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Comparative Policy Analysis of PV Industry Development: Case Studies of China and the United States

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Abstract. With global climate change, energy issues have evolved into critical global concerns. The development and utilization of new energy sources have garnered widespread attention, making large-scale advancements imperative. Solar photovoltaics, as one of the more mature sectors within the new energy landscape, have been particularly notable in recent years. By 2024, numerous countries have established comprehensive legal frameworks and policies for the new energy industry, forming robust industrial systems. Despite the rapid development of the solar photovoltaic industry, numerous challenges persist. This article examines the development conditions and current state of the solar photovoltaic industry in China and the United States, focusing on three key aspects: economy, policy, and technology. By comparing and analyzing these dimensions, this study aims to identify similarities and differences between the two countries, explore the underlying reasons, and evaluate the strengths and weaknesses of each nation's solar photovoltaic sector through quantitative analysis. Based on this analysis, this study will make predictions regarding future developments. Finally, this study will provide a well-founded outlook on the future of the solar photovoltaic industry in China and the United States.

Keywords: Solar Photovoltaic Industry; New Energy; Economy; Policy; Technology.

1. Introduction

In recent years, the energy issue has developed into a global problem, radiating impacts on many key areas. Traditional energy is complex and variable within the existing application range, with strong uncertainty. At the same time, its widespread application causes increasingly serious environmental pollution. Therefore, new energy is imperative. The use of new energy can effectively reduce environmental pollution and address global climate change. Solar photovoltaic (Pereafter PV) is the third largest renewable power technology and an important component of new energy. In recent years, it has attracted attention and accounts for 4.5% of the world's total power generation. China and the United States are the two most influential countries in the world's photovoltaic industry. In 2022, China accounted for approximately 38% of the growth in solar photovoltaic technology, while the United States accounted for approximately 15%, making it the country with the highest and third highest growth rates in the world's total installed photovoltaic capacity, respectively [1]. Therefore, understanding and analyzing the current solar panel industry in China and the United States can provide a useful reference for other countries in the world and help promote the development of the new global energy economy.

This paper aims to analyze and compare the development of the solar photovoltaic panel industry in China and the United States and identify the similarities and differences between the two countries. Select representative companies in the solar photovoltaic panel industry from both countries for analysis based on relevant indicators such as popularity and installed capacity. This study will examine the photovoltaic installed capacity, supply chain, and policy aspects of the solar photovoltaic industry in both countries, highlighting their similarities and differences. Firstly, the economic foundation determines the superstructure and a thorough analysis of the financial aspects and key characteristics of the selected companies is conducted, with a focus on representative companies that can reflect the competitiveness of the solar panel industry in China and the United States; Secondly,

the superstructure has a counterproductive effect on the economic foundation. This article will also focus on analyzing the relevant policies and government intervention measures for solar photovoltaic panels in China and the United States in order to understand their impact on industry development. Finally, summarize the impact of the photovoltaic industry in both countries on global energy and provide relevant industry predictions based on the collected information.

2. Description of China and the United States

2.1. Solar PV Industry in China

China has a high demand for PV solar panels. In recent years, China's solar PV industry has been growing rapidly. According to the International Renewable Energy Agency (hereafter IRENA), China's Cumulative installed solar capacity reached 392.44 GW in 2022, a year-on-year growth of about 28% [2]. Investments in ground-mounted solar PV projects are increasing due to intense competition from large utility projects and incentives offered by the government. 216 GW of new solar PV capacity was added in China in 2023, which is 14% of the world's total installed capacity [3]. Most of China's concentrated ground-mounted solar farms are located in the west, while electricity demand is concentrated in the east. Therefore, China has shifted its development focus to small-scale distributed solar projects in the east. 2021 In 2021, the Chinese government launched a national PV program to encourage the construction of rooftop solar. As of November 2023, 676 counties in 31 provinces have signed on to the program, and about 157 GW of rooftop solar has been built, twice as much as in the United States [4].

China's dominant role in the PV panel supply chain has attracted a significant amount of Global solar manufacturing capacity from Europe, Japan, and the US to China. Since 2011, China has invested more than $50 billion in new PV supply capacity and created 300,000 manufacturing jobs. Today, China's share of all manufacturing stages of solar panels (such as polysilicon, ingots, wafers, etc.) exceeds 80% [5]. Thus, China's PV market is highly competitive, and based on visibility as well as capacity and other relevant information, Chinese solar companies such as JinkoSolar, JA Solar, Trina Solar, LONGi Green Energy, and China New Energy have become the world's leading companies, laying the groundwork for China's future solar energy development [6].

