China's vision for carbon neutrality shows the world the possibility of limiting global warming to below 2°C and striving to achieve the 1.5°C target. It also further clarifies that tackling climate change is an important component of China's socialist modernization. Hence, the long-term low-carbon development strategy should be compatible with the two-stage goals and strategies for socialist modernization (He Jiankun, 2018). Peaking carbon emissions before 2030 and scaling up INDC targets should be included as important content in the first-stage strategic plan to promote high-quality economic development. Achieving near-zero emissions before 2050 and carbon neutrality before 2060 should be taken as the leading targets and tasks in the second stage to drive the progress towards a beautiful China and foster green low-carbon modes of production and lifestyle.

⁹ Proposal of the CPC Central Committee on Drawing up the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035.
http://www.gov.cn/zhengce/2020-11/03/content_5556991.htm [2020-12-14].

3.1.1. Near term: Early peak of carbon emissions in certain areas and sectors

The 14th FYP period will be crucial for China to peak carbon emissions. It covers the first five years after the vision of carbon neutrality is incorporated into the economic and social development plan. Faced with difficulties and challenges unlike before, more attention should be given to strengthened alignment of energy and industrial development planning and national climate change planning. In particular, the development directions and priorities of energy and industrial transition during the 14th FYP period should be oriented to the mid- and long-term strategic goals of achieving carbon neutrality and building a beautiful China. In accordance with green and low-carbon requirements, China will speed up appropriate advanced deployment of infrastructure and industries, optimize the spatial layout of energy structure adjustment, green and low-carbon industrial transformation and resilient urban development, and promote "investment in greenness, growth, employment and future", with a view to new development pattern featuring green and low-carbon "dual circulation".

In these five years, carbon emissions should enter a plateau period. They are supposed to peak first in some of the advanced eastern provinces, southwestern provinces, and cities with sound renewable energy endowments, and high-carbon sectors such as power, steel and cement. Coal will account for 50% or so in primary energy consumption and renewable energy, more than 20%. The peak of carbon emissions will arrive through structural adjustment of coal power and strict control of coal chemical industry. In terms of policy support, coordinated plans will be formulated as soon as possible, including the special plan on climate change, action plan for peaking CO₂ emissions, integrated work program for saving energy and reducing emission, and work program for green industrial system and green living. A cap system for carbon emissions will be established, which replaces the cap on energy consumption with a more effective GHG emission target. Flexible mechanisms and pathways for carbon emission reduction targets will be explored. A mechanism that combines inter-regional indicator trading, clean development and horizontal compensation will be adopted. Based on scenario analysis and consultation-based consensus, China's NDC will be updated in both intensity and breadth. They will contain the targets of carbon peaking and zero or net-zero emissions in the near and long term; incorporate green recovery, nature-based solutions (NBS), and non-CO₂ GHG emission reduction; and expand the scope of indicators and space of flexible adjustments. China will step up technology research & development and deployment for transition to a zero-carbon society to get well prepared for industrial transformation, lifestyle change and possible global competition in low-carbon technologies¹⁰. Meanwhile, China will strengthen global cooperation in research & development and promotion of low-carbon and zero-carbon

¹⁰ Wang Yi, member of the NPC Standing Committee: We must be fully prepared for the global carbon neutral competition. <https://view.inews.qq.com/k/20201215A03AKD00> [2020-12-15].

technologies.

3.1.2. Middle term: Early peak and steady decline of carbon emission overall

In 2025–2030, China will strive for the early peak of carbon emissions. Research suggested that given the set deadline for carbon neutrality, an earlier peak of carbon emissions will lower the total emission reduction cost of the whole society (Pan et al., 2020). Even so, steps to carbon neutrality need to conform to China's social and economic conditions. Action will be taken according to capability to seek outperformance and cost-effective accomplishment of phased goals. To well fulfill NDC commitments, the share of non-fossil energy in primary energy consumption will be raised to 25% or higher. At the same time, China will promote and lead climate action and international cooperation around carbon neutrality.

China's primary energy consumption is expected to enter the plateau period during 2025–2030. Through constant optimization, the overall energy mix will be comprised of coal, oil and gas, and non-fossil energy. End-use power consumption will increase significantly. Carbon emissions will have reached the peak in all provinces and cities across the country, and will peak in transportation, building and other sectors. As to measures, structural adjustment and systematic innovation will be combined to boost green transition. Reforms will be deepened in industrial, energy, transportation, and land use structures, and layouts of major infrastructure and related industries will be advanced and adjusted oriented to the zero-carbon vision. By promoting the deep integration of digital and intelligent technology into economic and social fields, green and low-carbon industrial chain, supply chain and value chain, as well as corresponding green climate finance policy system and sustainable business models will be formed and consolidated.

3.1.3. Long term: Construction of a carbon-neutral economic and social system

In 2035–2050, China will set up an energy supply and consumption system based on renewable energy, speed up the phase-out of fossil energy, and accelerate the deployment of carbon negative technologies including carbon capture and storage (CCS) and bioenergy with carbon capture and storage (BECCS). It will strive to achieve near-zero CO₂ emissions, further enhance adaptation capacity, continuously improve the green, low-carbon, circular and sustainable social and economic system, and foster the pattern of sustainable consumption.

In 2050–2060, China will move towards carbon neutrality by means of carbon sequestration and carbon negative technologies and non-CO₂ emissions control, and strive for a carbon neutral world before 2070.

3.2. Transition pathways towards mid- and long-term climate goals

3.2.1. Adjustment of development model to build a green and low-carbon industrial structure

A modern industrial system serves as the biggest driving force for carbon emission reduction. Research suggested that industrial restructuring could contribute up to about 60% to China's carbon intensity target (Wang Wenju and Xiang Qifeng, 2014). A green, low-carbon and circular industrial system is an important component of a modern economic system. It is necessary to develop green strategic emerging industries such as energy conservation and environmental protection, clean production, and clean energy, and put in place technological and financial support systems and institutional and policy environments that are suitable for green, low-carbon, and circular industries. The construction of new infrastructure characterized by green, low-carbon and digital content should be accelerated; and the service sector should pursue green development at a higher level, creating new drivers for green, low-carbon and circular development. In the meantime, carbon emissions embodied in export trade should be reduced. In 2016, carbon emissions embodied in exports accounted for 12.5% of China's total carbon emissions (Gu Alun et al., 2020), which could make a difference in carbon emission reduction. China's manufacturing sector should try to climb to the high end of global value chain, while the service sector can increase the proportion of exports.

3.2.2. Implementation of energy revolution to develop a green and low-carbon energy system

Energy mix decarbonization offers a key way to achieve carbon neutrality and contributes to a sound energy security system in China. It can be achieved through five aspects. 1) A roadmap for orderly withdrawal from coal production should be developed. More forceful measures are necessary to control the consumption of fossil energy, especially coal; continuously optimize the structure and reduce the scale of coal utilization; and tighten the control over bulk coal. Effective measures are also needed to curb the impulse of coal-related projects in some local industries and limit the scale of high-carbon industries such as coal chemicals, in order to avoid the resulting high carbon lock-in effects and huge costs. 2) The electrification level should be significantly raised in the end-use sectors. The industrial sector should speed up the substitution of electricity for the direct use of fossil energy in the manufacturing process. The building sector should adopt distributed renewable energy systems and expand the application of electricity in heating, while conserve building energy use and refine the energy efficiency standards. The transportation sector should vigorously develop electric vehicles, restrict and gradually eliminate fuel vehicles; and facilitate the commercial development of hydrogen fuel cell vehicles. Energy consumption in various industries should be further upgraded with the orientation of electrification, efficiency improvement and intellectualization; 3) An energy supply system blending high proportion of renewable energy should be fostered. It will encompass various

suitable technologies, infrastructures and models developed through disruptive innovation, covering infrastructure, smart grid, distributed energy, energy storage, multi-energy complementation and flexible regulation, as well as smart energy. China will steadily advance the development and construction of cascade hydropower and build a group of basin-wide integrated energy bases for hydropower, wind and solar power. China will vigorously promote the coordinated development of wind power by combining centralized and decentralized development models and putting equal emphasis on local absorption and external transmission and on onshore and offshore wind power. China will move faster to expand the diversified solar power layout. For the eastern region, innovative photovoltaic plus models can be introduced to accelerate agricultural photovoltaic system and rooftop photovoltaic system and facilitate industrial and commercial distributed photovoltaic development. For Northeast China, North China, and Northwest China, photovoltaic development should be integrated with ecological governance, and solar power bases will be created. Experiences, collaborative models and NBS will be summarized and extended with respect to renewable energy in poverty alleviation, agricultural and forestry production, ecological restoration, and green hydrogen production. Biomass energy development should be adapted to local conditions while actively promoting the development and application of geothermal energy. 4) The research & development and application of technologies including energy storage, hydrogen energy, and smart grid should be accelerated to provide support for high-proportion blend of renewable energy. 5) A sound guarantee mechanism for the absorption of renewable energy power should be put into place and practice. Technological and institutional innovation is also expected to create good conditions for high-proportion blend and high-quality development of renewable energy.

3.2.3. Overall planning to promote diversified and coordinated regional low-carbon transformation and development

There are sharp regional differences in China with a vast territory in economic development model, economic structure, social development level, natural resource endowment, and technological level. This puts different requirements for the design of carbon emission reduction pathways in various regions. Due to the strategic layout for national economic and social development and actual local resource endowments, the central and western regions bear considerable emission transfers from eastern provinces while producing large amounts of energy and electricity (Lv Jiehua, 2020). Preventing carbon leakage between regions is of importance not only for rational and equal decomposition of carbon emission reduction targets, but also for the realization of low-carbon development goals and just transition. Therefore, on the basis of the existing division of emission responsibilities, differentiated regional low-carbon development goals should be set, reflecting consumption-based emissions and emission transfers.

Specifically, the more developed areas along the eastern coast and some southwestern areas with abundant renewable energy resources should study and plan to take the lead

in peaking CO₂ emissions during the 14th FYP period, creating favorable conditions for peaking nationwide in the next five years. The manufacturing sector will be required to accelerate the transfer to clean energy bases in the northwest and southwest for the purpose of local absorption of renewable energy. Potential issues of equity and justice in the transition process are worth special attention. Particularly, employment and economic development in coal-dependent areas and access to clean energy in poverty-stricken areas need to be properly addressed through means such as capacity building, financial transfer payment, and ecological compensation. Besides, it must be recognized that NBS will play an important supplementary role in pursuing carbon neutrality. Nature reserves will be gradually enlarged while strengthening natural restoration; and carbon storage capacity will be improved for forests, grasslands, wetlands, and agricultural land. NBS will be intentionally employed as an integrated solution to climate change, sustainable development, biodiversity conservation, disaster prevention and reduction, and poverty alleviation, thereby producing multi-field collaborative effects (Sustainable Development Strategy Study Group of the Chinese Academy of Sciences, 2021).

