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A Feasibility Assessment for an Offshore Wind Accelerator (OWA) in China

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Batch 24, I enjoy studying and working with you. And I will miss the Batch 24 time.

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Abstract

Facing the challenges of climate change and energy depletion, the world needs to deploy more renewable energy to replace fossil fuels. As the largest energy consumer and carbon emitter, China's sustainable energy transition is particularly important. Owning the vast offshore wind (OW) resources, the Chinese Government has set ambitious goals on OW that provides a reliable and reasonable alternative to fossil fuels. However, the deployment of OW energy faces challenges, including high cost, technical difficulties, and knowledge gaps. In China, the lack of innovation has caused a high failure rate and low generation efficiency. As the frontrunner on OW, the UK provides a valuable example to learn for China. The Offshore Wind Accelerator (OWA) initiated and managed by the Carbon Trust plays a role in OW technical innovation in the UK. The OWA is developed based on the idea of innovation collaboration and that OW developers work together to prioritize their common technical needs and support the promising innovations. Working with the Carbon Trust Beijing Office, this thesis assesses the feasibility of forming an OWA in China. Primary and secondary data were collected to analyze the conveners, potential partners, and relevant authorities relating to the OWA. According to the analysis, there is low feasibility of forming an OWA in China in the current situation due to some fundamental limitations. First, the Carbon Trust and China Wind Energy Association (CWEA), the two conveners of the OWA, have sufficient knowledge and credibility but lacks funding. Second, the OW developers have few motivations because of a low level of interdependence, low sensitiveness to innovation risks, the innovation culture focusing on quick return, a high entry barrier to OW industry, and the current priority on construction. Third, the Chinese Government has issued policies to make the state-owned utilities "bigger and stronger" by providing more political and economic support, which further reduces the motivations of the OW developers to collaborate. Since the Chinese Government holds enormous power over the developers, forming an OWA may be feasible if the government supports the project. However, the obstacles existing in the OW market mean that an OWA cannot be sustained in the long-term.

Keywords: offshore wind, innovation, collaboration, feasibility assessment, China's power sector, SOEs

Executive Summary

Background

Our world is being threatened by human-made climate change. According to IPCC (2018), human activities have caused around 1.0°C of global warming above pre-industrial levels, and the increasing level is projected to reach 1.5 °C between 2030 and 2052 if we do not introduce significant changes. Global warming can cause catastrophic consequences for the natural environment and human society. The current energy system relying on fossil fuels has to be transited to a system with more renewables to combat climate change.

As the largest energy consumer in the world, China's energy structure is particularly significant for the systematic energy transition. In 2018, China consumed 3273.5 million tonnes oil equivalent (t.o.e) energy, accounting for 23.6% of the world energy consumption (BP, 2019). Furthermore, China's most significant energy source was coal, which caused substantial carbon dioxide emissions. To achieve China's climate targets, the Chinese Government has set ambitious goals on renewable energy, including offshore wind (OW) energy.

However, the development of OW energy faces obstacles in China. The high cost, technology difficulties, knowledge gaps constraint OW energy development. China's OW sector lacks innovation capacity, causing a high failure rate and low generation efficiency. To solve these challenges, it is necessary to promote OW technology innovation.

The UK is a frontrunner with the largest OW installed capacity in the world. In the UK's OW system, powerful and resourceful actors have formed a highly networked coalition to boost the credibility of and resources into the OW sector. One successful example of OW collaboration in the UK is the Offshore Wind Accelerator (OWA), which is initiated and managed by the Carbon Trust. The OWA is approved to be an effective collaboration mechanism to promote OW technological development.

Based on the successful experience of the OWA in the UK, Carbon Trust, as the managing organization of the OWA, has motivations to expand the collaboration mechanism to other areas. Considering China's abundant OW market potential, the Carbon Trust Beijing Office intends to develop an OWA program in China to promote OW technological innovation.

Problem definition

Based on the Carbon Trust's need, the practical problem is understanding the feasibility of forming an OWA in China. Some critical criteria need to be assessed to understand the advantages and disadvantages of creating an OWA. For the possible result, if forming an OWA is feasible, the technical innovation of OW in China can be accelerated by the collaboration mechanism; if not, understanding the critical obstacles to collaboration can help the Carbon Trust design future projects targeting on the barriers. Thus, this thesis can benefit China's OW development and energy transition.

Meanwhile, innovation collaboration in China's OW sector needs to be researched in detail. First, collaboration has been studied from various perspectives, but the innovation collaboration in a specific renewable energy sector needs more attention. Second, instead of giving a whole picture of a country's renewable energy system from an overall angel, the innovation and collaboration behavior of specific actors needs to be researched. This thesis uses China's OW sector as an example to study the feasibility of collaboration between the government, OW developers, and other organizations.

Aim

This thesis is based on two key research questions that explore the feasibility and sustainability of the OWA model in China.

RQ1: What is the level of the feasibility of forming a collaboration similar to the OWA model in China?

1.1 Do the conveners have sufficient credibility and resources to convene potential partners for an OWA?

1.2 Do potential partners have strong motivations to participate in an OWA collaboration?

1.3 What incentives and disincentives do government policies provide for forming an OWA?

RQ2: What are the barriers for the utilities in China to collaborate on a platform like OWA?

Research methodology

Based on the existing literature, this thesis divided the factors that can affect the forming of collaboration into three groups according to the roles of organizations. First, conveners need to have adequate credibility and influence in the sector and knowledge and skills of the problem domain to identify and persuade key stakeholders. The factors influencing the participating decisions of the key stakeholders include relationship, learning ability, interdependence, industrial and technological characteristics, and the power of buyers. The government can issue policies to provide incentives or barriers for organizations to collaborate. This thesis used a framework including these factors that guided data collection and analysis.

To assess the feasibility of forming an OWA in China, the author conducted an in-depth case study mainly through qualitative approaches. First, a process map was developed to guide the feasibility assessment for forming an OWA in China. Second, the author collected data through literature reviews, interviews, and observation. All data are in the form of text, tables, or images. Third, a code structure was developed based on the framework. Fourth, the author went through all the data during which some new factors that may influence forming the OWA were noticed and added into the code structure. Fifth, the author used the improved structure to analyze the data. Then the contents were synthesized in a matrix based on their codes. The author compared the information in the synthesis matrix and summarized the findings.

Key results

Conveners. There are two conveners, Carbon Trust and CWEA, that try to establish an OWA in China. Carbon Trust mainly provides knowledge support, and CWEA uses its network in OW industry to persuade potential partners, i.e., the government and critical OW developers.

The market potential in China. The Chinese Government has set strategies and targets of OW energy development. Many OW projects have been consented, and large areas are planned for developing OW energy. OW energy in China will keep growing at a steady or faster pace.

Potential partners. In China's OW market, Longyuan and SPIC are dominant developers, and Guodian, CTG, Huaneng, CGN, and Luneng are important developers. A small number of SOEs form a close circle that controls OW development. These companies are the key participants who own substantial financial advantages and political support. The key stakeholders have prior ties and understand each other well. They have the same owner, SASAC, who can give direct orders to the developers. NEA can also influence the developers through OW development plans and policies. The developers tend to focus on near-term innovation that can quickly provide benefits and be used by their projects soon. For domestic private utilities and foreign-owned utilities, the entry barrier to enter China's OW sector is extremely high. Currently, the FiT of OW energy is RMB 0.85 Yuan/kWh, much higher than other energy sources.

Policies. The Chinese Government does not provide strong incentives for OW developers to collaborate on innovation. First, although the government issued market-oriented reform on the electricity sector, the "bigger and stronger" objective of SOEs reform with merger and acquisition policies will keep the market situation that some central SOEs monopolize the OW development. Second, the change of FiT has pushed the OW developers to set their priorities on construction rather than long-term innovation. Third, the government has not issued policies about promoting collaboration between OW developers.

Main conclusions

Due to the advantages and barriers from three perspectives, the feasibility of forming an OWA in China is low.

First, the Carbon Trust and CWEA as two conveners together have sufficient knowledge and skills but lack a clear and detailed plan for the funding.

Second, the major OW developers who are vital participants of the OWA have low motivations for the OWA because of four factors: a low level of interdependence; low sensitiveness to innovation risks and the innovation culture preferring quick returns; a high entry barrier to the OW sector; the current priority of the OW developers on construction.

Third, the government policies further reduce the motivations of OW developers for innovation collaboration due to the acquisition and merge in the power sector and the cancellation of the FiT.

Since the Chinese Government plays a particularly significant role in forming an OWA in China, building an OWA in China may be feasible if the government provides funding and encourages the developers to collaborate. However, the features in China's OW sector, such as relative monopoly, lack of interest in breakthrough innovation, and construction priority, make the OWA challenging to sustain.

Recommendations

Targeting at the barriers identified in this thesis, the Chinese Government can promote innovation collaboration on renewable energy by implementing the following policies:

- Create a fair utility market by reducing political and economic privileges to state-owned utilities.
- Create an open utility market by encouraging Chinese private companies and foreign-owned companies to enter China's utility market.
- Issue policies to prevent the negative impact of canceling the OW FiT.
- Support innovation collaboration platforms.

Having the successful OWA experience in the UK and facing the vast OW market potential in China, Carbon Trust should keep pushing the OWA idea in China through the following methods:

- Keep working with CWEA on the OWA.
- Strengthen the promotion of the OWA model.
- Enhance communication with government authorities and OW developers in China.

For future studies, it is valuable to research the innovation behavior and collaboration behavior of the utilities in China. It is significant to compare the difference between state-owned utilities and private utilities on technical innovation. Also, the scholars can look into the relationship, such as cooperation and competition between the state-owned utilities in China.

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Abbreviations

CCP: Chinese Communist Party

CNREC: China National Renewable Energy Center

CPI Group: China Power Investment Corporation

CREEI: China Renewable Energy Engineering Institute (CREEI)

CWEA: China Wind Energy Association

CWEEA: China Wind Energy Engineering Association

FiT: Feed-in Tariff

MOST: The Ministry of Science and Technology

NDRC: National Development and Reform Commission

NEA: (China) National Energy Administration

OW: Offshore wind

OWA: Offshore Wind Accelerator

PICC: The People's Insurance Company of China Limited

SASAC: State-owned Assets Supervision and Administration Commission of the State Council

SME: small and medium-sized enterprises

SOE: state-owned enterprise

t.o.e: tonnes oil equivalent

1. Introduction

Facing the challenges of climate change, developing and deploying renewable energy is becoming necessary and urgent, especially for China, the biggest energy consumer and carbon dioxide emitter (BP, 2019). Due to China's increasing energy demand and the enormous OW energy potential, OW energy provides an attractive solution to transit China's energy system. Collaboration between various companies can foster technological innovation to promote energy transition. One successful example of innovation collaboration is the OWA in the UK.

1.1 Background

Human-made climate change is threatening our world. According to IPCC (2018), human activities have caused around 1.0°C of global warming above pre-industrial levels. The increasing level is projected to reach 1.5 °C between 2030 and 2052 if human does not introduce significant changes (IPCC, 2018). The global warming can cause catastrophic consequences for the natural environment and human society: environmental impacts include biodiversity loss, ecosystem disturbance, ocean acidification; societal impacts means that global warming threatens human health, food security, water supply (IPCC, 2018). As a response to the challenges led by climate change, the world reached the Paris Agreement aiming to "hold(ing) the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (the United Nations, Paris Agreeme, 2015, Article 2). The world has to transit the current energy system relying on fossil fuels to a system with more renewables that will need to supply 70-85% of electricity by 2050 to meet the 1.5°C target (IPCC, 2018).

