

# Analysis of the energy trade game between major countries under the background of "carbon neutrality": A case study of the photovoltaic industry in China and the United States

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**Abstract.** With the global climate change poses a major threat to human society, more and more countries begin to "carbon neutral" as a national strategy. As a major country in the global carbon emissions, China and the United States focus on the development of the clean industry - photovoltaic industry to increase investment, in order to deal with global climate problems. At the same time, China and the United States for the photovoltaic industry game also presents a two-way interaction situation, on the one hand, the two countries for the "carbon neutral" energy strategy affects the two countries' trade borders, on the other hand, the two countries' trade strategy also affects the global "carbon neutral" process. This article will be based on the current stage of the two sides of the energy use, the development of photovoltaic industry strength comparison and other aspects of the photovoltaic energy game between China and the United States to discuss.

## 1 Introduction

### 1.1 Background of "carbon neutrality"

At present, countries are emitting about 51 billion tons of greenhouse gases into the atmosphere every year, and these greenhouse gases have a serious impact on the global climate and ecological environment. In order to avoid severe climate disaster, the Paris Agreement signed by many countries in Paris requires the parties to the United Nations Framework Convention on Climate Change to immediately specify nationally determined contributions to mitigate climate change, peak carbon emissions as soon as possible, and zero net carbon emissions by mid-century. To achieve by the end of this century, the global surface temperature relative to the pre-industrial Revolution rise of 2 degrees Celsius. In addition, since the reform and opening up, China's manufacturing industry continues to take off behind the need for more energy support, the use of traditional fossil energy in the decline of air quality, but also because of the inadequate use of energy restricts the further development of China's manufacturing industry. As the largest developing country and the largest coal consumer in the world, China's carbon emissions peak as soon as possible and work with other countries to achieve net zero carbon dioxide emissions by the middle of this century are of Paramount importance to global climate response. To this end, in 2020, based on its inherent requirements for sustainable development and its responsibility to build a community with a shared

future for mankind, China announced the goal and vision of carbon peak and carbon neutrality.

### 1.2 Changes in energy industry structure guided by "carbon neutrality"

In order to achieve the goal of "carbon neutrality", China has proposed to take low-carbon energy as the starting point, optimize the energy structure, promote the clean and efficient use of coal, rationally develop natural gas, safely develop nuclear power, vigorously develop hydropower, wind power, solar energy, biomass and other non-fossil energy generation, produce and utilize green hydrogen energy, and improve the capacity of energy transmission and distribution networks and storage facilities. To build a safe, clean, low-carbon, efficient and economical energy system energy development path [1].

Under the vision of "carbon neutrality", the development idea of traditional energy is mainly "low carbonization", starting from the aspects of improving energy utilization rate, using chemical means such as secondary combination, and recycling combustion products, etc., to carry out the "carbon reduction" utilization of traditional energy.

The clean energy development goal will be based on the "new energy" + "smart energy" system, so that it has the characteristics of intelligent, clean and efficient energy system, through the energy form will be from high carbon emissions of fossil energy to low carbon or no carbon emissions of new energy; In terms of energy technology, the transformation and upgrading of the

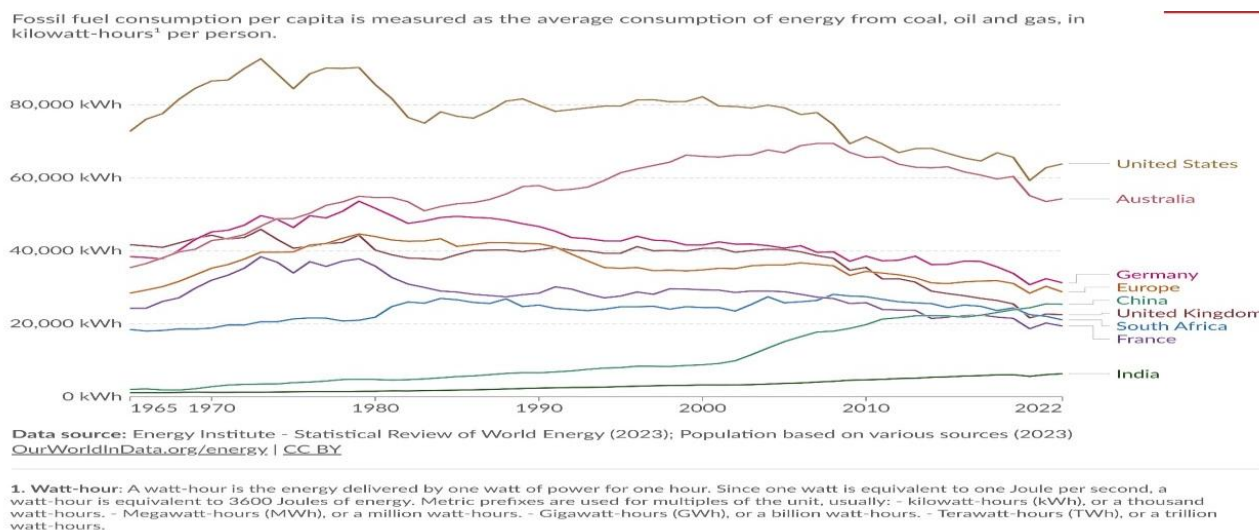
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energy resource-based market into an energy technology-based market, the use of technological innovation to make up for the lack of energy reserves and other means, the carbon neutral science proposed "energy saving and efficiency", "low-carbon fossil energy", "clean energy scale", "electrification of terminal energy use", "intelligent energy system" and other carbon reduction paths are gradually implemented. Is the only way to achieve carbon neutrality [2, 3].