3.2.4. Establishment of a green modern comprehensive transportation system through both soft and hard measures

Transportation systems and services need to be transformed systematically. At present, low-carbon technology barriers have been basically cleared for the main modes of transportation in China. However, an effective low-carbon comprehensive transportation system and a corresponding low-carbon transportation service system have not yet formed to support the low-carbon transition of transportation sector. For this reason, focus should be put on adjustment of transportation structure for low-carbon transportation development. In pursuit of a modern comprehensive low-carbon transportation system, the comparative advantages and combination efficiency of various modes of transportation should be given into full play. To establish a modern comprehensive transportation system, efforts can be made in three aspects: 1) Vigorously promote the road-to-rail transition of bulk cargo transportation and accelerate the major road-to-rail projects; 2) Actively revitalize inland waterway transportation by making smooth major river sections and transportation channels sooner, strengthening the weak links of inland waterway transportation and enhancing the truck-branch linkage capability; and 3) Actively encourage innovation in modes of transportation and accelerate the penetration of advanced methods for transportation organization. For the purpose of optimizing the passenger transportation structure, a convenient and high-quality passenger transportation service system should be constructed to provide better services. Transportation network layout also needs optimization to enhance the intensive utilization of resources, including by promoting low-carbon transportation modes for mid-long distance travels such as inter-cities travel. In terms of green travel, promoting green transportation consumption and improving green travel system are taken as a major strategic choice for low-carbon transportation development. A sound passenger transportation service system should

be put in place for green travel, and publicity and education activities on green travel will be carried out for the whole people. As a measure to improve the overall energy efficiency and emission reduction efficiency of transportation, work should be quickened to advance the electrified, intelligent and shared application of new energy vehicles and improve the technology research & development capabilities and innovation mechanisms for low-carbon transportation.

3.2.5. Reduction of non-CO₂ GHG emissions

China's mid- and long-term emission reduction commitments towards the years 2030 and 2060 do not specify the coverage of non-CO₂ GHGs. In 2014, non-CO₂ GHGs accounted for about 16% of China's total GHG emissions. In the future, with the realization of deep emission reduction targets in the energy sector, the proportion of non-CO₂ GHG emissions will show an upward trend. This will lead to a steep increase in the marginal costs of non-CO₂ GHG emission reduction (Teng, 2019). Since there are currently few effective solutions in this regard, it is necessary to assess emission reduction indicators for source-specific non-CO₂ GHGs and short-lived climate pollutants (SLCP), develop overall GHG emission reduction targets covering all economic sectors, and timely include them into the carbon neutral vision. This will help China better respond to Article 4 of the Paris Agreement—Developing country Parties "are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances" (UNFCCC, 2015). China should advance the implementation of the Kigali amendment, strengthen the research & development and application of breakthrough technologies for non-CO₂ GHG emission reduction, and accelerate financial support to combine non-CO₂ GHG (especially methane) emission reduction with CO₂ emission reduction, orderly coal phase-out, replacement of ozone depleting substances (ODS), cooling efficiency improvement and air pollution control.

3.2.6. Deployment of a low-carbon technology system supporting carbon neutrality

The realization of carbon neutrality vision will ultimately rest on the extensive application of low-emission, zero-emission and negative-emission technologies in production and life. To meet the needs of carbon neutrality as soon as possible, China should begin to formulate a mid- and long-term plan for low-carbon technological innovation, and accelerate the research & development and application of key carbon neutrality technologies. With a view to building a world-leading low-carbon technological innovation system, China will push for innovative research & development and commercial application of key common technologies, cutting-edge leading technologies and disruptive technologies, covering energy efficiency, large-scale grid-connected renewable energy, distributed renewable energy, advanced nuclear energy, hydrogen fuel cell, large-scale energy storage, smart grid, renewable resource recycling, carbon capture, utilization and storage (CCUS), BECCS, and direct air capture (DAC). Through a group of forward-looking, systematic and strategic

projects for low-emission technology research & development and innovation, China will seek to break through technological bottlenecks in the fields of key materials, instruments and equipment, core processes, and industrial control devices, and gradually build a global innovation center of new technologies, new products, new business formats and new models for carbon neutrality.

Meanwhile, China will promote the deep integration of next-generation information technologies and advanced low-carbon technologies, and significantly enhance the overall efficiency of energy utilization. Guided and driven by the carbon neutrality vision, China will cultivate new growth drivers in high-tech, high-efficiency and low-emission fields with large development potential and strong driving force, such as digital economy, clean energy and smart city, and gradually form a number of international advanced green low-carbon manufacturing clusters. China will further strengthen carbon-neutrality-oriented international technical cooperation and technical assistance, launch China-led international scientific and technological plan on climate change and carbon neutrality, and create relevant international organizations.

3.2.7. Demand structure change to nurture the concept of low-carbon consumption

China will introduce consumption policies and pricing mechanisms that encourage green and low-carbon products, and expand the supply of green and low-carbon products and services. China will promote the labeling system for low-carbon and zero-carbon products and reduce certification costs for green and low-carbon products, so as to improve the recognition and market share of green and low-carbon products, creating an atmosphere of green consumption. China will scale up green procurement and build conservation-oriented institutions, low-carbon schools, low-carbon communities and low-carbon hospitals. China will make scientific plan for urban development, promote urban mixed land use to reduce travel distance, build low-carbon public leisure & entertainment facilities and cultural consumption infrastructure, and vigorously develop urban public transportation that facilitate low-carbon travel. Guidance will be provided to the public to nurture a consumption concept of diligence and thrift and a civilized and simple way of life, which is conducive to the construction of a low-carbon society. Public opinion guidance and information dissemination will be strengthened to raise public awareness of climate change, and broad engagement and active action by the public and grassroots groups will be encouraged.

3.3. Policy guarantee system

3.3.1. Establishing a sound legal and regulatory system led by the climate change law

China will initiate the legislative process on climate change, and include the Climate Change Law or Carbon Neutrality Promotion Law in the current legislative plan and the Legislative Plan of the 14th NPC Standing Committee. The advancement of climate

legislation will help China gain the initiative in international climate negotiations and enhance the image of a responsible big country. The climate change law should center on the system of capping carbon emissions or GHG emissions and lay down supporting systems such as carbon emission permit, carbon emission space allocation, carbon emissions trading, and carbon emission measurement, reporting and verification, while taking into account the legal system with flexible implementation mechanisms for clean development and green low-carbon transition, so as to promote the realization of carbon neutrality and a zero-carbon society.

On this basis, considering the comprehensiveness and complexity of the carbon neutrality goal, China will formulate and amend the relevant laws in a coordinated manner. In specific, the Energy Law, Electricity Law, Coal Law, Renewable Energy Law, and Energy Conservation Law will be enacted and amended oriented to energy mix adjustment and optimization, and the Circular Economy Promotion Law and the Cleaner Production Promotion Law will be revised to promote the efficient use and recycling of resources. For the purpose of building a nature reserve system with national parks as the mainstay for adapting to climate change, the Nature Reserve Law, National Park Law, Wetland Protection Law, and Nature Reserve Regulations will be formulated and revised to provide NBS-related legal guarantees for China's comprehensive green and low-carbon transition. Under the above-mentioned legal framework, all departments and local authorities should develop relevant administrative regulations and local regulations to provide institutional guarantees for the normal operation of the carbon market, green low-carbon transition and clean development. In addition, China will set up a progressively upgraded standard system serving the goals of high-quality development and carbon neutrality. In light of the time nodes for achieving carbon neutrality, new green and low-carbon standards will be designed based on high-quality development requirements, product life cycles and full life-cycle impacts, in order to cost-effectively extend product service cycle and improve service quality. These standards, which cover industries, technologies, products, climate investment and finance, will provide technical specifications and guidance for achieving carbon peaking and carbon neutrality (Sustainable Development Strategy Study Group of the Chinese Academy of Sciences, 2021).

3.3.2. Improving the macro coordinated management mechanism on climate change

To fully play the due role, the National Leading Group on Climate Change, Energy Conservation and Emission Reduction will improve office settings and coordination procedures to promote work institutionalization and normalization, and strengthen overall coordination by further improving the responsibilities and working procedures of relevant departments. As such, the work of tackling climate change will be valued and implemented by various central functional departments, and a broader consensus and coordination and cooperation mechanism can be formed. At the same time, capacity building in responding to climate change and implementing low-carbon transition will

be strengthened at the local level. In view of the importance of international cooperation in tackling climate change, it is necessary to improve China's leadership for foreign negotiations. China and the EU have reached consensus on climate change and circular economy, and created mechanisms for high-level environmental and climate dialogue and green partnership. Given this, considering the configuration of officials and institutions on climate change in the Biden administration, China should move faster to institutionalize the existing communication channels, establish peer-to-peer mechanisms, strengthen communication and cooperation among various departments, and formulate relevant strategies and measures in a coordinated manner for policy synergies.

3.3.3. Establishing a cap-based emission reduction target system and related systems

Different from the absolute reduction of carbon emissions implemented by developed countries, China needs to set up a cap-based carbon emission target system under the current administrative regime. This system will combine top-down and bottom-up approaches, and meet the needs of economic recovery and moderately advanced development. It is suggested that China establish a cap-centered carbon emission target system with dual reduction of carbon intensity and energy intensity to replace the existing energy dual-control system, and include the work into the 14th FYP Outline. This target system directly serves the goals of carbon peaking and carbon neutrality. It is also conducive to promoting economic restructuring and building a safe, efficient, clean and low-carbon modern energy system, especially an energy system blending high proportion of renewable energy, while overcoming the adverse effects on economic development brought by hard constraints on the total amount of energy consumption at this stage. Regarding specific target, China should learn from the experiences and methods of developing and applying the existing energy and environmental constraint indicators. The cap-based carbon emission target system should reflect the overall development of economy, energy and environment, and define the range of target values through estimates based on potential economic and environmental development targets, including GDP, energy intensity reduction, and share of non-fossil energy in total energy consumption. At the same time, the statistical accounting system and related systems on carbon emission will be further improved (Sustainable Development Strategy Study Group of the Chinese Academy of Sciences, 2021).

The central and local governments will develop and decompose carbon emission targets through consultation, and promote policy synergies between local areas and various industries. The cap-based control on carbon emissions of specific regions and industries should consider factors such as economic development stage, structural adjustment, technological upgrading, energy substitution potential, air quality, and requirements for air pollution control. Reasonable space allocation, peak and time arrangements should be made, taking into account the impact of inter-regional electricity transfer and

population flow on carbon emission. In addition, in view of the current uncertainties in international and domestic economic development, progress assessment should be conducted on a regular basis during the 14th FYP period, so that targets can be appropriately adjusted according to the actual situation (Study Group of the Institute of Science and Technology, Chinese Academy of Sciences, 2020).

3.3.4. Exploring policy synergies between local areas and various sectors in peaking carbon emissions

In order to ensure the effectiveness and international visibility and influence of actions taken by local areas and various departments and sectors, it is suggested that the CPC Central Committee and the State Council issue the Action Plan for Peaking CO₂ Emissions Before 2030. This plan will prompt local areas and various sectors to recognize the importance of such actions, require local areas and key sectors to formulate respective roadmaps and action plans, define the responsibilities of relevant departments in such actions, and facilitate the formation of policy synergy and sound governance system.

Local areas and key sectors will be mobilized to peak carbon emissions. MEE should, in conjunction with relevant departments, support and urge provinces (autonomous regions and municipalities) to take the following actions in light of their respective economic and social conditions and high-quality development requirements: 1) conduct in-depth research on the potential of CO₂ emission reduction; 2) where appropriate, set the target year and develop the roadmap, action plan, key projects and supporting measures for peaking carbon emissions; and 3) reflect them in local and industry development plans and earnestly put them into practice. Provinces and cities that have already pledged to peak carbon emissions need to further verify the intensity and feasibility of targets, and release the action plan in 2021. Developed eastern provinces and cities with good work foundation will be required to publish before the end of 2021 their target year and action plan. The deadline would be 2023 for provinces and cities with relatively backward economic and social development and insufficient work foundation. Requirements specific to key industries will also be discussed and released, including target years, key technologies and major measures, with priority given to energy-intensive and high-emission industries. At the same time, China will explore the approaches and pathways for coordinating the targets and measures of local areas and sectors for peaking carbon emissions.

