

Establishing a Carbon-Neutrality Oriented Economic System through Green, Low-carbon, and Circular Developmentⁱ

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Abstract: Carbon neutrality requires a profound socio-economic revolution. Since the 21st century, China has been promoting social & economic transformation, and put forward a series of strategic directions for development transformation. As China enters the new era of socialism, building a green, low-carbon and circular economic system has become an important direction for future economic development and transformation. This paper analyzes the relationship between the green, low-carbon and circular economic system and carbon neutrality, and points out that green development, low-carbon development and circular development will greatly reduce carbon emissions of economic development and help realize the carbon goal through co-benefit effect, structural adjustment and resource recycling. Finally, the paper puts forward some suggestions for promoting the transformation of the economic system to green, low-carbon and circular development.

Key Words: Carbon Neutrality; Green development; Low carbon development; Circular development; Economic transition

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I. The Strategic Orientation of the Economic Transformation of China Since the 21st Century

1.1 Development transformation and sustainable development

Since the industrial revolution, the productivity of human society has been greatly improved. However, it has also brought about a series of problems such as indirect economic or financial crisis, the widening gap between the rich and the poor in society, destruction of the ecological environment, and climate change. Although the solution given by some studies is to “stop growth”, such as the “zero growth strategy” proposed in the book *The Limits of Growth* of the Club of Rome, or “A Steady-State Economy” proposed by Herman E. Daly (Daly, 1973) and “The Economics of the Coming Spaceship Earth” raised by American scholar Kenneth Boulding (Boulding, 1966), the problems arising from development still need to be resolved in development at the practical level. The key lies in the innovation of ideas and the transformation of the economic development model.

According to the definition of economics, the model of economic development is “the model of distribution, input, combination and use of production factors”. The traditional economic growth model is usually extensive or factor input-driven, which refers to the economic growth based on the quantitative expansion of production factors. The key features of such growth are high input, high consumption, high emissions, low product quality, and low economic benefits; Similar concepts also include the black development method (Hu Angang, 2004), the linear model of “resources-products-waste”, and the extended growth. The traditional economic growth model usually applies to countries with low levels of industrialization to gain a price advantage at low factor costs. However, this is usually accompanied by huge consumption of resources and energy, a sharp increase in pollutants and greenhouse gas emissions, damage to ecological space, and a lower position in the value chain. Therefore, it is not conducive to the sustainable development of the social economy to go beyond the “middle-income trap”.

When it comes to the transformation direction of the economic development model, different

development and transformation directions are chosen based on different dimensions. If the focus is placed on the economy, it is proposed to transit from extensive economic growth to intensive economic growth or from extended economic growth to internally-driven growth. It emphasizes that growth will be achieved through optimizing production factors, improving the quality and efficiency of production factors, technological advancement, improving the quality of workers, and increasing the utilization rate of funds, equipment, and raw materials. If the focus is placed on society, transformation towards inclusive growth and shared development is expected. The former was proposed by the Asian Development Bank in 2007, emphasizing that economic growth should not only benefit a few people or a minority group of people, and the results of reform should not be enjoyed by only a few people, but to make economic development benefits accessible to more ordinary people so that their lives could be substantially improved; the latter is proposed by the *Proposals of the Central Committee of the Communist Party of China on Formulating the 13th Five-Year Plan for National Economic and Social Development*. If the focus is placed on resource and environmental protection, the keywords of transformation are “circular”, “ecology”, “green”, and “low carbon”.

Multiple transformation directions under the dimension of resources and environment also have their focus. A circular economy and resource-saving society are proposed to address excessive resource consumption and insufficient resource utilization in economic development to improve resource utilization efficiency and control the total resource consumption; the concept of the ecological economy was developed by American scholar Boulding in the 1960s to emphasize the use of ecological economics principles and system engineering methods to change production and consumption methods within the capacity of the ecosystem, and to develop some economically developed and ecologically efficient industries. The green economy was first proposed by Pearce *et al.* (1989) and became a hot topic after the global financial crisis in 2008. The Organization for Economic Cooperation and Development (OECD) countries passed the Ministerial Council Declaration in 2009, advocating “green growth” (OECD, 2009). The low-carbon economy was first covered by the energy

white paper of the UK government entitled *Our Energy Future: Creating a low carbon economy* in 2003, and it spread extensively across the world around the 2009 United Nations Climate Change Conference.

Based on the international practical experience, the transformation of the economic development model is a systematic process involving concept innovation, technological progress, and system reform. Successful transformation is by no means easy. Japan and South Korea succeeded in transforming their economic development models, surpassing the middle-income trap and tackling environmental hazards. For example, both countries attach great importance to education and technological innovation in terms of the economy. The government and industry have achieved industrial upgrading through cooperation. In terms of society, both countries have implemented the concept of inclusive growth. South Korea launched the “New Village Movement” in 1971 to support rural construction, reduce the gap between urban and rural areas and redirect a large amount of government investment to rural areas; Japan initiated the “Income Doubling Plan” to narrow the income gap. The two countries have also paid attention to resources and the environment, and have made considerable progress in developing circular economy and green economy. However, a considerable number of countries fall into the middle-income trap, hardly achieving a sustainable growth of the social economy. With such gloomy prospects, it is difficult to improve the quality of the ecological environment.

1.2 The direction of the transformation of the economic development model of China since the 21st century

Since the reform and opening up, China has made tremendous economic achievements, but various overlapping resource and environmental problems have also surfaced in a short period. The problems that have been identified gradually in the development process of industrialized countries in the past 200 years have emerged in a short time in China; the issues of resource waste, environmental pollution and ecological damage overlap while domestic energy and environmental problems are intertwined with global climate change challenges. Take greenhouse gas emissions as an example. China has surpassed the

United States to become the world’s largest emitter in 2006, and its current carbon emissions have surpassed the total emissions of Europe and the United States. The urgency of development and transformation is beyond doubt. The current resource and environmental problems facing China are unprecedented. To cope with various challenges in the process of social and economic development, the tasks are also increasingly complex and arduous (Research Group on Sustainable Development Strategy, Chinese Academy of Sciences, 2014).

Obviously, the spontaneous industrialization and urbanization process cannot address these challenges. A series of major development model transformations and institutional changes are necessary to move towards sustainable development. China has begun to explore the transformation of the economic development model very early from the perspective of decision-making by the government. As early as 1995, when China formulated the “9th Five-Year Plan”, it proposed “two transformations”, that is, the model of economic growth shall shift from extensive to intensive, and the economic system is expected to transform from traditional planning to a socialist market economic system. After entering the 21st century, China has joined the World Trade Organization, and the stage of social and economic development has entered the second stage of the heavy chemical industry. Restrictions are imposed on industries such as coal, electricity, oil, and transportation. Power outages have reemerged in various places. Facing the challenges, a series of strategic directions of the transformation of the development model were identified by the nation (Wang Yi *et al.*, 2019).

The first is “new industrialization”. This is the concept put forward in the report of the 16th National Congress of the Communist Party of China in 2002. It insists on mutual promotion between industrialization and information technology to identify a new path to industrialization with a high level of scientific and technological development, good economic benefits, low resource consumption, less environmental pollution, and full utilization of the advantages of the human resource. China’s core purpose of proposing a new path to industrialization is to avoid issues such as “governance of the environment after the economic development”,

“pollution first, treatment later”, “destruction before remediation” in the industrialization process of Western developed countries.

