中国环境与发展国际合作委员会
China Council for International Cooperation on Environment and Development

Green Innovation

CCICED Issues Paper 2023

Preface

Established in 1992, the China Council for International Cooperation on Environment and Development (CCICED) is a high-level international advisory body to the Government of China. Along with China's rapid social and economic progress, CCICED has witnessed and taken part in the country's historic shift in development philosophy and model. It opens the door to advanced international experience in sustainable development and connects China with the international community focused on environment and development. CCICED also provides a valuable platform of exchange, enabling the international community to understand China and support the country's engagement with the world.

Since 2002, the International and Chinese Chief Advisors have produced an Issues Paper each year for the use of CCICED Council Members, high-level policy-makers, and others during the Annual General Meeting, where research findings and recommendations are discussed.

Green Innovation is the 22nd Issues Paper published by the CCICED. Against a backdrop of the much-needed recovery of the global economy, the paper provides thoughts on how to empower green innovation and promote high-quality development from a market and synergy perspective. The preparation of the Paper is led by CCICED Chief Advisors, Mr. Scott Vaughan, and Mr. Liu Shijin, with contributions from International Chief Advisor Support Group and the Chinese Associates.[1]

[1] The ICA supporting group mainly includes Mr. Knut Alfsen and Mr. Dimitri de Boer. The Chinese supporting team mainly includes Mr. Zhang Huiyong and Ms. Mu Quan.

I Context

The world economic outlook continues to be volatile, facing inflation and geoeconomic fragmentation that is affecting rates of economic growth, unemployment, trade, and foreign direct investment. The World Bank's June 2023 *Global Economic Prospects* report warns of precarious economic prospects ahead, especially for many emerging and developing countries, while World Trade Organization (WTO) trade statistics reveal the increased use of export restrictions, as well as a decline in intermediate merchandise trade in 2022.

Following pandemic restrictions, uncertainties in the property sector, weak export demand, and other factors, China faces slower-than-expected rates of economic recovery.

Compounding economic challenges are the mounting costs of extreme weather events linked to climate change. 2023 marked the highest world average temperature ever recorded. China has experienced record heat waves and severe flooding in several regions. Wildfires across Canada blanketed large regions of North America, exposing millions to chronic air pollution and causing billions in economic losses. The *State of the Global Climate 2022* assessment by the World Meteorological Organization (WMO) expects extreme events to worsen in the coming 5 years due to a combination of heat-trapping greenhouse gases (GHGs) and El Niño, affecting the food security of millions.

Multilateral Environmental Commitments: Despite an overall increase in geopolitical fragmentation, there have been several important international breakthroughs. The successful completion of the Kunming-Montreal Global Biodiversity Framework (GBF) at the United Nations Convention on Biological Diversity (UN CBD) Conference of the Parties (COP 15) in December 2022 exceeded most expectations as countries pledged to halt and reverse biodiversity loss, meet "30x30" target for nature, and mobilize new and additional financial resources. An important step in GBF implementation is the June 2023 agreement to establish, via the Global Environment Facility (GEF), a new GBF trust fund. Other important steps include the new UN oceans treaty adopted in June 2023 and ongoing negotiations toward a global plastics treaty.

A Carbon Control System: In July 2023, President Xi Jinping called for the transition from the current energy control system to a carbon control system. The elements to enable a comprehensive transition toward a carbon control system include incentives, carbon markets, and green finance to accelerate both supply-led low-carbon technologies and demand-side efficiency measures, working in tandem with regulations and standards to limit carbon pollution. Several jurisdictions have adopted a national climate law to support regulatory coherence and raise the profile of both compliance promotion and effective enforcement. A carbon control regime can also be supported through national and sub-federal carbon budgets, as well as real-time GHG emissions reporting to measure current conditions and scenarios for carbon peaking and carbon neutrality.