3.3.5. Accelerating the construction of market mechanisms represented by the national carbon market

To address this issue, China will make efforts in five aspects: 1) Keep improving the top-level design of national carbon market to support long-term stable market expectations. In the future, carbon prices should be maintained at a certain level through guaranteed scarcity of carbon emission allowances, market mechanisms including

carbon finance, and strict market supervision. This will give rise to long-term stable expectations of carbon prices in market entities. Through effective price transmission mechanism, they will exert influence on the investment decisions of enterprises, so as to stimulate innovation of low-carbon technologies and products; 2) Reinforce the legal foundation for carbon market construction. Property rights should be clearly defined, which serves as a prerequisite for establishing a carbon emission element market (Partnership for Market Readiness and International Carbon Action Partnership, 2016; Yu Tianfei, 2007). Clarifying the asset attributes of carbon emission allowances, including whether carbon emission allowances need to or can be recognized as property rights, will help avoid market failures in the allocation and trading of carbon emission allowances. At the same time, by providing a legal basis for strict law enforcement, this can effectively guarantee the smooth operation of carbon market; 3) Ensure appropriate policy alignment and capacity building in the process of national and local institutional reforms; 4) Draw up a roadmap for international cooperation in carbon market, and set phased targets and key tasks. On the one hand, China will continue to strengthen cooperation with the European Union, the UK and other developed countries and regions. By drawing on the experiences and lessons of foreign carbon markets, China will improve the overarching design of the domestic carbon market and predict problems that may arise in the process of market development. On the other hand, with the in-depth advancement of the Belt and Road Initiative, China will consider cooperation on carbon market interconnection with the Belt and Road countries. In this way, China can get involved in the development of relevant international rules, international cooperation roadmap and phased goals and key tasks regarding carbon market. This will facilitate the alignment with China's various measures to promote a community with shared future for mankind; and 5) Reserve a policy window for carbon tax while carrying out carbon emissions trading, and put into effect the carbon tax policy when appropriate. Due to the limitations of government's management capabilities and enterprises' trading capabilities, the carbon market can neither cover all companies and carbon emissions nor ensure the avoidance of price failures (Zhu et al., 2019). In addition, due to large regional disparities, it is unlikely to effectively regulate carbon emission behaviors in various places by relying solely on the carbon market. In short, the carbon emissions trading scheme alone cannot secure the realization of China's carbon emission reduction targets. In light of China's actual national conditions, it is necessary to reserve a policy window for carbon tax and when appropriate, put it into effect for coordinated implementation with the carbon emissions trading scheme.

3.3.6. Improving the policy system for climate investment and finance

China will gradually put in place a policy system for climate investment and finance pursuant to the Guiding Opinions on Facilitating the Investment and Financing for Responding to Climate Change. By incorporating climate factors, the green investment and finance system will fundamentally ensure the climate-friendly orientation of investment and finance, and provide the taxonomy and policy basis for guiding climate investment and financing activities of market entities and standardizing product

innovation by financial institutions. Governments at local levels will scale up financial investments and tax incentives for green low-carbon transition and development, creating a favorable policy environment for climate investment and finance. The local pilot of climate investment and finance will be kicked off as soon as possible, and the innovation of climate investment and financing products and tools will be encouraged. China will develop an applicable, efficient and advanced system of climate investment and finance taxonomy, optimize the governance structure of funds from diversified sources, and guard against green debt risks. The National Green Development Fund will identify key areas of investment for boosting all-round green and low-carbon transition and innovation, or a separate green recovery and just transition fund will be created, which gives priority support to the orderly withdrawal of coal production, the transformation and upgrading of energy-intensive industries, and the just transition of backward and difficult areas. With respect to the environmental responsibility and investment performance of enterprises, China will promote a comprehensive framework of environmental, social and governance (ESG) criteria, advance corporate environmental information disclosure, long-term environmental and climate planning and comprehensive performance evaluation, and formulate corresponding investment and financing guidelines.

3.3.7. Strengthening the coordinated governance of climate change and air pollution

The coordinated governance of climate change and air pollution conforms to China's national conditions and governance realities. The advancement of industrialization and urbanization entails a large amount of energy consumption. As the current energy mix is still dominated by coal, the total emissions of GHG and conventional air pollutants remain high, and the reduction for better environmental quality will take a long time. For China, the world's largest developing country, it is more urgent to control air pollution and even more necessary to effectively combine climate policies and air pollution control policies. Addressing climate change and controlling air pollution have long fallen into the responsibility of different departments. Climate authorities control GHG emissions by formulating energy plans, energy efficiency standards and industrial policies, while air pollution control authorities reduce air pollutant emissions through measures such as end-of-pipe emission control and corporate production adjustment. These two types of policies are relatively inadequately coordinated.

It is advisable to strengthen the coordinated governance of climate change and air pollution. Socio-economic development planning, energy development planning, and sector-specific plans should give full consideration to the co-benefits of climate action and air pollution control. Meanwhile, emission indicators such as regional and industry carbon emissions and carbon intensity should be aligned with air quality indicators. Climate authorities should strengthen coordination with energy, resource, environment and other authorities to jointly advance the establishment of a climate-friendly economic, social and environmental governance system. In terms of specific policy,

China should adopt a climate-friendly air pollution control strategy, coordinate the measures for control over conventional air pollutants and GHG emissions, and optimize the combinations of such measures to achieve win-win results at a minimum cost.

4. A Market Mechanism Centered on Carbon Pricing

4.1. About carbon pricing

Among policies and measures for reducing GHG emissions, market mechanisms have received more and more attention and are widely used. Carbon pricing policies, especially emissions trading scheme carbon tax, has become a main economic measure for many countries worldwide to control GHG emissions.

Carbon pricing are mechanisms that gives clear pricing to the ton of carbon dioxide equivalent (tCO₂e) of GHG emissions. It mainly includes carbon tax, carbon emissions trading scheme (ETS), carbon credit mechanism, results-based climate finance (RBCF).

Carbon taxes converts the environmental costs caused by carbon dioxide emissions into production and operation costs.

ETS is a policy instrument for emission reduction. It sets emission limits for emitters and allows them to achieve compliance by trading emission allowances. There are mainly two forms of ETS: cap & trade scheme, and baseline & credit scheme. In the first form, the government sets an emission cap for a specific scope of economic sectors. The emission allowances can be auctioned or issued for free. For every ton of carbon dioxide emitted, the entity shall turn in a unit of emission allowance. Entities can choose to use the government-issued allowances to offset their own emission reduction obligations or for trading. In the second form, the government sets an emission baseline for the bound entity. When the emissions exceed the baseline, the entity shall turn in carbon credits to offset the emissions; when the emissions fall below the baseline, the entity can obtain carbon credits and sell them to other emitters who need the credits.

Column: Advantages and Disadvantages of Carbon Tax and ETS

Carbon tax mainly has the following advantages: **First, it takes effect quickly.** It can directly increase the cost of GHG emissions, quickly squeeze the profit margins of emission-intensive enterprises, and force them to adopt energy-saving and emission-reduction measures or measures to limit temperature rise, hence achieving substantial emission reductions in a short period of time. **Second, it has a low implementation cost.** The implementation of the carbon tax mainly relies on the existing taxation system, without the need to set up new institutions or to consider issues such as supporting infrastructure. **Third, the tax rate is stable.** This can form a stable carbon price expectation guideline so that enterprises can make medium and long-term emission reduction plans. **However, it should be noted that carbon tax does not allow direct control of the total carbon emissions.** If the carbon tax rate is relatively low, high-emission and high-yield enterprises can maintain their original

production and business models, with low willingness for emission reduction.

ETS has three main advantages. First, the result of emission reduction is definite. Under ETS, the government directly determines the total carbon emission allowances within a period of time, that is, the carbon dioxide emissions cap, so the emission reduction result is straightforward and clear, without the need for intermediate parameters. **Second, it propels enterprises to reduce emissions through price mechanism, and has an embedded price discovery mechanism.** In addition to regular trading of allowances, ETS also allows trading of derivatives such as allowance futures and options, which can further improve market efficiency. **Third, it can promote the coordination of cross-border emission reduction.** Different carbon markets can achieve interconnection and form a cross-border and cross-regional emissions trading market. After the interconnection, ETS can optimize emission reductions on a larger scale while improving market liquidity. **However, it should be noted that an ETS is more difficult to design and costly to operate.** Key parameters such as emission allocations can only be determined by estimation, and some unforeseeable situations could create unexpected challenges to the emission reduction effort and the implementation of ETS as planned. The government will need to continuously monitor and evaluate the operation of ETS and make corresponding adjustments, which requires a large amount of administrative resources.

4.2. Carbon pricing has been continuously practiced worldwide

4.2.1. Development of the carbon pricing mechanism globally

As of May 2021, 64 carbon pricing mechanisms were being implemented globally, and 3 were planned to be implemented¹¹, covering 21.5% of the global carbon emissions, in sharp increase from 15.1% in 2020. This increase was mainly due to the launch of China's national ETS. In 2020, the carbon pricing mechanism created USD 53 billion in revenue globally, an increase of about USD 8 billion over 2019, which was mainly due to the increase in the price of allowances in the EU.

1. The carbon pricing mechanism is continuing to be mainstreamed. In order to strengthen climate commitments, many countries and regions have expanded the coverage of the carbon pricing mechanism. More and more jurisdictions are considering adding new carbon pricing mechanisms beyond the scope of the existing ones to achieve emission reduction targets. For example, Europe, Germany, Austria and Luxembourg are planning to implement carbon pricing policy for sectors that are not included in the EU Emissions Trading Scheme (EU ETS). In order to achieve net zero

¹¹ State and Trends of Carbon Pricing 2020 (May), World Bank, Washington. DOI: 10.1596/978-1-4648-1586-7

emissions, many jurisdictions have strengthened the adoption of credit mechanisms and results-based climate finance (RBCF). As the issue of Carbon Border Adjustment Mechanism (CBAM) is put back on the agenda in Europe, countries are likely to be motivated to implement carbon pricing mechanisms more proactively.

2. Although carbon prices continue to increase in many regions, they are still far below the level required to achieve the goals of the *Paris Agreement*. According to the estimates of the High-Level Commission on Carbon Prices, to reduce carbon emissions in a cost-effective manner, the carbon price must reach at least USD 40-80/ton of carbon dioxide before 2020 and USD 50-100/ton before 2030. However, only less than 5% of the GHG emissions covered by the existing carbon pricing mechanisms have reached this price range. About half of the emissions are priced below USD 10/ton. According to IMF estimates, the current global average carbon price is only USD 2/ton.