Subsequently, the concept of “circular economy” aimed at the recycling of resources was adopted by the Chinese government. HU Jintao, then General Secretary of the Central Committee of the Communist Party of China, emphasized at the 2004 Meeting on Central Population, Resources, and Environmental that “It is necessary to accelerate the transformation of the economic growth model and integrate the development concept of the circular economy into regional economic development, urban and rural building and product production so that resources can be utilized most effectively”. In 2008, the Standing Committee of the 11th National People’s Congress passed the *Law on Promoting the Development of a Circular Economy*.

In 2005, China further proposed the concept of a “resource-saving and environment-friendly society” from the perspective of social forms. The entire social economy shall be based on resource conservation and environmental friendliness, forming a society in which man and nature live in harmony. The Fifth Plenary Session of the 16th Central Committee of the Party pointed out “an important way to build a resource-saving, environment-friendly society and achieve sustainable development”. As a core measure of building such a society, China has begun to implement large-scale energy conservation and emission reduction actions during the “11th Five-Year Plan” (2006–2010).

In 2009, the discussion on climate change gained more attention from the international community. China, then the world’s largest developing country and the second-largest emitter of greenhouse gases, was under tremendous pressure in international negotiations. Under the influence of domestic and external factors, China began to advocate “low-carbon development” to mitigate climate change. HU Jintao, then General Secretary of the Central Committee of the Communist Party of China, delivered a speech at the United Nations Climate Change Summit in 2009, proposing that “China will further incorporate climate change into its economic

and social development plans”, “actively develop a low-carbon economy and a circular economy, and develop and promote climate-friendly technologies.”ⁱⁱⁱ

In 2015, General Secretary of the Central Committee of the Communist Party of China XI Jinping put forward the new development concept of innovation, coordination, greenness, openness, and sharing at the second meeting of the Fifth Plenary Session of the 18th Central Committee of the Communist Party of China. Green development was included in his speech. The new development concept is the testimony of the development concepts, direction, and focus during the “13th Five-Year Plan” (2016–2020) and even beyond. It is a profound change related to the overall development of China, an action guide for building a moderately prosperous society in an all-around way, and the guidance for the two centenary goals.

In order to tackle the resource and environmental issues in the process of social and economic development as well as achieve sustainable development, China proposes the direction of the transformation of the development model from different perspectives to coordinate the relationship between environment and development. Environmental issues and socio-economic development have driven the innovation of ideas, and the development of ideas has guided the development of resource environmental protection practices.

1.3 Green, low-carbon and circular development an important direction for future economic development and transformation

The report of the 19th National Congress of the Communist Party of China concluded that socialism with Chinese characteristics had entered a new era, signaling a new historical direction for China’s development. In 2019, China’s GDP was close to 100 trillion yuan with the GDP per capita exceeding 10,000 U.S. dollars, and disposable income per capita exceeding 30,000 yuan for the first time (National Bureau of Statistics, 2020). The economy has undergone drastic changes since the Reform and Opening-up Policy. However, China consumes nearly half of the world’s

ⁱⁱⁱ Work Hand In Hand to Address the Challenge of Climate Change – Speech at the opening ceremony of the United Nations Climate Change Summit. http://www.gov.cn/dhd/2009-09/23/content_1423825.htm [2020-11-12].

steel and cement, and around a quarter of the world's energy to account for about 16% of the world's GDP.

Looking to the future, development is still key to all the problems in China, but the necessity and urgency of the transformation of the development model are even more prominent. According to relevant predictions, the resource and pollution-intensive industries in China will reach peaks and plateaus in the next 5 to 10 years, which means that conventional pollutant emissions and consumption of main resources and raw materials will peak around 2025; from 2020 to 2030, as the total population of China reaches its peak, industrialization and urbanization in the traditional sense are completed. The total carbon emissions will reach the peak, enter a plateau period and begin to decline. The quality of the ecological environment is expected to improve in an all-around way. The development and transformation tasks are still very arduous to attain the goal of building a beautiful China by 2035, establishing China as a great modern socialist country that is prosperous, strong, democratic, culturally advanced, harmonious, and beautiful by 2050, and achieving carbon neutrality in 2060.

The report of the 18th National Congress of the Communist Party of China regards “green, circular and low-carbon development” as important ways to realize ecological civilization, which leads to the fundamental transformation of the future economic development model. Only through green and low-carbon circular development, paying more attention to reducing consumption and pollution, restoring the ecology, focusing on the quality and benefits of development, and aligning economic and social development with population, resources, and the environment, can we promote high-quality economic development and realize the sustainable development of China. Green development, circular development, and low-carbon development are interrelated and coordinated with each other. They are the fundamental ways to promote ecological civilization, realize the efficient use of resources and improve the ecological environment. It is also a major means of tackling the society's main problems and achieving high-quality development. The

green, low-carbon, and circular development should be regarded as an important guide for modernization, manifesting in all aspects of economic and social development. Efforts shall be made to accelerate the formation of spatial patterns, industrial structures, production methods, and lifestyles that conserve resources and protect the environment.

II. Economic Transition towards Green, Low-Carbon and Circular Development and Carbon Neutrality Targets

President XI Jinping announced at the General Debate of the 75th United Nations General Assembly that “China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures, and strive to have CO₂ emissions peak by 2030 and achieve carbon neutrality by 2060”⁴. The transformation to a green, low-carbon, and circular economy is closely related to the goal of carbon neutrality.

2.1 Green development and carbon neutrality

The concept of green development could be defined both broadly and narrowly. In a broad sense, green development refers to the coordinated development of green economy, low-carbon economy, and circular economy; in a narrow sense, it refers to the development model that optimizes spatial configuration at the source, improves resource and energy utilization efficiency in the process, and reduces pollution emissions at the end, taking the improved quality of the ecological environment as the fundamental purpose. The relationship between carbon neutrality and green development in a narrow sense is more of a synergy, that is, efforts to improve air quality in production and consumption can reduce greenhouse gas emissions to a large extent, which is an important way to support carbon neutrality.

2.1.1 The synergistic effect of industrial green transformation and greenhouse gas emission reduction focusing on the control of air pollutant emissions

⁴ Speech by XI Jinping at the General Debate of the 75th United Nations General Assembly (full text). http://www.xinhuanet.com/politics/leaders/2020-09/22/c_1126527652.htm [2020-11-30].

There is a great synergy in tackling climate change, controlling greenhouse gas emissions and air pollutant emissions since their sources are the burning of fossil fuels. Air pollutants mainly include fine particulate matter (PM_{2.5}), ozone, sulfur dioxide (SO₂), and nitrogen oxides (NO_x), most of which are generated by the consumption of fossil fuels. In terms of sources of greenhouse gases, according to China's greenhouse gas inventory (excluding land use, land-use change, and forestry, namely LULUCF), CO₂ in 2014 accounted for 84% of total greenhouse gas emissions, and 87% of CO₂ generation is related to energy activities. Therefore, controlling fossil fuel consumption helps to achieve the synergistic effect of air pollutant emission and greenhouse gas emission reduction.

One important part of green development is to realize the green industry transformation, and the control of fossil fuel consumption is one of the driving mechanisms to realize this goal. To that end, efforts should be made to: *i*) promote a green industrial structure by guiding the orderly exit of enterprises with high energy consumption, high emissions, low added value, and low competitiveness; *ii*) make the production process more circular to reduce the input of raw materials, conduct energy conservation and consumption reduction, recycle waste heat, pressure, and water by following the principles of energy saving, emission reduction, and clean production; *iii*) accelerate the development of renewable energy industry and the use of new energy in terms of energy structure adjustment, so as to promote the reduction of coal consumption, and achieve industrial development and energy transformation.

