A Comparative Analysis of Offshore Wind Energy Industries in China and the United States: Policy, Supply Chain, and Development Pathways

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Abstract. This paper provides an in-depth comparison of the development status of the offshore wind industry in China and the United States up to 2023. Given the critical role of offshore wind in the global transition to renewable energy, this paper focuses on the comparative progress of the two countries in this area and the drivers behind it. The research methods cover the technical capability, policy environment and supply chain construction of offshore wind energy. The results of the study show that China has demonstrated significant advantages in the offshore wind energy sector, mainly due to strong state support and systematic development planning. In contrast, the United States has lagged in this area, with major obstacles including policy inconsistencies and supply chain problems. Based on these findings, this paper provides insights and recommendations for China and the United States to enhance their offshore wind capacity and jointly contribute to the global goal of carbon neutrality.

Keywords: Offshore wind energy, policy, supply chain.

1. Introduction

In 2023, according to IEA (International Energy Agency), a new record of 37.4 Gt emissions of CO2 has been reached. The huge amount of CO2 emissions has threatened the natural environment, and even the survival of human beings as the emissions of CO2 can cause the greenhouse effect, which contributes to issues like global warming, ice cap melting, ecosystem disruption e.g. The massive emission of CO2 is mainly because of consumption of fossil fuel, especially coal. To prevent irreversible damages due to CO2 emissions, countries signed the Paris Agreement in 2015 and set goals to achieve net zero carbon emissions and carbon neutrality. Globally, in 2023, the offshore wind capacity globally reached 65-70 GW [1]. China, the US, and Denmark are example members of the industry. In China, offshore wind capacity reached approximately 42-45 GW. In the US, offshore wind capacity reached 1 GW. In Denmark, the total offshore wind capacity had reached 2.6 GW. It can be seen easily that China holds a leading position, and the US is not keeping pace with the rest of the world in this industry. In this paper, research about why China is so dominant in the industry and why there is a large difference between offshore wind energy capacity in the US and China will be done. The objective of this paper is to conduct a comprehensive evaluation and comparison of the offshore wind energy industries in China and the United States, focusing on their current capacities, developmental progress, and outlook.The offshore wind industry is mainly using a wind farm to harness wind energy from the sea. There are two types of offshore wind farms [2]. One is fixed-bottom wind farms, which are mounted on a structure that is anchored to the seabed, and the other one is floating on the sea surface and anchored to the seabed with mooring lines. The components of offshore wind farms are a wind turbine, which is larger than that of onshore wind; a substructure, which steadies the wind turbine and can withstand harsh environments; and an electrical infrastructure, which transfers energy from the turbines to onshore. Because it is very challenging on the sea, the offshore wind farm needs regular maintenance, which can usually be done by crews using service vessels and occasionally helicopters. The energy supply of offshore wind farms is stable as there are consistent and strong winds offshore.

2. Comparative Analysis of Offshore Wind Power Resources Between China and the Us

2.1. Industry in China

In 2021, the accumulated installed capacity of the Chinese offshore wind industry was soaring to over 42GW. There are several reasons. To begin with, China has a Coastline of 14,500 kilometers and 73 offshore wind farms along the coastline of eight provinces of China. Secondly, there are companies like Mingyang, Goldwind, and Sinovel, which contribute to 40-50% of the world's total wind turbine production. Also, to achieve high design efficiency, in 2019, China was using upscaled wind turbines with a rotor diameter of 150m; and a hub height of 103m. However, although these turbines are huge, China still produces the cheapest wind turbines in the world. China's overcapacity in steel and its effective and competitive supply chain result in 14 percent more gross profit margin than other international turbine players on average. In addition, at present, out of the top 10 firms providing wind turbines, six are from China, and offer 4 types of generator technologies, with a total of 44 models above 7 MW [3]. The current foundations of Chinese wind farms are mainly taking place in shallow water and close to the shore, about 10-20 km off the coast in water depths of about 0-25 m. These foundations are named monopile, which can deal with any kind of geological conditions. Additionally, China exported around 30-40% of its wind turbines to regions such as Europe, Latin America, and Southeast Asia [4].