2.2. Solar PV Industry in United States

The US solar industry is growing rapidly, with more than 10,000 companies and 263,000 employees per state in 2022. The cost of solar installations has decreased by more than 40% over the past decade, allowing the industry to enter new markets and install thousands of systems across the country [7]. According to the IRENA, the cumulative installed solar capacity in the US reached 111.54 GW in 2022, an increase of about 18.8% from the previous year. By 2023, the solar industry's installed capacity will reach 32.4 GW, a 51% increase from 2022, a record high for the industry. This includes a 13% increase in installed residential PV capacity, a 19% increase in installations in the commercial PV sector, a 3% increase in installations in the community solar PV industry, and a staggering 77% increase in capacity in the utility PV sector [8]. Solar PV accounts for 53% of new generating capacity in 2023, more than half of new capacity for the first time and the first time in 80 years that renewables account for the majority of new installed capacity [9].

However, domestic production capacity in the US supply chain is currently limited. Until recently, most PV solar panels sold in the United States were not actually manufactured here. The United States Government has adopted a variety of financial incentives and subsidies for the solar panel industry aimed at promoting its development and growth. Through policies such as the Inflation Reduction Act (IRA), the US government has taken a number of measures to support the development of the industry. Fiscal incentives are an important part of this, reducing investment and holding costs and stimulating willingness to install through measures such as income tax credits and excise and property tax breaks. In particular, an extension and modification of the ITC (Investment Tax Credit) policy are proposed, with the ITC policy receiving a 10-year extension and the credit rate for solar projects being

adjusted in favor of residential, small commercial, and industrial projects [10]. In addition, in the case of large corporations and other entities, the implementation of the PTC (Production Tax Credit) policy prioritizes local manufacturing, further demonstrating the government's support for local industry. In addition, the US government promotes industrial development through direct support measures such as financial subsidies, focusing mainly on new energy vehicles and energy storage industries. The implementation of these policies helps support the development of emerging industries and promotes industrial diversification and long-term development. At the same time, the US also protects local industries through local trade protection measures, such as antidumping and countervailing duties on Chinese PV cells. However, despite these protective measures, the US solar industry remains closely linked to China, especially in the supply of PV modules, with a high dependence on Chinese manufacturers.

3. Comparative of China and the United States

3.1. Similarity Identified between China and the United States

Both China and the United States have successively introduced and implemented many policies for the development of their respective solar photovoltaic panel industries.

3.1.1. China policy.

(1) Overview of the Development of China's PV Industry Based on Policy Perspectives

The PV industry is an important engine to promote China's energy transition, an important part of new energy, and an important way to achieve "carbon peak and carbon neutral". According to the "Ninth Five-Year Plan" (1996-2000) to the "Fourteenth Five-Year Plan" (2021-2025) of China's national economy, the state support policy for the PV industry has gone through a series of changes from the "Ninth Five-Year Plan" (1996-2000) to the "Fourteenth Five-Year Plan" (2021-2025). According to the "Ninth Five-Year Plan" (1996-2000) to the "Fourteenth Five-Year Plan" (2021-2025) of China's national economy, the state support policy for the PV industry has gone through the changes from "active development" to "focus on development" and then to "vigorously promote", and from the concept of new energy proposed at the national macro level to the clear development of PV power generation, It has gone through the process from the concept of new energy proposed at the national macro level to the clear development of PV power generation to the inclusion of PV industry in the strategic emerging industries, and the focus on planning and promoting the optimization and upgrading of the path of energy structure, China has made a leapfrog development in less than 20 years, and owns the world's largest PV industry chain [11]. China's PV industry has made remarkable achievements, which is an example of the success of the Chinese government's policy-oriented strategy, which cannot be separated from the strong policy support and macro-control of the Chinese government. China's PV industry policy took the Circular on Matters Relating to PV Power Generation in 2018 as a turning point and experienced a market-oriented reform from a large-scale direct financial subsidy policy to an incentive policy based on stimulating the vitality of market players, which has transformed China's PV industry from a policy-oriented one to a vibrant market player-oriented to the market and scientific and technological innovation. In terms of the PV power generation assembly field, also from the original government-led centralized PV power plant to centralized and distributed PV power generation and promote the diversified development of regional PV power generation assembly, as shown in Table 1 and Table 2.