In fact, in view of the *Air Pollution Prevention and Control Action Plan and the Three-Year Action Plan for the Defense of the Blue Sky*, the measures taken in the two initiatives include controlling new production capacity in high-energy-consumption and high-pollution industries, promoting clean production, accelerating the adjustment of energy structure, and strengthening energy conservation and environmental protection constraints.

From the perspective of the actual effect of the synergy, after the implementation of the *Air Pollution Prevention and Control Action Plan*, the air quality has been significantly improved, and the effect of reducing

greenhouse gas emissions is also evident. According to the report *Synergizing Action on the Environment and Climate: Good Practice in China and Around the Globe* issued by the Institute of Climate Change and Sustainable Development of Tsinghua University and the Climate Change and the Climate & Clean Air Coalition (2019), one ton of CO₂ emission reduction in China is equivalent to reducing 2.5 kg of SO₂ and 2.4 kg of NO_x from 2005 to 2018. Due to differences in industrial structure, energy structure, urbanization level, and climatic conditions in different regions, the efficiency of coordinated emission reduction varies in time and space.

2.1.2 Synergy between ecological protection-based green industrialization and increasing carbon sinks

Among multiple sources of greenhouse gas emissions, LULUCF is an extremely important source. According to the latest national greenhouse gas emission inventory data submitted by 185 countries, the agriculture and LULUCF sectors each generate 6.13 billion equivalent tons of CO₂ net emissions and 1.49 billion equivalent tons of CO₂ net absorption, accounting for 14.6% and 3.6% of the total emissions (excluding LULUCF), respectively.

In addition to industrial green development, green industrialization is also an important part of green development, which highlights the importance of ecological protection. These measures can increase carbon sinks and protect the ecological environment to a large extent. For example, constructed wetlands can filtrate and cleanse water while serving as a carbon sink, and promoting large-scale land greening is an important part of the ecological building. On the other hand, curbing deforestation or ecosystem degradation will greatly reduce carbon emissions, given that natural ecosystems (forests, farmlands, wetlands), while storing a large amount of carbon on the ground, in the water or in the soil, can absorb extra carbon every year.

Green industrialization and the realized value of ecological products can also promote the development of industries that are highly dependent on natural capital, such as tourism and agriculture. As General Secretary Xi Jinping put forward, "lucid waters and lush mountains are invaluable assets", among them, green industrialization is an important way to transform "lucid

waters and lush mountains” into “invaluable assets”. Green industrialization promotes green development in accordance with the laws of industrialization, provides green products or services based on socialized mass production and market-oriented operation, promotes the transformation of green elements to production elements, ecological wealth to material wealth, and fosters the development of a virtuous cycle of environment and economy. Its essence is to achieve the preservation and appreciation of ecological resources by establishing a virtuous circle between green development and economic development based on unique resource endowments and ecological environmental conditions. For this reason, Nature-based Solutions (NbS) have become the main approach to respond to climate change.

2.1.3 Frugal and moderate green consumption helpful for reducing carbon emissions

Promoting green consumption is an important means to comply with the consumption upgrade trend, encourage supply-side structural reforms, and cultivate new economic growth pillars. It is also an important means to ease the pressure on energy resources and reduce greenhouse gas emissions.

Green consumption includes purchasing green products, reducing environmental impact through behavior changes during the consumption process, returning waste to the production process to the maximum extent at the end of consumption, and reducing pollutant emissions. Green consumption is a kind of rational consumption that has emerged with the development of the environmental protection movement in recent years. It usually refers to conservation-oriented consumption that features no pollution and low energy consumption. Green consumption advocates the consumption concept of “living within one’s means, simple and moderate consumption”, which encourages consumers to choose green products, try not to cause environmental pollution during consumption, pay attention to environmental protection, and save resources. Promoting green consumption is of great significance

for transforming development means, lifestyles and reducing greenhouse gas emissions. On the one hand, green consumers tend to purchase products or services that have low energy consumption and greenhouse gas emissions. For example, they tend to choose products with higher-level of green and low-carbon energy efficiency labels, save electricity and energy, and use products with less pollution and low carbon emissions during the manufacturing process. On the other hand, green consumption advocates recycling and reusing waste materials instead of discarding them casually, indirectly reducing greenhouse gas emissions caused by the waste of resources. At the same time, the attention and demand of consumers for green and energy-saving products can enable more companies to actively focus on energy-saving and carbon-reduction goals, and lead their product development and marketing towards green and low-carbon development.

In 2016, the *Guiding Opinions on Promoting Green Consumption*, which was jointly issued by ten ministries and commissions including the National Development and Reform Commission, stated that “green consumption refers to consumption behavior characterized by resource conservation and environmental protection, which is mainly embodied by advocating frugality, reducing losses and waste, choosing high-efficiency and environmentally friendly products and services to reduce resource consumption and pollution emissions in the consumption process”⁹. At present, China has established systems such as environmental labels, energy-saving labels, green building labels, and organic food labels. With the continuous improvement of the green consumption system in China, the quality of green product supply continues to improve, and the willingness to green consumption of the market has been continuously fostered. In 2016, environmental label certification and energy-saving and water-saving-certified products saved about 19 billion kilowatt-hours of electricity, more than 4.6 million tons of water, and reduced more than 12.3 million tons of CO₂ emissions (CCICED “Green Transition and Sustainable Social Governance Special Policy Research” Task Force, 2020).

⁹ Guiding Opinions on Promoting Green Consumption. <http://www.gov.cn/xinwen/2016-03/02/5048002/files/e0d02a75cff54a3fb51e59295d852245.pdf> [2020-11-13].

2.2 Low-carbon development and carbon neutrality

Low-carbon development is undoubtedly the core path to achieving carbon neutrality, mainly by adjusting the industrial structure, optimizing energy structure, saving energy, and improving energy efficiency to reduce CO₂. Meanwhile, carbon sink projects will be carried out, including innovations in carbon capture, utilization, and storage (CCUS) technology to absorb CO₂ emissions from production and life.

2.2.1 Adjust the industrial structure to promote low-carbon economic development

The evolution of the industrial structure has gone through different stages, transforming from agriculture to non-agriculture, from labor-intensive to capital-intensive, and then to knowledge-intensive. There are great differences in energy demand and carbon emission levels at different stages of industrial structure development. During the period when agriculture dominated the industrial structure, industrial development was less dependent on energy, and the CO₂ generated was also very limited; in the early stage of industrialization, energy consumption generated by production began to grow, therefore CO₂ emissions increased as well; during the period of development where labor-intensive industries dominated, energy consumption was limited and maintained a steady growth trend with emissions rising steadily; during the period of capital-intensive industrialization, energy consumption increases rapidly and carbon emissions reach a peak; in the post-industrial development period, the tertiary industry, which is characterized by low energy consumption, dominates the national economy. At this stage, the growth rate of energy consumption is moderate or shows a declining trend.

As seen in the trajectory of the economic and social development of China, industrial structure adjustment and CO₂ emissions also follow this pattern. Following the reform and opening-up, as well as industrialization, the core of the industrial structure in China has gradually shifted from agriculture to industry. As a result, CO₂ emissions are showing a trend of rapid growth. Since China's move to promote the supply-side structural reform, the industrial transformation has been upgraded, and the low-carbon industry has

continued to develop. From 2016 to 2019, 900 million tons of outdated coal production capacity have been eliminated, leading to the optimization of the industrial structure. The incremental growth in CO₂ emissions has decreased from 2.58 billion tons in the "10th Five-Year Plan" period (2001–2005) to 1.99 billion tons in the "11th Five-Year Plan" period (2006–2010) and then reduced to 1.37 billion tons in the "12th Five-Year Plan" period (2011–2015). It is expected that it will drop to 630 million tons during the "13th Five-Year Plan" period (2016–2020). The average annual growth rate of CO₂ total emissions is 12.5% in the "10th Five-Year Plan" period, 6.1% in the "11th Five-Year Plan" period, and 3.3% in the "12th Five-Year Plan" period. It is expected to decline to around 1.4% during the "13th Five-Year Plan" period. The trend of rapid emissions growth has been reversed, and total emissions may enter a plateau.

