

Impact of the Development of a Low-Carbon Economy on Global International Trade

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Abstract. With the continuous development of human society, the high intensity of energy use has caused serious damage to the environment. Due to the aggravation of ecological problems, governments have gradually set their eyes on balancing economic development and environmental protection. In this context, the "low-carbon economy" emerged and became the keyword in the new policies introduced by governments around the world. However, along with the introduction of low-carbon policies in various countries, its significant impact on international trade has also begun to emerge. Due to the different national conditions and backgrounds of various countries, how to develop a low-carbon economy and how to develop international trade under the background of a low-carbon economy has become one of the key research topics of all countries in the world. By discussing the development of a low-carbon economy and its relationship with international trade, a feasible new strategy of international trade development under the background of low low-carbon economy is proposed.

Keywords: Low-carbon economy, international trade, green energy, international synergies.

1. Introduction

With the gradual development of human society, the process of industrialization is accelerating, and the use of fossil energy by mankind is gradually increasing. While bringing about rapid economic development, the massive use of fossil energy has caused environmental problems, such as global warming, serious air pollution, frequent unusually severe weather, increased desertification of vegetation, serious soil erosion, and an increase in the number and youthfulness of difficult diseases. Even Antarctica, which is far away from human life, has been affected, with the surface of the Antarctic ice cap melting over an area of 2,634,000km², or about 19 percent of the total Antarctic area in the short decade. Many of the ice shelves are experiencing runaway melting, with around 25 percent of the region's ice in danger of collapsing. As far away as the Arctic Circle, Greenland's ice sheet is not only melting, but it is melting faster than ever, with ice disappearing at four times the rate it did in 2003. The melting of large numbers of glaciers and ice shelves will lead to a rise in sea level, resulting in some cities at lower elevations becoming "underwater cities". Governments are beginning to reflect on the balance between economic development and healthy human life, asking whether it is worth damaging people's living environment for the sake of economic development and whether the existing development model needs to be improved and optimized.

As early as 2003, as a pioneer of the industrial revolution, the United Kingdom fully realized the importance of the climate issue, and for the first time put forward the concept of a "low carbon economy" in the UK energy white paper "Our Energy Future: Creating a Low Carbon Economy". In 2006, former World Bank chief economist Nicholas Stern led the Stern Report, which called for a global transition to a low-carbon economy. Low-carbon economy has become an important theme of global concern and discussion and has attracted the attention of various countries. The United Nations has proposed a development framework and emission reduction targets for a low-carbon economy. In this context, a series of new concepts such as a "low carbon economy" with low energy consumption, low emission, and low pollution as the core concepts have come to the public eye and the political arena, and countries have accordingly introduced many new regulations and policies to explore the paths to develop a low carbon economy. Due to the differences in national conditions, technology, capital, and other aspects, the development path is also different. At the same time, the

"low carbon economy" has brought different impacts on countries' participation in international trade. Based on this background, the research of the characteristics of the low-carbon economy, the conditions for the realization, and the implementation of the path, for the development of low-carbon economy in different countries has a better exploration significance and guiding significance. By researching the importance and urgency of the development of a low-carbon economy, exploring the ways to develop a low-carbon economy, and exploring the impact of a low-carbon economy on international trade, this paper puts forward feasible suggestions for promoting the development of a low-carbon economy, strengthening cooperation and exchanges among countries, promoting the growth of international trade, and improving the economy and the living environment of human beings.