Table 1. Key Policies for China's PV Industry Before 2018

Policy	Date	Substance
Renewable Energy Act	2005.2	Promote the development and utilization of renewable energy, increase energy supply, improve energy structure, ensure energy security, protect the environment and achieve sustainable economic and social development
Medium- and long-term development plans for renewable energy	2007.8	Solar power generation is listed as a key development area, and the total solar power generation capacity is proposed to reach 300,000 kilowatts by 2010 and 1.8 million kilowatts by 2020
Interim Measures for the Management of Financial Subsidy Funds for the Golden Sun Demonstration Project	2009.7	In principle, 50% of the total investment in the power generation system and supporting transmission and distribution projects shall be subsidized for grid-connected power generation projects, and 70% of the total investment shall be subsidized for independent solar photovoltaic power generation systems in remote five-point areas
Several opinions on promoting the healthy development of the photovoltaic industry	2013.7	Expanding the domestic market, improving the technical level, and accelerating industrial transformation and upgrading are the fundamental ways out and basic foothold to promote the sustainable and healthy development of the photovoltaic industry.
Comprehensive standardized technical system for the solar photovoltaic industry	2017.4	By 2020, a scientific and reasonable, technologically advanced, and coordinated photovoltaic industry-standard system will be initially formed, and light will be basically realized The full coverage of general standards and key standards of the industrial base meets the needs of the development of the photovoltaic industry as a whole

(Source: EIA and Oriental Securities Institute)

Table 2. Key Policies for China's PV Industry After 2018

Policy	Date	Substance
Regarding the encouragement of renewable energy power generation enterprises to build or purchase spiritual peak shaving energy Fang Lu Gang and business model correction	2021.7	Encourage power generation enterprises to build their own energy storage or peak regulation capacity to increase the scale of grid connection
Opinions on promoting the green development of urban and rural construction	2021.10	Encourage the integration and innovative development of smart photovoltaics and green buildings.
Notice the organization of the second batch of large-scale wind power photovoltaic base projects focusing on deserts, Gobi and desert areas	2021.12	It is planned to organize the second batch of large-scale wind power and photovoltaic base projects focusing on deserts, Gobi and desert areas
Action Plan for Innovation and Development of Smart Photovoltaic Industry (2021-2025)	2022.1	Promote the deep integration of the photovoltaic industry and the new generation of information technology.
"14th Five-Year Plan" Modern Energy System Plan	2022.3	By 2025, the proportion of non-fossil energy consumption will increase to about 20%, the proportion of non-fossil energy power generation will reach about 39%, the level of electrification will continue to increase, and the proportion of electric energy in terminal energy will reach about 30%.

(Source: EIA and Oriental Securities Institute)

(2) Great Prospects for Chinese PV Enterprises

According to the "14th Five-Year Plan and 2035 Vision Outline", building a modern energy system and clarifying the centralized and decentralised development of the PV industry provides a clear and ambitious blueprint for China's PV industry. The "14th Five-Year" Renewable Energy Development

Plan points out that China's renewable energy is at a new historical starting point and will be a large-scale, high-proportion, market-oriented, high-quality development with new features. Specifically, a large-scale development further accelerates the increase in installed power generation ratio; two is a high proportion of development, from energy and power consumption incremental supplement to the main body of the increase in energy and power consumption, the proportion of energy and power consumption in the rapid increase; three is the market-oriented development, the development of subsidies supported by the development of parity and low price development, from policy-driven development to market-driven development; four is the high-quality development of both large-scale development, but also a high level of consumption, more stable and reliable power supply. The fourth is high-quality development, both large-scale development and high-level consumption, which ensures a stable and reliable power supply. Meanwhile, a staggering amount of annual renewable energy generation - about 3.3 trillion kilowatt-hours - has been set for 2025, with a focus on wind and solar power generation, and the hope that the total amount will be doubled [12, 13].