In addition to climate change, the current energy structure also leads to other concerns including high oil prices, the energy security about importing energy from other countries, and environmental degradation led by burning fuels (Bilgen, 2014). The current energy consumption structure is far from the satisfying level to respond to the challenges. Figure 1 shows that fossil fuels still dominate world energy supply in 2018: oil accounts for 34%; coal accounts for 27%; natural gas accounts for 24%. A worrying fact is that the world energy consumption increased 2.9% in 2018, the fastest growth since 2010, and natural gas contributed over 40% of the increase (BP, 2019). As energy consumption increased by 2.9%, the carbon emissions from energy use increased by 2%, which is also the fastest increase for seven years. Thus, the energy transition is too slow to play its role in climate action and deploying renewable energy has become extremely significant.

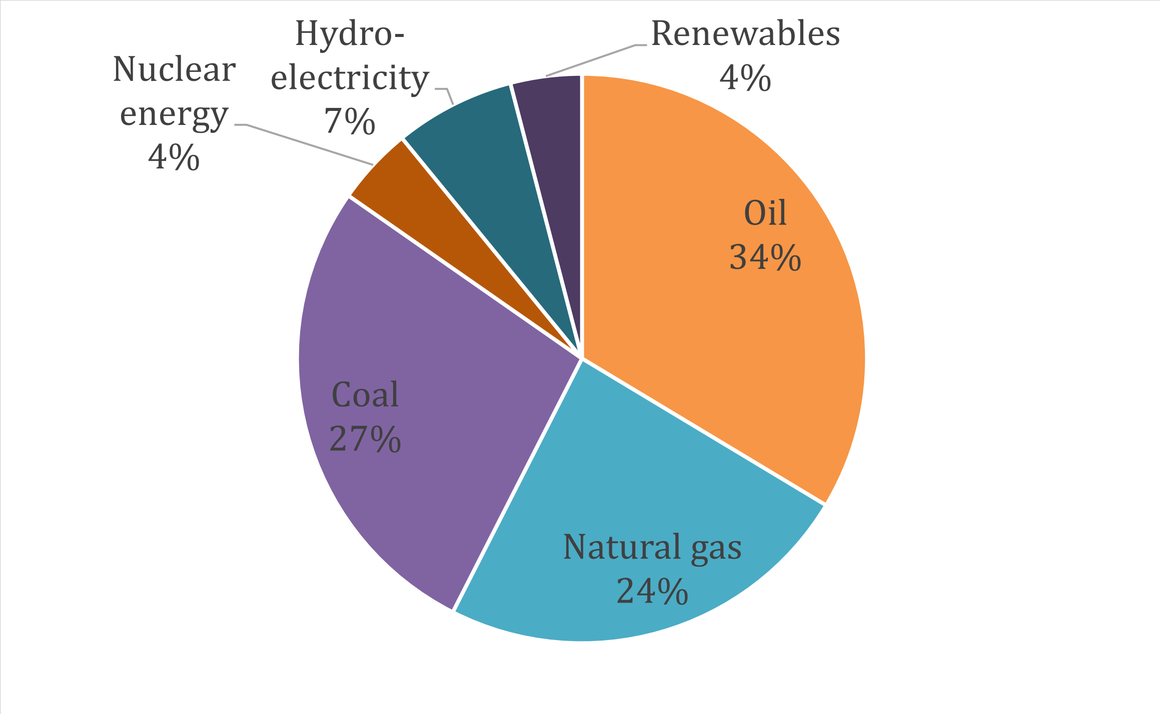

Figure 1. The world primary energy structure in 2018.

Source: Author. Based on the data from (BP, 2019).

As the largest energy consumer in the world, China's energy structure is particularly significant for the systematic energy transition. From 2000 to 2016, China's primary energy demands had increased over 160%, and the average increase rate per year was 6% (OECD/IEA, 2017). In 2018, China consumed 3273.5 million tonnes oil equivalent (t.o.e) energy, accounting for 23.6% of the world energy consumption (BP, 2019). Furthermore, China's most significant energy source was coal which accounted for 58% of the primary energy source in 2018 (Figure 2), and the reliance on coal will not change in the near-term due to energy security concern (Zhang, Zhang, Cai, & Ma, 2017). Because of the vast fossil fuel consumption, China emitted 9419.6 million tonnes carbon dioxide, accounting for 28% of the world emissions in 2018. Compare to China, the US emitted 5017.9 million tonnes carbon dioxide, accounting for 14.9% of the world emissions, much lower than China (BP, 2019). However, China's primary energy consumption per capita was 96.9 Gigajoules, still much lower than the OECD level 182.6 Gigajoules (BP, 2019). With economic growth, China's energy consumption is likely to keep increasing. In particular, the global coal demand is believed to increase from 3.6 billion t.o.e in 2010 to 12.9 billion t.o.e. in 2050 due to China's coal consumption (Bilgen, 2014), which can cause significant climate and environmental impact.

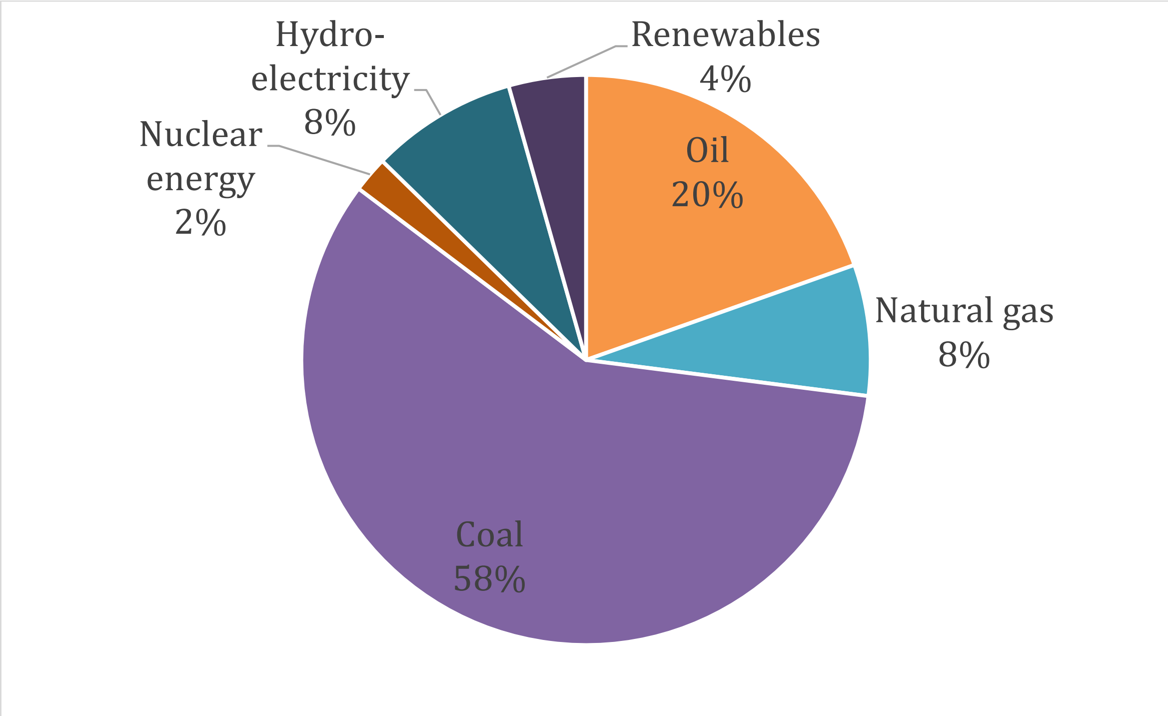

Figure 2. China's energy structure in 2018

Source: Author. Based on the data from (BP, 2019)

The current status and increasing prospect of China's energy consumption have caused obstacles to China's climate targets. The Chinese Government has promised three climate targets: (1) the carbon dioxide emission reaches the peak around 2030, making efforts to achieve it earlier; (2)the carbon dioxide emission per GDP decreases 60% - 65% from the 2005 level; (3) non-fossil energy accounts for approximately 20% of the primary energy consumption by 2030 (OECD/IEA, 2017). To achieve these targets, the Chinese Government has actively support developing and deploying renewable energy including hydro, wind, solar, biomass, and oceanic power (Xiliang, Da, & Stua, 2012; Y. Zhang, Tang, Niu, & Du, 2016). Among these energy types, some of them have apparent disadvantages. For example, nuclear energy causes security concerns, and hydropower may create adverse environmental impact on river conservation (Esteban, Diez, López, & Negro, 2011). Compared to other conventional energy and renewable energy, wind energy provides a reasonable alternative with little negative impact and has high potential to become a significant energy source in the future (Leung & Yang, 2012).

1.1.1 Offshore wind ambition in China

China's population and economic activities concentrate in the eastern coastal areas, having significant energy demands. There are 11 provinces (including mega-city clusters in Bohai Rim, Yangtze River Delta, and Pearl River Delta) located in the coastal areas that have 30% of the population, 40% of the GDP, and 90% of the exports in China (Hong & Möller, 2011). The intensive society and dynamic economy lead to enormous electricity demands, contributing to 70% of energy demand growth and 55% of electricity consumption in China (Hong & Möller, 2011). Since the coastal areas lack energy resources such as coal and hydro, resources and electricity have to be transported from other regions, which causes high economic and environmental costs (Hong & Möller, 2011).

Developing OW energy is a reasonable choice for the coastal areas as the areas have huge OW potential. China's east coast has around 200 GW OW potential within water depth of 25m and

300 GW OW potential in water depth between 25m and 50m (Wyatt et al., 2014). Besides, the ocean regions with OW potential do not interfere with shipping and fishing, and no Force 3 or stronger typhoons occur in the ocean areas (Wyatt et al., 2014). In addition to environmental benefits, the close distance between the coastal areas and possible OW farms means that deploying OW can reduce transport cost and power transmission loss.

China has set ambitious targets to use OW resources. Before, the government proposed to improve installed OW capacity to 5 GW by 2015 and 30 GW by 2030 (Hong & Möller, 2011; J. Zhang et al., 2017). However, the actual development pace is slower than expected. For example, China only achieved around 20% of the 5 GW target by 2015 (Zhang et al., 2017). Then, the government set new goals that the installed capacity of OW energy reaches 5 GW and 10 GW under construction (NEA, 2016b). Some challenges cause slow progress.

High cost, technology difficulties, knowledge gaps are main challenges that OW sector is facing. First, because installing towers, foundations, and underwater cabling is more painful and expensive in the ocean environment, deploying OW energy costs 1.5 - 2 times higher than onshore one (Leung & Yang, 2012). When settling wind turbines further from the coast and in deeper waters to absorb more wind energy, the cost increases sharply (Leung & Yang, 2012). Second, due to the difficulty in accessing the site, it is challenging to operate, maintain, and repair OW farms (Leung & Yang, 2012). Thus, to solve these obstacles, it is necessary to develop OW technology further.

The development pace of OW technology in China is relatively slow. Compared to wind turbines manufactured and installed in Europe, the turbines in China have smaller capacities. The wind farms in China have more operation accidents and lower generation efficiency than in the US (Lu et al., 2016). To better support OW technology innovation and development, it is necessary for China to learn from leading countries on OW energy.

1.1.2 Offshore wind experience in the UK

The UK is a frontrunner in terms of OW utilization, owning 36% of the installed OW capacity in the world (IRENA, 2019). In the OW system in the UK, powerful and resourceful actors have formed a highly networked coalition to boost the credibility of and resources into the OW sector (Kern et al., 2014). This kind of collaboration is significant for the legitimacy improvement of OW technology despite its high costs (Kern et al., 2014). The legitimacy improvement is able to support the sustainable development of OW energy in the UK.