2. Background to the Emergence of the Concept of a Low-Carbon Economy

Low-carbon economy is a new form of economic development, which refers to the mode of economic development that takes the form of reducing carbon emissions. The dominant mode of development in the past industrialized era was the use of high-carbon energy sources such as coal and oil, with high carbon emissions. However, the low-carbon economy minimizes the consumption of coal, oil, and other high-carbon energy, and more use of low-carbon energy such as wind, hydropower, and photovoltaic for production, which can reduce the greenhouse gas emissions caused by carbon, and reduce the pollution of the air and the impact on the climate, to achieve economic and social development and ecological and environmental protection of win-win economic development pattern [1]. Although high-carbon energy sources represented by natural gas, and oil, are still an important basis for the development of an industrialized economy, their large-scale use has brought great damage to the global ecological environment. High carbon emissions cause a dramatic increase in the concentration of carbon dioxide in the air, which can adversely affect the climate, natural environment, and human health. According to European satellite measurements of Antarctic Sea ice in 2023, the area of Antarctic Sea ice is only 11.7 million square kilometers, about 2.6 million square kilometers less than the 1981-2010 average. Satellite data in the Arctic show Arctic summer ice has reached a level of 13% reduction per decade since 1979. The U.S. Center for Atmospheric Research predicts that summer ice in the Arctic Ocean could disappear completely by 2024 and that the Arctic could see ice-free summers for decades to come. The United Nations has warned that extreme weather such as heat waves, high temperatures, droughts, and hurricanes will become more commonplace in the future.

To cope with the harm caused by climate change to human beings, the whole world is advocating the development of the economy in a low-carbon emission way, to reduce the pollution of the air and the adverse impact on the climate and human health life. As early as 1896, the Swedish physical chemist Svante August Arrhenius published a paper on "The Influence of Atmospheric Carbon Dioxide on the Earth's Temperature", which for the first time put forward the idea that "the emission of carbon dioxide into the atmosphere by human beings will cause the earth's surface to warm up continuously. The idea that "human emissions of carbon dioxide into the atmosphere will cause the Earth's surface to warm continuously" was put forward. Moreover, the United Nations has established the Intergovernmental Panel on Climate Change (IPCC), which conducts specialized research and risk assessments on climate change. The States Parties also adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, which has given impetus to countries around the world to take effective measures to reduce carbon emissions. Not only that, the United Nations pushed the parties to sign the Kyoto Protocol in 2005, which specifies the emission reduction targets of each country; In 2015, the countries of the world signed the Paris Agreement, which defines the emission reduction responsibilities and milestones undertaken by each country. Therefore, a low-carbon economy is a key means to solve this issue, and how to make use of appropriate ways to carry out industrial transformation and optimize the energy structure has become a significant issue for countries around the world.

3. Different Development Paths for a Low-Carbon Economy

The low-carbon economic development pathway to reduce carbon emissions mainly includes the following aspects: first, controlling and reducing the carbon emission levels of existing industrial production patterns; second, increasing the proportion of new low-carbon energy production and improving the production and economic structure, so that overall carbon emissions will continue to decrease. They are thirdly, expanding the area of greening or adopting carbon conversion technologies to absorb or convert carbon so that the carbon content of the air will tend to decrease as a result of absorption and conversion.

3.1. Controlling the Level of Carbon Emissions from Existing Industries

Industrialization has developed over hundreds of years. The utilization of high-carbon energy sources such as oil and gas has become the dominant pattern, and it will be difficult for countries to achieve the cessation of their use in a short period. Therefore, the Government should first control the existing level of carbon emissions. This involves investment in the following areas: first, increase equipment investment, such as increasing the exhaust gas tower, activated carbon adsorption equipment, such as plasma exhaust gas treatment equipment, etc., in the exhaust gas emissions before a greater degree of purification, to achieve "emission reduction". Second, the application of new technologies to control the level of carbon emissions. By improving the production and manufacturing processes, as far as possible, the implementation of harmless or low-hazardous production and processing of raw materials, improve production control capabilities, increase the recycling of carbon dioxide, and reduce the level of carbon emissions. Thirdly, by adjusting the production layout and realizing intensive production, small and medium-sized production enterprises that are incapable of controlling carbon emissions will be shut down, and the carbon targets will be transferred to large enterprises, to implement large-scale production and comprehensive and effective control of carbon emissions. For example, the Western Climate Initiative of the United States and Canada has established a comprehensive carbon market that includes multiple industries, which entered full operation in 2015 and covers 90 percent of the country's greenhouse gas emissions, achieving a 15 percent reduction in emissions by 2020 compared with 2005. Cross-border cooperation can also increase the size of the market and reduce the cost of emission reductions. During the 2020 epidemic, China closed more than 10,000 small and medium-sized chemical companies to reduce carbon emissions and also achieved better results by expanding large coal companies to replace the production of small and medium-sized ones, and by acquiring small and medium-sized companies through the merger and acquisition of large iron and steel companies to intensify their operations.