2.2. Industry in the USA

The USA had an accumulated installed capacity of about 42 MG, which was much less than that of China, 26 GW. Compared to China, the USA has a coastline of 153,646 kilometers, which is longer than that of China. Usually, a longer coastline should have higher wind capacity, however, the USA has such a low capacity reflecting that they are not using the land resources efficiently. Secondly, the first operational wind farm in the US includes Block Island Wind Farm in Rhode Island. Rather than building in shallow water, the US prefers to build in deeper waters, for example, projects like Vineyard Wind and Ocean Wind. These projects use floating foundations in the deeper ocean about a depth of 30-60m. US turbines are generally smaller, around 120 meters. Because the US has less mature supply chains, it is more expensive for the US to produce wind power, around $60-$80 per MGh. Thirdly, in the US, there are 3 companies (General Electric (GE), Siemens Gamesa, and Vestas) that occupy only 10-15% of global wind turbine production. The US exports approximately 10-15% of its wind turbines to countries in the Americas and some in Europe. China exports more in quantity and has more customers. In price comparison, China has the cheapest wind turbine in the world, generally ranging from $800,000 to $1.5 million per megawatt. In the US, it is much more expensive, typically ranging from $1.2 million to $2 million per megawatt [5].

In general, scale and technological Maturity supply chain efficiency policy support and strategic planning; and geographical and strategic focus, these factors will affect the offshore wind industry, and this is the reason why there is a huge gap between the two countries, the US and China. These findings will help industries to get higher efficiency, and lower the cost of production so that the process of getting rid of oil fuels to reach carbon neutrality can be accelerated.3. The major energy production companies of China and the United States [6].

3. PRC

China Huaneng Group Co., Ltd. is a key state-owned company established with the approval of the State Council. With a registered capital of 34.9 billion RMB, the Company is mainly engaged in the following businesses: development, investment, construction, operation, and management of power sources; production and sale of power and heat; development, investment, construction, production, and sale of businesses and products related to finance, coal, transportation, renewable energy, and environmental protection; industrial investment, operation and management.

With the approval of the CPC Central Committee and the State Council, CHN Energy Investment Group (CHN Energy) was formally established on November 28, 2017, following the merger of China Guodian Corporation and Shenhua Group.

China Three Gorges Renewables (Group) Co., Ltd. (CTGR, ticker: SSE 600905) is China Three Gorges Corporation's (CTG, state-owned) alternative energy arm that operates CTG's new energy business and fulfills its mission to develop new energy.

State Power Investment Corporation Limited (SPIC) is one of China's five power generation groups, with businesses covering centralized power and heat generation, consumer-side integrated smart energy, green power to X, power-related and supporting segments, and asset-light businesses.

4. US

The Ørsted vision is a world that runs entirely on green energy. Ørsted develops, constructs, and operates offshore and onshore wind farms, solar farms, energy storage facilities, renewable hydrogen and green fuels facilities, and bioenergy plants. Ørsted is recognized on the CDP Climate Change A List as a global leader in climate action and was the first energy company in the world to have its science-based net-zero emissions target validated by the Science Based Targets initiative (SBTi). Headquartered in Denmark, Ørsted employs approx. 9,000 people. Ørsted's shares are listed on Nasdaq Copenhagen (Orsted). In 2022, the group's revenue was DKK 132.3 billion (EUR 17.8 billion).Whether your focus is balancing a generation and load portfolio, meeting a renewable portfolio standard, or meeting your corporate or institutional sustainability goals, people can provide a customized solution for your specific renewable energy needs. Avangrid Renewables' national scale and best-in-class trading and asset management platforms offer you an unparalleled scope of service.