3. In order to reduce carbon emissions, more and more enterprises have begun to adopt internal carbon pricing. In 2020, a total of 853 enterprises around the world announced that they had adopted internal carbon pricing, and 1,159 enterprises expressed their intention to do so in the next two years, including 226 of Fortune Global 500, a total increase of 20% over 2019. The total market value of enterprises involved increased from USD 7 trillion in 2017 to USD 27 trillion. This shows that the private sector has begun to incorporate climate risk into its strategy and that carbon prices have gradually become an important factor for investment decisions. However, internal carbon pricing has problems such as lack of transparency and inconsistent standards. At present, it is difficult to compare the levels of internal carbon pricing among enterprises and evaluate its impact.

4. More and more financial institutions have begun to directly participate in carbon pricing. Currently, most carbon markets have strict restrictions on participants, but several key carbon markets are gradually opening up to financial institutions. The EU carbon market has seen the active participation of about 250 investment funds. The participation of financial institutions can help improve market liquidity, but not without risks. For example, speculative behavior of financial institutions will cause large fluctuations in the price of the allowances, which requires strengthened supervision.

5. Carbon credit trading has begun to gradually shift to projects outside the “Kyoto Mechanism”. The latest data shows that there are more than 14,500 registered carbon credit projects, with a cumulative emission reduction of nearly 4 billion tCO₂e. In the past, the Clean Development Mechanism (CDM) often dominated carbon credit activities. However, after the price collapse in the CDM market in 2012, trading in CDM projects has stabilized. Enterprises interested in valuing their emission reduction efforts remain active in the voluntary carbon market, and carbon credits under independent crediting mechanisms accounted for almost two-thirds of the total in 2019. Similarly, governments are also developing domestic carbon credit mechanisms. These projects will not only bring about benefits locally, they will also create a certain degree

of flexibility for enterprises to adapt to domestic carbon pricing policies.

4.2.2. Development of the carbon pricing mechanism in typical countries and regions

The European Union

After a long time of practice and exploration, the European Union has established a carbon pricing mechanism with Emissions Trading Scheme (hereinafter referred to as EU ETS) at its core.

The EU ETS has four development stages, with the first stage being 2005-2007, the second being 2008-2012, the third being 2013-2020, and the fourth being 2021-2030. The third stage marks the maturity of the EU ETS. In addition to the transition from bottom-up to top-down determination of the total emission allowances by the EU, the allocation of the allocation of allowances has also changed from mostly free issuance to in majority auction-based. In 2013, more than 40% of the allowances were auctioned and the proportion will increase year by year (with 100% auction for the power sector). Regarding the allocation of the remaining free allowances, given the large amount of detailed data on enterprise-level emissions obtained in the first and second stages, benchmarking has replaced grandfathering and become the main method of free allocation. It covers a wider range of sectors: power generation and heating, energy-intensive industrial sectors, and intra-European commercial aviation. It also covers more types of GHGs, expanding from CO₂ to CO₂, N₂O and PCF. In order to solve the problems of oversupply of allowances and low carbon prices in the first two stages, the European Union decided to introduce the mechanism of the Market Stability Reserve (MSR) in 2019. The core role of MSR is to reduce the total allowances circulating in the market so as to increase the scarcity of allowances. The flexibility mechanisms of EU ETS are the Clean Development Mechanism (CDM) and Joint Implementation (JI) under the framework of the *Kyoto Protocol*, allowing the relevant countries to offset their domestic emissions with the Certified Emission Reductions (CERs) and Emission Reduction Units (ERUs) generated from assisting other countries in reducing emissions, hence achieving cost-effective emission reduction. The EU ETS penalties are also becoming stricter. For emitters that fail to meet the emission reduction targets, not only will they have to make up for the unfulfilled allowances in the next year, the fine will also be increased from 40 euros per ton of carbon dioxide equivalent to 100 euros.

The remaining greenhouse gases are covered by the Effort Sharing Regulation (ESR) adopted in 2009 and revised in 2019. The sectors covered by ESR are all sectors except those covered by EU ETS, including transportation, buildings, small industrial emissions(except those covered by EU ETS), waste and agriculture, forestry, etc. The ESR targeted at all six types of GHGs (CO₂, CH₄, N₂O, HFC, PCF and SF₆) specified under the framework of the *Kyoto Protocol*. ESR allocates country-level emission budgets for sectors outside of the EU ETS with some flexibility mechanism, including some transfers between European Member States.

2. The United States

Although there is no federal-level carbon trading mechanism in the United States, local initiatives exist. Some states or enterprises have initiated carbon trading systems to limit GHG emissions, encourage innovation in energy technology and green employment. Among them, the Regional Greenhouse Gas Initiative (RGGI) and the cap-and-trade system of California are the most influential.

Since 2018, the emission targets of RGGI have been continuously strengthened. The plan is to reduce CO₂ emissions in the power sector by 50% by 2020 compared with the 2005 level, and by a further 30% by 2030 compared with the 2020 level. RGGI's reform measures also include the establishment of a cost containment reserve (CCR) to deal with the imbalance between supply and demand of allowances, that is, when the price of allowances in the secondary market reaches USD 10 per short ton of CO₂, the reserve will be triggered to release allowances to contain and stabilize carbon prices. The trigger price will be raised year by year.

At the end of 2018, California approved the reform measures for its carbon trading system after 2020. In order to help achieve California's GHG emission reduction target for 2030, the carbon trading system has been revised in terms of allowance cap, price containment measures, reduction of free allowance allocation and restrictions on the use of emission reduction offsets, and has taken effect in April 2019.

3. Canada

Starting in 2019, Canada, under the Pan-Canada framework, requires all jurisdictions to establish carbon pricing mechanisms in the forms of carbon trading, carbon tax, or a combination of the two after 2018, or else, the Federal Backstop System shall apply. The Federal Backstop System mainly includes two parts: (1) Fossil fuel regulatory fee will be levied at 20 Canadian dollars/tCO₂e (14 US dollars/tCO₂e) starting from 2019, and will be increased by 10 Canadian dollars/tCO₂e (7 US dollars/tCO₂e) each year till it reaches 50 Canadian dollars/tCO₂e (35 US dollars/tCO₂e) by 2022; (2) An output-based pricing system (OBPS), which sets emission intensity standards for power generation and more industrial activities. OBPS is applicable to facilities that emit more than 50,000 tCO₂e per year in the jurisdictions or any facilities that meet the conditions and volunteer to participate in the system. The two parts can be implemented together or separately. OBPS entities can also offset their emissions with qualified carbon credits.

Some provinces and regions have begun to implement the Federal Backstop System. In addition, the Northwest Territories (NWT) put into force carbon tax on September 1, 2019. New Brunswick also began to impose carbon tax on April 1, 2020 at a rate of 30 Canadian dollars/tCO₂e (21 US dollars/tCO₂e), replacing the fuel fee under the federal mechanism with carbon tax. Alberta abolished carbon tax on May 30, 2019, and replaced the Carbon Competitiveness Incentive Regulation (CCIR) with the

Technology Innovation and Emission Reduction (TIER) program. TIER is a baseline-and-credit emission trading system effective from January 2020. Manitoba, New Brunswick and Ontario are considering the use of supplementary carbon pricing mechanisms.

4.2.3. Challenges for the carbon pricing mechanism in practice

First, there is a risk of carbon leakage, which can hinder global joint actions on emission reduction. Carbon leakage refers to the phenomenon that after carbon tax or ETS is implemented, multinational enterprises can transfer high-carbon productions to areas with low emission costs, causing the carbon emissions that should have been reduced to be transferred to and emitted in other areas, greatly reducing the effect of the local carbon tax policy. The European Union is discussing the launch of a Carbon Border Adjustment Mechanism in 2021, imposing taxes on certain high-carbon products imported from countries with low carbon prices, or providing export tax rebates for exporters of countries with high carbon prices so that countries leading in emission reduction do not find themselves at a disadvantaged position in competition while avoiding the problem of carbon leakage. At present, the Carbon Border Adjustment Mechanism has not been implemented, with the main challenges being difficulties in calculating the carbon content of imported goods and compatibility with WTO rules, etc.

Second, the low level of carbon tax rates or surplus of carbon emission allowances can hinder the carbon pricing mechanism from exerting its regulatory function. The carbon price directly reflects the cost of carbon emission cost for the company. At present, in the carbon tax system, tax rates are generally low; in the emission trading scheme, the government often overestimates the demand for allowances and even grants allowances for free and allows unused allowances to be accumulated over years, leading to excess allowances and low trading prices. For high-emission and high-profit companies, low carbon prices will weaken their motivation to reduce emissions, hence the failure to achieve the expected policy results.

Third, social inequality may be exacerbated. Carbon prices may push up the prices of some daily necessities, especially electricity prices. Since the expenditure on daily necessities accounts for a larger proportion of the total expenditure of low-income groups, carbon tax or ETS will pose greater impacts on low-income groups as compared to middle and high-income groups. Therefore, part of the revenues from carbon tax or auction of emission allowances can be recycled to help the disadvantaged groups.

4.3. Progress and problems of China's carbon pricing mechanism

4.3.1. Carbon pricing as an important policy tool for China to achieve carbon neutrality

Pricing the externalities of carbon emissions in both explicit and implicit ways, thus motivating emitters to include carbon emission factors into their production and consumption decisions, is a crucial paradigm of GHG emission control policies. For a long time, China's climate policy has relied on the synergies among energy, environmental, industrial and other policies, gradually giving rise to a "free-rider" policy structure where synergistic policies are not specially designed to control carbon emissions. As China continues to raise its ambition to tackle climate change, the lack of specific climate policies will gradually widen the remaining emission gap, failing to meet the country's medium- and long-term emission reduction needs. In this case, carbon pricing, which specially targets reducing GHG emissions, will become the dominant means for China to deepen its climate governance and achieve carbon neutrality.

Carbon pricing is an important tool to drive emission reduction. The international community is pushing for effective carbon pricing mechanisms as an important tool to address climate change. Carbon pricing can provide comprehensive incentives for transition and provide a clear value orientation for key emitting industries, while revenues generated through carbon pricing mechanisms can be used to support a just transition. Carbon pricing is also a cost minimization tool, which can generate price signals to curb the "free-rider" effect and guide spontaneous green investment and innovation in society. Moreover, carbon pricing can increase the cost of carbon consumption and then contain unnecessary high carbon consumption activities. If major global carbon emitters have generally established carbon pricing mechanisms, these mechanisms can provide price signals for global cooperation. In particular, carbon pricing can play a critical role in specific industries such as power, cement and iron & steel, and quicken the pace of carbon reduction in key emitting industries. Looking ahead, carbon pricing of other GHGs can also contribute to earlier carbon neutrality, as IEA studies suggest that carbon pricing can include methane and other GHGs and model studies conclude that carbon prices equivalent to USD 20 could sufficiently promote methane emission reduction with more effective efforts.

4.3.2. Progress of carbon pricing in China

China is accelerating the establishment of a carbon pricing mechanism. On October 28, 2020, the Administrative Measures for National Carbon Emissions Trading (for Trial Implementation) (Draft for Comments) and the Administrative Measures for National Carbon Emissions Registration, Trading and Settlement (for Trial Implementation) (Draft for Comments) were open to comments. The two official documents were adopted at the MEE Ministerial Meeting on December 25, 2020 and took effect on February 1, 2021. In addition, the MEE published

the 2019-2020 Implementation Plan for the Cap and Allocation of Carbon Emission Allowances (Power Generation Industry) on December 31, 2020. These policies and actions will effectively support the national carbon market to enter the substantive stage of operation. On May 14, 2021, the MEE issued the Administrative Rules Governing Carbon Emissions Registration (for Trial Implementation), the Administrative Rules Governing Carbon Emissions Trading (for Trial Implementation) and the Administrative Rules Governing Carbon Emissions Settlement (for Trial Implementation) to further regulate the registration, trading and settlement of carbon emissions nationwide. On June 22, 2021, Shanghai Environment and Energy Exchange promulgated the Announcement on Matters Related to National Carbon Emissions Trading, which makes clear trading details and other related matters. On July 16, 2021, China's national carbon market was opened, realizing the leap from a ten-year pilot program to the roll-out throughout the country.