3.2. Vigorous Development of New Energy Economic Models

Aware of the adverse impact of the high-carbon model on economic development, climate, and people's lives, countries have begun to pay attention to the application of low-carbon new energy sources, and are vigorously developing non-petrochemical wind power, hydropower, photovoltaic, and other green energy sources. Taking China with high carbon emissions as an example, in terms of wind power generation, the new installed capacity of 55.92GW, an increase of 2.7% year-on-year; the cumulative installed capacity of 346.7GW, an increase of 19.2% year-on-year, to maintain stable growth. In 2022, the national wind power, photovoltaic power generation installed capacity exceeded 120 million kilowatts, for the third consecutive year exceeded 100 million kilowatts. Wind power and photovoltaic power generation exceeded 1 trillion kilowatt-hours, reaching 1.19 trillion kilowatt-hours, an increase of 21% year-on-year, accounting for 13.8% of the total electricity consumption of the whole society, close to the national urban and rural residents living in the country's electricity consumption. By the end of 2021, China's installed hydropower capacity will be about 391GW, accounting for about 16.4% of the country's total installed power generation capacity, with a new addition of 23.49GW. Along with China's social consumption of electricity and optimization of the

energy structure, the country's demand for electricity is still growing, and the space for the development of new energy sources will remain vast in the future.

3.3. Expansion of Green Areas

According to research, forests absorb 1.8 tons of carbon dioxide for every cubic meter of wood grown through photosynthesis. With an average of 41 tons of carbon sequestered per hectare of forest and 3.46 tons of carbon sequestered per hectare of grassland, increasing the area of greening is a significant contribution to reducing carbon emissions.

According to the report released by the Chinese Academy of Sciences, over the past decade, the global terrestrial ecosystem absorbed an average of 13.7 billion tons of carbon dioxide per year, of which China's terrestrial ecosystem absorbed 1.3 billion tons per year, accounting for one-tenth of the global total. For example, China has fixed nearly 400 million tons of carbon dioxide annually due to the implementation of large-scale afforestation ecological projects. This shows that expanding green areas is also a high potential way to reduce carbon emissions [2]. According to NASA and Nature reports, China's forest coverage rate has increased from less than 10% 60 years ago to 24.2% at present, and China's afforestation work contributes up to 42% to global greening.

3.4. Research and Application of Carbon Conversion Technology

In addition to the conventional use of new energy sources and research into new means of reducing emissions, carbon conversion is a potential means of reducing carbon emissions. Carbon conversion technologies such as bio-enzyme technology, and plant and microbial sources of soil organic carbon conversion technology, are carbon conversion technologies with great potential, which can capture carbon elements and convert them into harmless materials. Taking bio-enzyme technology to realize carbon conversion as an example, research has proved that we are expected to achieve more stable and efficient carbon conversion by modifying carbon sequestering enzymes in natural carbon sequestration pathways or using artificial organisms with highly efficient carbon sequestering enzymes, coupled with the use of more efficient and stable catalysts [3].

Governments can also reduce carbon emissions by compression burial of CO₂. For example, China has a large potential for geological storage of CO₂, and the deep saline aquifer can be used as the main storage space to sequester the captured CO₂, which can form a 100,000 tons/year CO₂ geological storage technology system [4]. Among them, the result shows that through the geological storage of carbon dioxide in the saline aquifer or carbon dioxide water-driving technology, the geological storage of carbon dioxide in the Junggar basin can be realized up to $480 \times 10^8 \sim 1640 \times 10^8$ tons.