From Trade-Offs to Take Off: The expansion of China's installed renewable energy has outpaced planned targets. Estimates suggest that 2023 will see China exceeding 150 gigawatts of new solar power and wind power. This faster-than-expected growth in renewable energy is further evidence that trade-offs between either energy security or low-carbon energy and developments are obsolete.[2]

A new paradigm of high-quality green development is underway, creating millions of new jobs and expanding highly competitive markets. International Renewable Energy Agency (IRENA) reports that USD 500 billion was invested in 2022 in photovoltaics and onshore and offshore wind turbines, while sales of electric vehicles (EVs) continue to grow. A recent trade-climate scenario report by the World Economic Forum (WEF) envisions that 15% of global merchandise trade could be made up of low-carbon goods by 2030.

Green Innovation: At the heart of high-quality green development is innovation. There is no single innovation blueprint. No two innovations are identical. Yet an increasingly vital part of green innovation involves synergies between low-carbon green technologies and digitization. A recent review of China's climate policies, led by Professor Nicholas Stern and Professor Min Zhu of the London School of Economics and Political Science, underscores the need for a comprehensive innovation system to implement the dual control targets. Chinese Chief Advisor of CCICED Shijin Liu recently pointed to the dynamic links between low-carbon technologies, digitization, and market-based innovation at the 2023 China Development Forum.

Digitization and climate are connected on numerous levels. As significant energy users, data hubs run by leading companies like Tencent and Microsoft are implementing ambitious net-zero and negative carbon targets, including through the use of green power (including through large-scale green power purchase agreements where they are available). They are investing in new solar and wind-generating capacity, upgrading energy efficiency, and using Direct Air Capture (DAC) technologies. Data hubs and digital infrastructure are also increasing their resilience to climate-extreme weather events like flooding.

However, the most important synergies are those in which digitization is being put to work to identify least-cost decarbonization pathways across many areas and sectors, from emerging smart, low-carbon,

[2] China is the main driver behind this renewable energy breakthrough. In 2022, according to the China Electricity Council (CEC), solar energy increased by 28.1% to 392.6 GW, and wind power increased by 11.2% to 365.4 GW. With plans to install 160 GW of additional capacity in 2023, solar and wind power are poised to more than double the total production capacity of China's total hydropower generation (currently at 413.5 GW). Bloomberg recently estimated that based on current trends, China's rates of new renewable energy could exceed 200 GW in 2024.

and resilient cities to hard-to-abate industrial sectors. Coalitions like C40 Smart Cities are sharing case studies in low-carbon pathways while digital technologies and industrial Internet platforms work within emerging digital twin approaches to identify low-carbon engineering solutions in hard-to-abate steel and other heavy industrial manufacturing processes. Other examples of linking digitization, decarbonization, and sustainability outcomes include finding new ways to inform online consumers of sustainable fashion options; the use of digital blocks to improve sustainable sourcing through better traceability systems for soft commodity value chains like palm oil and soy; and widening applications of digitization to provide granular and real-time environmental and climate monitoring.

II Unleashing Innovation Through Markets

The private sector is the most effective in moving inventions made in the lab to new products available at scale in the market. Governments have a crucial role to play in fostering both inventions and innovations, as well as being first movers through procurement. A new wave of green industrial policies that include large-scale subsidies for green technologies, like large-scale battery storage systems for electricity grids, are lowering the cost of decarbonization pathways for companies and consumers lucky enough to receive subsidies.

As part of green development innovation, carbon markets are a vital instrument. The World Bank identifies carbon markets in over 70 jurisdictions, including China's national carbon market. Analysis by the Organisation for Economic Co-operation and Development (OECD) concludes that carbon prices-the central feature of carbon markets-are especially effective in decarbonizing power markets, with coal being the most responsive to cross-price supply elasticities linked to carbon pricing.

An important aspect of energy policy and climate policy coordination is finding synergies between the anticipated pricing effects of carbon markets with wider power market reforms. China is currently reforming its national power market, to build a coherent national market that will improve the ability of power companies to interconnect between jurisdictions and integration of renewable energy. Led by the National Development and Reform Commission (NDRC), the first iteration of the reforms will be completed in 2025.

China's national Emissions Trading System (ETS) has the potential to become a key catalyst in accelerating market dynamics and allocative resource efficiencies to encourage innovation in meeting China's dual control goals.