The national carbon market is first opened to the power generation industry in consideration of the following: first, the power generation industry is a major emitter of carbon dioxide. As the 2,000-plus key emitters, including captive power plants, in the power generation industry emit 4 billion tons of CO₂ a year, opening the national carbon market to the industry can fully leverage the positive role of the carbon market in controlling GHG emissions. In fact, China's carbon emissions trading scheme has become the one covering the most GHG emissions in the world. Second, the power generation industry boasts a relatively sound management system and a solid data foundation. Having access to accurate and effective emission data is a prerequisite to carbon market trading. The power generation industry is highly automated with a monotone line of products, complete metering facilities for emission data, normative and verifiable data management, and simple and easy allocation of allowances. Third, the power generation industry features large CO₂ emissions and high coal consumption, so incorporating the industry into the national carbon market first can create synergies between pollution mitigation and carbon reduction.

At its inception, the national carbon market is only available for spot trading of allowances between key emitters in the power generation industry, and is incorporated into the carbon intensity management system in effect in China, with the first batch of allowances approved and allocated to key emitters in the power generation industry using the baseline method and the carbon emissions accounting, reporting and verification system strictly implemented to improve data quality. At present, among the institutional design pertaining to the national carbon market, policy measures such as improving allowance allocation methods and introducing an offset mechanism should be considered to guide market expectations and then form reasonable carbon prices.

Next, China will speed up the revision of relevant the national standards for GHG emissions accounting and reporting in the principle of approving and releasing a standard after it is mature. China will then consider and develop industry-specific allowance allocation schemes and, after the carbon market for the power generation industry is on the right track, further expand the scope of industries covered by the carbon market.

Existing carbon pricing practices have paid off. First, motivated by carbon prices, enterprises begin to consider emission allowances a factor of production, which can help internalize the external costs of carbon emissions. Second, China's carbon pricing practices have facilitated low-carbon innovations in enterprises, and the more significant the carbon price signal is, the more it can induce innovation in low-carbon technologies. Third, such practices have strengthened the capacity building in response to climate change, enhanced the ability of government agencies to supervise carbon emissions and improved the ability of carbon emitters to manage their own emissions. Finally, carbon pricing practices reflect China's positive attitude towards participating in global climate governance and have increased China's voice and influence on this regard by incorporating China into the international carbon pricing system.

4.3.3. Problems and challenges facing China's carbon pricing mechanism

- 1. Carbon pricing lacks a solid rule-of-law foundation and is not adequately aligned to the overall policy objectives.** At present, China has not yet identified the status of carbon pricing in the carbon peak and carbon neutrality targets, or set or decomposed binding emission reduction targets under the carbon peak and carbon neutrality targets, disabling effective long-term restrictions on emissions, and depends heavily on the “free-rider” governance structure and campaign-style governance model. Although market mechanisms serving carbon intensity targets can indeed play a role in emission reduction, they cannot help realize the carbon peak and carbon neutrality targets. China's carbon market should match the carbon peak and carbon neutrality targets by gradually shifting from a baseline approach to a system based on absolute emission caps.
- 2. China's carbon pricing mechanism fails to exert the role of price discovery.** While the national carbon market has clearly updated the mindset and highlighted the responsibility of enterprises for emission reduction, the legal status of carbon allowances in China's carbon market remains unclear, and administrative allocation for free of carbon allowances still dominates the distribution process of allowances. The administrative allocation of carbon allowances requires the competent authorities to be neutral, but they are easily affected by stakeholders in the policy implementation, impeding the market equilibrium and barring the carbon market from discovering the true prices of carbon.
- 3. The nature of property rights in China's carbon market is still unclear.** Carbon allowances are allocated by the government to enterprises for free; such an arrangement does comply with the orientation of the macro policy of cutting taxes and administrative fees, but ignores the responsibilities and obligations that enterprises should have undertaken and the polluter pays principle.
- 4. The carbon trading market is faced with the risk of price failure.** Carbon prices lie at the core of the carbon trading market system. Only under the action of the market supply and demand mechanism and the competition mechanism can reasonable carbon

prices be formed in the carbon market. Then, emission reduction resources can be reasonably allocated under the guidance of the price mechanism, enabling enterprises to save energy and reduce emissions at the lowest cost. This, however, entails accurate emission data, tight allowance cap, strict laws and regulations, moderate liquidity, considerable trading volume, diversified investor structure and other important conditions. As indicated by the pilot program, it will take some time to meet the above-mentioned conditions in the environment of market economy in China. Even in the EU, where the market economy is relatively well developed, the EU carbon trading market has experienced price failures and it may be difficult to avoid such risks in the development process of China's carbon market. Therefore, China should consider using carbon taxes, apart from full free market-based means, to solve price failures in carbon trading.

4.4. Suggestions for promoting the gradual improvement of China's carbon pricing system

Practices show that the top-level design of carbon pricing should be law-based and market-oriented. **Being law-based** means that China should provide fundamental guarantee for climate governance by leveraging the mandatory nature of laws, form long-term signals for low-carbon transition through the stability of law-based means, and ensure efficient and equitable carbon pricing in a law-based manner. **And being market-oriented** means that China should give full play to the role of the market in allocating climate capacity resources, raise the cost-effectiveness of carbon emission reduction policies and minimize the macroeconomic impact of carbon pricing by making use of explicit carbon pricing. Compared with government regulation-based administrative means, market-based means are more efficient in reducing emissions and can avoid the controversy over "the government picking the winners" and international trade frictions caused by government subsidies.

1. China should develop a carbon emission cap system to provide an institutional basis for carbon emissions trading. China should consider and build a carbon emission cap system to provide a top-level institutional basis for the carbon market, establish the cap of allowances covered by the carbon market in a bottom-up manner and then allocate the allowances vertically to emitters in different industries. In the light of the carbon emission cap targets set by the country for different regions, a dual constraint mechanism that reflects the principles that emitters pay and that local governments undertake the overall responsibility for the environmental quality within their respective jurisdictions should be established; finally, an evaluation system that deals with the implementation of carbon emission cap targets should be formed, where administrative examination should prevail at the beginning and end of planning, law-based supervision dominate in daily operation and the role of market regulation be fully exerted.

2. China should steadily accelerate the establishment of a national carbon

emissions trading system and build a hybrid carbon pricing system in due course.

China should gradually increase the proportion of allowances for auction, introduce renewable energy into the national carbon emissions trading system dominated by the power industry as early as possible and incorporate other key emitting industries such as iron & steel, aluminum, cement, chemical engineering and petrochemical engineering step by step. China should develop a hybrid carbon pricing system in the principle of controlling trading costs. Enterprises with high emission concentrations should be included in the carbon trading system, and a carbon tax system that controls the cost of carbon reduction should be applied to diffuse small emission sources.

3. China should phase in carbon financial instruments to unlock market vitality and fuel low-carbon transition. Relevant financial institutions and carbon asset management companies should be encouraged to participate in market trading and innovate products and instruments, expand the capital supply for low-carbon investments, and guide the formation of stable carbon price expectations. China should appropriately relax restrictions on market access and explore the establishment of a self-discipline mechanism for the carbon finance industry. China should foster intermediaries and the intermediary market, and encourage deep integration between digital technologies and carbon finance.

4. China should enhance its basic capabilities of carbon emissions accounting, and increase the transparency of the carbon pricing mechanism. On the grounds of the existing corporate carbon emissions accounting system, China should organize the formulation of carbon emissions accounting standards for key exports. China should accelerate the development of administrative measures for GHG emissions accounting, reporting and verification for key products, and upgrade the guidelines and technical specifications on GHG accounting and reporting. An information disclosure system for carbon emissions should be established in line with international standards.

5. China should drive the negotiations on carbon market mechanisms under the Paris Agreement to produce results, avoid carbon leakage and promote fair trade. On the one hand, China should take the opportunity of the COP26 to advance the negotiations on the implementation rules for market mechanisms under Article 6 of the Paris Agreement and reach a consensus on the market mechanisms related to carbon emission reduction. China should, by means of assistance or technical assistance, facilitate the establishment of market mechanisms in other countries that have not yet established carbon emissions trading mechanisms, and push these trading mechanisms to converge. On the other hand, China should cement its partnership with the EU and promote China-EU and other joint climate actions within the framework of international multilateral climate governance. China should promote economic and trade cooperation with the EU by means of green investments under the Belt and Road Initiative, and zero- and low-carbon technology trade, and step up its efforts to address climate change through pragmatic cooperation.

5. Global Climate Cooperation in the New Era and China's Role

5.1. State of global climate cooperation after the pandemic

Green recovery after the COVID-19 epidemic has become a broad consensus of the international community. The green recovery of global economy will not only involve the rational use of public resources, but also improve climate resilience on all fronts. Countries around the world are actively exploring pathways for low-carbon transition along with economic recovery. Although international cooperation in the fields of environment and climate encountered bottlenecks after the outbreak of the epidemic, the historical trend of win-win cooperation and development will not change by any means, so will the principles of extensive consultation, joint contribution and shared benefits. Aiming for green recovery and low-carbon transition, it is more necessary to establish an effective multilateral cooperation mechanism and strengthen international cooperation to jointly meet global challenges.

5.1.1. Overall situation of international cooperation in global climate governance

The global climate governance system has gone through a process of continuous development and improvement. As underpinning key documents, the United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and Paris Agreement lay down the core principles and key institutional designs for climate governance (Niu Zhankui, 2020). In essence, they play a role of coordination to maintain the efficient operation of climate governance system and provide adequate and timely support to developing countries with institutional arrangements and public funds, thereby delivering the long-term goal of tackling climate change.

1. Under the new situation of unprecedented global changes, challenges faced by the international community have become more complex and hampered the process of global climate cooperation. Faced with complex issues in various aspects of post-epidemic economic and social recovery, countries tend to compromise the priority of policies and actions on climate change because of the urgency to solve other domestic issues, resulting in weaker intensity and progress of actions on climate change. In the field of climate change, there are obvious differences in interest demands between "two camps", i.e. developing and developed countries. The United States and the European Union are the representatives of the "two forces" of the developed world, while China is the core leader of the developing country group. The game relationship among China, the United States and the European Union has a critical impact on the progress of global climate governance.
2. The COVID-19 epidemic has prompted countries to think deeply about the way to green transition and showed clearly the importance of global cooperation to meet common challenges. Reforming and improving the global climate governance system

has become a common concern of the international community. Climate change is a common challenge facing human society at present, from which no country can stay aloof. The good experiences gained in the global combat against the epidemic may provide implications for post-epidemic global climate governance. Global coordination and international cooperation strengthened during the epidemic for joint research on global solutions highlight the value of the concept of a community with shared future for mankind. In this regard, the severe challenges brought about by global climate change present a shared future for mankind in some sense. It is such shared future that has laid a deep moral and ethical foundation for cooperation between countries around the world to cope with global climate change based on consensus and rules (Li Huiming, 2018). As Chinese President Xi Jinping emphasized in his speech at the Climate Ambition Summit 2020, "In meeting the climate challenge, no one can be aloof and unilateralism will get us nowhere. Only by upholding multilateralism, unity and cooperation can we deliver shared benefits and win-win results for all nations."¹²

5.1.2. Practical demand for international cooperation on green recovery and low-carbon transition

Sustained economic recovery is an important challenge facing countries in the post-epidemic era. Green and low-carbon economic incentive measures have become the focus of attention for the international community. China, the European Union and its member states have all made funding arrangements for green development and low-carbon transition in their respective recovery plans. Since international cooperation is indispensable for pursuing green low-carbon development and tackling climate change, there are extensive demand and space for cooperation among countries in the fields of green infrastructure, green trade, green policies, low-carbon technologies, clean energy, and circular economy.

