

Impacts of Factors of Production and Public Policy on the US and China Offshore Wind Industries Analysis

Zexue Zhou *

Shenzhen College of International Education, Shenzhen, China

* Corresponding author: s22211.zhou@stu.scie.com.cn

Abstract. In 2023, global carbon dioxide emissions climbed to a staggering new high of 37.4 metric tons, a grim situation driven primarily by the massive consumption of fossil fuels, particularly coal. In this context, the offshore wind power industry has emerged as a key part of tackling climate change and emission reduction challenges. This paper provides an in-depth analysis of how productive factors and public policy work together to shape the development of the offshore wind industry in the United States and China, highlighting the importance of land availability, labor market quality and size, and capital investment flows in shaping the future of the industry. At the same time, the paper also carefully examines how the government can effectively attract and promote investors to participate in offshore wind power projects through a series of public policies, such as tax incentives, subsidies and other financial incentives. The results show that China has a clear lead in the offshore wind market compared to the United States. This paper aims to make insightful suggestions for the sustainable development of offshore wind power industry in both countries through comparative analysis of the advantages and disadvantages of the two countries.

Keywords: Offshore wind, policy, factors of production, China, United States.

1. Introduction

In 2023, according to IEA, a new record of 37.4 Gt emissions of CO₂ has been reached. The huge amount of CO₂ emissions has threatened the natural environment. 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, and ecosystem disruption [1]. The massive emission of CO₂ is mainly because of the 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. The clean energy, especially offshore wind energy, plays an important role in the process. The industry has huge potential and proper prospects. Globally, in 2023, the offshore wind capacity globally reached 65-70 GW. In China, offshore wind capacity reached approximately 42-45 GW. In the US, offshore wind capacity reached 1 GW. There is a huge difference between China and the US. In this paper, research about how Factors of Production and Public Policy could contribute to offshore wind industries in China and US. Factors of Production are essential when discussing the development of the offshore wind industry. Firstly, the length of the coastline, which is the Land in Factors of Production, directly affects how many winds farms the US and China can build. The capacity is larger when there are more wind farms. Secondly, the quality of labor, which means if workers are trained or not, will affect in efficiency while producing, and then affecting the whole capacity. Thirdly, the quantity of labor, which means the amount of workforce, these contributes to countries' production potential of offshore wind industry. Additionally, the capital. The offshore wind industry requires substantial upfront investment, including costs related to environmental assessment and construction of facilities (turbines and wind farms). Investing in the latest technology and innovations in grid integration can increase efficiency as well. Also, the investment in expanding the farms will be devoted to a greater capacity. Moreover, the enterprise. Entrepreneurs often introduce new technologies and have innovations that can make offshore wind projects more viable and efficient. Also, entrepreneurs can reduce the cost by managing the supply chain and effective maintenance strategies. Another way entrepreneurs contribute higher capacity is that they often attract additional capital into the sector by showing startups with promising

technologies or business models, they can draw interest from venture capital and other investors looking for opportunities in renewable energy. There are several ways that public policy influences the offshore wind industry as well. Firstly, governments can use financial incentives such as reductions in taxes, subsidies, and fees in tariffs to help lower economic barriers to entry of new projects and encourage both domestic and foreign investors. Secondly, the permitting process and environmental regulation can significantly impact the industry as a clear and efficient permitting process and environmental regulation can reduce the lead time and complexity in offshore wind projects. Thirdly, public policy can support the industry by promoting partnerships between academia and industry. This could result in cost reduction and technological advancements. Additionally, trade policies affect offshore wind by influencing the cost and accessibility of buying turbines and other technological components. Overall, both the factors of production and public policy play crucial roles in shaping and developing the offshore wind industry.

The research objective of this article is to find out the ways public policy and to give pertinent advice. (In part 1, factors of production will be discussed. In part 2, the public policy will be discussed)

2. Effects of Factors of Production Analysis

2.1. Land

Land is important to be discussed because it refers to resource availability, such as the availability of wind; and location accessibility, such as the accessibility to coastline. These will affect the amount of wind farms that the US and China can build, therefore, affecting the total wind capacity.

China has abundant offshore wind resources. There are 6000 islands and 1.8×10^4 km of mainland coastline. Rendering to 758 GW exploitation capacity, 3×10^6 km² of sea area is available for offshore wind electricity generation [2]. China has excellent resource availability and superb location accessibility; therefore, China has an outstanding advantage in developing the offshore wind industry as the Land is abundant. In 2019, there were 23 offshore wind projects, and the total capacity is 7 GW. 13 of them are in China, making it one of the largest offshore wind power countries in the world.