However, to unleash the full market potential of the ETS system, four design adjustments warrant consideration within the wider context of ongoing power market reforms. First, increase the scope of the ETS beyond the current power sector to include other sectors like steel, cement, aluminum, chemicals, and others by which different marginal abatement costs across sectors would increase the efficient allocation of resources. A second step is to move from an intensity-based system to an absolute emissions cap, which would send a clear signal about the supply scarcity of carbon credits.

A particularly effective market-based instrument applied to large, stationary, energy-intensive, and trade-exposed sectors like steel, cement, aluminum, and other sectors is an Output-Based Pricing System (OBPS) or performance-based system, which links sector-based emission factor averages to a graduating carbon price. While there are varying carbon prices across different markets, the International Monetary Fund (IMF) suggested a carbon price of USD 75/tonne by 2030, which is a useful benchmark for the price trajectory of China's ETS over time.

A final feature is clarifying the ETS's roles and responsibilities, including the supporting roles of a quality GHG data system, compliance promotion through training and education, and enforcement.

A Comprehensive System Approach: As noted, China leads the world in renewable energy. It will likely install more solar and wind power in 2023 alone than the entire renewable energy capacity of either the European Union (EU) or the United States (U.S.). Estimates suggest as much as 200 GW of renewable power could be installed in 2024. At the same time, there has been an increase in new fossil fuel-based electricity generation capacity since 2021. While numerous older and inefficient coal plants have been retired, the net effect of recent approvals is an estimated 10% rise in China's coal generation, equivalent to 100 new plants.

In light of the faster-than-planned expansion of renewable energy, coupled with the forthcoming power market reforms, a review of the need to proceed with recently-approved coal-fired electricity generation is warranted since newly installed renewables are on track to supplement the declining output from hydropower.

Flexible Electricity Grid Innovation: A key innovation challenge is to ensure that all segments of the power generation system have innovative features designed to work together to create a modern, holistic, and green power system. This emphasis on an integrated system is a conclusion of both CCICED's 2023 research and the International Energy Agency (IEA) China 2022 report, which recommends the adoption of a flexible power system.

There are numerous examples linking renewable energy with more flexible demand-side models. Innovation in renewable energy production is being matched by innovation in energy delivery and pricing models such as pay-as-you-go, plug-and-play, and others. China's Whole-County Rooftop Solar program enables flexible ownership and leasing arrangements to scale up rooftop solar panels in residential and commercial buildings. The analysis identifies two major flexibility clusters: (i) panels are sold to the property owner, who in turn can sell surplus power back to the project developer, or (ii) the developer retains ownership of the solar panels, providing the property owner electricity at a discount in return. To date, the program is being implemented in over 600 counties across the country.

The key link between clean renewable power production and flexible demand-side consumption is the transmission grid system. China continues to make significant new investments in Ultra-High Voltage (UHV) transmission lines, investing a reported RMB 150 billion (USD 22 billion) in the second half of 2022. New models of electricity grids are quickly emerging that include smart grids, battery-storage

banks, distributed power generation, embedded sensors, digital and AI capabilities, applied research in flexible alternating-current transmission systems (FACTS), and other features. Taken together, more innovative transmission systems have been characterized as on the cusp of a wholescale shift in grid technology "from electro-mechanical to electronic and from rigid physics to programmability electricity grid models".

There are a growing number of new-generation electricity grid models. The California Energy Commission plans to install 49,000 MW of battery storage capacity by 2045 as a vital component in supporting carbon neutrality goals.[3] In Germany, due in part to permitting backlogs, rather than replacing older transmission lines, investments are underway to upgrade older lines with sensor and digital capacities to allow continuous monitoring that is improving efficiency by up to one-third during colder temperatures.

For good reason, most electricity grid operators are state monopolies: infrastructure and operating costs are high, public planning often requires complex public reviews and approval, and reliability needs to be matched with accessibility and affordability to all communities. However, China could consider opening gird operations to more competitive, market-type dynamics. Examples include provincial-level grid entities operating in Canada (Ontario and Alberta), the U.K. Office of Gas and Electricity Markets (Ofgem), and the designation in Texas of Competitive Renewable Energy Zones (CREZ).[4]

One step in opening grids to market dynamics is for China to introduce more options for households and businesses to purchase green power. Examples include California's Renewable Auctions Mechanism and the United Kingdom's auction system to accelerate investments in renewable energy under its Contracts for Difference scheme. As more companies adopt net-zero targets, large green power purchase agreements led by Amazon, Microsoft, Google, and Walmart exceeded 36 GW in 2022.