1. Under the situation of the COVID-19 epidemic superimposed on profound changes unseen in a century, the green recovery path demands a more effective cooperation mechanism at the global level. In the post-epidemic era, the top priority facing all countries is to restart the economy and restore people's livelihoods, and the path to recovery will have an extremely important impact on the direction of global climate governance. Sustained green recovery rests on a strong ecological system and a more efficient economic structure. Countries all over the world are rethinking the path to sustainable development goals (SDGs) and economic recovery and will adhere to low-carbon development path in the new economic stimulus plan to jointly promote green recovery. They also consider including green and low carbon indicators of economic stimulus plan in the updated INDCs. The green recovery and low-carbon transition in

¹² Remarks by Chinese President Xi Jinping at the Climate Ambition Summit (Full Text).
http://www.xinhuanet.com/politics/leaders/2020-12/12/c_1126853600.htm [2020-12-15].

economy require in-depth cooperation between countries, including coordination and exchanges at the levels of technologies, policies, standards and systems. The original global climate governance system has already been unable to meet the realistic needs of countries in the process of economic recovery, or to effectively cope with realistic non-traditional security challenges such as climate change and public health crisis (Liu Hongyan, 2020). This puts forward new requirements for the reform and improvement of global climate governance system in the new situation, the establishment of a multi-level cooperation mechanism among the government, enterprises and industry associations, and the advancement of deeper and more effective international cooperation.

2. In light of deep uncertainty in the international political and economic landscape, removing green barriers and expanding funding channels necessities stronger green financial cooperation between countries. There is an upward tendency to create green barriers on the grounds of climate issues, as well as a growing momentum of protectionism that increases trade barriers by means of carbon tariffs. Aid funds and transfer payments are also facing the risk of substantial shrinkage due to the global economic downturn or even recession. In this context, governments and organizations at all levels should further step up pragmatic cooperation, including the formulation of international mechanisms, rules and standards, implementation of activities and formation of standardized and unified monitoring, reporting, and verification system with respect to climate investment and finance, and the establishment of robust multilateral financial institutions and platforms. They should expand cooperation and funding channels in multiple ways, and make capital allocation and use more efficient. With enhanced mutual trust and board consensus, the identification cost of green investment and finance can be reduced, and multinational investment in green and low-carbon fields will be boosted, providing financial support for green recovery of the global economy.

3. The new round of technological revolution and industrial transformation paves the ground for the development and application of green and low-carbon technologies. Realizing low-carbon transition and jointly addressing climate change requires more international cooperation in the field of technology. In the midst of a new round of technological and energy revolution worldwide, the global industrial chain is facing green reconstruction. The advancement of key low-carbon technologies represented by energy efficiency, energy storage and negative emission technologies, as well as the deep integration of digital technology with the economy and society, have smoothen the way to green low-carbon development. In the context of arduous recovery and deep adjustment of the global economy, the European Union insists on implementing the Green New Deal (European Commission, 2019), and aims to reshape the global industrial chain and cultivate new green growth drivers through the development of emerging green industries, with the hope of leading the global industrial sector to the path of green development. Green technologies and industries themselves are helpful for improving the utilization efficiency of natural resources and nurturing new drivers

of economic growth. They can also contribute to solutions to environmental pollution and ecological damage associated with fixed industrial structure and energy structure, thereby improving the level of public health. In pursuit of a competitive and climate-neutrality world economy and the global energy and economic low-carbon transition, it is necessary not only to set up a new international cooperation mechanism on green and low-carbon technologies, but also to strengthen the alignment of standards for low-carbon technologies, equipment and products and jointly promote technological innovation in green and low-carbon industries.

5.2. Suggestions for strengthening international climate cooperation

The international political and economic landscape and the strategic pattern of responding to climate change are experiencing profound changes. International relations are also undergoing long-term, fundamental and structural changes. Populism and anti-globalization trends are now prevailing. Especially after the outbreak of the COVID-19 epidemic, the agenda of international negotiations in the climate field was forced to postpone. Prolonged transition period, absence of leadership and inadequate global provision of public goods all present new challenges to global climate governance and dampen the prospects for future international cooperation and joint action. Nevertheless, climate change is one of the major and pressing global issues facing human society. Mankind is a community with a shared future that is bounded together for good or ill. Responding to climate change and promoting green low-carbon development requires the international community to boost confidence, build consensus, act actively and strengthen cooperation. China is the largest developing country and one of the major carbon emitters in the world. Despite its own arduous development tasks and challenges, China should play a more important role in international cooperation on green recovery and low-carbon transition.

1. China should actively shoulder the responsibility of a great power to promote global green low-carbon development. As a developing country, China has made unremitting efforts and positive contributions to addressing climate change, which accomplishing tremendous achievements that are obvious to all in its development process. The Proposal of the CPC Central Committee on Drawing up the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 clearly stated that "carbon emissions will be steadily reduced after reaching the peak" and "(China will) get actively involved and take a driver seat in the international environmental cooperation, including addressing climate change."¹³ China will assume the responsibility of a great power in international cooperation for global green and low-carbon development. It will actively fulfill its due international

¹³ Proposal of the CPC Central Committee on Drawing up the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035. http://www.xinhuanet.com/2020-11/03/c_1126693293.htm [2020-11-15].

obligations and responsibilities and honor its commitments to addressing global climate change. This will help China establish the image of a responsible power in the international community and increase its voice in global governance system. This move also meets the inherent requirements of China's endeavor to accelerate the change of growth drivers and promote high-quality economic development in the new stage of development, with a view to sustainable development.

2. China should strive for a more fair and reasonable international cooperation mechanism. Global climate governance is one of the most complex, difficult and consensus-challenging international public issues. The key factor behind is that climate change has a more direct impact on developing countries, especially poor countries dominated by agriculture. In the process of climate cooperation, the philosophy of seeking common ground while shelving differences and meeting each other halfway should be upheld. On the basis of fully affirming the broad consensus of various countries reached through long-term efforts, practical and effective institutional arrangements should be made under the UNFCCC to further promote close cooperation between developed and developing countries and build a more fair, just and reasonable order of global climate governance. China will strive to gradually shift the focus of cooperation to the completion of short-term and medium-term emission reduction targets, and will urge developed countries to fulfill their commitments, including providing financial and technical support to developing countries and assisting developing countries in capacity building to deal with climate change.

3. China should expand international exchanges on green and low-carbon technologies. China has always been a defender of global climate governance and an active participant of multilateral climate process, and strived to fulfill its commitments on climate change. China attaches great importance to the research of technologies to deal with climate change, and scales up the input of resources to deal with environmental changes. At present, China has gradually realized parallel technology imports and exports, rather than an importer of green and low-carbon technologies. However, the global distribution of technologies to cope with climate change is scattered. Given regional differences in technology research & development standards, international standards and unified paradigms for basic research & development, systemization, and customization have not yet formed. This has greatly increased the transformation costs of related technologies, which underscores the urgency of international standardization for technologies. Under the new situation, China should actively seize the opportunity and make a strategic layout. Through multilateral and bilateral cooperation, China can build a mechanism for climate research cooperation and result sharing, and promote joint research & development plans for low-carbon technologies with developed countries such as the European Union, the United States and Japan. Climate-friendly low-carbon technologies can be identified to provide strong technical support for global response to climate change. Through breakthrough international scientific and technological cooperation in the field of climate change, China can lead the global climate governance towards new direction.

4. China should promote regional cooperation in climate change. As an all-time defender of global climate governance, China has actively upheld and participated in multilateral cooperation and spared no efforts to honor their commitments. In the face of enormous changes in the world, China should pay more attention to regional climate cooperation while actively advancing global climate governance. Building on experiences in regional cooperation and regional governance, China will continue to push forward South-South cooperation action plan on climate change and strengthen the going-global strategy for green and low-carbon technologies under the framework of South-South cooperation by providing strategic consulting services and technology transfer services for recipient countries and summarizing and disseminating the best cases of applicable technical assistance. China will put forward an initiative of interstate cooperation on green and low-carbon technologies to spur regional cooperation on research & development of common technologies, create bilateral green technology cooperation and will improve the global climate information sharing platform to scale up the sharing of scientific and technological achievements. China should strengthen the active role of multilateral organizations such as the International Climate Technology Center (UNEP IETC) and the United Nations Industrial Development Organization (UNIDO) in the diffusion of green technologies China will deepen the China-EU climate partnership and properly handle China-US climate cooperation. By reducing disputes in a divide-and-conquer approach, the overall environment can be improved based on small consensus, and major changes can be achieved based on small breakthroughs, so that China will continuously enhance its voice and influence in climate cooperation.

5. China should strengthen third-party market cooperation with key countries in Southeast Asia, Central Asia and Africa. China can push forward the reform of global climate governance system by assisting developing countries in low-carbon transition and sustainable development. On the one hand, China will create a multi-level cooperation mechanism involving the government, enterprises and industry associations, establish an enterprise-dominated and market-oriented technological innovation system in the fields of wind, solar and nuclear energy and bioenergy for joint technology and product development, and advance the transformation of research results into applications in the Belt and Road Initiative. On the other hand, China will strengthen the alignment of green standards, and develop the Belt and Road markets and international rules together with its partners. While facilitating exchanges between developed and developing countries on global environmental governance issues, China will accelerate the construction of six major economic corridors as cooperation platforms, expand the cooperation with relevant international organizations and institutions, and build a win-win global climate governance system for jointly coping with the challenges of energy security, environmental pollution and climate change.

6. China should strengthen climate cooperation between non-state actors. China, the U.S. and Europe should carry out cooperation at provincial, state, and city levels to promotes exchanges between think tanks, enterprises, universities and research

institutions, thereby creating a cooperation environment along multiple tracks (Green Recovery Research Group, Academy of Science and Technology Strategy Consulting, Chinese Academy of Sciences, 2020).

6. Gender Equality Analysis

Gender equality is the basic right of human. Without gender equality, half of the population lose the chance to live life at its fullest. This is particularly the case in relation to mitigation and adaptation of climate change. At the 52nd Session of the IPCC in February 2020, the Panel adopted the Gender Policy and Implementation Plan, aimed at enhancing gender equality in its processes and in order to promote a gender-inclusive environment. Gender equity is also mentioned in the Paris Agreement, as part of the issues that should be taken into consideration when taking action to address climate change. In the Nationally Determined Contributions (NDCs) submitted in 2016, 64 parties include a reference to women or gender, and when countries submit their new and updated NDCs, most of the enhanced NDCs include a reference to women or gender, demonstrating a stronger awareness and willingness to tackle gender equality in climate considerations.¹⁴

Gender equality is part of the basic state policy of China. To promote the status of women and gender equality, China focuses on ensuring women's equal opportunities and participation in economic activities, employment, and entrepreneurship.¹⁵ In the latest National Program for Women's Development 2011-2020, "women and the environment" is set as one of the seven major topics. Taking a step forward, following the UNFCCC framework and Paris Agreement, China should further recognize the importance of the link between gender equality and climate change, and include reference to women or gender when updating its NDC in order to mainstream the awareness and action towards gender equality in the implementation of its climate policies.