Also not a company, it can easily find that in the PRC, all the main companies are state-owned, and on their website, they just talk about their scale, they are state-owned, etc. Some of them are established by some policies, they have the support of the government. So they do not need to worry about their cost recovery, their revenue is stable, so when they are facing some new segments, they are more confident in investing.

While in the US, Orsted, the Shell, are foreign companies, so they just care about their reputation and their revenue. Also, the main local companies, like Avangrid and Eversource, are not government corporations. So when they are facing new segments, they need to consider their profit, and their cost, so they may not be as confident as those in PRC.

In the PRC, because of the planned economy, China has stable Five Year Plans(FYPs), but in the US, the policy seems inconsistent, for example, ex-president Trump, he is a firm defender of coal fuels, so during his presidency, he just never care about the renewable power, which has cause a stop in offshore wind power. In the last 3 FYPs, the PRC has achieved all stages in offshore wind, but in the US, they just published their first document in 2022.

Also, the election progress in the 2 countries is quite different. In the US, the president always needs to do some acts to seek the support of their voters, which may cause inconsistency in policies. But in the PRC, due to the democratic centralism system, the president does not need to show it, so the policies may be much more stable.

In PRC have achieved each goal in the 12th to 14th FYP represent representatively, but in the US, they just started their first stage in 2022. So have the picture to show it.

There is an interesting fact that most times, the 2 countries do not make decisions at the same time, they take turns and decide one by one. So both of them have the advantages of being the first mover and the second mover, they can refer to each other, for instance, in US document in 2022, they came up with the idea of floating turbines, which PRC had decided to develop in 2021. Moreover, whether they can make good use of the advantages depends on their executive capacity of the government system.

5. Industry Outlook

The offshore wind industry is thriving due to its alignment with global energy transition objectives, economic competitiveness, and government policy support, and it is expected to play a significant role in the future energy mix.

According to WFO, in 2023, China was the largest market for installed capacity growth globally, with an increase of 31,527 MW, representing approximately 10% of China's total wind capacity, and nearly equivalent to the United States' prospective offshore wind capacity (36 GW), thereby underscoring the nation's leading role in offshore wind energy utilization. The United States ranked 15th in the world for this metric, with an additional 42 MW of installed capacity. In the ranking of the largest offshore wind farms under construction in 2023, seven out of the top fifteen wind farms are from China, while the United States accounts for one, Vineyard Wind 1, which is ranked seventh globally.

China has committed to reaching its peak carbon emissions before 2030 and achieving carbon neutrality before 2060, with offshore wind playing a crucial role in this strategy. On the one hand, China's national ability to run large utility-scale offshore wind capacity is upgrading. As an emerging energy powerhouse, China's steadfast pursuit of carbon neutrality is evident, underpinned by strategic Five-Year Plans and the execution of policies such as the Green Power Trading Rules. These are complemented by substantial industrial incentives and an eased investment environment, which have synergistically driven the consistent expansion of China's offshore wind sector. On the other hand, the distribution of China's offshore wind farms is undergoing dynamic evolution. With the development of technologies related to deep-sea wind power and floating wind power, a new round of offshore wind project planning and approvals has been completed in more coastal provinces, including Zhejiang and Guangzhou.

However, China's wind power industry is facing significant challenges in innovation and bidding pressure at present. Amidst fierce competition in China's wind power sector, more than 10 manufacturers have been driving technological advancements. This cutthroat market has catalyzed innovation, prompting OEMs such as Mingyang and Haizhuang to develop larger and more powerful turbines. Moreover, the development of nearshore and deep-sea wind power technologies is not synchronized at present. The nearshore wind power technology has already gained cost competitiveness, while the deep-sea wind power technology, which has just entered the market, does not have a cost advantage and still requires the support of national policies.