Therefore, adjusting the industrial structure can effectively reduce the dependence of economic development on fossil fuels and reduce greenhouse gas emissions based on theoretical research and development practice. This is also an important effort to support carbon neutrality in the future.

2.2.2 Increase the proportion of clean energy consumption by optimizing the energy structure

The rapid economic growth brings about rising CO₂ emissions mainly due to the increasing demand for fossil fuels. There is a close relationship between energy structure and carbon emissions. Different energy types have completely different levels of carbon emissions. With the total energy consumption unchanged, CO₂ emissions can be reduced by optimizing the energy structure. Since 2005, the energy structure adjustment (reduction of CO₂ emission per unit of energy) has contributed more to CO₂ emission reduction, especially during the "13th Five-Year Plan" period with its share increasing from 7% of the "12th Five-Year Plan" to 16% during the "13th Five-Year Plan".

Coal is the main energy source of China with carbon-based energy accounting for the largest share of energy structure. Fossil fuel consumption makes up more than 80% of the total, of which coal accounts for up to 55%. In the future, China should adjust its energy structure orderly. Under the background of anti-globalization, China should explore ways to adapt

to the trend for resource advantages, develop energy diversification strategies, and develop alternative energy sources for the substitution within traditional energy sources as well as between the traditional and the new energy sources. Renewable energy is the direction of future energy structure transformation as it can reduce the excessive dependence of economic development on fossil fuels. As clean energy sources such as wind power, solar power have reached the historic turning point of parity on the grid, the competitive advantages of the market have become more prominent, and the optimization of energy structure will play a greater role in reducing emissions. According to statistics from the Ministry of Ecology and Environment, the installed capacity, power generation, investment, and the number of patents of renewable energy in China ranked first in the world for several consecutive years with renewable energy investment exceeding 100 billion U.S. dollars for five consecutive years. For this reason, it is necessary and feasible to further optimize the energy consumption structure to support carbon neutrality.

2.2.3 Saving energy and improving energy efficiency to optimize carbon production capacity

Energy efficiency is an important indicator to measure the quality and benefit of the development of a country and region. Improving energy efficiency has always been a priority in the energy strategies and policies of various countries. Major developed countries have set mid and long-term energy efficiency improvement goals, which are used as the basis for enhancing energy security, optimizing energy structure, and improving environmental quality. China faced realities such as a huge energy consumption base, the dominance of coal in energy supply, and the nascent development of renewable energy. Therefore, energy conservation is still an important means to reduce carbon emissions. We need to greatly improve energy efficiency to reduce fossil fuel consumption, thus reducing CO₂ emissions. According to relevant research calculations, to achieve the economic and social development goals by 2020, 2030, and 2050, that is, building a moderately prosperous society in all respects, entering the ranks of high-income countries, realizing modernization, and building a beautiful China, the contribution of carbon emission reduction through

energy conservation in 2020, 2030 and 2050 will reach 76%, 56% and 55% of the total emission reduction respectively among all the potentials alternatives of carbon emission reduction formed by different development path (Xie Zhenhua *et al.*, 2017).

Based on previous experience, energy saving is also the most economical way with the greatest potential for emission reduction. From 2013 to 2019, the energy consumption per unit of GDP has dropped by 24.6%, saving 1.27 billion tons of standard coal, which is close to the current annual total energy consumption in Beijing-Tianjin-Hebei and Yangtze River Delta regions. As one of the countries with the fastest reduction in energy intensity in the world, the energy savings in China accounted for about half of the global total in the same period, which is a significant contribution to reducing CO₂ emissions. As of 2019, the average standard coal consumption for the power supply of thermal power plants has dropped to 306 g/kWh, down 63.6 g/kWh from 2005. The coal consumption efficiency of coal-fired power plants maintains an edge over other counterparts in the world. In 2019, the national thermal power plant generated a relative emission reduction of 860 million tons of CO₂ (compared to the 2005 level) due to the decline in coal consumption in the power supply alone. Statistics released by the Ministry of Ecology and Environment show that the energy consumption per unit of the industrial added value of enterprises above designated size in 2019 has dropped by more than 15% compared with 2015, saving energy costs of about 400 billion yuan. It can be concluded that in the medium and long term, energy conservation and energy efficiency improvement are still needed to improve carbon production capacity to reduce carbon emissions and even achieve carbon neutrality goals. It is also an effective way to reduce carbon emissions by reducing energy consumption at the source.

2.2.4 Expanding the economic benefits of CCUS technology

Adjusting the industrial structure, optimizing the energy structure, and improving energy efficiency can reduce CO₂ emissions through energy consumption. CCUS is the most direct method to reduce emissions as it can capture, use and store CO₂ from the end. CCUS is the only technical solution to reduce emissions in

the cement production process, and it is also the most cost-effective technical means to reduce emissions from the steel and chemical manufacturing process; CCUS can also support the rapid expansion of low-carbon hydrogen production scale to meet the current and future energy needs of transportation, industries, and buildings; finally, for emissions that cannot be directly avoided or reduced, CCUS can offset this part of carbon emissions by removing carbon from the atmosphere and help build a net-zero energy system (IEA, 2020). Therefore, it is critical to accelerate the innovation, demonstration, and application of CCUS technology to achieve the carbon neutrality vision before 2060 and to form a technology cluster with economic benefits.

Innovation, promotion, and application of CCUS technology is not a “green light” for high-carbon industries but a strategy to guarantee carbon neutrality. There are certain limits when it comes to adjusting the industrial structure, optimizing energy structure, or improving energy efficiency. The completion of the “last mile” ahead of the carbon neutrality goal depends on CCUS. China regards CCUS as an important strategic reserve technology to promote the development of low-carbon technologies and actively respond to climate change. A series of positive measures have been taken to promote research and development, demonstration and promotion. At present, large domestic energy companies are carrying out CCUS-related technology research and pilot demonstrations. For example, Shaanxi Yanchang Petroleum Group put forward the first megaton-level CCUS demonstration project construction plan in China in 2018. Therefore, efforts should be made to carry out research on policy standards and technical specifications of CCUS by effectively integrating research resources of major domestic institutions, promoting the research, development, and exchange of related technologies, and encouraging the large-scale promotion and application of experimental demonstrations. They are important to support the goal of carbon neutrality.

2.3 Circular economy and carbon neutrality

2.3.1 The development of a circular economy brings huge carbon emission reduction potential

Based on its practices, circular economy includes energy saving, and the reduction of energy consumption

and CO₂ emissions, which are consistent with the goal of low-carbon development. Circular economy refers to the economic form or development model that produces economic, social, and environmental benefits by recycling resources. It features low consumption, low emissions, reuse, recycling, and high efficiency, highlighting the efficient use of resources and minimal waste emissions. Recycling development is based on the principle of “reduction, reuse, and resource utilization” and reconstructs the socio-economic system in accordance with the laws of material circulation and energy flow in the natural ecosystem. The mainstream linear production model of “resource-product-waste” formed since industrial civilization is transformed into a feedback production process of “resource-product-renewable resource” so that the social and economic system can be harmoniously incorporated into the material cycle of the natural ecosystem. Recycling development achieves low or even zero-pollution through efficient recycling of resources and cascade utilization of energy, thereby achieving sustainable development of society, economy, and environment. A circular economy makes full use of resources and reduces waste as much as possible, including improving energy efficiency and minimizing CO₂ emissions, which is consistent with the goal of low-carbon development.