## 2 Comparison of energy situation between China and the United States

### 2.1 Energy use in China and the United States

With the rapid development of the global economy, energy consumption has become an important support for national economic development. China and the United States occupy a pivotal position in the world energy consumption market.



**Fig. 1.** Per capita consumption of fossil energy in major countries and regions of the world, 2023 [4].

As Figure 1 shows, overall, China's total energy consumption has continued to increase over the past decade, and the growth rate has been relatively fast. In contrast, total energy consumption in the United States is also increasing, but at a relatively slow pace. This is mainly due to China's rapid economic development, which has led to its growing demand for energy. At the same time, the United States is paying more attention to technological innovation and the development of clean energy, and its energy consumption structure is gradually transforming to clean.

From the perspective of energy consumption structure, in order to meet domestic production needs and improve its power generation, transmission and storage capacity, China still takes fossil fuels as the main energy, that is, traditional energy such as oil, natural gas and coal. The United States, due to its rapid development of science and technology and the perfect development of high-end industries in the local, pays more attention to the development and application of clean energy, and clean energy also accounts for a large proportion in the country's energy consumption.

From the perspective of per capita energy consumption, China's per capita energy consumption is relatively low and growing fast. Due to the large population base of China, the resources per capita are relatively small. In contrast, the United States has a higher per capita energy consumption, which also reflects the differences between the two economic development models and paths.

### 2.2 Development of photovoltaic industry in China and the United States

As an important part of clean energy, the photovoltaic industry has been widely developed and applied in the world. According to the "World Energy Outlook" report released by the International Energy Agency (IEA) and relevant public information, this paper makes a comparative analysis from the macro perspective, the production of photovoltaic components in the country, the proportion of photovoltaic enterprises in the global energy industry, and the export of photovoltaic components overseas, in order to have a more in-depth understanding of the development of the photovoltaic industry in the two countries.

From a macro point of view, China's photovoltaic industry has developed rapidly in the past decade. China's PV installed capacity continues to increase, and the growth rate is relatively fast. In contrast, the growth rate of the photovoltaic industry in the United States is relatively slow. The reason is that China's huge population size, the vast domestic consumer market has led to its huge demand for energy, in the past few years, by the epidemic and the changes in the international situation such as the Russia-Ukraine conflict, oil and gas and other traditional energy import costs continue to rise, but the application of the photovoltaic industry is limited to lower-end models at scale.

From the perspective of photovoltaic components and other production in the country, in China, the photovoltaic industry has a very wide range of

applications, including the production of solar panels, installation, power generation and other fields. Among them, the production of photovoltaic panels is one of the largest markets, accounting for nearly 70% of the global market share. In addition, China is also actively promoting the construction and operation of photovoltaic power plants to improve the efficiency of renewable energy utilization. The United States focuses on the development of cutting-edge technologies in the photovoltaic industry, and there is still a certain distance for the mass production and large-scale market use of high-end photovoltaic components.

In terms of the global proportion of photovoltaic enterprises, with the strong support of national policies, China has emerged in the solar panel manufacturing and research and development area, a number of high-end photovoltaic enterprises with a high technical level and market share, such as Longi Shares, JA Technology and other enterprises in the global market have a high visibility and influence. The United States' First Solar (First Solar) ranks seventh among global photovoltaic module manufacturers and is one of the world's leading solar photovoltaic module manufacturers. Unlike the Chinese PV companies, First Solar is taking the thin-film solar cell route.

Starting from the export of photovoltaic components overseas, in the past decade, China has been one of the world's largest exporters of photovoltaic components. With the increasing demand of the domestic market and the continuous improvement of the technical level, the export value of China's photovoltaic components is also rising year by year. Among them, the export volume of key components such as silicon wafers and battery wafers is large, leading the global photovoltaic industry trading market. In order to limit the further development of Chinese enterprises in the international photovoltaic industry, the United States said that photovoltaic components produced in China and photovoltaic components "with Chinese ancestry" are applicable to the "Section 301" when imported, in order to suppress the Chinese photovoltaic industry and maintain local enterprises.