The US also has plentiful offshore wind resources. The US has a total mainland coastline of 1.5×10^5 the US coasts, mostly in the Northeast and along the Atlantic, offshore massive shallow water for building wind farms ideally. The Department of Energy notes that the technical potential for the US coasts can reach 2000 GW of capacity. By the end of 2019, compared to countries like China, the UK, and Germany, the US was still in the early process of developing large-scale offshore wind electricity generation.

To sum up, although the US has richer offshore wind resources and more significant potential than China, China has greater capacity than the US. This demonstrates that the US is not using the resources efficiently and wisely.

2.2. Labor

Labor is a crucial factor in production. Labor is important because it involves human effort and skills to transform raw materials into finished goods. Labor with a massive amount and labor with expertise and skills can increase the quantity and quality of offshore wind turbines production. This can directly influence the capacity of China and the US offshore wind industries. Over 574,000 technicians will be needed globally by 2027 for the construction, installation, operation, and maintenance of wind fleets. 43% of both countries' required technicians will be new to the industry.

By the end of 2030, the number of technicians in the offshore wind industry will be about 2,400,000 people in China, and the shortage will be about 30,000 technicians. To obtain such a massive talent reserve and to reduce the shortage, China's government actively gives support to the industry through subsidies. The subsidies are given to technicians after education, training, and getting a certificate. Taking Zhongshan as an example, the government gives 1500 yuan to PhD per month; and 1000 yuan to master per month for subsidizing technicians on their livings. Moreover, the government subsidizes PhD 1500 yuan per month; masters 1000 yuan per month; undergraduates

700 yuan per month; and juniors 500 yuan per month for renting houses. The financial incentives will attract more technicians to work in offshore wind industries. Secondly, China offers training programs for technicians in offshore wind industries. The GWO training program prepares technicians with knowledge about engineering, turbine maintenance, and maritime safety.

The U.S. offshore wind market is preparing for rapid growth, and our understanding of specific workforce requirements and pathways to meet those requirements is not keeping pace [3]. By the end of 2030, the demand for technicians in the offshore wind industry in the US is estimated to reach 258,000 people, but the workforce is estimated to be only 134,000 people, which means that there will be a gap of 124,000 shortage in the workforce. To achieve those states like Massachusetts and New York have invested in collaborations between industry, government, and educational institutions to establish curricula with industry needs. Ensuring a steady pipeline of qualified workers. To attract more workers, companies are giving comparative wages of around 105 yuan per hour.

In conclusion, by the end of 2030, China will have a much higher talent reserve in the offshore wind industry compared to that in the US, and a much smaller shortage of technicians. This demonstrates that the offshore wind industry is more mature in China. The huge difference in talent reserve is the one of the reasons why there is a huge gap between the two countries capacity.

2.3. Capital

Offshore wind industry development needs significant upfront initial investments, which will cost in site surveys, turbine manufacturing, installation, and construction. Offshore wind projects are often capital-intensive, so capital is essential for the industry. Also, as capital flows into the industry, economics of scale can be achieved. This reduces the cost per unit of energy produced.

Chinese government finances the offshore wind through direct investments and policy support, which includes subsidies and financial incentives. For example, the Feed Tariffs, which is the major policy tool of China's government, guarantee a fixed price for purchasing the electricity generated by wind farms for a specific period. The price is often higher than the market price. This will decrease the risk of investing in the offshore wind industry and make the investment more attractive. Secondly, wind power producers are allowed to sell a green certificate along with their power sold, which expands ways that producers can gain profit. This will attract more power producers. The Chinese government also reduces value-added tax and import duties on key components used in wind turbines, enhancing the return on investment for developers, which will attract more investors. Secondly, state-owned enterprises are also crucial players in China's offshore wind industry as well. The state-owned enterprises ensure a steady influx of capital by building and operating wind farms. Moreover, it facilitates large-scale projects such as Guangdong Yudean Yangjiang Shapa Offshore Wind Farm, Jiangsu Rudong Offshore Wind Farm, and Fujian Changle Offshore Wind Farm E.g. Thirdly, China also engages in international cooperation to boost its offshore wind capacities. For example, State Power Investment Corporation (SPIC) and Siemens Gamesa-Siemens Gamesa have supplied turbines for various projects developed by SPIC. China Three Gorges Corporation and Energias de Portugal (EDP)-China Three Gorges Corporation has acquired a significant stake in EDP. It has gained access to extensive expertise in offshore wind energy. In 2023, China's investment in the offshore wind industry has reached \$76.7 billion. China's installed wind energy capacity also underwent growth.