Based on the long-term international and domestic practical experience, developing a circular economy will bring huge carbon emission reduction benefits, which can effectively facilitate carbon neutrality. Some international institutions have studied and estimated the contribution potential of circular economy to the neutrality goals. According to the relevant research of the United Nations Environment Programme, the development of a circular economy combined with relevant policies and measures to address climate change could reduce 28% of global resource extraction and 63% of CO₂ emissions by 2050 while increasing global economic output by 1.5 percentage points. A report released in 2018 covered heavy industries that produce basic materials (steel, plastics, aluminum, and cement), analyzed and predicted the potential to reduce carbon emissions through better production, use, and reuse of materials. The research results show that if strong circular economy measures are adopted in the industrial sector, the EU will reduce as much as 296 million tons

of CO₂ emissions per year by 2050, accounting for more than half of the total emission reductions of 530 million tons. The world can reduce carbon emissions by approximately 3.6 billion tons annually. That is, more than half of the industrial net zero emissions of the EU can be achieved through effective circular economy measures. These international practices and studies have shown that the development of a circular economy can effectively promote the goal of climate neutrality (Material economics, 2018).

As far as the practical experience of China is concerned, the development of a circular economy in China has undergone a process of gradual exploration. After years of promotion and effort, the circular economy in China has achieved significant results, greatly improving energy efficiency and reducing CO₂ emissions. According to comprehensive calculations by relevant research institutions, the circular economy activities of China reduce over 1 billion tons of CO₂ emissions every year. At the end of 2019, the energy consumption per unit of GDP of China dropped by 13.2% compared with 2015, and the total amount of waste resource utilization exceeded 2 billion tons. According to statistics, more than 20% of the raw materials for non-ferrous metal and pulp come from renewable resources, and more than half of the raw materials for building materials such as cement come from industrial waste. Each ton of waste resources used to replace primary resources saves an average of 4.12 tons of mineral resources, 1.4 tons of standard coal and reduces waste discharge by 6 to 10 tons.

2.3.2 Circular economy: an important approach to promoting green recovery at home and abroad as well as achieving the goal of climate neutrality

European countries regard the circular economy as an important approach to promoting green recovery and growth and have put forward clearer goals and key action timetables. In December 2019, the new EU Commission launched the “European Green Deal”, proposing that the EU will achieve the goal of carbon neutrality by 2050. It hopes that by taking into account the prevention of global warming and economic development, it will minimize transportation emissions, improve building energy efficiency, increase the use of renewable energy, protect biodiversity, and

strive to achieve net-zero emissions by 2050 (Wang Zichen, 2019). In March 2020, the European Union released a new version of the Circular Economy Action Plan. The core of it is to integrate the circular economy with the entire life cycle of product design, production, consumption, maintenance, recycling, and secondary resource utilization, and to extend the coverage of circular economy from several leading countries to major economies in the EU, accelerate the shift of linear economic development methods, reduce resource consumption and “carbon footprint”, increase the utilization rate of recycled materials, and lead the development of the global circular economy (Liao Hongyun *et al.*, 2020). The EU plans to achieve the goal of substantially reducing waste and halving non-recyclable urban waste by 2030. In the next 10 years, the European Union will invest 1 trillion euros in legislative reforms in waste management. The plan has identified seven key areas to focus on the implementation of sustainable product concepts and policy frameworks and will issue detailed industry-specific legal policy recommendations and measures before 2022. As an important pillar of the “European Green Deal”, the new plan will promote the European circular economy from partial demonstration to mainstream large-scale applications, facilitating the goal of climate neutrality by 2050, and realizing the decoupling of economic growth and resource utilization.

China also regards the development of a circular economy as an important approach to comprehensively promoting resource conservation and intensive utilization, energy conservation, and emission reduction, and to promoting the green and low-carbon circular transformation and high-quality development of the economic system. In September 2020, XIE Zhenhua delivered a speech at the EU-China Seminar on Green Recovery and Green Stimulus, stating that “circular economy is a fundamental solution for decoupling economic and social development from pollution emissions and mitigating climate change” (Xie Zhenhua, 2020). Looking into the future, it is foreseeable that the development of a circular economy will continue to release the huge potential for carbon emissions reduction, and it will become an important way to achieve carbon peak by 2030 and carbon neutrality by 2060. Taking industry as an example,

it can bring great potential for energy saving and emission reduction through the development of “steel-electricity-cement” industrial waste recycling. According to research calculation and analysis: Compared with 2015, the “steel-electricity-cement” industrial cycle system can save 35.74 million tons of standard coal in 2020 and reduce 189,000 tons of SO₂ emission, cutting 139,000 tons of NO_x emissions and 64,000 tons of PM emissions. Energy-saving and emission reduction accounted for 1.9%, 6.5%, 3.2%, and 2.7% of the total energy consumption and emissions of the three industries in 2020. In the *Iron and Steel Industry Adjustment and Upgrade Plan (2016–2020)*, the iron and steel industry is expected to reduce its total energy consumption by 10% and pollutant emissions by 15% in 2020. The overall goal put forward in the *13th Five-Year Development Plan of the Cement Industry* states that the pollutant emissions of the cement industry should be reduced by an average of 30%. The energy-saving achieved through the industrial circulation system accounts for 19% of the overall target, and the proportion of pollutant emission reduction to the overall target is 10% and 40% (Cao *et al.*, 2020). It can be concluded that the development of an industrial circular economy will make a greater contribution to the carbon peak and neutrality goals of China.

In summary, the practice at home and abroad has proved that a circular economy is an important path to achieving sustainable development and green transformation, and it is of great significance to respond to climate change and tackle global environmental problems. The development of a circular economy can mitigate climate change and has great potential to promote the realization of global carbon neutrality and sustainable development goals.

III. Policy Recommendations on Promoting the Transformation of the Economic System towards Green, Low-carbon, and Circular Development

3.1 Formulate the “Green and Low-Carbon Circular Development Action Plan”

It is important to accelerate the establishment of an economic system featuring green, low-carbon, circular, and sustainable development by making good use of

the current key ten-year period from 2020 to 2030, and guide and press the transformation of the development model towards the vista of carbon neutrality. It is recommended to formulate a “Green and Low-Carbon Circular Development Action Plan” to achieve full coverage of promoting green and low-carbon circular development.

Promote the full coverage of green and low-carbon circular development in the fields of production, circulation, and consumption. It has to build a green development system to ensure the reduction of resource and energy consumption as well as the recycling of production materials during production, circulation, and consumption. To start with, we need to promote green and low-carbon circular production. Guided by high-quality development, with the deepening of supply-side structural reforms as the main body, we will focus on building a technological innovation system, enhancing new drivers of industrial development, promoting industrial transformation and upgrading, tapping into new advantages in green industry development, innovating green industry development paths, and expanding new space for green industry development. Secondly, promote green and low-carbon recycling in circulation. Work has to be done to promote energy-saving and emission-reduction of enterprises involved in circulation, create green products supply chain, build a green circulation service system, and foster a new development model of circulation that features “new commodities-second-hand commodities-discarded commodities” by advocating green and low-carbon practices in the whole process of circulation, grasping the circulation that is closely related to production and consumption, adopting modern information technology and management methods to transform traditional circulation models, and applying green energy-saving technologies. Thirdly, advocate green consumption. Improve the green procurement system of the government, increase the proportion of recycled products and remanufactured products in government procurement, promote paperless office and video conferencing, and strengthen the assessment of green practices by government agencies. To this end, a good job should be done to guide enterprises to provide resource-saving and environment-friendly products and services, and encourage the public to establish

a scientific, healthy, environmentally-friendly and green consumption model. In addition, efforts should be made to encourage people to switch to a simple, moderate, green, low-carbon, culturally-advanced and healthy approach in terms of clothing, food, housing, transportation, and travel, and guide consumers to buy energy-saving, low-carbon, and environmentally friendly products.