The transformation of old energy sources, the application of new energy sources, greening and ecological projects, as well as carbon conversion, on the one hand, relies on people's heightened awareness of the importance of a low-carbon economy; on the other hand, requires a large amount of investment in capital, technology, and equipment. In terms of capital investment, the bill passed by the United States in 2021 will invest nearly \$500 billion in government support in the field of green sustainability over the next 10 years, and together with social investment, the total amount will reach \$7 trillion. According to China's carbon emission control target, the average annual investment scale will reach US\$1.5 trillion, and to reach the carbon peak target in 2050, the cumulative increase in investment funds will need to be about US\$40 trillion. The capital market has also begun to participate deeply in the carbon market investment, Wall Street's Morgan Stanley, Goldman Sachs, and other financial institutions and more than a dozen investment institutions set up a climate risk investor network to promote analysts, rating agencies, and investment banks to invest in the carbon market risk of research. The network already has more than 80 institutional investors in the market with total assets of \$8 trillion. Europe set up the world's largest carbon emissions trading system in 2005, mainly trading carbon emission allowances, and its total trading value is up to 750 billion euros in 2022, accounting for 87% of the total global carbon emissions trading (Lufthansa data). The capital market provides sufficient financial support for the prosperous development of the carbon trading market.

The development of a low-carbon economy leads to the need for countries to increase investment in large amounts of equipment. For example, wind turbines required for wind power generation, including wind wheels, generators, and towers, are high-tech, high-quality, large-scale equipment that requires large investments, including costs for purchase, installation, and maintenance. For example, wind wheels need to be strong and lightweight mostly made of glass fiber reinforced plastic or other composite materials, such as carbon fiber, in addition to the need to attach a gearbox and governor to increase the speed to maintain a constant rotational speed; towers need to be constructed to be higher than the average ranging from 6 to 20 meters high. The production of solar panels for photovoltaic power generation requires oversized monocrystalline or polycrystalline silicon and other materials, solar energy conversion technology, electrical energy storage equipment, electrical energy transmission technology and equipment, and so on. The investment in hydropower is even more enormous, requiring the construction of dams, large-scale power generation equipment, power transmission lines, and equipment, a huge amount of investment.

The purchase of patents and the introduction of talent are also indispensable channels for the development of a low-carbon economy. Wind power, photovoltaic power, and hydroelectric power, all of which require specialized high-tech, high-quality equipment, are not available in different countries, so it is necessary to bring in specialized technology and training from the countries that have patented the technology. Moreover, a large number of specialized personnel are required for the production and manufacture of the equipment, as well as for installation, commissioning, maintenance, and operation.

4. The Role of the Low-Carbon Economy in International Trade

4.1. Low-carbon Economy Provides New Development Opportunities for International Trade

The development of a low-carbon economy relied on new energy technologies, which means that Governments were bound to invest more in capital, technology, equipment, and land. Due to the imbalance of resources and different R&D technological capabilities among countries, developing countries may not have all the technologies, resources, and experience required for a low-carbon economy, so the transformation of a low-carbon economy is a task for governments around the globe, not for individual countries. Globally, Europe and the United States have strong technological strength, and because of their well-developed capital markets, they can raise funds through the issuance of stocks and bonds and syndicated loans, so they have a strong financial advantage; while the Asia-Pacific region has a strong production capacity and resource advantage. In terms of photovoltaic power generation, more than 80 percent of the world's photovoltaic modules are produced and supplied by China.

According to statistics, China's market share of photovoltaic products ranked first in the world, with photovoltaic modules accounting for 75% of the world, batteries accounting for 80% of the world, and silicon wafers accounting for as much as 95%. More than 60% of China's photovoltaic products are sold overseas (mainly to Europe). In 2022, China's total exports of photovoltaic products exceeded US\$51.2 billion, an increase of 80.3% year-on-year, while in the first half of 2023, exports exceeded US\$29 billion, with exports showing rapid growth over the years. Countries are interconnected and co-operating in the development of a low carbon economy, which greatly contributes to the growth of global trade [5]. Taking China and Europe as an example, the bilateral trade volume between China and Europe reached 856.3 billion euros in 2022, a year-on-year increase of 23.1 percent, mainly relying on the rapid growth of trade in lithium batteries, new energy vehicles, photovoltaic modules, and other green products. It also drives the growth of overseas investment, with European investment in China of \$12.1 billion in 2022, up 70% year-on-year, and Chinese investment in Europe of \$11.1 billion, up 21% year-on-year. As the low-carbon economy continues to grow, the volume of global trade will gain immeasurable momentum.