The US federal government offers the Investment Tax Credit (ITC) and the Production Tax Credit (PTC) to reduce the cost of developing new offshore wind projects. To begin with, the ITC allows a tax credit of up to 30% of the capital cost. This credit is applied to the income tax of the projects' developers and can be gained by the year that the project begins. The ITC largely reduces the initial investment for entering this industry. The high initial cost of the industry will be considered as high-risk; therefore, fewer investors will invest in the offshore wind industry; however, the ITC largely reduces the barriers and threshold for entering this industry. Secondly, the PTC provides a per kilowatt hour(kWh) tax credit for the first 10 years of a project. The rate for wind projects is about 0.0025 USD per kWh. For a 1,000 MW producing wind farm, it could get a credit of \$25 million per year. The PTC reduces the cost of operating and enhances the interests of investors. In addition,

Public-Private Partnerships (PPPs) have been the tool in advancing offshore wind developments as the public capital. By combining public and private resources, high risk and high initial costs of projects can be easily overcome. For example, the Vineyard Wind, which is in Massachusetts, is a collaboration between Avangrid Renewables and Copenhagen Infrastructure Partners. It is one of the first PPPs in the US offshore wind industry. It aims to generate 800 MW of power and generates enough electricity to supply over 400,000 homes and businesses. The project takes advantage of both the state and federal incentives, including tax credits and environmental approvals. The private capital provides most of the financial sources, and the state reduces the cost. The risk of projects can be significantly decreased through this collaboration. The US is seeking international collaboration as well. Ørsted, a Danish multinational power company, invested billions of dollars in the Ocean Wind Project in New Jersey. The project aims to produce a capacity of around 1,100 MW and is designed to power hundreds and thousands of homes and businesses.

In summary, China is leading in the industry because of its direct governmental financing and support, streamlined regulatory environment, and strategic international partnerships. The US is operating in a more market-based framework which can delay in scaling up its offshore capacities.

3. Effects of Public Policy Analysis

Subsidy and Taxation Policies are important because they can lower the prices associated with factors of production, such as the cost of producing wind turbines, which means that the risk of high initial investment will be decreased; therefore, the offshore wind industry can become more attractive to investors. Thus, the financial incentives (subsidy and taxation credits) encourage the growth of the offshore wind industries.

3.1. Subsidy and Taxation Policies- China

Subsidy plays a critical role in China's offshore wind industry. For instance, the subsidy for offshore wind power was 0.051 USD/kWh which was 47.87% of the price in Jiangsu. The power generated by Jiangsu offshore wind reached 6.19 billion kWh in 2018 and the total subsidy for the offshore wind exceeded 0.3 billion USD [4]. Additionally, the tax policy that China takes is the Feed Tariff (FiT). The FiT policy benefits China's offshore wind industry through the government providing guaranteed prices, long-term contracts, cost-based compensation, and access to the grid. Due to the introduction of the FiT policy, China's wind industry underwent rapid growth. The implementation of the policy delivered a message to investors that investing in the offshore wind industry was not risky and profitable. The installed capacity soared from 450 MW in 2013 to 4445 MW in 2018 [4]. However, the price mechanism may hinder the development from a view of the market [5]. Thus, China should look forward to reducing its subsidy to 0 like European countries did step by step so that the growth can be sustainable.

3.2. Subsidy and Taxation Policies- The US:

The US promotes the growth of the offshore wind industry through two federal tax incentives: the Production Tax Credit (PTC) and the Investment Tax Credit (ITC). The federal income tax of taxpayers based on renewable energy project capital investments can be reduced by ITC. The PTC has been the key to the production in the offshore wind sector [5]. Currently, the policy for wind energy stands at an income tax credit of 0.021 USD/kilowatt-hour, the value of which is subtracted from the business taxes a wind producer would pay [6]. Secondly, the Inflation Reduction Act of 2022 (IRA), which aims to boost the domestic supply chain, extends and modifies tax credits for the offshore wind industry. The IRA ensures the economic benefits of renewable energy [7].

To sum up, although both the US and China offer favorable policy support, but US's policies are not continuous, and China's price mechanism is unhealthy for sustainable development.

4. Conclusion

To sum up, the record-high emission of CO₂ emphasized the urgent need to transition to clean energy sources such as offshore wind. China has established itself in a very leading position due to long coastlines, robust training projects for technicians, and favorable government subsidy and tax policy. These provide financial incentives resulting in a substantial talent and capital reserve that is crucial for the industry's growth. However, the problem of a lack of workforce is vital to China's offshore wind industry, and the inappropriate price mechanism will hinder its continuous development.

On the other hand, the US has long coastlines but they are not used efficiently. Despite this, the US faces the challenge of a shortage in the workforce to meet the demand of the offshore wind sector. States like Massachusetts and New York are making progress in developing educational partnerships to address the gap. However, the subsidy and tax policy the US applied is not cohesive, which might be inefficient.

Moreover, the analysis reveals that capital investment is critical in increasing offshore wind capacity. Both countries should prioritize investments in technologies and infrastructures to ensure sustainable growth.

China and the US should leverage their unique strengths and address their weakness by learning from other countries to significantly contribute to global efforts toward carbon neutrality and ensuring a sustainable energy future.

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