Regulations and Compliance Markets Working in Synergy: While carbon markets are an essential tool for achieving carbon peaking and carbon neutrality, they work best in the context of regulations and mandatory standards. Decades of experience in mandatory energy-efficiency standards for household, office, and business appliances has fostered a thriving market for innovative products, such as air conditioners, lighting, refrigeration, and heating systems that employ millions and are a vital

[3]Researchers from the National Renewable Energy Laboratory have shown that for meeting an electricity storage duration of 120 hours, the least-cost approach combines hydrogen systems with geologic storage and natural gas with carbon capture.

[4]An important obstacle for energy state-owned enterprises (SOEs) is accessing sufficient private capital to modernize their grids and other operations, a topic examined in a helpful analysis of Association of Southeast Asian Nations energy SOEs.

part of the world's trading system and billions of households. In saving energy, these standards are also a major cause of avoided GHG emissions: the IEA estimates that mandatory standards have led to annual energy savings equivalent to 15% of total energy use in many jurisdictions while avoiding 700 million tonnes of GHG emissions per year in China, the EU, and the U.S.

Carbon Compliance Markets and Carbon Sequestration: As noted, there are a growing number of jurisdictions with compliance carbon markets, including China's ETS; the EU's ETS; Canada's graduation federal carbon price; and sub-federal systems, such as those in California, Quebec, and the northeastern U.S. states (through the Regional Greenhouse Gas Initiative (RGGI)).

Governments and companies are paying closer attention to the role of carbon offset markets to help meet their decarbonization pathways. For example, China allows companies to offset a maximum of 5% through offsetting. Unlike the current state of voluntary carbon markets, which continue to face significant credibility problems, credits derived from compliance markets are the preferred option.

As domestic carbon markets expand, more work is needed to ensure governance systems are in place across different jurisdictional levels, whereby credits are only issued once they adhere to robust and transparent carbon sequestration methodology based on Intergovernmental Panel on Climate Change (IPCC); use models, inventories, and field testing appropriate for different ecosystems, such as forests[5]; have clear roles and responsibilities for credit approvals; and apply robust and transparent accounting standards.