Extend the full coverage of green and low-carbon circular development in agriculture, industry, and service industries. To meet this target, it is advisable to: *i)* advance technological innovation and structural adjustment, improve the quality and efficiency of development, comprehensively promote resource conservation and recycling efficiency, and promote a fundamental shift in the use of resources; *ii)* promote the conservation and cleanliness of production resources, improve the harmless treatment and resource utilization of waste in the agricultural sector, and facilitate the transformation of agricultural production methods; *iii)* encourage the high-efficiency water-saving irrigation technologies, advocate soil pollution control, strengthen comprehensive supervision of chemical fertilizers, pesticides, agricultural film, bait, and feed, advance formula fertilization by soil testing, and promote the development of organic agriculture; *iv)* strengthen the resource utilization of agricultural waste, focus on promoting the high-value utilization of agricultural organic such as straw, livestock, and poultry manure by returning them to the field nearby, and advance the recycling and reuse of agricultural inorganic residues such as waste agricultural film; *v)* fully implement the green production method of “source reduction, process control, vertical extension, horizontal coupling, and end regeneration” in the industrial sector, develop the ecological design, promote clean production, strengthen energy-saving, emission-reduction, and water-saving technologies in key industries, and improve intensiveness land use in industry; *vi)* comprehensively promote the circular economy operation model, advance the recycling of the industrial park industry chain, and implement the comprehensive recovery and resource utilization of production waste, wastewater, exhaust gas, and waste heat; *vii)* conduct green mining, focus on improving the recovery ratio of mineral resources, the recovery rate of beneficiation, and the comprehensive

utilization rate of co-associated, low-grade, and tailings, and promote the simultaneous advancement of mining and environmental protection measures; *viii)* build a green service industry system, develop low-consumption and low-pollution service industries such as finance, e-commerce, culture, health, and elderly care, and promote ecological-friendly practices, clean service processes, and green consumption patterns in service industries such as commerce, tourism, catering, transportation.

Promote the full coverage of green and low-carbon circular development in urban and rural areas. The principal contradiction facing Chinese society has evolved. What we now face is the contradiction between unbalanced and inadequate development and the people’s ever-growing needs for a better life. Green development must be integrated into coordinated development, especially important strategies such as rural revitalization. In the process of coordinating regional development and urban-rural coordinated development, especially supporting the old revolutionary base areas, ethnic group areas, border areas, and poverty-stricken areas, the green development transformation of these areas must not be ignored, and attention must be paid to improving the production methods in these areas and maintaining the quality of their ecological environment. Specifically, it is necessary to adapt measures to local conditions, respect the natural pattern, determine the development boundary properly based on the carrying capacity of resources and environment, natural endowment, development basis, population size, the functional orientation of different regions, optimize the urban-rural planning, promote ecological green urban and rural areas, and prevent the practice that “one size fits all”, and enhance the ecological functions of urban and rural areas.

Advance the development of a green and low-carbon cycle with full coverage from hardware to software. The development of a green and low-carbon cycle should be embodied throughout the entire process of economic, political, cultural, and social endeavors. On the one hand, it is necessary to promote the green transformation of hardware, such as the infrastructure. In terms of the green transformation of hardware, we should coordinate the development of traditional and

new infrastructure to create a modern infrastructure system that is intensive, efficient, economical, smart, green, safe, and reliable. It is necessary to strengthen the green transformation of traditional infrastructure while paying attention to the green evaluation of new infrastructure. The green contribution of new infrastructure is uncertain. The information and communication industry involved in new infrastructure has become a key energy-consuming sector in China. During the steady development of new infrastructure, it is recommended to establish a green assessment of the whole process and all elements of the infrastructure to establish a sustainable guarantee for long-term green development. On the other hand, we must also promote the green transformation of soft systems and policies. We will promote the transformation of green development and the prosperity of the green economy, and foster the sustainable and healthy development of the economy and society by green development in systems and policies such as laws, administrative orders, fiscal and taxation, and market. Cultivate and establish green values, promote Chinese traditional culture, advocate harmonious coexistence between man and nature, and develop green culture.

Finally, we need to strengthen the synergy of green, circular, and low-carbon economies. Green economy, circular economy, and low-carbon economy are economic development models that are consistent with the concept of sustainable development. They all emphasize the interdependence of humans and nature and believe that it is necessary to save resource input, improve utilization efficiency, and carry out cleaner production; moderation in consumption and material use and recycling is highlighted in all three models. However, due to their different priorities, the three still need to strengthen their coordination to improve resource utilization efficiency while minimizing carbon emissions and reducing environmental impact. We shall incorporate the green, low-carbon and recycling practices into the entire process of resource extraction, product manufacturing, commodity circulation, product consumption, and waste product recycling. We shall also firmly grasp the key element of fossil fuel to actively promote the energy revolution, advance renewable energy and new energy, and cultivate energy-saving industries.

3.2 Accelerate the establishment of a policy and management system for the green, low-carbon and circular mode of economic development

As a development model with positive externalities, green and low-carbon circular development also requires the support of laws and regulations, planning, policies, and standard systems, as well as the establishment and soundness of positive incentives and negative restraint mechanisms. It is necessary to study and explore the “ecological focus” of laws and regulations in accordance with the guidelines of integrating ecological civilization into “the whole process of economic, political, cultural, and social endeavors”, and to create a legal and policy system for green and low-carbon circular development.

Highlight the ecological focus of the legal system. At present, China has formed a legal system with the Constitution as the overarching benchmark and the laws of seven legal departments, including the Constitution, Civil Law, Criminal Law, Economic Law, Administrative Law and Civil Action, Criminal Procedure and Administrative Litigation, as the backbone, which is composed of multiple levels of legal norms such as laws, administrative regulations, local regulations. In the field of ecological civilization, a relatively complete legal system of resources and ecological environmental protection and a system of administrative and technical specifications have also been formed. But on the whole, there is still a big gap between the legal system in China and the requirements of green and low-carbon recycling development as insufficient attention is paid to ecological friendliness. Therefore, on the one hand, it is necessary to study the integration of the concepts, principles, and norms of green and low-carbon circular development into the seven legal systems, such as in-depth research and revision of relevant laws such as the General Principles of Civil Law, Property Law, Rural Land Contract Law, Guarantee Law, Tort Liability Law in accordance with the requirements of improving the natural resource property rights system and the ecological environment damage compensation system. Based on the experience of various countries, the seven legal systems are essential for the effective implementation of resources and ecological environment laws. If there are conflicts or inconsistencies, they will hinder the effective implementation of such laws. On the other hand, it is necessary to further study and

improve the legal and institutional system of resources and ecological environmental protection to provide a complete legal system for promoting the development of green and low-carbon recycling.

Promote the green transformation of the planning system. In the process of shifting from a planned economy to a socialist market economy, China has gradually shifted from “fixed planning” to “strategic planning”. The government implements macroeconomic regulation, public affairs management, and the supply of public products through strategic planning. The green transformation of the planning system is required for the green and low-carbon circular development. On the one hand, integrate the concept of green and low-carbon circular development into the existing planning system, and plan preparation should highlight the requirements of green and low-carbon circular development; on the other hand, formulate special plans for green and low-carbon circular development.