One successful example of OW collaboration in the UK is the Offshore Wind Accelerator (OWA), which is initiated and managed by Carbon Trust. The key participants of OWA include the Scottish government and key OW developers. The objective of the accelerator is to "*reduce the cost of offshore wind, overcome market barriers, develop industry best practice and trigger the development of new industry standards*" (Carbon Trust, n.d.-b).

Different actors in the OW sector collaborate in the OWA to promote technical innovation. Figure 3 shows the structure of the OWA where nine partners form a steering committee and four technical groups. The technical working groups identify and prioritize key technology challenges according to the potential influence and cost savings (Carbon Trust, n.d.). To address these challenges, the Carbon Trust management team designs and implements projects through international competitions to inspire innovations and select best solving ideas (Carbon Trust, n.d.). The proposals with the highest potential are then developed, de-risked, and commercialized as the OWA works closely with innovators, designers, and supplier through the development process (Carbon Trust, n.d.). In addition to the nine partners in the OWA program, the Carbon Trust also cooperates with other significant stakeholders such as founders, finance community, innovators, designers, and research institutes (Villiers, n.d.).

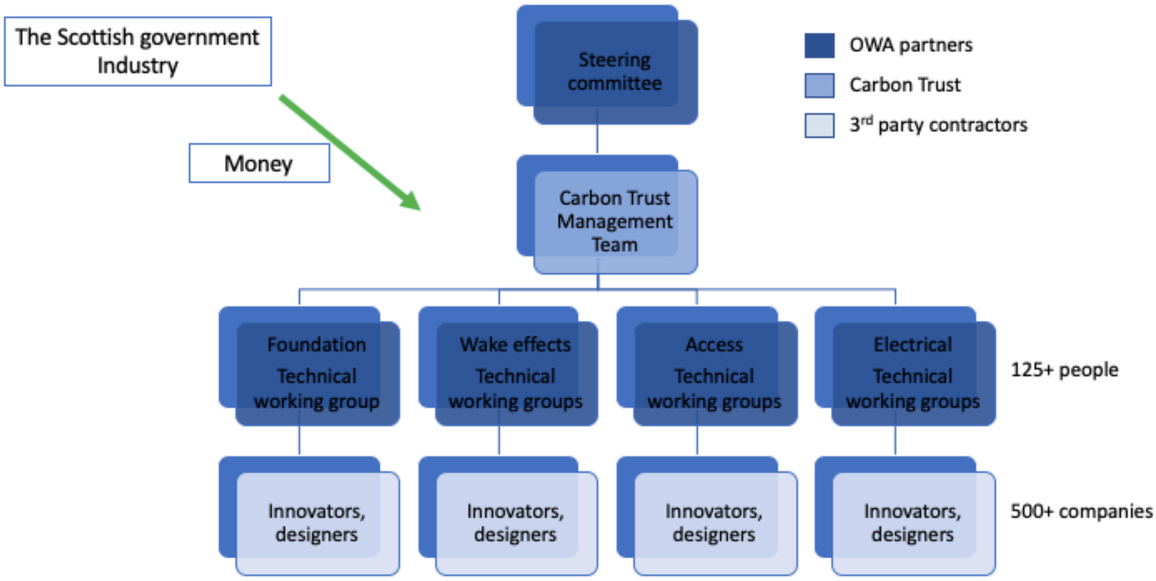

Figure 3. The participants and structure of OWA in the UK.

Source: Adapted from (Villiers, n.d.)

The OWA is approved to be an effective collaboration mechanism to promote OW technical development. The program has run over 150 projects to support innovations, including foundation design, 66kV cables, and wake modeling (Carbon Trust, n.d.-a). The accomplished innovations have delivered a 15% reduction in the Levelized Cost of Energy (LCOE) (Carbon Trust, n.d.-a). The cost reduction makes OW more competitive than before in the energy system.

Based on the successful experience of the OWA in the UK, Carbon Trust as the managing organization of the OWA has motivations to expand the collaboration mechanism to other areas. Considering the abundant OW market potential, the Carbon Trust Beijing Office intends to run an OWA program in China to promote OW technical innovation and development.

1.2 Problem Definition

The purpose of this thesis is to assess the feasibility of launching an innovation collaboration, the OWA, in China. Due to China's massive energy consumption and carbon dioxide emissions, developing and deploying OW is critical for climate mitigation and environmental protection. Understanding the significance of OW, the Chinese government has set ambitious targets on OW development. However, OW development faces the challenges of high cost and technical bottlenecks. To meet these challenges, China can learn lessons from the leading countries on OW. One leading country is the UK that has the largest OW capacity and has effectively developed OW technology through collaboration. One representative example of collaboration is the OWA in which the Carbon Trust, OW developers, and innovators cooperate to accelerate technical innovation. The Carbon Trust plans to spread the successful experience of the OWA to China and therefore want to understand if it is feasible. Based on the practical needs of the Carbon Trust, this thesis plans to assess the feasibility of forming OWA in China. The OWA in China will not be completely the same as the UK version because some adjustments will be made based on China's context. Some critical criteria need to be evaluated to assess the feasibility. If forming an OWA is feasible, the technical innovation of OW in China can be accelerated by the collaboration mechanism; if not, understanding the critical obstacles to collaboration can help Carbon Trust design future projects targeting on the barriers. Thus, this thesis can benefit China's OW development and energy transition, which are significant for climate mitigation and environmental protection.

Meanwhile, innovation collaboration in China's OW sector in China needs to be researched in detail. First, collaboration has been studied from various perspectives, but the innovation collaboration in a specific renewable energy sector needs more attention. Second, instead of giving a whole picture of a country's renewable energy system from an overall angel, the innovation and collaboration behavior of specific actors needs to be researched. This thesis uses China's OW sector as an example to study the feasibility of collaboration between the government, OW developers, and other organizations.

1.3 Objective and Research Questions

The primary objective of this thesis is assessing the feasibility of form the OWA model in China. This thesis divides the stakeholders of OWA into three groups to assess the feasibility: the conveners who want to start the collaboration process; the potential partners whom the conveners will invite to the OWA; the authorities who can issue policies to influence the collaboration. Based on the literature review, the feasibility of OWA is determined by the features of three groups: the conveners need to own sufficient credibility and resources; potential partners need to have motivations to participate in the collaboration; the government policies play a crucial role in influencing conveners' credibility and potential partners' motivation. Thus, Research Question 1 and its sub-questions are formed based on the significance of conveners, potential partners, and authorities.

RQ1: What is the level of the feasibility of forming a collaboration similar to the OWA model in China?

1.1 Do the conveners have sufficient credibility and resources to convene potential partners for an OWA?

1.2 Do potential partners have strong motivations to participate in an OWA collaboration?

1.3 What incentives and disincentives do government policies provide for forming an OWA?

Based on the answers of the RQ1 and its sub-questions, the author can sum up the factors that may affect the collaboration. It is valuable to analyze the collaboration barriers existing in China's power sector. In other words, the author expands the findings from the OW sector to the broad utility sector. Therefore, the Research Question 2 is formed.

RQ2: What are the barriers for the utilities in China to collaborate in a platform like OWA?

Building on the identified barriers, this thesis provides recommendations for the government and the Carbon Trust to solve the obstacles. For the government, policy recommendations are provided to promote innovation collaboration better; for Carbon Trust, the suggestions are to develop the OWA in China.

1.4 Scope

Since aiming to assess the feasibility of forming an OWA in China, this thesis focuses on China's OW sector. The boundary of this thesis was set with the three stakeholder groups. First, Carbon

Trust, as the initial original convener in the OWA, is within the research scope. In particular, Carbon Trust's Beijing Office and OW Team are key actors for forming the OWA. After the interview with Carbon Trust staff, Carbon Trust has chosen GWEA as the other convener of the OWA. Second, according to the OWA design, the potential partners of OWA are the key OW developers in China. Therefore, seven OW developers were selected based on their market share in China's OW industry. The small OW developers were excluded from the research. Third, the research scope also includes the policies that have a direct or significant impact on collaboration between OW developers.

1.5 Audience

By analyzing the conveners, the key OW developers and the governmental policies in China, this thesis can provide valuable information for Carbon Trust, policymakers, researchers, and OW industry.

For **Carbon Trust,** this thesis answers the question of the feasibility of forming an OWA in China. Concrete evidence is laid out to discuss the advantages and disadvantages of creating the collaboration. The evidence can deepen Carbon Trust's knowledge of China's OW sector. Furthermore, the thesis can help inform Carbon Trust on future OW projects, including potentially forming an OWA in the future.

For **policymakers**, this thesis discusses the existing obstacles to collaboration between the OW developers. Since collaboration is approved to be an effective method for promoting technical innovation, the policymakers can issue responding policies to solve the obstacles to boost China's energy transition.

For **researchers**, this thesis provides valuable information of China's OW industry. First, researchers and graduate students can use this thesis as an initial report to understand China's OW industry. Second, this thesis also contributes to the discussion of China's OW development. Instead of focusing on the broad picture of the whole industry, the thesis looks more in-depth at the key actors who dominate China's OW market. Besides, this thesis discusses both company behaviors and government policies.

For the **OW industry**, this thesis provides comprehensive and detailed information about China's OW sector. First, the companies who intend to enter China's OW market can understand the key OW actors and policies via this thesis. Second, the companies who are already in China's OW sector can understand the whole picture and possible trends of the market.

1.6 Ethnical Consideration

Clearly understanding the significance of research ethics, the author has put research principles into the whole thesis process from project design to thesis writing. First, the author, as a researcher, keeps being objective on data collection and analysis. Working with Carbon Trust, the author admires the company's mission to accelerate the global transition to a low carbon economy and has motivations to push the OWA project. However, the strong motivations should not make the author too optimistic and affect the rationale on the thesis. Second, the author takes efforts to make sure that the thesis will not bring damages to Carbon Trust and all interviewees. While discussing the internship, the Carbon Trust Beijing Office understood the author's intent to write a thesis and suggested possible thesis topics among which the author selected the OWA feasibility assessment. All interviewees were informed of the thesis background and interview purpose through emails and conversation for the interview invitations. The interviewees voluntarily determine whether or not participating in interviews.

Before any interview, the author explained the interview purpose again and asked the interviewees' consent. The names of the interviewees are all coded with numbers in both the interview documents and the thesis to make sure that they will not be identified. Third, the author handles the data carefully to prevent any data leakage. All files are stored in the author's personal computer and protected with passwords.

1.7 Disposition

Chapter 1 presents the needs of OW technical innovation and Carbon Trust's intent to expand the OWA model to China. Based on the problem, research questions and scope are discussed. The content then identifies the intended audience and ethnic consideration and provides a thesis outline.

In Chapter 2, a more thorough analysis of the literature relevant to OW energy and collaboration is presented, and the main gaps in the research field are outlined. Based on the literature review, an analytical framework used for guiding the research is presented.

Chapter 3 presents the research methods used for data collection and analysis.

Chapter 4 presents the analysis from the collected data and the main finding from the analysis.

Chapter 5 presents the discussion based on the findings. This chapter provides detailed answers for the RQs.

Chapter 6 presents the main conclusions of the analysis, explains how the work contributes to the literature and OW industry, and then provides recommendations directed to the principal audiences. This final chapters then outlines future research areas.

2 Literature Review

This chapter gives a detailed review of the existing literature on OW energy and collaboration. On the OW energy side, this chapter aims to understand OW technology, its impacts, and its status quo in China; on the collaboration side, this chapter seeks to explain collaboration's definition, benefits, and preconditions.