### **3 Sino-us energy trade game with photovoltaic industry as the core**

#### **3.1 The Sino-US energy trade game leads to changes in the international power pattern**

From the coal era to the oil and gas era, the transformation of energy structure has been the driving force for the change of international power pattern. With the proposed goal of "carbon neutrality", the historic substitution of clean energy for fossil energy is accelerating, and mankind is entering a new era of electric energy. This shift not only has a profound impact on the environment, but also brings new challenges and opportunities to the international political, economic and security landscape.

In the oil and gas era, the United States ensured its dominant position in the international oil and gas

political game by controlling key oil and gas producing areas and establishing the petrodollar system [5]. However, as the goal of carbon neutrality advances, this power structure is changing. On the one hand, the geopolitical influence of traditional fossil energy exporters and international organizations that depend on these resources is gradually diminishing [6]. On the other hand, because clean energy is widely distributed and resources are relatively even, most countries are able to secure their own energy supplies, thus greatly improving energy security.

Although the United States retains technological advantages in certain "carbon neutral" technologies, such as carbon dioxide capture and electrochemical energy storage, these technologies are still far from commercial application. China, by contrast, has made remarkable progress in renewable energy. Taking the photovoltaic industry as an example, China not only occupies a global leading position in output, but also has made major breakthroughs in technology research and development and market application.

With the influence of multiple factors such as economic globalization, political integration, and the continuous development of China's photovoltaic industry, the American hegemonic system dominated by oil and gas resources continues to decline, but the energy game between China and the United States may be in a strategic balance for a long time. On the one hand, the US is likely to remain ahead in some areas of technology; On the other hand, China's technological and industrial advantages in the field of renewable energy will be further highlighted. This balance is not only conducive to the cooperation and competition between the two countries in the energy field, but also may become an important factor in stabilizing the global energy political pattern. In this context, countries need to re-examine their policies and strategies to adapt to this series of changes.

#### **3.2 The Sino-US energy trade game leads to changes in the international trade pattern**

At this stage, the turnover of international fossil energy trade accounts for about 15% of the total global trade [7]. In the future, affected by the global "carbon neutral" development strategy, this part of the market share will be gradually replaced by the solar photovoltaic industry, hydrogen energy, combustible ice and other clean energy. Based on its own development needs and long-term strategic vision, China has established diversified import channels for oil and gas resources to ensure domestic energy security. In 2020, China's import of oil and gas resources is about 270 billion US dollars, accounting for about 13% of China's total annual import. In the same period, China's photovoltaic product exports were about 20 billion US dollars, and the cumulative installed capacity and new installed capacity continuously ranked first in the world [8]. At present, the year when most countries are expected to reach the "carbon peak" is gradually approaching, the global market demand for clean power equipment will continue to increase, and the

market prospects at home and abroad are very broad. This also points out the development direction for China's photovoltaic industry. With the gradual depletion of traditional oil and gas energy and the continuous optimization and adjustment of energy consumption structure of various countries, if China and the United States still basically maintain the current energy trade structure, the United States, which focuses on oil export industries such as Mobil and Shell, will further aggravate its trade deficit.

The proposal of the EU's carbon border regulation mechanism highlights the far-reaching impact of climate policy on international trade. The implementation of this mechanism will directly affect the export of electricity, steel, cement, aluminum and fertilizer to the European market in five areas. This not only means that the products of these industries need to meet new requirements on carbon emission standards, but also may trigger the implementation of a global carbon tax, thus changing the pattern of international trade [9].

With the decline of oil and gas trade, the global energy mix is undergoing profound changes. Traditional oil and gas trade routes, such as the Straits of Hormuz and Malacca, are becoming less important. In contrast, the construction and interconnection of regional power grids is becoming a new focus. This not only means that countries in the region will become more dependent on each other for energy supplies, but it could also lead to a reshaping of the global political landscape. Countries such as the United States, Japan and the European Union have been promoting the construction of regional power grid interconnection. The rise of power infrastructure not only provides countries in the region with a more stable and efficient energy supply, but also may become a new field of competition among great powers [10, 11, 12].

### **3.3 Sino-US energy trade shows a "Two-Way Interaction" situation**

Taking "carbon neutrality" as the development strategy will not only bring a new round of revolution in the development of the energy field, but also affect the global trade border and economic pattern to a certain extent, and change the current global power pattern. In today's world, there will be a two-way interaction between "carbon neutrality" and the international political landscape with climate diplomacy as an important factor.