Advocate for the green transformation of the policy system. While reflecting the requirements for green and low-carbon circular development in the legal system, it is also essential to take policy measures that are conducive to green and low-carbon circular development. In March 2019, General Secretary Xi Jinping published an article titled *Promoting the Ecological Civilization Building to a New Level in China* in the *Qiushi* magazine, emphasizing that environmental governance is a systematic project that requires the comprehensive use of various means such as administration, market, rule of law, and technology. From another perspective, this is also a requirement to reform the policy system based on the concept of green and low-carbon circular development and establish a policy framework that is conducive to green production and consumption means. At the practical level, promotion based on different categories should be conducted. For the policy documents that have been issued, in-depth study and analysis of the policy related to green and low-carbon circular development in the economic, political, and social fields should be conducted, and the parts that are not conducive to the requirements of green and low-carbon circular development should be sorted out and removed; for the policy measures that have not yet been introduced, it is necessary to study and implement a comprehensive

decision-making mechanism, introduce the ecological environmental impact assessment mechanism of the policy at an appropriate time, integrate the concept of green and low-carbon circular development into policies in the policies related to macro-control, market incentives, fiscal and taxation systems to establish a long-term mechanism.

Promote the green transformation of the standard system. By constraining energy consumption and pollution emissions, and setting new-entry values and advanced values, we can provide a technical basis for eliminating outdated production capacity, strictly controlling new projects, and guiding technological progress. This is the value and function of the standard system. It is recommended to establish standards that reflect national and regional characteristics, advanced indicator levels, and complete systems for green environmental protection, energy conservation, low carbon, and resource recycling to promote the development of green and low-carbon recycling. At the practical level, it is important to improve the scientific method, implement effective, updated, and timely standard formulation and revision mechanisms, and establish a standardized co-governance pattern of government guidance, market drive, and social participation; realize the full disclosure of the green and low-carbon circular standard system, full coverage of law enforcement, the full implementation of mandatory standards, and encourage the adoption of all recommended standards, etc.

Improve the management system for green and low-carbon circular development. Green and low-carbon circular development involves multiple areas. Therefore, it is also necessary to make full use of the governance concept of Xi Jinping’s thought on ecological civilization to strengthen the coordination of work and policy measures in various fields of green and low-carbon circular development to achieve the effect of “1+1>2”. Where the development of green and low-carbon cycles involves multiple authorities, a sound coordination mechanism should be established to facilitate smooth interaction and communication. It is necessary to effectively link the formulation and break-down of relevant targets for green and low-carbon circular development, including the connection between energy-saving targets and low-carbon targets.

It is important to strengthen the coordination of policies and measures for green and low-carbon circular development, such as linking carbon emission rights trading and energy rights trading, and improving the planning of pilot projects.

3.3 Comprehensively strengthen green technological innovation and give full play to the role of technological support

The support of technology is essential to green development. The efficiency of resource utilization can be improved, the space for resource utilization can be expanded, and pollution can be reduced through green technology innovation. The promotion of production technologies such as clean production mechanisms and circular economy has greatly reduced the consumption of resources and energy, making production and life safer and cleaner. Green technological innovation provides a comfortable environment and beautiful ecological space for the survival and development of mankind, and makes the production means, lifestyle, thinking, and consumption models green.

Tackling basic common technologies in the field of green and low-carbon recycling development is an effective prerequisite for green development. To this end, it is necessary to focus on market orientation and major needs for industrial development, highlight promoting regional industrial restructuring and industrial green transformation and upgrading, identify the key common technologies that restrict industrial development based on the characteristics and needs of key industries and technical fields, and specify the strategies, ideas, and goals and tasks for technological research and development. Meanwhile, efforts should be made to highlight guidance based on different categories, guide and gather innovative elements, and promote the industry to leap from the low end of the value chain to the high end.

Give full play to the 'guiding role of the government, and carry out research and development of industry frontier and common key technologies in priority areas. It is necessary to take the following actions: *i*) set up various green technology research, development, and public service platforms, and actively promote the open sharing of green technology resources; *ii*) make full use of the basic conditions and existing advantages of

national laboratories, comprehensive national science centers, and major national scientific and technological infrastructures to achieve openness and sharing of resources and in-depth exchanges; *iii*) fully leverage the national key scientific and technological projects, focus on the research and development of green technologies in national scientific research plans and projects, and comprehensively improve the basic research capabilities of green technologies.

Highlight the main role of enterprises and enhance their ability and motivation for green technological innovation. It is necessary to continuously enhance the motivation, initiative, and creativity of enterprises in green technology innovation. While making efforts to catch up with the world's cutting-edge green development technology, due attention should be given to the current domestic market demand, increasing investment in production technology, recycling technology, new energy development. It is important to promote enterprise system innovation and organizational innovation, and foster a complete green supply chain from development, production, processing, marketing to recycling. An incentive mechanism shall be established for corporate green innovative talents and to accelerate the training of R&D teams in green technology.

Strengthen the vitality of green technology innovation in universities and research institutes. Universities and scientific research institutes should take the research of green technology as a priority, accelerate the training of green technology talents, and actively promote the transformation and commercial application of green technology innovations. Based on comparative advantages and key areas, it is necessary to select a number of key universities and research institutes to create a group of green technological knowledge innovation and talent training bases.

Build a market-oriented technology innovation system that integrates industry, academia, research, finance, and intermediary to accelerate the breakthrough and industrialization of basic common technologies in green and low-carbon circular development. It is advisable to establish a green technology innovation system guided by the market, take into account not only ecological and social benefits, but also economic benefits, and rely more on market means to guide the development of common technologies for green and low-

carbon cycles. Efforts should be made to enhance R&D efforts in technologies in energy-saving, environmental protection industries, clean production and energy industries, providing strong technical support for green development. It is important to establish an achievement transfer and promotion mechanism with a market-oriented mechanism as the core, and accelerate the process of green technological innovation and the industrialization of achievements.

3.4 Improve market incentive and social participation mechanisms

Adhere to the market-oriented principle, with enterprises as the main body, and give full play to the decisive role of the market in allocating resources; establish and improve the social public participation mechanism and public opinion supervision mechanism, so that the general public and social organizations can participate in the building of a green and low-carbon circular economy; the government should play a guiding and promoting role in the building of a green and low-carbon circular development mechanism of co-governance among the government, the market and the public by providing institutions, policies, and services.

To start with, further improve the price incentive mechanism. It is necessary to build a more comprehensive market transaction system, and make full use of the market mechanism to allocate resources to encourage environmental protection means to control and manage pollutants. It is important to pressure enterprises to use new energy, encourage adoption of energy-saving and power-saving measures, and promote resource conservation and efficient utilization by introducing consumption tax and environmental tax, establishing a higher quality and correct price signal system for the development of green and low-carbon circular development. Work should be done to increase consumption taxes on products with high energy consumption and heavy pollution through the collection of environmental taxes, ecological protection taxes, such as CO₂ emission taxes, water pollution taxes; lower consumption taxes on green products and incentivize market players for environmental protection, and guide enterprises to develop green technologies and promote green production. In addition, efforts should be made to low-cost policy-based funds should be used to support

small and medium-sized green enterprises in financing, and major projects that play a prominent role in the green and low-carbon circular development are given priority to policy support such as financial subsidies and loans interest discounts.