2.1 Offshore Wind Energy

Wind power has been a part of human development for a long time. Human has a more than 3000-years history of using wind power, much longer than using coal and refined petroleum, and first used it to generate electricity around 120 years ago (Leung & Yang, 2012). After understanding the electricity generation from wind, small wind machines and windmills were used first (Leung & Yang, 2012). In the 1970s, wind technology development boosted due to the oil crisis but soon slowed down (Leung & Yang, 2012). In the 21st century, considering environmental consequences and energy security, some countries have issued policies to support wind energy development (Leung & Yang, 2012). Based on the technology of onshore wind, offshore wind has also been developing quickly in recent years. OW energy, due to its advantages compared to onshore wind, provides environmental-friendly energy for some countries, especially the countries having ocean territory and OW resources.

2.1.1 Estimations the OW energy potential

With more than 1800 km long coastline and more than 6000 islands, China has massive OW resource, especially in southeast coast and nearby islands, with an average wind density of 300 W/m^2 (Sahu, 2018). According to estimation conducted by China Meteorological Administration, China has approximately 200 GW offshore wind power potential at 5-25m water depth and 50m height, and around 500 GW at 5-50 water depth and 70 m height (Hong & Möller, 2011; Sahu, 2018; Xiliang et al., 2012). Another study conducted by UNEP and the US National Renewable Energy Laboratory concluded a similar result that China has 600 GW OW potential (Xiliang et al., 2012). Having so much OW potential, the Chinese Government has motivations to effectively and efficiently use it.

The Chinese Government has set ambitious targets on energy efficiency and OW application. In China's 13th Five-Year Plan (2016-2020), the Chinese Government aims to reduce energy consumption and carbon emissions per unit of GDP by 15% and 18% respectively (Sahu, 2018). Specifically, by 2020, the installed capacity of OW needs to reach 5 GW by 2020; the OW capacity under-construction needs to reach 10 GW; OW annual electricity generation needs to reach 420 TWh, approximately accounting for 6% of the entire electricity generation in China (NEA, 2016b). Although 6% sounds like a small part of total electricity generation, it means OW needs to become a mature energy source.

China's wind energy has been developing quickly in recent years and has the largest installed capacity of wind power in the world (IRENA, 2019). Specifically, Figure 4 shows the OW development trends in China, the UK, Germany, Denmark. In 2018, China's cumulative installed capacity reached 4,588 MW, accounting for 20% of the total world capacity (IRENA, 2019), meaning that OW development in China is very close to the 5 GW target set in 13th Five-Year Plan. China's OW installed capacity is still behind UK's 8,300 MW and Germany's 6,410 MW, accounting for 36% and 27% of the world capacity respectively. For the increase of installed capacity, China's average increase rate of installed OW capacity from 2011 to 2018 is 68%, lower than Germany's 84% but higher than the UK's 27%. Overall, China's OW has been developing quickly from a quantitative perspective.

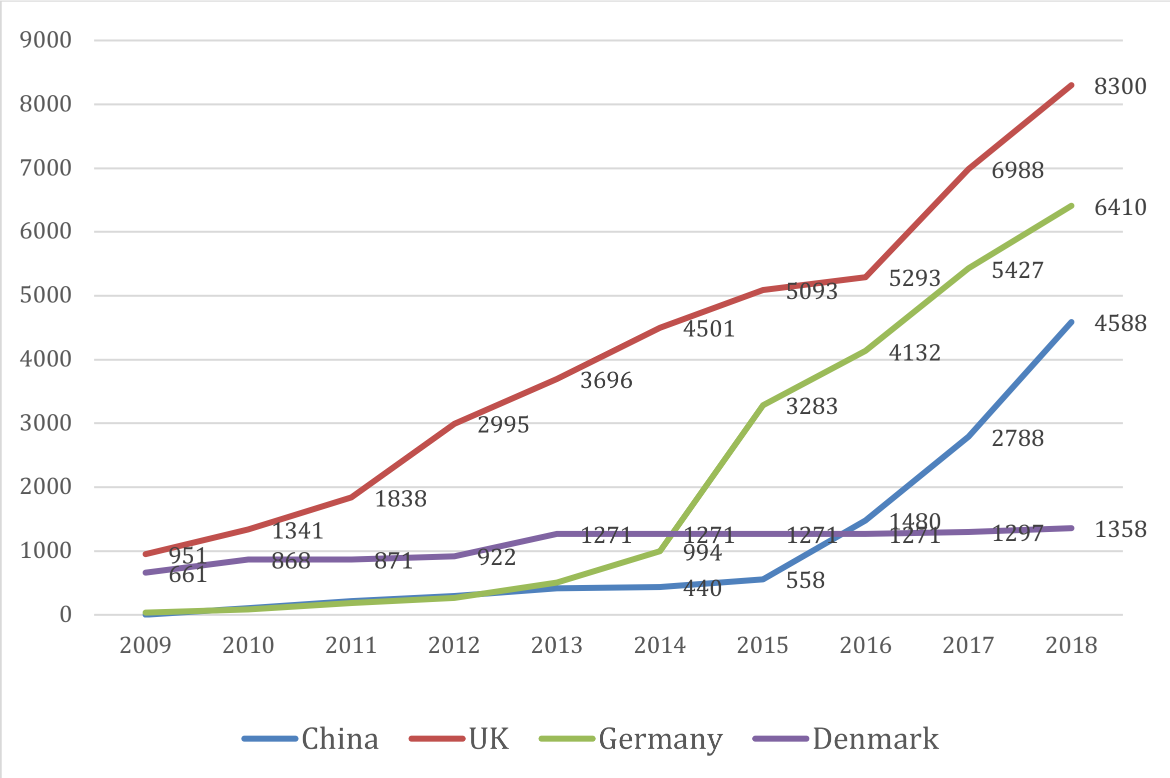

Figure 4. The cumulative installed capacity of OW in China, the UK, Germany, and Denmark (Unit: MW).

Source: Author. Based on data from (IRENA, 2019).

2.1.2 The benefits of using OW energy

Compared to other energy resources, wind energy, including OW, has various advantages. First, since the utilization of wind energy does not emit toxic and greenhouse gases, it is environmental-friendly and climate-friendly compared to fossil fuels (Leung & Yang, 2012; Zheng, Li, Pan, Liu, & Xia, 2016). Second, compared to nuclear energy that can provide significant power, the utilization of OW wind is much safer (Zheng et al., 2016). Although nuclear energy has several advantages such as high energy efficiency, long functional time-scales, and high energy outputs, it can cause catastrophic consequences by human mistakes (e.g. Chernobyl explosion in 1986 caused by operator errors) and natural disasters (e.g. Fukushima nuclear leakage in 2011 caused by tsunami) (Zheng et al., 2016). Third, solar can only generate electricity at daytime, but wind is available all day (Zheng et al., 2016). Finally, hydropower, which is the largest renewable energy source in China, can damage the river ecosystem, especially in naturally sensitive areas (Esteban et al., 2011).

Before using offshore, human started from onshore wind because it's easier to construct and operate wind turbines on land. In recent years, some countries have been paying more attention to OW because of some characteristics of OW. First, increasing with the distance from the coast, offshore wind is stronger than the onshore counterpart (Esteban et al., 2011; Leung & Yang, 2012; Zheng et al., 2016). The speed of surface wind 10 km off from the coast is usually 25% greater than the speed of onshore wind (Zheng et al., 2016). Because of the high quality of OW, the lifetime energy performance of OW farms is better than onshore ones. Second, the offshore wind is more uniform, causing fewer turbulence effects on wind turbines and therefore beneficial to the lifetime of wind farms (Esteban et al., 2011). Due to the high quality and long lifetime, the net electricity return of OW farms in China's context exceeds the onshore ones after 9.2 years operation, and the accumulated energy return of a 20-years lifetime is much more abundant than onshore ones (Zhang et al., 2017). In other words, although OW development is expensive, OW farm is a higher input-output choice compared to onshore wind farms whose advantages are quicker-return and lower-risks (Zhang et al., 2017).

Developing OW farms in the ocean also has other advantages. First, instead of constructing on land that is scared in some areas, OW farms are built on unlimited ocean space. Therefore, large OW farms can be constructed without the concern of human migration for farm construction (Zheng et al., 2016; Leung & Yang, 2012). Second, if OW farms are far enough from the coast and residential areas, the visual impact of OW farms is limited, and their noise pollution can be ignored (Esteban et al., 2011; Leung & Yang, 2012; Zheng et al., 2016). Therefore, it is possible to build large and efficient OW farms to generate electricity, causing little visual and noise impact (Leung & Yang, 2012).

In China, a particular advantage of developing OW energy is the close distance between OW farms and energy consumption areas. China has a very uneven distribution of population and economic activities that 40% of China's population, 60% of the GDP, and 90% of the exports concentrate in the coastal provinces, contributing to 55% of China's electricity consumption and 70% growth of the energy demands (Hong & Möller, 2011). Because of the lack of energy resources, the coastal areas need to import coal from inland Chinese provinces and oil from foreign countries to meet their energy demand, leading to high energy cost and transport pressure (Hong & Möller, 2011). Currently, most onshore wind farms are northwestern and northeastern China, far from energy-demanding areas and leading to high transmission cost and energy loss (Zhang et al., 2017). The close distance provides incentives for coastal areas to develop OW farms, which can reduce their energy imports from other regions.

In sum, developing and deploying OW can bring various benefits. First, OW can produce electricity without emitting GHG, which is significant for climate action. Second, compared to other renewable energy sources, including onshore wind, OW has advantages such as a high level of stability and efficiency and low environmental impact. In China's context, the coastal areas have high energy demands, providing a substantial market for OW energy. Further, the close distance between coastal regions and possible OW farms can significantly reduce energy loss, transport cost, and environmental impact.

2.1.3 The challenges of using OW energy

Although OW can bring significant benefits, utilizing OW faces some challenges such as high cost, technical difficulties, and knowledge gaps. First, developing OW needs massive investment due to the high cost of OW facilities, operation, and maintenance. For example, buying wind turbines accounts for 75% of the total investment of onshore wind projects; in OW projects, the percentage is 33% because of the high cost of other facilities and management (Esteban et al., 2011). Since there is usually no electrical infrastructure such as substations and cables that are to transfer the electricity generated by OW farms to electricity grids, OW developers have to invest in strengthening existing infrastructures or constructing new infrastructures while developing OW projects (Esteban et al., 2011).

Second, developing OW projects also face technical difficulties. First, technological development is needed based on onshore wind technology. Although OW turbines have a similar structure to onshore wind turbines, technical modification is required to better suit the ocean environment (Esteban et al., 2011). Besides the improvement for turbines, OW foundations need protection from corrosion problems. Second, technical innovations need to be continuously promoted to use OW more efficiently. For example, floating foundations are under development to use strong wind resources in deep-sea areas.

Third, installing wind turbines in the ocean environment also face some knowledge gaps that closely relate to technical difficulties. First, it is more challenging and expensive to evaluate the wind resource and then choose best farm sites in the vast ocean space (Esteban et al., 2011), which is an essential step in OW project development. Second, in the ocean environment, strong wake effects not only affect the performance of wind farms but also influence the lifetime of wind turbines (Esteban et al., 2011). Developing more advanced modeling method is necessary to understand wake effects over potential wind farms and therefore improve their performance. Third, although the impact is minor, wind farms can change the regional climate, whose long-term impact is still unclear (Leung & Yang, 2012). To comprehensively understand the environmental impact of wind farms, researchers are paying attention to climate concern.

Thus, although OW farms can bring a range of environmental and societal benefits, developing OW farms faces some obstacles. The first obstacle is the enormous cost of constructing and operating farms, resulting in high financial pressures to OW developers. The second one is the technical difficulties caused by installing wind turbines in deep seas, which require more technical innovations. The thirds one is the knowledge gaps such as wind measurement, wake effects, and climate impact which require more research.