Specifically, it is important to ensure that women are viewed as active agents who must have equal say in the design, decision-making and implementation of relevant plans and actions, and conduct gender and vulnerability analysis at the design stage and establish sex-disaggregated baselines, indicator and targets. Collection, use and analysis of sex-, age- and disability-disaggregated data and information in the formulation of climate policies and strategies for climate mitigation and adaptation is also helpful for ensuring gender-inclusive climate solutions. We list three main areas for specific work integrating gender equality with climate actions in China.

6.1. Gender and climate as cross sectoral issues would rely much on multi-ministerial efforts

Gender is not a stand-alone topic. It is an issue that every sector and every region must

¹⁴ Quick Analysis – Gender Climate Tracker. <https://genderclimatetracker.org/gender-ndc/quick-analysis>

¹⁵ Women, U. N. "Gender Dimensions of Vulnerability to Climate Change in China." (2016).

face. In China the National Working Committee on Children and Women under State Council is in charge of gender related work, coordinating relevant government departments to implement laws, regulations, and policies and measures for women and children. Its member departments include Ministry of Ecology and Environment, National Development and Reform Commission, Ministry of Science and Technology, and other departments responsible for climate actions and low-carbon transformation in China. It is important to make full use of the coordination power of the Committee, to mainstream gender with climate and low-carbon development. The Committee is in charge of drafting China's Outline for the Development of Women, which is a ten-year guiding document for gender equality and women's development. The latest Outline for the Development of Women (2011-2020) targeted women's equal participation in environment decision and management. For the next Outline, climate related targets could be included as a step forward, through effective coordination and communication between MEE and the Committee. Overall, it is important to strengthen cross department coordination and collaboration, to ensure coordinated efforts and co-benefit of both climate actions and low-carbon transformation, and gender equality and women's development.

6.2. Women's participation in the carbon-neutral job market

Carbon neutrality will need a systematic transformation of the economic structure, and will fundamentally change the job market. By phasing out carbon-intensive traditional sectors and building a new high-tech and low-carbon green economy, carbon neutrality provides a starting point for making women's contributions to society and the economy visible as well as the opportunity to revalue them. According to the ILO, taking action in the energy sector to limit global warming to 2 degrees Celsius by the end of the century can create around 24 million jobs, largely offsetting any job losses.¹⁶ These new job opportunities in the emerging green industries have a chance to reach men and women equally, especially those jobs that have not yet been recognized as "masculine", including a large number of technical and high-paying jobs and climate mitigation and adaptation policy and project jobs.¹⁷ It is important to ensure that pre-existing gender inequalities in conventional energy and industry sectors are not transferred to the emerging green economy.

Through incorporating active guidance and planning and regulation with a gender perspective into the green transformation policies, the co-benefits of green and low-carbon development as well as women's development could be achieved at the same time. In order to ensure women's equal opportunity in green jobs, it is also important

¹⁶ Bureau international du travail. World Employment Social Outlook 2018: Greening with Jobs. International labour office., 2018.

¹⁷ Pearl-Martinez, R. "Women at the forefront of the clean energy future." Washington, DC: United States Agency for International Development (2014).

to prepare education in a gender neutral way, implement capacity building programs for women and create awareness for women's participation in green job sectors, including in positions of leadership. Policy and decision makers should ensure employment and skills development policies designed for green job sectors are gender responsive, well informed, coherent and broadly supported by all relevant stakeholders. They must ensure that green job policies harness already existing international gender frameworks and treaties.¹⁸ Employers should ensure that job postings are inclusive.

6.3. Women's safety and transportation

Women's safety in public spaces has always been an important social issue in China and around the world. It limits women from using transportation service as freely as the low-carbon modal changes would encourage. A report published in May 2021 shows that more than ten percent female passengers has encountered inappropriate behavior of drivers when they use ride-sharing services, being exposed to safety risks.¹⁹ In another report which investigated violence cases towards women in public, 28.33% of the cases were reported in public transportation and another 6.67% were reported in taxis and ride-sharing services.²⁰ Concern of safety issues push women away from using public transportation and ride-sharing services. Instead of shared transportation, many women choose to drive, which leads to more carbon emissions. Improving women's safety in public – especially in public transportation – facilitates women to use transportation service in a more shared and low-carbon manner.

Improving women's safety in public requires joint efforts of stakeholders. Public security departments and media could raise awareness of gender and security, and ensure smooth reporting and complaint channels. Legislative department could improve related legislation and ensure its implementation. It would also be helpful to encourage and support civil society's participation in this area. Overall, improving women's safety in public and transportation will bring comprehensive benefits, including less carbon-intensive transportation of women.

While there would be many more, the three concrete examples above illustrate how gender equality could be promoted at the central and planning level, in the social changes that the low-carbon transition will drive, and as a multi-beneficial action that enhances gender equality and enables climate-friendly behaviors.

¹⁸ International Labour Organisation (ILO). "Gender equality and green jobs." (2015).

¹⁹ 网约车女性出行报告发布——女性安全出行问题应得到持续关注。http://www.nwccw.gov.cn/2021-05/10/content_292308.htm

²⁰ 中国女性安全出行报告：女性出行暴力事件中，性骚扰最为多发。<https://zhuanlan.zhihu.com/p/26425179>

7. Policy Recommendations

7.1. Gradually establish and improve an absolute carbon emission cap under the guidance of the carbon peaking and carbon neutrality goals.

First, a new dual control system based on “absolute carbon emissions” and “emission intensity” should be gradually put in place during the 14th Five-Year Plan period in key sectors and key regions, taking the lead to combine energy intensity control, absolute control and emission intensity control targets, with pilots of absolute carbon emission systems. Gradually promote it national-wide and throughout all sectors.

Second, continue to promote legislation to address climate change and provide a legal basis for carbon neutrality. further improve the monitoring, reporting and verification system of greenhouse gas emission and related infrastructures, and integrate them with energy and environment related mechanisms.

Third, further improve the carbon emission inventory and statistical accounting and reporting system, including by integrating non-CO₂ greenhouse gases. Promote the establishment of carbon accounts to market actors, and develop a carbon reporting infrastructure based on such mechanisms as the emission permit system and the energy audit systems.

Fourth, establish the regional and sectoral carbon emission target allocation methods, taking into account the characteristics of population dynamics, industrial layout, and inter-regional power transfer.

Fifth, select typical provinces, municipalities, sectors and enterprises to launch early demonstration pilots of the planning, innovation, investment and policies for early peaking and carbon neutrality.

Sixth, reinforce the functions and institutionalized role of the central working group on carbon peaking and carbon neutrality, strengthen the coordination of climate change with economics, energy, environment and other aspects. Coordinate the international and domestic climate affairs. Ensure that the fight against climate change receives recognition and is implemented in all departments of the government, and form a cooperation and consensus forming mechanism to consolidate the responsibilities of all parties. Guide government departments, local authorities, and enterprises to implement the carbon peaking and carbon neutrality.

7.2. Achieve both economic recovery and low-carbon development by actively carrying out deep decarbonization efforts in key industries

First, promote the in-depth development of the manufacturing industry towards decarbonization, strictly control new production capacity of the pollution-intensive and energy-intensive industries. Expand strategic emerging green industries such as energy efficiency, environmental protection, clean production, and clean energy.

Second, build a joint government-university-enterprise research and development platform to develop raw material, fossil fuel substitution and process innovation technologies. Promote the zero-carbon retrofit and innovation in high-carbon industries such as steel, non-ferrous metal, cement, chemical industry, and petrochemical industry, and actively explore technologies for carbon dioxide capture and utilization.

Third, accelerate the promotion of the integration of digital economy with the traditional economy sectors and enhance the application of big data and artificial intelligence technologies in improving energy efficiency and decarbonization.

Fourth, increase investment in low-carbon infrastructure, restrict new investments in traditional especially carbon-intensive infrastructures, and prioritize low-carbon infrastructure and the ones enabling a high share of renewables in the scope of the “New Infrastructure” as well as the 14th Five-Year-Plan.

Fifth, accelerate the restructuration of transport by developing green shipping and railways, upgrade urban cluster development driven by high-speed rail and transit networks, and set clear milestones for full electrification of vehicles and the phase-out of internal combustion engine vehicle.

Sixth, demonstrate and promote zero-carbon building technologies such as photovoltaic-energy storage-direct current-flexibility (PEDF) through leveraging low-income housing and old city renovation projects as catalyst and exploiting the structural opportunity of the development of metropolitan areas.

Seventh, protect and enhance the carbon storage capacity of forests, grasslands, wetlands, and agricultural land, and proactively implement nature-based solutions to simultaneously address climate change, sustainable development, biodiversity, disaster, poverty and unleash synergetic benefits across multiple fields and local communities.

7.3. Build a new power generation paradigm with low-carbon energy at its core, accelerate coal control and the large-scale deployment of renewable energy

First, boost the exploration of a new energy paradigm (especially new power system) centered on renewable energies and accelerate the establishment of relevant supporting policies, promoting utility-scale and distributed renewable energy according to local

conditions, and avoid risks of curtailments under the new wind and solar capacity targets. Accelerate pilots and promotions of and an energy system integrated between energy sources, grid infrastructure, load adequacy, and energy storage, that is based on renewables energies in accordance with local conditions. Systematically resolve problems of the “integration of wind power, solar power, hydro power, and energy storage” pilots, such as power imbalance, power insecurity, lack of the coordinated development of regional power grid and price transmission mechanism. Explore the cost sharing mode of energy storage, and strengthen the demand side response mechanism to provide economic incentives for adjusting peak and valley electricity consumption. Formulate a comprehensive national development masterplan for large-scale clean energy base to strengthen the development of utility-scale wind and solar energy power and the establishment of large-scale base, propel the deployment of the distributed wind and solar power in central-eastern and southern areas; and promote the construction of off-shore wind power along the eastern areas. Formulate policies to further reduce the financing costs of renewable energy enterprises, especially in terms of land allocation, IPO queuing in advance, targeted loans and reserve ratio reduction, to support the grid parity of wind and solar power.

Second, speedily implement President Xi Jinping proposal to strictly control coal power projects and the growth of coal consumption during the "14th Five-Year Plan" period, and gradually decrease coal consumption during the "15th Five-Year Plan" period. Formulate a policy framework and roadmap to orderly phase-out coal, and strive to reduce the proportion of coal in primary energy consumption to below 50%. During the “14th Five-Year Plan”, strictly control newly added thermal coal-fired power generation, phase-out scattered coal consumption and accelerate the reduction of industrial coal use. Control the development scale of carbon-intensive industries such as coal-based chemical industry. Develop fiscal and monetary policies and mechanisms conducive to phasing-out coal and avoiding stranded assets brought about by coal related projects.