Secondly, build a diversified green investment and financing mechanism. To this end, we should guide non-governmental enterprises and various types of non-governmental capital to participate extensively, mobilize various market entities to participate in green and low-carbon circular development, and promote the diversification of investment entities. It is important to apply green financial tools such as green credit, green bonds, and green industry investment funds to establish diversified green financial funding sources such as governments, enterprises, and non-governmental capital to ensure adequate funding. We should give full play to the role of the market mechanism, adopt multiple approaches such as investment rewards, subsidies, guarantee subsidies, and loan interest discounts to mobilize non-governmental capital to participate in projects in environmental governance and ecological protection, encourage various non-governmental capitals to invest in the environmental protection market, and attract various types of non-governmental capital to invest in environmental protection, attract all kinds of capital to participate in the investment, building, and operation related to green and low-carbon circular development. Work should be done to guide banks and other financial institutions to provide preferential loans and preferential services for companies that adhere to green and low-carbon circular development, boost support, and grant low-interest loans and unsecured loans to key projects that are conducive to resource conservation and protection of the ecological environment. Measures such as restricting loans, suspending loans, and recovering loans are taken to force enterprises for green development. In addition, enterprises are encouraged to issue green bonds, raise investment funds through the bond market, and non-governmental capital is motivated to set up various environmental governance and ecological protection industrial funds.

Finally, establish and improve the public participation mechanism. The first is to encourage the public to participate in environmental supervision,

stimulate the enthusiasm and sense of mission of the public to participate in the practice of green and low-carbon circular development through mechanism innovation, expand the scope of public participation, and create favorable conditions for their participation in environmental supervision. It is necessary to combine the supervision and participation of the public, guarantee public participation in environmental supervision in accordance with the law, specify the environmental rights of citizens, improve various rules and regulations for the participation of all members of the society, standardize participation procedures, and expand participation channels. The second is to give full play to the active role of environmental protection social organizations and the guiding role of the news media to enhance the awareness of the public in environmental protection, strengthen the ecological environmental responsibility of the public, and mobilize the public for green, circular, low-carbon life and consumption, and actively maintain ecological security and protect the ecological environment. The third is to establish an environmental information disclosure mechanism to provide an information platform for the public to participate in the building of a green and low-carbon circular economy. Strengthen the regulation and guidance of corporate environmental information disclosure, and strengthen the corporate environmental responsibility. Make full use of multiple channels such as government bulletins, television, newspapers, the Internet, WeChat, and Weibo to disclose environmental information to the public.

3.5 Strengthen international cooperation and exchanges for green and low-carbon circular development

Turn green and low-carbon circular development into an important national image. Although there are different interest groups, religious beliefs, ideologies, and social systems in the world, ecological civilization will allow human beings to coexist peacefully and choose a common future for mankind in a rational manner. A community with a shared future for mankind is also a “community of life.” Advocating green development is not only a requirement for achieving the goal of harmonious and sustainable development between man and nature, but also an inherent requirement for

building a community with a shared future for mankind. Adhering to green and low-carbon circular development is not only about building a beautiful China, but also a solemn commitment to maintaining global ecological security, which demonstrates the responsibility of China as a major power. China must have a deep insight and precise grasp of the global ecological security landscape, assume its due international obligations, prioritize green development as a major part of the international image, and create an international model of green and low-carbon circular development.

Take the concept of green development as an important guiding principle for opening up. To this end, we should: *i*) integrate the concept of ecological civilization and green development into the opening-up strategy with the “Belt and Road Initiative” as the core, fully implement the principles of ecological environmental protection, resource conservation, and environmental friendliness, and improve green transformation in policy communication, facility connectivity, unimpeded trade, financing, and support from the public. Integrate the concept of green and low-carbon circular development into all aspects and the whole process of opening up, incorporate the concept of greenness in specific exchanges, project operation, and engineering construction, implement the concept of green development with practical actions, and promote the shift from old drivers to new ones in the world; and *ii*) in the process of opening up to the outside world, especially when conducting the “going global” strategy, share the ecological civilization and green development concepts and practices of China with other countries, strengthen ecological environmental protection. Such actions are conducive to enhancing the mutual understanding and support of governments, enterprises, and the public of countries along the route of the “Belt and Road Initiative”, providing sound services, support, and guarantees for the Initiative.

Promote the global sharing of the new green development model of China. The “Belt and Road” regions are mostly covered by developing countries and emerging economies, and they are generally facing multiple challenges such as environmental pollution and ecological degradation brought about by industrialization and urbanization. A growing need for accelerating transformation and promoting green

development is identified. Jointly advancing the building of a green “Belt and Road” with countries along the route of the “Belt and Road Initiative” is an inevitable choice for conforming to and leading the international trend of green, low-carbon, and circular development, and an effective way to strengthen the momentum of sustained and healthy economic development. It is necessary to further summarize the best practices of China’s green development, and promote the exchange and cooperation of green development experience in countries along the route of the “Belt and Road Initiative”. Efforts should be made to explore replicable green development models, promote green development products, technologies, standards, and models of Chinese characteristics to go global, and help the countries along the route of the “Belt and Road Initiative” to achieve their Nationally Determined Contributions (NDCs) and sustainable development goals to address climate change. This will be conducive to expanding China’s influence in the regional green development of the “Belt and Road Initiative”, and to promoting regional integrated development.

Strengthen the connection and collaboration with green industries and technologies from all over the world. The major western developed countries boast more experience and technology in the development of green industries, which is the focus of our exchanges, introduction, cooperation, and promotion. It is imperative to strengthen cooperation with major western developed countries in applying and promoting green industry technology and jointly build a global green industry system and standards. The developing countries along the route of the “Belt and Road Initiative” have similar development stages to China, therefore it is easier to reach a consensus on the choice of development path since their development needs and conditions are similar to those of China. A large number of advanced applicable technologies and industrial systems of China can provide countries along the route of the “Belt and Road Initiative” with a more meaningful development experience. To meet the targets, work should be done to: *i*) consult on an equal footing with countries along the route of the “Belt and Road Initiative” to jointly formulate plans and measures to promote the development and cooperation of green industries in different countries;

ii) optimize the construction of green infrastructure in countries along the route of the “Belt and Road Initiative” to establish a green ecological network that maintains the ecological environment and promotes economic development cooperation; *iii*) facilitate the trade of ecological products in countries along the route of the “Belt and Road Initiative”, reduce trade and investment barriers, and promote regional green economic integration; *iv*) strengthen green industry cooperation among countries along the route of the “Belt and Road Initiative”, jointly build industrial chains, and share value chains; *v*) promote the integration of green and low-carbon standards, and strengthen the transfer and transformation of green, advanced, and applicable technologies in developing countries in the “Belt and Road” region; *vi*) deepen cooperation in green technology, give full play to the advantages of talent gathering and technological innovation, promote the transformation from the cooperation in “advantageous production capacity” of traditional industry to green “new production capacity”; and *vii*) promote the cooperation mechanism for co-building ecological environmental protection research and development platforms, technology sharing, and risk sharing to provide technical support for the ecological environment along the route of the “Belt and Road Initiative” and the high-quality development of the country.

Actively participate in global environmental governance. Currently, global unilateralism, protectionism, and populism are prevalent, and room for international cooperation is limited. However, ecological and environmental issues such as responding to climate change and protecting biodiversity are still important windows for China to participate in global governance. The Conference of the Parties to international conventions related to climate change and biodiversity has been postponed due to the Covid-19 pandemic, which presents both challenges and opportunities. China is capable of leadership in issues such as climate change and biodiversity. We should take this opportunity to pursue global ecological civilization, involve in global environmental governance, identify solutions to the world’s environmental protection and sustainable development and guide international cooperation in response to climate change.



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