2.1.4 Understanding OW technical development in China

The Introduction section discusses the fast increase of China's OW installed capacity, which helps to understand China's OW industry from a quantitative perspective. In addition to the installed capacity, it is critical to analyze China's OW industry from a technical quality perspective. As a catch-up country on offshore wind, Chinese OW suppliers have successfully developed their manufacturing capacity. In China, the manufacturers have formed a relatively complete supply chain of manufacture, marketing, transportation, installation, operation, maintenance, and overhauling (Fan & Wang, 2016). Some national and regional design and manufacturing centers have been established to promote technical development (Fan & Wang, 2016). Chinese OW technology developers have become important players in both domestic and abroad OW markets (Lam, Branstetter, & Azevedo, 2017).

Specifically, the capacity volume of OW turbines is a crucial aspect of OW technology. Currently, Chinese domestic manufacturers dominate China's wind turbine market; however, the phenomenon is partly because of China's protectionist policies. On turbine capacities, 4 MW turbines are the most popular type among all installed OW turbines by the end of 2018; the cumulative capacity of 4 MW turbines reached 2.3 GW, accounting for 52.8% of total installed capacity (CWEA, CWEEA, & CNER, 2019). 5 MW OW turbines are the newly developed type whose cumulative capacity reached 0.2 GW, accounting for 4.6% (CWEA et al., 2019). The turbines with such as 6 MW and 6.5 MW are rarely installed in China. Compared with the popular 6 MW OW turbines installed in Europe, the OW turbines in China have lower capacity.

The technical development and capacity increase do not mean China has strong innovation ability, especially compared to the OW leading countries. The patents of OW technology can be seen as a key indicator of technical innovation level. Chinese OW inventors have been granted many patents in China, but few patents in Europe and the US (Lam et al., 2017). Furthermore, the issued patents are less likely to be cited than the patents from other countries such as Germany, Denmark, and Japan (Lam et al., 2017). The phenomenon of the high patent number and the low citation is caused by China's patent incentive mechanism that companies can get government tax reduction or subsidy based on patent numbers, leading to many "junk" patents (Lam et al., 2017). Although both the OW installed capacity and manufacturing capacity have developed quickly, China's technology development has failed to promote the global state of the art of OW, and the development is more like technology transfer or technology absorption, rather than technical innovation (Lam et al., 2017).

The lack of technical innovation is a critical obstacle faced by China's OW industry. Because technology innovation is the primary approach to improve technical quality and create new core technology, the lack of core technologies and inferior quality resulted in the high failure rate of wind turbines in China (Lin, Tu, Liu, & Li, 2016). Furthermore, the low quality has also caused poor performance, resulting in less electricity generation compared to the wind farms with similar capacity in other countries (Lu et al., 2016). In another word, even though the installed capacity of OW is high in China, the performance of the OW farms is not efficient, reducing the significance of OW for replacing conventional fossil fuels.

Thus, China has rapidly developed OW technology on manufacturing and development, which can partly explain the significant increase of the installed OW capacity. Chinese domestic manufacturers dominant the wind turbine market. However, it is technology transfer or technology absorption that leads to the OW technology development in China. Compared to the countries that are advancing on technology innovation, China is suffering a high failure rate of wind turbines and low generation efficiency of OW farms. To solve these problems, Chinese OW companies need to concentrate efforts on innovation to promote the performance of OW turbines and the global state of the art.

2.2 Conceptual Framework

2.2.1 Definition of collaboration

Collaboration is a concept similar to alliances, cooperative agreements, and networks (Dodgson, 1993). Several researchers have defined collaboration. A short and broad definition of collaboration is an activity "*where two or more partners contribute differential resources and know-how to agreed complementary aims*" (Dodgson, 1993, p. 24). Because of the research objective, this thesis focuses on interorganizational collaboration rather than collaboration inside an organization. Interorganizational collaboration means several organizations reach a cooperative agreement to share resources such as capital, technology, or organization-specific assets to codevelop common goals (Gulati, 1995). Wood and Gray (1991) gave a comprehensive definition that "*collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structure, to act or decide on issues related to that domain.*" *(p. 146)* This definition provides answers to "who is doing what, with what means, toward which ends" in a collaboration (Wood & Gray, 1991). Stakeholders are the groups and organizations who may have both common and different interests in a problem domain (Wood & Gray, 1991). Within a collaborative alliance, the stakeholders establish shared rules, norms, and structures; meanwhile, they still own their independent decision-making power (Wood & Gray, 1991). The stakeholders interact to reach an agreement on decisions and actions toward an objective (Wood & Gray, 1991).

Different from public organizations and private organizations that are common in human societies, interorganizational collaboration is a different functional form in a society. Instead of being controlled by market mechanism or hierarchical order, collaboration is built on negotiations between partners in an ongoing communicative process (Hardy, Phillips, & Lawrence, 2003). Economists have argued that the intermediate position of collaboration between markets and hierarchy can be explained from the transaction cost theory that collaboration can complete an exchange for which associated cost is too high for a market deal but not high enough to establish vertical integration (Gulati, 1995). Thus, collaboration can play a role in making up for deficiencies of markets and public organizations.

We can understand a collaboration based on its form, relationship, and function details. Collaboration has several forms: first, infrastructure collaboration is a part of national innovation systems for promoting technical development; contractual collaboration is that two or more companies decide to establish a separate company such as joint venture in which the partners work closely; informal collaboration means knowledge trading between companies (Dodgson, 1993). The above three forms divide collaboration from a high level. The broad types of collaboration mean collaboration is a relatively common phenomenon. If we want to understand a collaboration from details, two key features are: (1) how collaboration works including the definition and transaction of rights; (2) what the relationship and mechanisms are, as these relationships and mechanisms are significant for information sharing and decision-making (Powell, 1998).

For the relationship between companies, one particular phenomenon is that companies simultaneously cooperate in some activities but compete in others, which is also called coopetition (Bengtsson and Raza, 2016). In coopetition, companies play complex roles at the same time: companies pursue common interests and private benefits; companies share knowledge and prevent knowledge sharing; companies learn from each other and try to win a race (Bengtsson and Raza, 2016). The competition in coopetition can cause tension and therefore restraint the performance of cooperation (Bengtsson and Raza, 2016). One typical example is knowledge spill-overs. To minimize the negative impact of competition, collaboration needs to implement multiple management methods including setting up governance structure (e.g. clear work division), information flow control, knowledge legal management (e.g. contracts, leadership negotiations, patents protection), and profit-sharing agreements (Bengtsson and Raza, 2016). For collaborating companies, negotiating and implementing these methods can be time-consuming and challenging.

2.2.2 Benefits of collaboration

Why would companies like to collaborate? The "why" question is significant to understand the benefits that collaboration can bring to its participating organizations. These benefits can also be seen as motivations for organizations to participate in collaboration.

Developing capacity and promoting innovation

Collaboration provides an opportunity to cooperate with and learn from other organizations. Companies that pool resources into a collaboration work together to find solutions to problems (Hardy et al., 2003). Through the process of solving problems, companies themselves also learn new skills and find new opportunities (Gulati, 1995). In other words, collaboration can help organizations develop a range of their capacities, including identifying opportunities, learning skills, and solving problems.

As a significant part of the capacity of companies, innovation is created by new knowledge that often requires other knowledge (Powell et al., 1996). The knowledge comes not only from R&D activities inside a firm but also from ongoing social interactions between firms, universities, research laboratories, suppliers, and customers (Hardy et al., 2003; Powell et al., 1996). Participating in a collaboration can broaden a firm's sources of information that is usually difficult to be generated by a firm itself or obtained through regular market transactions (Powell et al., 1996). Especially in high-tech fields, organizations in a collaboration can have access to up-to-date knowledge and resources, and the timely information can test the organization's internal expertise and learning capabilities (Powell, 1998).

The exchange of know-how information between external organization requires long-term relationships in which participants respect a learned and shared code called "absorptive capacity" (Powell et al., 1996). A firm with higher capacity can learn extensively from external collaboration partners and contribute more to a collaboration's R&D performance (Powell et al., 1996). Therefore, internal capability and external collaboration activities complement each other on a company's innovation capacity (Powell et al., 1996).

Improving networking capacity

With many networking activities, collaboration is also beneficial to the communication capacity of organizations. Collaborating with partners not only enhances a company's experience of cooperation but also enhances its reputation as a valuable and reliable partner (Powell et al., 1996). Working with other companies also helps to refine an organization's routine and improve its skills in managing networks in a given time (Powell et al., 1996). Furthermore, collaboration networks provide an excellent platform to develop other formal partnership and informal relationship (Powell et al., 1996), which helps a company find more collaboration opportunities. Therefore, collaboration is like a networking form that can develop the networking capacity of organizations further.

Increasing external influence

While networking with other organizations in collaboration, companies also improve its external impact. Participating in a collaboration can be beneficial to a company's strategic position, and companies with well-connected partners are usually located at the most cohesive and central positions in a collaboration (Gulati, 1995; Powell et al., 1996). At a central position, companies have significant influence over other organizations and the evolution course of a field (Powell et al., 1996). In other words, participating in a collaboration can help companies influence on others in a specific field.

Managing uncertainty

Collaboration can help companies increase the ability of organizations to cope with uncertainty. Companies dislike uncertainty since it can bring potential risks to their operation. When companies face significant uncertainty in the market, they are more likely to collaborate to reduce the uncertainty (Gulati, 1995). Collaborating with other organizations can increase the resources for uncertainty management.

In sum, collaboration can bring multiple benefits to participating organizations, including developing capacity, promoting innovation, improving networking skills, increasing external influence, and managing uncertainty. When collaboration can bring these benefits, organizations have incentives to participate in the collaboration.

2.2.3 Preconditions for collaboration

To answer the question of the level of feasibility to launch a collaboration platform like OWA in China, it is critical to understand that under what preconditions a collaboration can be formed. The above section summarizes why companies create a collaboration. The next question is when companies form a collaboration with whom. For the "when" and "with whom" questions, researchers have conducted research from different perspectives. Table 1 summarizes the preconditions for or motivations of collaboration from various theoretical perspectives.

Table 1. Preconditions for a collaboration from different theoretical perspectives.

Theoretical perspectives	Preconditions for collaboration
Resource dependence	High stakes and high level of interdependence among stakeholders

Corporate social performance/institutional economics	Confluence of macrosocial conditions
Strategic management/social ecology	Degree of organization in a problem domain and motivations to collaborate
Microeconomics	The need and possibility to maximize efficiency and reduce transaction costs
Institutional/negotiated order	The need to achieve a shared understanding of and approach to a problem influencing stakeholders; the need to enhance institutional legitimacy; the need for isomorphism with environmental force.
Political	Need to protect the interest of common resources and need for governance rules for commons, shared purpose.

Source: (Wood & Gray, 1991)

Through Table 1, we can find that making collaboration possible requires the need and potential of stakeholders to protect (individual or collective) interests (e.g. common resources) or derive (individual or collective) benefits (Wood & Gray, 1991). For individual stakeholders, forces can drive or restrain their motivation and ability to collaborate with others. The specific forces include the following factors:

Relationship

Companies establish or strengthen their ties with other companies through a range of activities. These prior ties create a social network in which organizations are embedded and able to investigate the reliability and capability of their current and potential partners (Gulati, 1995). For companies, the first-hand information that they obtain through ties is particularly valuable because (1) it is cheap; (2) companies tend to believe their first-hand information more than other information; (3) partners have incentives to avoid jeopardizing future ties (Gulati, 1995). The information collected from a network helps firms learn about other companies' existence and features such as needs, capabilities, and collaboration willingness (Gulati, 1995). Through communication with other companies in a network, companies may enhance trust in partners and find new collaboration opportunities (Gulati, 1995). Furthermore, companies with prior ties have incentives to avoid noncooperative behaviours (Greve et al., 2010). Long-term relationships also provide companies confidence and trust to share know-how with their partners (Powell et al., 1996).