Unlike China, the offshore wind industry in the United States is still a mixed picture. According to the GWEC, The United States has set a target to reach 15 GW of floating wind by 2035, which builds on the country's existing goal of deploying 30 GW of offshore wind by 2030. The advantage of the U.S. offshore wind power industry lies in the strong innovation of the manufacturing sector and the vast number of patents, which provide technical support for the industry's growth. The US government has also introduced corresponding incentives. The passage and implementation of the Inflation Reduction Act (IRA) in the United States has led to an increased interest in offshore wind. A crucial component of the IRA is the provision of a production tax credit and an investment tax credit for wind and solar energy projects through 2024 – which will eventually become a technology-neutral tax credit that will be available through 2032.

However, due to the indifferent attitude of the Republican Party in the United States towards sustainable energy policies, investors are concerned that the discontinuity of policies may lead to asset stranding, which could hinder the continuous development of the U.S. offshore wind power industry. This instability in policy may adversely affect long-term planning and investment decisions within the industry, thereby impacting the healthy development of the entire sector.

Another setback faced by the U.S. offshore wind industry lies in the significant increase in costs. Unpredictable events, including the historic inflation triggered by the pandemic and the Russia-Ukraine conflict, have dealt a severe blow to the emerging offshore wind power sector. Just as several projects were preparing to sign contracts with suppliers, the construction costs for wind power arrays were substantially driven up. What's worse, the U.S. supply chain is not yet ready to cope with a

sudden surge in large-scale construction enthusiasm, and it has not reached the critical mass required to manufacture offshore wind towers, blades, and rotors, or to build and operate the vessels necessary for offshore installation.

6. Conclusion

The significant disparity between China and the United States in the development and implementation of offshore wind energy, sheds light on the factors that have contributed to China's dominance in the global offshore wind market. As of 2023, China's installed offshore wind capacity far surpasses that of the United States, with over 42 GW compared to just 1 GW in the US. This stark difference can be attributed to a combination of political, economic, and industrial factors that shape each country's approach to renewable energy.

Additionally, the US has faced policy inconsistencies, which have created uncertainty in the renewable energy sector. The political landscape in the United States, characterized by shifting priorities depending on the administration in power, has slowed the momentum of offshore wind development. For instance, under the Trump administration, there was a notable emphasis on supporting fossil fuels, which stunted the growth of renewable energy projects, including offshore wind. While the Biden administration has renewed efforts to promote offshore wind, policy discontinuities remain a concern for investors. This lack of long-term stability has made it more difficult for the US to build a strong offshore wind industry, leading to higher production costs and a slower pace of development compared to China.

Another key factor contributing to the gap between the two nations is the efficiency of their respective supply chains. China has a well-established and highly efficient supply chain for wind turbine manufacturing, enabling it to produce turbines at a lower cost. In contrast, the US offshore wind supply chain is still in its infancy, with limited capacity to manufacture the necessary components domestically. The reliance on imports and the relatively higher cost of production in the US has made it difficult for the country to compete with China in terms of both scale and price.

Despite these challenges, the United States has potential for growth in the offshore wind sector. The country has made recent strides, such as setting ambitious targets to increase its offshore wind capacity to 30 GW by 2030, with a particular focus on developing floating wind farms in deeper waters. However, to achieve these goals, the US will need to address the structural barriers that currently impede its progress. This includes developing a more robust supply chain, ensuring policy consistency across political administrations, and fostering collaboration between the public and private sectors.

In conclusion, China's offshore wind industry has benefitted from a combination of state support, efficient supply chains, and favorable geographical conditions, allowing it to lead the world in offshore wind capacity. The US, on the other hand, faces challenges related to policy instability, higher production costs, and a less mature supply chain. However, with the right policies and investments, the US has the potential to become a major player in the global offshore wind market. By learning from China's model of state coordination and addressing its structural inefficiencies, the US can make significant strides in offshore wind energy development, contributing to global efforts to reduce carbon emissions and combat climate change. Both nations will play critical roles in shaping the future of renewable energy, and their success in the offshore wind sector will be vital in achieving carbon neutrality and securing a sustainable energy future.

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