3.1.2. US policy.

First, Fiscal Incentives: Through the adoption of income tax credits and consumption tax, property tax reductions significantly reduce investment and holding costs and stimulate the willingness to install. (1) ITC policy: The Inflation Reduction Act (IRA) proposes a 10-year extension of the ITC policy, increasing the credit from 26% to 30% for projects up to 1MW and reducing the credit from 26% to 6% for projects over 1MW (30% if conditions are met). The updated ITC policy will be favorable to residential, small commercial, and industrial projects and unfavorable to large corporations and other entities. (2) PTC policy: similar to the ITC policy but favorable to projects with larger capital volumes. It is worth noting that the PTC's preference for local manufacturing, i.e., the use of all US steel products and meeting the 40% domestic content threshold (20% for offshore wind) for facilities to receive an additional 10% credit, reflects the Biden administration's determination to break the new energy industry's dependence on China.

Second, regulatory policy: The system is designed to make the commercial, market-based model clear. (1) Quota system: A quota system refers to a mandatory requirement in a country or region that a certain percentage (i.e., the quota standard) of the electricity supplied by the power system must be renewable energy supply. In the US, the quota target is set by each state individually. According to statistics, 31 states and 2 special districts in the US have set RPS/CES targets. The establishment of the quota system guarantees the new energy development targets of each region. (2) Net metering policy: Electricity companies are required to deduct their self-generated renewable energy from the total electricity consumed by customers, and the customer is required to pay the difference. According to DSIRE, as of August 2021, 39 states, including Washington, DC, and 4 overseas territories have mandatory net metering in place. (3) PPA tariff: refers to the medium- and long-term energy purchase agreements signed between power users and power generation companies; PPA tariffs are mainly determined by the relationship between supply and demand, with lower PPA tariffs in resource-rich regions; when investment costs tend to be higher, power generation companies tend to increase PPA tariffs.

Third, Financial Subsidies: Supporting Industrial Development through Direct Subsidies From the perspective of direct subsidy policy in the past 3 years, focusing on new energy vehicles and energy storage industry, it believes that financial subsidies mainly support emerging industries through government financial support, so the current stage of subsidies focuses on diversified energy storage technology and application of long-term energy storage, as shown in Table 3.

Table 3. 2020-2022 US PV Industry Support Policies

Policy	Date	Subsidy amount and project
Inflation Reduction Act	2022.8	$369 billion (In response to climate change, including a large number of new energy investment projects)
Infrastructure Investment and Jobs Act	2022.5	(1) $3.16 billion (to increase production of U.S.-made batteries) (2) Allocate $60 million (to support the secondary application of used electric vehicle batteries) (3) Launched the $505 million initiative (to facilitate deployment and reduce the cost of long-term energy storage) (4) Invest US$26 million (for solar, wind, and energy storage) (5) Allocate $10 million (for some communities to start solar energy)
National Blueprint for Lithium Batteries (2021–2030)	2021.6	$200 million over five years (electric vehicles, batteries, and connected car projects)
Energy Storage Grand Challenge Roadmap	2021.3	$20 million (R&D to improve the manufacturability of neutral flow battery systems, increase the scale of energy storage and efficiency in the use of clean energy)
Energy Act 2020	2020	US$1 billion authorized over 5 years (Cross-domain Energy Storage Research and Development Demonstration Program)

(Source: EIA and Oriental Securities Institute)

3.2. Differences Identified between China and the United States

China's solar PV policy is characterized by direct government intervention, including supply-side measures such as tax incentives and demand-side policies like feed-in tariffs. These interventions, driven by political considerations, result in less reliance on market mechanisms. The circumstances changed after 2018, and the Chinese government has shown a tendency to promote the marketization and refinement of the PV industry in recent years. In contrast, the US implements more market-based demand-side policies, facilitating efficient participation in the electricity market. Additionally, US trade protectionism aims to safeguard the development of its new energy industry, which is driven more by geopolitical considerations than purely economic ones. But the United States, since the Trump administration continued the Biden government trend is to continue to strengthen the support for the domestic PV industry trade protectionism trend, which can be regarded as the United States of America's dominance in the field of new energy as an important component of the status of maintaining their own, and more and more attention.