Indirect ties, such as having joint partners, also affect collaboration. First, joint partners create a mechanism bringing firms together, which can enhance the understanding of each other (Gulati, 1995). Meanwhile, companies having common partners tend to have confidence in each other as they are aware of the potential negative consequence of noncooperative and opportunistic behaviour (Gulati, 1995). The social networks based on prior ties play a role in forming collaboration by providing information, enhancing trust, and preventing opportunism. On the other hand, the conflicting history between organizations can reduce their collaboration possibilities because of the low level of confidence.

Interdependence

Interdependence is as an organizations' necessity for complementary resources or capabilities (e.g. capital, specialized skills, and market access) that can be provided by other companies (Gulati, 1995). When partners have distinct and complementary resources, companies rely on partners to a certain extent and have motivations to collaborate with them (Bengtsson & Raza-Ullah, 2016).

Besides resources owned by other companies, the level of interdependence is also affected by several factors including market position, size, performance, solvency (Gulati, 1995). Based on these influencing factors, companies with a high level of interdependence have strong motivations to collaborate (Gulati, 1995).

The interdependence level can also restrict collaboration between companies. When the collaboration beyond a certain level, partners may start to limit future collaboration by controlling the ties between them to avoid overdependence relationship (Gulati, 1995). The fear of overdependence reduces the motivation of companies to collaborate.

Industrial and technological characteristics

The development level and characteristics of industry affect the motivation of companies in the industry to collaborate. Relating to the uncertainty management discussed above, companies tend to collaborate when the industrial sector is at an initial stage with high uncertainty and instability (Bengtsson & Raza-Ullah, 2016). While facing high uncertainty, organizations tend to interact more with other companies to access more knowledge and resources to cope with the uncertainty (Powell, 1998). Besides, if an industry has frequent interfirm agreements, companies may face confusion out who is an ally and who is not (Powell et al., 1996). In this situation, the position in the "value-chain" and the level of technological sophistication can affect collaborating decisions (Powell et al., 1996).

Industrial characteristics are closely related to technical features (Bengtsson & Raza-Ullah, 2016). First, companies that are in technologically intensive fields are likely to establish collaborative relationships to access, investigate, and exploit new technological opportunities (Powell, 1998). The uncertainty is related to technical features such as technology complexity, R&D costs and risks, the intensities of technological change, and the level of technology maturity (Bengtsson & Raza-Ullah, 2016). Second, if there is rapid erosion of competitive advantage or reduction of entry barrier, companies may lose control of advanced technology, which pushes them to collaborate with other companies to improve their safety and strength in the industry (Bengtsson & Raza-Ullah, 2016). Also, technological convergence, which means that a product or technology needs knowledge and skills from different disciplines, drives companies toward collaboration (Bengtsson & Raza-Ullah, 2016). In sum, when companies cannot address technical challenges, or have to solve the problems with significantly high cost, they look for collaboration with others (Bengtsson & Raza-Ullah, 2016).

Policy

Policies can cause incentives or barriers for companies to collaborate. Based on the objective of an industrial sector, the government can issue strategies to drive or restraint collaboration through several approaches. The government approaches include financial mechanisms (e.g. subsidy), regulatory deterrence, reform, and the implementation of specific models (Bengtsson & Raza-Ullah, 2016; Gray, 2008). The organizations targeted by these policies may have more or fewer incentives and motivations to collaborate with other companies.

Others

Other factors can also influence the collaboration decisions on organizations decision. First, the differential ability to learn new skills can affect companies to collaborate (Powell et al., 1996). Companies with strong learning ability are comfortable to collaborate with other companies. Second, companies tend to collaborate with counterparts of different sizes. Two reasons can explain this phenomenon: company's size affects its role of interdependence, which is also mentioned above in the Interdependence sub-section); companies usually compete most intensely with others of similar size and cooperate with others of different size (Gulati, 1995).

Third, if companies have an influential common buyer, the buyer may force the companies to collaborate in order to safeguard and pursue their interests (Bengtsson & Raza-Ullah, 2016). Under the pressure of an influential joint buyer, companies may choose to collaborate.

Gray (2008) divided the factors that can influence the forming of collaboration into two groups: (1) strategic factors that are under the control of collaborative partners; (2) institutional factors that reflect the influence of the wider environment and therefore cannot be changed by individual partners. However, it is difficult to categorize some factors into a strategic group or an institutional group. For example, a prior relationship is not under the control of companies, but they can start developing their relationship at any time to improve the possibility of future collaboration. Therefore, although prior ties as an influencing factor cannot be changed, the relationship can be influenced by companies. Therefore, this thesis understands that the rationale of the division between institutional and strategic factors but do not use the division to sort the influencing factors.

We can also divide the above factors into driving forces and restraining forces based on their effects on the formation of collaboration. Specifically, driving forces provide incentives for organizations to collaborate such as close prior ties, the high degree of interdependence on other organizations, the benefits of scale economy, the need for settling a conflict between different organizations, policy incentives provided by government or other actors, requirements and encouragement mentioned by legal and regulatory mandates (Gray, 2008). Restraining forces provide disincentives for companies to collaborate such as the lack of prior ties, high competition, perception of control loss, lack of constituent support, internal conflicts with other partners, disincentives set by economic or government system, power imbalance, cultural norms as well as conflict and mistrust history (Gray, 2008). The author considered the driving or restraining effects of the above factors while analyzing data.

2.2.4 Conveners of collaboration

In addition to the preconditions discussed above, forming a collaboration requires one or several organizations to begin the collaboration forming process. The organizations that start the process are called conveners. To establish a collaboration, conveners need to (1) identify and motivate potential partners to participate, (2) assess whether the collaboration is feasible (Carlson, 1999). Therefore, conveners can conduct a collaboration feasibility assessment to determine whether potential partners have sufficient motivations to ally (Gray 2008).

To achieve their objectives to convene potential participate in collaboration, conveners need to have sufficient resources and credibility to play its role. Based on their credibility and resources in a sector, conveners have different levels of influence on other stakeholders. Considering their importance, conveners may choose different approaches to intervene. Table 2 illustrates four convening modes based on the different types of influence and intervention.

Table 2. Dominant modes of convening and central attributes of conveners

The modes of convening		Type of influence by convener	
		Formal	Informal
Types of intervention	Requested by stakeholders: convener is responsive	Legitimation: convener is perceived as fair	Facilitation: convener is trusted

	Initiated by convener: convener is proactive	Mandate: convener is powerful	Persuasion: convener is credible

Source: Adapted from (Wood & Gray, 1991). Notes: For conveners requested by stakeholders, if they do not want to take the convening responsibility, either the collaboration process will not proceed, or stakeholders will find another convener.

In this thesis project, Carbon Trust as a convener has an informal influence on other stakeholders and intends to initiate the OWA collaboration. Therefore, the convening conducted by Carbon Trust to form an OWA is a persuasion mode. In the persuasion mode, a convener persuades stakeholders to participate through using its credibility, influence, knowledge, and skills of the problem domain and interrelationships with other stakeholders (Wood & Gray, 1991). Among these attributes, the convener's credibility is the key because the convener has to provide convincing and credible arguments for other stakeholders to participate in the collaboration that is also the convener's initial idea (Wood & Gray, 1991). Besides, the fairness of the convener's approach is significant because fairness is a crucial source of credibility in the eyes of stakeholders (Wood & Gray, 1991). Therefore, a convener needs to adopt balanced approaches to design the collaboration and convene other stakeholders.

It is necessary and critical for conveners to identify and persuade key stakeholders in the problem domain that the conveners want to solve. Conveners do not need to identify and induce all stakeholders in a problem domain, as there may be a high number of stakeholders (Wood & Gray, 1991). Instead, conveners can take efforts on finding and discussing with some types of stakeholders: (1) the stakeholders who have substantial interest in solving a common problem or achieving a common goal; (2) the most powerful and influential stakeholders who seek solutions to challenges in a sector; (3) the majority of stakeholders of a problem domain who has power to establish a new social norm that can induce other stakeholders to participate eventually; and (4) existing social networks of the stakeholders in a problem domain so that the participation of some stakeholders can push other stakeholders in the same network to participate too (Wood & Gray, 1991). These four types of stakeholders are vital partners that conveners need to identify and induce.

2.2.5 Framework for collaboration

From the literature discussed above, we can understand that many factors can affect the forming of a collaboration. The sub-sections 2.2.3 and 2.2.4 explain the factors about stakeholders and conveners respectively. It is valuable to summarize and list these factors in a systematic way. Figure 5 illustrates the conceptual framework for collaboration feasibility used in this thesis. The framework is based on the existing literature and divided the factors that can affect the forming of collaboration into three groups according to the roles of organizations playing in forming a collaboration. The three groups include:

1. **Conveners**. In this thesis, convening an OWA is in a persuasion mode as Carbon Trust that intends to initiate the collaboration has informal influence. Like (Wood & Gray, 1991) explained, conveners in a persuasion mode need to have adequate credibility and influence in the sector and knowledge and skills of the problem domain. These factors are critical for conveners to identify and persuade key stakeholders.
2. **Stakeholders**. Conveners identify and persuade stakeholders to participate in a collaboration. Some influencing factors that are stakeholders themselves include relationship (Greve et al., 2010; Gulati, 1995; Powell et al., 1996), learning ability (Powell et al., 1996), and interdependence (Bengtsson & Raza-Ullah, 2016; Gulati,

1995). Meanwhile, some factors are directly related to stakeholders including industrial and technological characteristics (Bengtsson & Raza-Ullah, 2016; Powell, 1998; Powell et al., 1996) and the power of buyers (Bengtsson & Raza-Ullah, 2016).

3. **Government policies.** The government can issue policies to provide incentives or barriers for organizations to collaborate (Bengtsson & Raza-Ullah, 2016; Gray, 2008)**.** There are two reasons for policies were divided as a separate group. First, it is the government (instead of conveners and stakeholders) that controls policies. Second, the Chinese Government holds massive power on companies, which means policies are particularly in China.

Figure 5. A conceptual framework for collaboration feasibility.

Source: Author.

3 Research Methodology

To assess the feasibility of forming an OWA in China, the author conducted an in-depth case study mainly through qualitative approaches. Based on the conceptual framework, the author analyzed the credibility and skills of the conveners, the key features of potential partners, and the influence of external policies.

This section explains the research methods that were applied to implement the case study and to answer RQs. First, a process map was designed to guide the feasibility assessment for forming an OWA in China. Second, data collection subsection explains how the data that are relevant and significant for the RQs were identified and collected. Third, data analysis is about how the collected data were synthesized and analyzed in a logical way to answer the RQs.

3.1 Feasibility Assessment

Feasibility assessment is considered as a necessary step to identify and understand the motivations of potential partners to participate in a collaboration before conveners launch it (Gray, 2008). O published a process of feasibility assessment that includes seven steps: determining convener's goals, identifying issues, examining the context, identifying stakeholders, identifying potential needs, and identifying obstacles to collaboration. After getting definite answers to all seven steps, the convener can conclude that it is feasible to launch the collaboration (Carlson, 1999).

However, there are some drawbacks to the process. First, some steps in the process are repetitive and thereby unnecessary. For example, the second step of identifying the issues that need to be addressed in collaboration is broad and much repetitive with other steps such as determining collaboration objectives, examining the context, and identifying stakeholders because one significant part of identifying issues is identifying and understanding stakeholders. Second, the process does not include policy analysis. Policies are very substantial for industrial development in China since the government holds substantial power and has a strong influence on companies. Third, Carlson (1999) argued that if any step gets a negative answer, the assessment can finish, and the collaboration is considered as non-feasible. However, this is practical but not suitable for the thesis study that aims to carry out a thorough examination and understanding of launching an OWA in China.