Third, promote the economic and social transition of coal-dependent cities. Accelerate the development of a diversified economy, foster non-coal industries suited to local advantages, put forward solutions to social problems such as resettling compensations and employment transformation, carry out training and capacity building in the fields of emerging sectors, and set up special subsidies and funds to support local governments’ coal economy transition.

Fourth, speed up electrification by promoting the deployment of electric furnace steel, building materials electric kiln and electric vehicles; applying heat pump, electric cold storage air-conditioning, thermoelectric boiler storage in culture and sports facilities, shopping malls, office buildings, hotels, airport terminal buildings; and continuously improving the proportion of electricity consumption in sectors including manufacturing, transportation, and household livelihood.

7.4. Accelerate the development of carbon pricing, carbon market and carbon finance mechanisms and promote green finance

First, accelerate the research and implementation of the establishment of carbon asset rights and provide supporting policies, strengthen the disclosure of climate information in financial actors.

Second, steadily accelerate the construction of the national carbon emission trading scheme and set a clear absolute cap for the carbon market. Gradually increase the proportion of allowances allocated by auctions, and prioritize the introduction of renewables in the current national ETS (currently power generation only). Gradually incorporate other large emitting industries such as steel, electrolytic aluminum, cement, chemicals and petrochemicals.

Third, develop a hybrid carbon pricing system based on the principle of controlling transaction costs. Emission intensive companies will be included in the carbon trading system, while those with low emission intensity will be included in the carbon tax system.

Fourth, develop carbon finance to allow carbon assets can be used as a pledge and to develop carbon futures. Establish the connection between carbon market and finance market and ensure carbon market has enough capital inflows. Finance the purchase of emission quotas to keep carbon price at a certain level and form the expectation that the carbon price will rise, so that low carbon transition could be further stimulated and investment and technological innovation is promoted.

Fifth, promote green finance by bridging with the international standards on green finance and taxonomy, incorporating environmental and climate consideration into financial risk assessment. Promote mandatory disclosure of climate-related information by financial institutions, advancing the coordination and synergy of policies for green finance, industry and climate.

Sixth, promote the achievements of negotiations on the Paris Agreement rulebook on market mechanisms, preventing carbon leakage and promoting fair trade.

7.5. Strengthen international exchanges and extensively participate and lead the global climate governance and implement the Paris Agreement

First, overcome the barriers to personnel exchanges and information exchanges caused by the pandemic and the complex international environment. Through various online and offline methods, various platforms including the CCICED can be used to promote and strengthen the international exchanges between Chinese and other countries' government departments, and with non-state actors, keeping information flow unimpeded. At the same time, the government should actively ease conditions for

international exchanges.

Second, actively carry out climate dialogues and exchanges at the expert level, and create opportunities to carry out dialogues on Track 1.5 and even Track 1. Through information exchanges, dissolve doubts, enhance mutual trust and understanding, and jointly promote multilateral processes. Enhance Sino-American and Sino-European, and China-developing countries mutual political trust. Timely manage differences, strengthen cooperation, and eliminate the negative impact of political difficulties and disturbances in non-climate issues on the global fight against climate change.

Third, facilitate main bilateral and multilateral climate dialogues based on the governance structure of the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. Use the Climate summits, the Major Economies Forum (MEF), the Ministerial on Climate Action (MoCA), the G20, the CBD15 and the COP26 to discuss climate cooperation mechanisms, green finance and carbon finance policies, fiscal policies for the low-carbon economic recovery from the pandemic, and low-carbon infrastructure investment cooperation.

Fourth, restrict and gradually stop public finance for overseas coal power investments. Clarify policies as soon as possible to guide policy banks and state-owned commercial banks to stop coal power investments in the “Belt and Road” region and build the green “Belt and Road Initiative” (BRI). Supports BRI countries to construct low-carbon energy infrastructures, deploy renewables and build up sustainable business model of green energy via developing better policies of green finance, strengthening technological collaboration, developing third-party cooperation.

Fifth, optimize China’s portfolio of foreign trade and investment, facilitate the integration of regional supply chain of low-carbon manufactures, and accelerate China’s green recovery and the development of low-carbon industry, by using every advantage of some regional mechanism such as the competitive position in low carbon manufacture chain that the “Regional Comprehensive Economic Partnership Agreement” (RCEP) countries have.

Acknowledgement

We are very grateful to the China Council for International Cooperation on Environment and Development (CCICED) for establishing and supporting the Special Policy Study on "Global Climate Governance and China's Contribution", providing a platform for Chinese and international experts to discuss and exchange together. Our special thanks go to Mr. Xie Zhenhua, CCICED Vice Chairman, for providing instructive guidance to our research. We are grateful to Prof. Liu Shijin, Chinese Chief Advisor of CCICED, Dr. Scott Vaughan, International Chief Advisor of CCICED, Dr. Arthur Hanson, CCICED's former international Chief Advisor, Dr. Knut Alfsen, Member of CCICED Chief Advisor's Group, Mr. Guo Jing, Director General of the Department of International Cooperation of the MEE, Mr. Li Gao, Director General of the Department of Climate Change of the MEE, and Mr. Li Yonghong, Assistant Secretary General of CCICED and Deputy Director of the Foreign Environmental Cooperation Center of the MEE for their detailed suggestions and advice during this research. We would like to thank Mr. Zhang Huiyong, Director of CCICED Secretariat, Ms. Liu Kan, Deputy Director of the CCICED Secretariat, Ms. Yao Ying and all colleagues from the CCICED Secretariat and the International Support Office (SISO) of the CCICED for providing support and coordination for our SPS.

References

- Antonio Guterres.2020.Secretary-General's remarks at the Climate Ambition Summit.<https://www.un.org/sg/en/content/sg/statement/2020-12-12/secretary-generals-remarks-the-climate-ambition-summit-bilingual-delivered-scroll-down-for-all-english-version>[2020-12-14].
- Bitkom.2020.Climate protection through digital technologies.
https://www.bitkom.org/sites/default/files/2020-05/2020-05_bitkom_klimastudie_digitalisierung.pdf[2020-12-15].
- Falk J , Gaffney O , Bhowmik A K , et al.2020.Exponential Roadmap.
https://exponentialroadmap.org/wp-content/uploads/2020/03/ExponentialRoadmap_1.5.1_216x279_08_AW_Download_Singles_Small.pdf[2020-12-10].
- IEA.2019.CO2 Emissions from Fuel Combustion.
https://iea.blob.core.windows.net/assets/eb3b2e8d-28e0-47fd-a8ba-160f7ed42bc3/CO2_Emissions_from_Fuel_Combustion_2019_Highlights.pdf[2020-12-31].
- ILO. 2018.World Employment Social Outlook 2018: Greening with jobs.
https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_734455.pdf[2020-10-18].
- Department Economic and Social Affairs, United Nations.World Economic Situation and Prospects 2021.
<https://www.un.org/development/desa/dpad/publication/world-economic-situation-and-prospects-2021/>
- IPCC.2018.Global warming of 1.5°C.
https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf[2020-12-10].
- Jiang Z J, Lyu P J, Ye L, et al.2020.Green innovation transformation, economic sustainability and energy consumption during China's new normal stage.Journal of Cleaner Production, 273, 123044.

Pan X Z, Chen W Y, Zhou S, et al.2020.Implications of near-term mitigation on China's long-term energy transitions for aligning with the Paris goals.Energy Economics, 90, 104865.

Partnership for Market Readiness , International Carbon Action Partnership.2016.Emissions trading in practice: a handbook on design and implementation. Washington DC: World Bank.

Tang L, Qu J B, Mi Z F, et al.2019.Substantial emission reductions from Chinese power plants after the introduction of ultra-low emissions standards.Nature Energy, 4:929-938.

Teng F, Su X, Wang X. 2019.Can China peak its non-CO₂ GHG emissions before 2030 by implementing its nationally determined contribution? Environmental Science & Technology, 53, (21) : 12168-12176.

The World Bank.2020.Global economic prospects.
<https://www.worldbank.org/en/publication/global-economic-prospects>[2020-12-31].

UNFCCC.2015.The Paris Agreement.
https://unfccc.int/sites/default/files/chinese_paris_agreement.pdf[2020-11-12].

UNEP.2015.The Emissions gap report 2015.
https://uneplive.unep.org/media/docs/theme/13/EGR_2015_301115_lores.pdf[2020-10-31].

UNEP.2019.Emissions gap report 2019.
<https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf>[2020-10-31].

Von der Goltz J, Dar A, Fishman R, et al.2020.Health impacts of the Green Revolution: evidence from 600, 000 births across the Developing World.Journal of Health Economics, 74, 102373.

Zhu J M, Fan Y C, Deng X H, et al.2019.Low-carbon innovation induced by emissions trading in China. Nature Communications, 10:4088.

Zhu Y F, Wang Z L, Yang J, et al.2019.Does renewable energy technological innovation control China's air pollution?A spatial analysis.Journal of Cleaner Production, 250, 119515.

柴麒敏, 傅莎, 温新元, 等.2019.中国实施2030年应对气候变化国家自主贡献的资金需求研究.中国人口·资源与环境, 29 (4) : 1-9.

顾阿伦, 何建坤, 周玲玲.2020.经济新常态下外贸发展对我国碳排放的影响.中国环境科学, 40 (5) : 2295-2303.

国家应对气候变化战略研究和国际合作中心.2019.传播干预公众低碳消费项目 成 果 报 告 .<https://www.efchina.org/Attachments/Report/report-comms-20190804/%E4%B8%AD%E5%9B%BD2030%E5%92%8C2050%E5%B9%B4%E4%BC%A0%E6%92%AD%E5%B9%B2%E9%A2%84%E4%BD%8E%E7%A2%B3%E6%B6%88%E8%B4%B9%E9%A2%86%E5%9F%9F%E8%AF%86%E5%88%A B%E6%8A%A5%E5%91%8A.pdf>[2019-08-04].

何建坤. 2018. 新时代应对气候变化和低碳发展长期战略的新思考. 武汉大学学报(哲学社会科学版), 71 (4) : 13-21.

黄晶. 2020. 中国 2060 年实现碳中和目标亟需强化科技支撑. 可持续发展经济导刊, (10) : 15-16.

李碧浩, 陈波, 黄蓓佳, 等. 2017. 基于 CFDAM 模型的中国气候资金需求分析. 复旦学报(自然科学版), 56 (5) : 557-563.

李慧明. 2018. 构建人类命运共同体背景下的全球气候治理新形势及中国战略选择. 国际关系研究, (4) : 3~20

吕洁华, 张泽野. 2020. 中国省域碳排放核算准则与实证检验. 统计与决策, 36 (3) : 46-51.

牛站奎. 2019. 全球气候治理体系的复合多层次分析. 中共中央党校硕士学位论文

解振华. 2020. 2060 年前实现碳中和任务艰巨, 但势在必行. <http://www.chinareports.org.cn/rdgc/2020/1013/17799.html> [2020-10-15].

王文举, 向其凤. 2014. 中国产业结构调整及其节能减排潜力评估. 中国工业经济, (1) : 44-56.

于天飞. 2007. 碳排放权交易的产权分析. 东北农业大学学报(社会科学版), 5 (2) : 101-103.

中国科学院科技战略咨询研究院绿色复苏课题组. 2020. 实现经济的绿色复苏-中欧合作研究报告

中国科学院可持续发展战略研究组. 2021. 2020 中国可持续发展报告——探索迈向碳中和之路. 北京: 科学出版社