3.3. Problem Identified

Due to the inertia of capitalist system thinking, the United States has formulated a series of policies aimed at protecting the solar photovoltaic industry in the United States

In November 2011, the US Department of Commerce announced that it would initiate a "double antidumping" and "countervailing duty" investigation into Chinese PV cell imports into the US. In May 2012, the US Department of Commerce announced that it would impose a preliminary antidumping duty (ADD) of 31% on Chinese PV cell imports, which would be combined with a new countervailing duty (CVD) of 2.9% to 4.7% on all Chinese crystalline silicon PV cell imports. In May 2012, the US Department of Commerce announced a preliminary antidumping duty (ADD) of 31% on imports of Chinese PV cells, which, together with a new countervailing duty (CVD) of between

2.9% and 4.7%, would apply to all imports of Chinese crystalline silicon PV cells. In January 2018, the USTR announced the imposition of a 30% tariff for four years on imports of solar wafers from China under Article 201 of the EU Directive on Trade-Related Aspects of Intellectual Property Rights. Even if the US implements trade protectionist measures, the Chinese industrial chain remains indispensable due to its significant cost advantage. According to EIA data, in 2021, the US will have 30.45 GW of available module shipments, of which imported PV modules will account for 22.97 GW, or 75%, and local production will account for only 4.23 GW, or less than 14%. Among the imported countries and regions, 49.2% are from Mainland China, Taiwan, Singapore, and Vietnam, most of which are Chinese manufacturers. 21.7% come from South Korea and Thailand, where Atlas, Trina Solar, TengHui, and Astronergy have factories. This means that more than half of the module supply in the US will have to rely on Chinese manufacturers, and Chinese companies will benefit from the rapid growth of the US market.

4. Suggestion

4.1. China

Accelerate Power Generation Installation: Align with the trend of large-scale development by further accelerating the improvement of the power generation installation rate.

Increase Proportion of Development: Shift focus from merely increasing energy and electricity consumption to enhancing the entities responsible for energy and electricity consumption. This should result in a rapid increase in the proportion of energy and electricity consumption.

Promote Market-Oriented Development: Develop subsidies that support the transition to parity and low prices, shifting from policy-driven to market-driven development. Encourage the entry of more private capital into the market.

Enhance Safety and Quality: While pursuing economies of scale, also prioritize improving the safety of power supply and consumption. High-quality development requires not only large-scale growth but also high-level consumption to ensure a stable and reliable power supply.

4.2. United States

Reduce Sanctions and Seek Cooperation: Reduce unnecessary sanctions against China's solar photovoltaic industry and focus on seeking cooperation with the Chinese government and enterprises. Emphasize mutual benefits rather than zero-sum games.

Improve State Policies: Continue to refine policies for the solar photovoltaic industry. Each state should flexibly formulate and adjust regulations according to its specific circumstances to foster local industry development.

Strengthen Market Supervision: Enhance market supervision and ensure effective macroeconomic regulation. Strive to balance economic benefits with social benefits, ensuring sustainable development of the industry.

By implementing these strategies, both China and the United States can further advance their solar photovoltaic industries, contributing to global efforts in addressing energy and climate challenges.

5. Conclusion

Solar photovoltaics, a critical component of new energy, are highly valued by both China and the United States. This article employs comparative and empirical analysis to examine the solar photovoltaic panel industry in these two countries from the perspectives of economy, policy, and technology. Utilizing authoritative data and quantitative analysis, this study finds that China's solar photovoltaic industry is significantly influenced by policies, whereas the U.S. industry is more affected by economic factors and exhibits greater spontaneity. Technological progress has driven the

development of the photovoltaic industry in both nations, and currently, China and the United States are on par technologically.

China's solar PV policy is characterized by direct government intervention, including supply-side measures such as tax incentives and demand-side policies like feed-in tariffs. These interventions, driven by political considerations, lead to less reliance on market mechanisms. However, since 2018, the Chinese government has shown a trend towards promoting marketization and refinement of the PV industry.

In contrast, the U.S. employs more market-based demand-side policies, facilitating efficient participation in the electricity market. Additionally, U.S. trade protectionism aims to safeguard its new energy industry, driven more by geopolitical considerations than purely economic ones. Since the Trump administration, and continuing under the Biden administration, there has been a trend towards strengthening support for the domestic PV industry through trade protectionism. This approach underscores the United States' strategy to maintain its dominance in the field of new energy and reflects increasing attention to securing its status in this sector.

By analyzing these differences, this study can better understand the strengths and challenges each country faces in advancing their solar photovoltaic industries.

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