To the shortcomings of Carlson's process and make the assessment process concrete, the author integrated the influencing factors that are identified and summarized in the Literature Review section. The integration of the factors can better guide the process of data collection and analysis as these factors can tell what data are relevant to collaboration feasibility. In addition to the elements, the author also considered the Chinese context in the feasibility assessment process. Table 3-1 shows the detailed information of the steps, objectives, key questions to ask, and research methods to conduct a feasibility assessment of launching an OWA in China.

Table 3. Feasibility assessment process for OWA in China.

Steps	Objectives	Key questions to ask	Research methods
Determine what Carbon Trust wants to accomplish	To clarify the goals and motivations of Carbon Trust's intents and motivations to establish an OWA in China.	Why does Carbon Trust intend to develop an OWA in China? Does Carbon Trust believe that launching an OWA will provide benefits for itself? What is the vision and form of an OWA in China?	Interviews with Carbon Trust staff.

		Who will persuade other stakeholders to participate in the OWA?	
Examine convener's characteristics	To understand the features of the conveners.	How is(are) the credibility/influence/knowledge/skills of the convener(s)? How is the relationship between the convener(s) and potential partners? Which employee(s) at Carbon Trust is (are) responsible for OWA work?	Interviews with Carbon Trust staff Content analysis
Examine the context	To understand the context in which the OWA functions.	What is the status quo of OW energy in China? What is the prospect of OW energy use in China? What are the barriers to OW energy technology development in China?	Content analysis of China's OW industry and policies
Identify and examine other stakeholders	To identify and analyze the stakeholders whom Carbon Trust intends to convene to participate in the OWA in China.	What organizations does Carbon Trust want to include in the OWA? How is the relationship between the stakeholders? What is the interdependence level (depending on the resource, market position, size, etc.) between the stakeholders? Who is(are) the primary buyer(s) of electricity generated by OW farms? What power does the buyer hold? What are the industrial and technological characteristics (uncertainty, technical convergence, entry barrier etc.) in China's OW sector? How do the stakeholders evaluate the OWA idea?	Content analysis of China's offshore wind industry. Interviews with Carbon Trust staff, researchers, and OW professionals.
Examine the policies	To identify and examine the policies that promote or limit forming an OWA.	What policies that provide incentives for potential partners to collaborate with others? What policies can cause obstacles for potential partners to collaborate?	Content analysis of China's OW policies. Interviews with Carbon Trust staff and other professionals.
Identify resource needs	To determine what resource are required and whether they are available to support the collaboration.	What essential resources does the collaboration need? Such as information, process expertise, staff support, as well as funding. What are the possible sources of the resources needed? What is alternative funding strategy if the financial resource is not enough?	Content analysis of the OWA program in the UK. Interviews with Carbon Trust staff and professionals.

Source: Adapted from (Carlson, 1999)

3.2 Data Collection

The first step of research implementation is defining the research population, the actual segment of reality that can answer the research questions (Verschuren, Doorewaard, & Mellion, 2010). Based on the research objective and questions, the research population of this thesis includes the Carbon Trust (and other possible conveners in the collaboration), the OW developers in China, and the government authorities relevant to OW collaboration. The population is directly related to the OWA collaboration and able to determine whether or not the collaboration is feasible.

The next step is identifying research resources (e.g., people, situations, documents) that can provide useful information (Verschuren et al., 2010). From the research population mentioned above, the author identified various research resources including people (e.g., Carbon Trust staff, researchers of and professionals in China's OW industry) and documents (e.g., developers' annual report and government policies). The selection of the research resources was based on two criteria: first, they are accessible; second, they are relevant to and significant for RQs.

After identifying the research resources, the next step is to obtain useful information from the resources (Verschuren et al., 2010). The information that needs to be collected were identified in the Literature Review section, especially the factors that can affect a collaboration's formation (Figure 5). The data was collected mainly through three channels: literature, interviews, and observation (Table 3 also shows the data collection methods). The detailed information of each method as explained below.

3.2.1 Literature

On the convener side, the author collected the documents of Carbon Trust and CWEA. First, as Carbon Trust has conducted several projects on China's OW development, the deliverables of these projects provide an excellent source to understand their expertise in China's OW sector. Second, the news from the Carbon Trust website and social media (WeChart) were also collected to understand its interaction with other organizations in the OW sector. Third, the initial presentation slides about China's OWA were collected to understand OWA's objectives, structure, and participants in China. Fourth, the author obtained the CWEA's 2018 Annual Report, which included comprehensive information about its responsibilities and interactions with other stakeholders in the OW industry. Last but not least, as an intern at the Carbon Trust Beijing Office, I have had opportunities to conduct research on and discuss with colleagues about OW technologies, markets, and policies. Although most tasks are not directly about the thesis topic, I have obtained the knowledge of OW industry, which helped me develop the thesis.

On the potential partner side, the primary documents include a dataset about China's OW farms and annual reports of these partners. In the initial interviews with Carbon Trust staff, the staff mentioned that China OWA wants to collaborate with the developers to prioritize their common innovation needs and then inform the needs to innovators in the OW supply chain. Therefore, the information that who the OW developers are in China should be collected. The current statistic is mainly about China's total OW installed capacity or data about both onshore and offshore wind developers. Therefore, the author could not collect data specifically about the OW developers in China from existing statistics. To solve the problem, the author downloaded a dataset of 1810 OW projects in the world from 4C Offshore, a consultancy and market research organization focusing on offshore energy markets (4C Offshore, 2019b), on June 11, 2019. Since Carbon Trust has a subscription of 4C Offshore, the dataset could be downloaded for free. All Chinese OW projects were selected and divided by their developers to understand the landscape of the OW developers in China. Then the information about crucial OW developers was collected from their annual corporate reports and sustainability reports to get the detailed information of these companies. If several companies own a wind project, the stake share information about the project was collected. If the specific information does not exist, which is very rare, the wind farm was excluded from the analysis. Besides, the academic articles about China's power sector and reform were also collected to analyze the relationship between the developers, the characteristics of OW industry and technology, and the power of the electricity buyers.

On the policies side, policies that are relevant to OW collaboration were collected. First, the author searched keywords pertinent to the thesis topic on the Chinese Government document database (http://www.gov.cn/zhengce/xxgkzl.htm). The key words include power sector, new energy, renewable energy, OW, collaboration, innovation. After noticing that most OW developers in China are SOEs, the author also collected the policies about SOEs. Besides, the author also collected the policies mentioned by the interviewees. These policies may provide incentives or disincentives for the formation of an OWA in China.

3.2.2 Interviews

The interviews were conducted to obtain an internal understanding from OW researchers and professionals. In total, the author conducted six interviews. Table 4 shows all interviewees. To protect the privacy of interviewees and increase their enthusiasm for interviews, all interviewees were kept anonymous. The interviewees were selected from different sectors so that they can provide ideas from different perspectives. First, the author interviewed two Carbon Trust staff who understand the OWA's plan, objective, and structure. The interviews also helped understand the Carbon Trust's opinion on China's OW industry. One staff is responsible for Carbon Trust's OW projects in China, and the interview is also an opportunity to assess his/her knowledge on the OW industry. Second, the author also interviewed two people who have published articles about China's OW energy to obtain opinions on China's OW sector, technology development, and market competition from the academic perspective. Third, the author interviewed two professions in the OW industry to obtain opinions from the internal view. The two interviewees are familiar with OW stakeholders' behavior and give a direct assessment of the feasibility of OWA in China. In addition to formal interviews, the author had several casual conversations about OW and OWA with Carbon Trust staff and OW professionals. The author wrote down important messages from the discussions.

The author conducted all interviews through a systematic process from interview preparation, implementation to transcription. First, based on the conceptual framework, the author designed an interview questionnaire based on the conceptual framework. Second, the author contacted potential interviewees to introduce the thesis project and interview intention via emails, texts, or WeChat. After got an affirmative response, the author sent the interview outline and asked practical issues such as available interview dates and places. Once the interview was confirmed, the author modified the interview questionnaire according to the interviewee's background. Appendix II shows one interview questionnaire for an OW researcher. Third, the author conducted the interviews via different methods, including personal communication, telephone, and WeChat. Fourth, once completed an interview, the author immediately transcribed the interview tape into text.

Table 4. Interviewee list.

Interviewee	Background	Interview date	Interview channel
Interviewee A	PhD student	04.07.2019	Telephone
Interviewee B	Carbon Trust staff	10.07.2019	Personal conversation
Interviewee C	Carbon Trust staff	11.07.2019	Personal conversation
Interviewee D	OW company staff	12.07.2019	Text
Interviewee E	OW company staff	15.07.2019	Telephone

Interviewee F	ESG staff; The author of an OW article	20.07.2019	Telephone

Source: Author.

3.2.3 Observation

Working as an intern as the Carbon Trust Beijing Office, I had the opportunity to conduct first-hand observations of Carbon Trust's operation. The observation concentrated on two aspects: internal observation such as communications between OW experts and other staff, Carbon Trust Beijing Office and London Headquarters; Carbon Trust's external communication with potential partners such as multilateral banks, industry associations, research institutes, and government authorities. The author wrote down messages and notes relating to the OWA in a document. Although the author did not participate in some events, the observations helped to understand Carbon Trust's knowledge, credibility, and relationship with other organizations.

Table 5. Major activities observed during the thesis process.

Date (2019)	Activity
June	Participating in the UK-China 10th Economic and Finance Dialogue
July	Discussing OW with a multilateral bank
July	Discussing potential OW projects
July and August	Implementing a OW project with a research institute
August	Discussing potential projects with local partners
August	Providing training on UK OW policies for local institutes

Source: Author.

3.3 Data Analysis

In the data analysis process, the author sorted, coded, and synthesized the collected data. First, according to the types and topics of data (e.g., project reports, company annual reports, and interview documents), the data were sorted and then imported to NVivo, a qualitative analysis software. The dataset of China's OW projects were sorted and analyzed by Excel. Second, a code structure, including influencing factors on collaboration was developed based on the conceptual framework. The author read each document first and then coded the contents on NVivo. When the author found some factors that can also affect collaboration or OWA in China, these factors were added to the code structure to improve the structure. Third, the coded contents were sorted by their codes and put to a synthesis matrix in Excel. The matrix was established to sorted and compare the information from different sources. Findings of the RQs were obtained based on the synthesized information.

Figure 6 shows the overall research process for this thesis. First, the author collected data through literature, interviews, and observation. All data are in the form of text, tables, or images. Second, a code structure was developed based on the conceptual framework discussed in the Literature Review section. Third, the author went through all the data during which some new factors that may influence forming the OWA were noticed and added into the code structure. Fourth, the author used the improved structure to analyze the data. Then the contents were synthesized in a matrix based on their codes. The author compared the information in the synthesis matrix and summarized the findings.