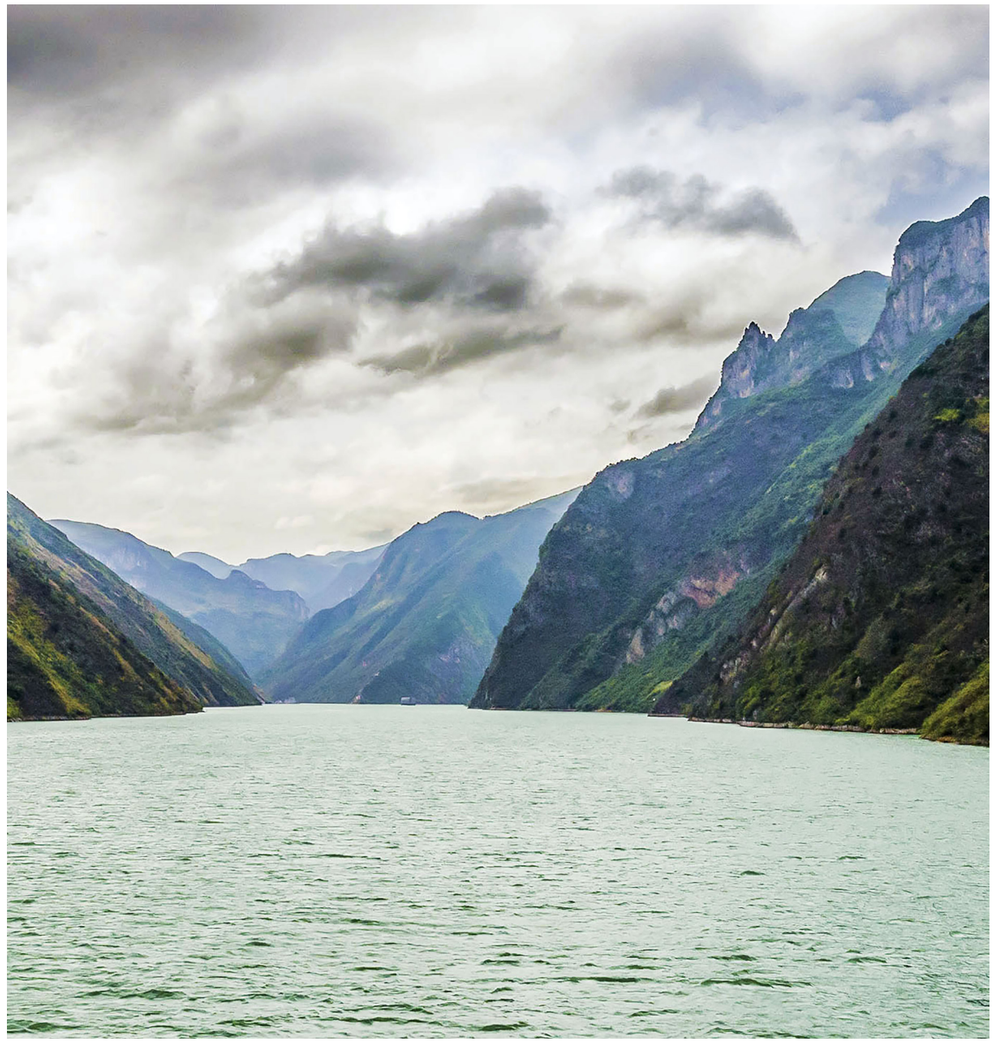
Special attention is warranted for emerging carbon capture and storage technologies. The current contribution of roughly 60 Carbon Capture, Utilization, and Storage (CCUS) projects to total carbon sequestration is roughly 0.5% compared to the 99.5% that natural carbon sequestration solutions like oceans, forests, peatlands, and other ecosystems provide. However, following the IPCC's report noting

[5] Progress has been made in forest inventories at differing scales, which are integrating both satellite-based data with tailored models. One example of national system is the China Forest Resource Inventories (CNFRI), conducted every 5 years. This data has been combined with other inventories, such as the China Forest Ecosystem Inventory System (CFEIS), as well as with model algorithms (linear regression, random forest, and extreme gradient boosting) to estimate the biomass of the subtropical forests in Hunan Province, China. In 2015–2016, Guizhou Province conducted its fourth forestry inventory through the Forest Resource Planning and Design Survey. Data from the survey breaks out over 100 tree stand attributes and site conditions. During the survey, some 3 million stands were recorded, including land-use type, forest land type, plant type, dominant tree species, average age, age class/group, stand volume per hectare, stand area, origin, soil type, community structure, disaster class, health class, and other data points.

Other examples include U.S. Agriculture and Forestry GHG Inventory 1990–2018: estimates of carbon density and carbon pools are presented as carbon dioxide equivalent per hectare.

the potential role of CCUS, many companies, especially in carbon-intensive sectors, are increasing CCUS investments.

No question that calculating rates of carbon sequestration in a given landscape or seascape is more complex than monitoring GHG emissions from stationary or other sources. Recent mandatory climate risk disclosure and reporting standards, like the EU's Sustainable Finance Disclosure Regulation (SFDR), the U.S. Securities and Exchange Commission's draft Climate Disclosure Rules (its final version is once again delayed), and the International Financial Reporting Standards (IFRS) Foundation's International Sustainability Standards Board (ISSB)'s climate disclosure rules contain frameworks for the disclosure of carbon offsets by companies. It will be important that China's evolving disclosure rules, based on Task Force on Climate-Related Financial Disclosure (TCFD), are comparable and interoperable with those of the international community.