#### **3.3.1 "Carbon neutrality" affects the Sino-US energy trade border**

##### **(1) Increased risk of trade conflicts**

With the gradual withdrawal of traditional fossil fuels, Sino-US oil and gas-related trade is likely to decline at this stage. In the long run, countries will adopt a series of policy measures to achieve the goal of "carbon neutrality", some of which may go beyond the simple climate scope and have an impact on trade, economic and other issues. This could lead to a trade conflict between the two countries, particularly in the area of a

low-carbon economy. For example, Mr Biden's proposed carbon tax on some high-carbon imports could hurt the competitiveness of Chinese exports. If the United States agrees to the carbon border adjustment mechanism proposed by the EU, it will further link international trade and carbon emissions, increasing the risk of trade conflicts around carbon emissions on a global scale.

(2) New points of conflict regarding overseas infrastructure investment.

In a "carbon neutral" era, infrastructure investment is critical to achieving emissions reductions. Developing countries have huge investment needs, and the competition between China and the United States in this area is becoming increasingly prominent. The Building a Better World Initiative (B3W) proposed by the United States is intended to counterbalance China's Belt and Road Initiative. While the specifics of how B3W will be financed and carried out are unclear, the United States has demonstrated its ambition to compete with China in overseas infrastructure investment. Such competition may give rise to new points of conflict and affect the cooperation and exchanges between the two countries in this field.

#### **3.3.2 The Sino-US energy trade strategy affects the global "carbon neutrality" process**

As the world's largest economies, China and the United States play a pivotal role in technology research and development, equipment manufacturing and business model innovation. The United States is known for its advanced research and development capabilities and innovation system, especially in the digital information technology and digital technology industry has a strong strength, and has a number of globally competitive leading enterprises and rich market experience. In addition to China's remarkable technological and industrial advantages in the fields of photovoltaic, battery and electric vehicle manufacturing in recent years, it also relies on its complete manufacturing system and huge market size to make full use of the advantages of scientific and technological industrialization and economies of scale to reduce the cost of energy conservation, emission reduction and pollution reduction.

Looking ahead, China and the United States have formed many potential complementarities in the field of renewable energy, namely, China's strong wind equipment industry and manufacturing capacity, the potential huge demand of their respective markets, as well as the United States in the intelligent, materials and other aspects of high-end research and development capabilities. Once these advantages are combined and cooperation obstacles and blockages are removed, China and the United States will carry out joint technological research and development in green industries, reduce trade barriers, encourage mutual investment, and exchange and coordinate industrial policies and standards, which will greatly reduce emission reduction costs and accelerate the global and bilateral energy transition. Achieve a win-win situation of climate change mitigation, industrial and economic green development

for both sides and even the world [13]. To ensure the well-being of mankind, China and the United States should go hand in hand, actively engage in dialogue, jointly promote global energy transformation, and create a new situation of green economic development.

## 4 Conclusion

The "carbon neutrality" strategy is still in its infancy, and it will redefine the relations between major countries in the future and have a profound impact on the international pattern. However, at the same time, the diversified path to achieve "carbon neutrality" should not be divorced from the current political situation, and the objective development law focusing on promoting global economic development and building a community with a shared future for mankind must be firmly grasped.

As important economies in the world, China and the United States play an increasingly prominent role in global climate governance, and their "carbon neutral" actions will have a decisive impact on global climate change. This makes cooperation and competition between the two countries in the field of climate especially critical. On the one hand, the climate issue may further exacerbate strategic tensions between China and the United States and expand the scope of strategic competition between the two sides. On the other hand, it also provides a new cooperation platform for the two sides to find new points of cooperation by jointly addressing the challenges brought by climate change, and thus inject new vitality into China-US relations. However, the development of things is always in twists and turns, in the context of "carbon neutrality", Sino-US relations are also facing a series of risks and challenges. With the growing competition between the two sides in trade, investment and other areas, the climate issue may become a flashpoint for more economic and trade frictions. Especially in the field of overseas infrastructure investment, the two sides may engage in fierce competition for resources and market share. Such competition is likely to further fuel bilateral recriminations, undermining the already fragile political trust between China and the United States.

Despite the many challenges, China and the United States share the same long-term vision and goals in addressing climate change. With the return to the political scene of former key figures in climate cooperation, the possibility of climate engagement between the two sides has increased. This is not only expected to ease tensions in Sino-US relations in the short term, but may also become an important means to manage the risk of further decoupling of relations between the two sides. In the long run, climate cooperation has the potential to transcend the political disturbances brought about by the change of parties in the United States and become an important pillar of stable Sino-US relations.

In addition, if China and the United States can carry out healthy competition in low-carbon technology research and development and "carbon neutral" business models, jointly guide global climate governance, reduce

the cost of countries to achieve "carbon neutrality", and accelerate the process of "carbon neutrality", it will be of great significance to maintain global climate political stability.

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