4.2. Low-carbon Economy Will Enhance the Quality of International Trade

The low-carbon economy has put forward new and higher requirements for traded products, and once countries comply with this requirement, the production of traded goods will certainly be made to meet the requirements of the low-carbon economy, and a considerable portion of the original raw material-based roughly processed products may not be able to meet the requirements of the low-carbon economy. To achieve low-carbon trade, it is necessary to enhance the technical content and standards of products, which will inevitably promote the enhancement of trade product quality, thus improving the overall level of trade.

While improving the quality of trade, new barriers to trade may also emerge. For example, as greenhouse gases and carbon emissions issues become the focus of world attention, more countries and regions require that import and export products must be marked with low-carbon labels, products in the entire manufacturing as well as recycling process caused by the emission of greenhouse gases, which need to be quantified ultimately reflected in the label. Goods that do not meet the requirements will not be able to be exported, which will become a new type of barrier in international trade [6]. If the carbon emissions of the products exceed the standard, it will be possible to be charged with additional carbon tariffs, which increases the cost of trade and hurts the promotion of trade [7]. If the low-carbon economy becomes a consensus for global development, it is believed that all countries will be able to commit themselves to meeting low-carbon requirements and thus overcome trade barriers.

4.3. Low-carbon Economy Advances Changes in the Structure and Pattern of International Trade

The low-carbon economy is also driving trade patterns in many countries, as countries pay more attention to low-carbon and environmentally friendly issues. As mentioned earlier, if products are to be sold in other countries, they will need to be labeled as "low carbon", otherwise they will be subject to carbon tariffs, and may lead to consumer boycotts [8]. Countries that have made the transition earlier are likely to have stronger and more advanced energy-saving and emission-reduction technologies, which will make it easier for them to produce qualified products for export, giving them a first-mover advantage. However, developing countries also have the advantage of some original green resources, especially agricultural products, and handicrafts with low-carbon characteristics, which can turn a disadvantage into an advantage. Alternatively, developing countries can have a latecomer's advantage by purchasing large quantities of materials, equipment, resources, and technology to facilitate their transformation and optimization of their energy structure, introducing low-carbon technologies to improve their economic development model, and avoiding the accumulation of high carbon emissions brought about by industrialization [9]. The development of a low-carbon economy has changed the global trade pattern and structure to a certain extent, and will eventually have a positive impact on the quality and structure of international trade [10]. It can be seen that the low-carbon economy can not only promote trade development but also improve the level of trade development.

5. Conclusion

Based on the above analyses, this essay puts forward the following three policy recommendations to promote the development of a global low-carbon economy. Firstly, raise the awareness of all countries in the world of the importance and urgency of developing a low-carbon economy. Through signing various international cooperation agreements on low-carbon transition, governments should endeavor to reach low-carbon development goals that align with each country's national conditions, and step by step promote the development of the low-carbon economy. Secondly, developed countries should step up their efforts to implement low-carbon economic measures, to make a good global demonstration effect, become role models for all countries to follow, and accumulate all kinds of experience for the reference of other countries, so that they can make less detours. Finally, developed

countries have the responsibility to help developing countries implement a low-carbon economy. As developed countries have achieved industrialization ahead of schedule, they have a higher standard of living and possess stronger technological strength and financial advantages, while developing countries do not have all the conditions for a low-carbon economy, especially difficulties in terms of technology and financing. Therefore, developed countries had a responsibility to provide the necessary technical and financial support to help developing countries accelerate the pace of development of a low-carbon economy.

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