III Coordination

Green innovation presents enormous opportunities to accelerate the implementation of China's dual carbon goals. At the same time, innovation presents challenges around policy coordination on at least four levels, noted briefly below.

Development First: An important outcome of China's 2023 Two Sessions was the importance of coordinating the development, social prosperity, economic security, carbon peaking, and carbon neutrality goals.

A central focus of climate mitigation policies across multiple jurisdictions is ensuring jobs and labor markets adjust in ways that ensure stability at the household and community levels. Ongoing programs around just transition in Canada, the EU, France, and elsewhere entail ensuring that the jobs and regions in sunsetting and carbon-intensive industries are supported through public policies to deliver new jobs in sunrise green sectors. Since these shifts are comparable to structural changes associated with trade competition, lessons from trade policy can be useful in the green transition.

So too is a growing body of research that suggests a net gain in employment because of the green transition. The WTO and IEA estimate that over 2 million Chinese jobs are related to green power, while researchers at Oxford point to higher employment, better financial returns, and wider social benefits from the green transition compared to high-carbon and polluting industries.

An emerging tool to contribute to development, sustainability, nature, and climate progress is through the innovative use of enhanced international green credit arrangements. Among the outcomes of the June 2023 New Global Financing Pact, which included Premier Li Qiang, is the creation of a new task force to examine options for the use of new debt instruments like debt-for-climate swaps, a tool the IMF has noted has the potential to help emerging and developing economies in meeting their Paris Nationally Determined Contribution goals as well as addressing rising debt distress levels.

Co-Control: A second feature of coordination involves what the 2022 20th National Congress emphasized as "reducing carbon emissions, managing pollution, restoring ecology and promoting growth" in a coordinated manner. The CCICED 2023 Special Policy Study (SPS) on Collaborative Mechanism for Carbon Reduction, Pollution Reduction, Green Expansion and Growth demonstrates the multiple co-benefits of tackling GHGs emissions and criteria air pollutants simultaneously, including substantial public health benefits from reduced long-term exposure to $PM_{2.5}$, smog, and other pollutants.

Climate Action Coordination: A third feature of coordination involves aligning the growing number of policy tools that together make up carbon neutrality goals. The characteristics of nearly all net-zero policy frameworks are remarkably similar and comprise sector-based and wider targets within which carbon markets, green subsidies, research and development (R&D) investments, regulations and mandatory standards, green finance, and operational measures like green procurement and greening government operations are enacted. To illustrate the scope of climate actions, the U.K. climate framework is supported by over 360 indicators to track progress, too many to provide a clear overview of progress. Other jurisdictions like the EU, France, Sweden, Canada, and New Zealand are implementing several dozen decarbonization measures.

The World Resources Institute (WRI) has recently identified good country practices in carbon neutrality, which include crucial coordination governance mechanisms. The U.K. Climate Policy Dashboard is intended to unclutter hundreds of data points to inform decision-makers and the public of key GHG trends. France has adopted measures to screen all budgetary measures through a climate lens.

Such coordination approaches are also important in ensuring gender issues are highlighted and mainstreamed in the design of low-carbon measures, especially within the context of support for shifting labor markets and the need for social safety net policies to help displaced workers and communities. Gender issues remain a strategic priority for CCICED, and a report on gender mainstreaming based on the current 2022-2023 CCICED SPS is forthcoming.

Private–Public Partnerships in Innovation: A final coordination challenge involves effective partnerships between the private sector and government. Yet reviews of innovation policies identify common bottlenecks, from different levels of risk acceptance to complex interactions across innovation chains from start-up manufacturing, finance, consumer markets, and global supply chains. Governments can help clear innovation pathways by uncluttering minor impediments to innovation that together create barriers. Examples include obtaining multi-year R&D funding; adjusting sales tax to incentivize R&D; improving R&D grants within and across funding agencies; reducing first-mover risks, as well as some operational costs like installation; patent applications; labor skill gaps; and community distrust of new technologies.

Conclusion: Green Innovation is a key catalyst for achieving the dual control goals, as well as concurrently tackling pollution and ecosystem stewardship. As climate action engages economywide in all key sectors and regions, linking a green innovation national system with policy coordination will be key.