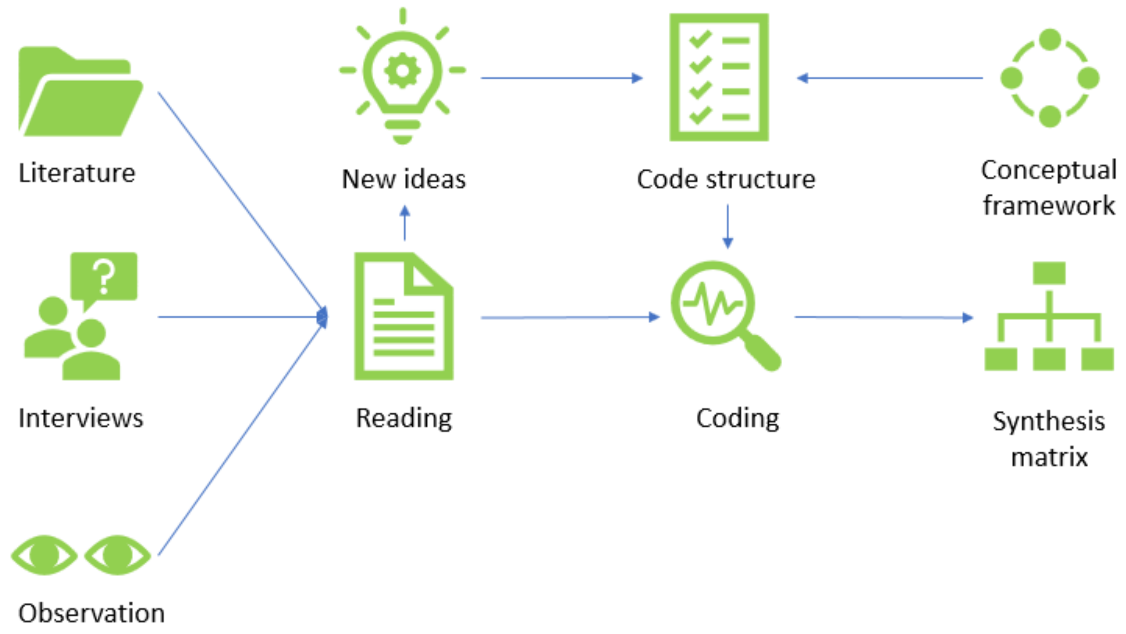

Figure 6. The process map of data collection and analysis.

Source: Author.

4 Analysis

This section explains the systematic and detailed analysis of the collected data to answer the RQs. Besides answering the RQs, the findings from the analysis provide a basis for further discussion. The structure of this section is based on the feasibility assessment process illustrated in Table 3.

4.1 Form of OWA in China

As a sustainability consulting company, Carbon Trust has several motives to develop a Chinese OWA. First, owning the successful OWA experience in the UK, Carbon Trust wants to promote its expertise in China where the OW market is vast. Second, establishing and managing an OWA in China is likely to bring a range of benefits to Carbon Trust such as financial revenues, market influence, and business reputation. Third, as a UK company, the Chinese OWA can help facilitate knowledge and technology transfer to China, helping UK enterprises find more opportunities. Encouraged by these motives, the Carbon Trust Beijing Office tries to launch an OWA in China.

Figure 7 shows the key participants and the convening relationships in the China OWA design. Based on the assessment of its resources and credibility, Carbon Trust wants to introduce the OWA model into China instead of establishing the collaboration platform by itself (Interviewee C, 2019). To achieve this target, Carbon Trust plans to find and convene a partner such as industry associations and government authorities to launch the collaboration together (Interviewee B, 2019). Carbon Trust tries to persuade China Wind Energy Association (CWEA) to start the collaboration and convene other partners. CWEA agrees that the OWA is valuable and intends to obtain support and resources from a government department. Currently, the authority that CWEA has been convening is Yanjing Government in Guangdong Province. After receiving the Yangjiang's support, CWEA will start to convene the leading OW developers in China.

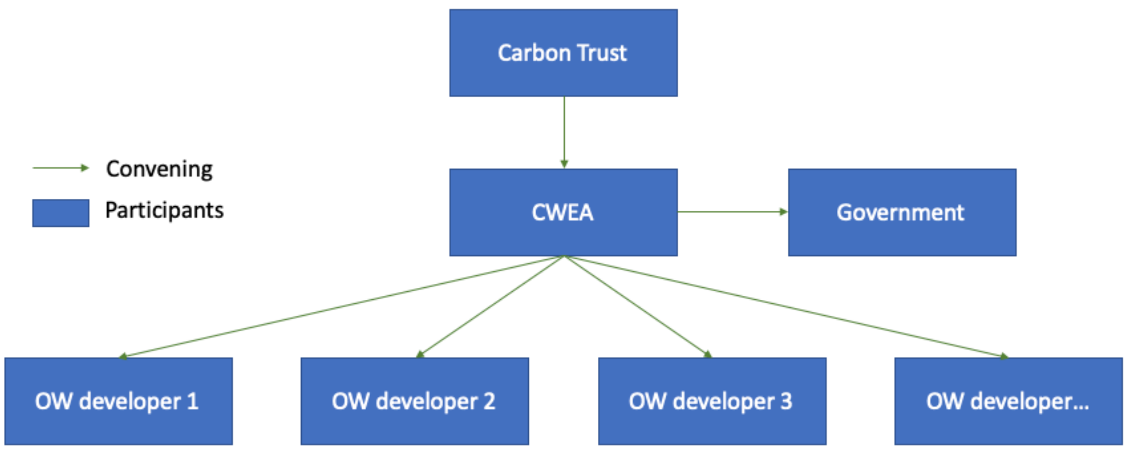

Figure 7. Participants and convening relationship in the China OWA design.

Source: Author. Based on (CWEA, 2019b).

According to the design, the OWA in China includes three departments: OW developers form a Steering Committee that mandates the OWA's operation and several Technical Working Groups that focus on several key areas such as turbine foundations, cables, and wind resource;

the Carbon Trust and CWEA as third parties form a Program Management Office to manage the collaboration program (CWEA, 2019b). In the OWA, Carbon Trust utilizes its experience obtained in the UK to provide consulting service and knowledge support on project design, funding, and management (Interviewee C, 2019). Under this structure, the Technical Working Groups organized by OW engineers prioritize their collective innovation needs; then, the Program Management Office organizes competitions targeting at the needs; finally, promising innovation solutions will be supported by and cooperated with the Working Groups (Interviewee C, 2019).

According to CWEA's initial plan, the main areas that the OWA in China focuses on include environmental impact assessment (EIA), pioneering OW technologies, supporting policy mechanism, mid- and long-term development objectives, project management, supply chain, market information and data (CWEA, 2019b). The selected areas are actually too broad for CWEA and Carbon Trust to manage. However, it might be a tactic to persuade Yangjiang government to finance the OWA. During the thesis process, the Carbon Trust and CWEA are still waiting for the response from Yangjiang government.

4.2 Conveners in OWA in China

There are two conveners, Carbon Trust and CWEA, that try to establish an OWA in China. Carbon Trust mainly provides knowledge support, and CWEA uses its network in OW industry to persuade potential partners, i.e. the government and key OW developers. The influence, credibility, knowledge, and skills of the two conveners are crucial for the success of the convening.

4.2.1 Carbon Trust

Carbon Trust has undertaken several OW programs and projects in the world from which it has gained in-depth knowledge of OW energy. The programs and projects cover different aspects. First, it has provided policy advice for the government and international organizations. For example, it provided recommendations for the UK government and the wider industry to accelerate OW development. Second, it has published several OW technical reports. For instance, it published a technical roadmap of floating LiDAR including the strategies and details of deploying LiDAR for designing OW farms. Third, Carbon Trust manages several multi-million-pound programs such as the OWA supporting technological innovation, Offshore Renewable Joint Industry Project reducing the consenting risks on offshore programs, and Floating Wind Joint Industry Project developing the technology for floating OW farms. From these projects, Carbon Trust has developed considerable expertise in OW policy, technology, and knowledge.

Compared to the projects in the UK, Carbon Trust has limited OW project experiences in China. One significant project was implemented in 2014 aiming to address the consenting issues that hindered OW deployment progress in China. The project also intended to develop a program that could provide an OW framework and knowledge for all Chinese provinces that were interested in OW energy. The British Embassy in Beijing funded the project, and CWEA and CECEP Wind-Power Corporation supported the project (Wyatt et al., 2014). The primary outcome of the project was a report reviewing China's OW policy, market, and technology and providing recommendations based on the UK experience. Since the report was published in 2014, and OW has developed rapidly since then, most of the contents in the report are not suitable for the current situation. Also, Carbon Trust participated in some small projects like researching the UK and Danish OW policies (e.g., tendering, contract for difference (CfD), floating OW farms). Overall, Carbon Trust has done a small number of OW projects in China so that Carbon Trust has not gained in-depth knowledge of and skills on China's OW industry.

One reason for the limited number of OW projects in China is that Carbon Trust Beijing Office is quite small without OW technical experts. There are four full-time employees in Beijing Office, and two of them work on OW. One is the country manager who oversees Carbon Trust's overall initiatives and programs in China. Therefore, he needs to make decisions on possible OW projects, but he does not do detailed research on OW issues. The other staff did some analysis on OW industry in detail and participated in the 2014 OW project. In addition to OW projects, the staff is also responsible for office operation and other projects like carbon foot-printing and science-based target (SBT), which takes up the working time. The staff understands the macro situation of OW industry and has interactions with other OW organizations. However, according to the working background of the staff, the staff is not a technical expert on OW energy. Although Carbon Trust has an OW team with technical experts in London, they are not familiar with the Chinese OW context. The limited knowledge of China's OW sector weakens Carbon Trust's ability to persuade other stakeholders.

One thing that undermines Carbon Trust's credibility as a convener of China's OWA is its identity as a foreign enterprise. Both Carbon Trust staff and OW professionals think that the big state-owned OW developers are unlikely to discuss or cooperate closely with a relatively small foreign-owned enterprise (Interviewee C, 2019; Interviewee D, 2019; Interviewee F, 2019). One OW professional mentioned that convening OW developers is a challenging work for private organizations, and government support is the key to the convening process (Interviewee D, 2019). The need for the authority can partly explain why Carbon Trust chose CWEA as the other convener, and why CWEA wants to obtain support from Yangjiang government.

Carbon Trust has been trying to establish a relationship with other organizations in the OW sector. First, Carbon Trust has close contact with the British Embassy in China, which funded the 2014 OW project. Carbon Trust is also a part of the OW cooperation between China and the UK and was invited to the China-UK Offshore Wind Industrial Advisory Group Meeting (Carbon Trust, 2019a). Second, Carbon Trust has participated in several international energy conferences. For example, one OW project manager at Carbon Trust participated in China Wind Power 2018 and introduced the OWA experience (Carbon Trust, 2019b). Third, by implementing OW projects, Carbon Trust has established relationships with some institutes, including CWEA, a crucial OW industry association and CREEI, a key think tank under NEA. Carbon Trust also provided some OW training to practitioners in local planning and research institutes. Overall, Carbon Trust has established relationships with research institutes. However, Carbon Trust has limited interaction with OW developers and manufacturers, which limits its credibility in the view of OW developers and manufacturers.

4.2.2 CWEA

As the other convener in the OWA, CWEA is a significant industry association in China with government support. CWEA was established in 1981 having different technical groups including wind resource group, turbine blade group, wind farm group, etc. (CWEA, 2019a). CWEA aims to promote wind energy development and increase social awareness on renewable energy (CWEA, 2019a). CWEA takes various responsibilities including conducting industry research, undertaking government commissioned work, organizing academic communication events, establishing industry communication platform, and promoting cooperation with foreign organizations (CWEA, 2019a).

A significant advantage of CWEA is that it has a close relationship with other actors, especially the government. CWEA undertakes work commissioned by high-level government ministries. For example, under the commission of the Ministry of Science and Technology (MOST), CWEA is responsible for the communication work of Clean Energy Ministerial (CEM) in China

(CWEA, 2019a). Besides, under the commission of NEA, it conducted a research project on new energy insurance with PICC (CWEA, 2019a). The close relationship with authorities enhances the government's trust to CWEA, which is significant for obtaining government support for the OWA program in China.

CWEA knows China's OW sector. One responsibility of CWEA is to conduct industry research for policy recommendations (CWEA, 2019a). Under the commission of NEA, CWEA collects and publishes annual statistics of wind energy in China such installed capacity and turbines (CWEA, 2019a), meaning that CWEA understands the whole picture and trends of China's wind sector. CWEA also participates in scholarly communication with international organizations. For example, CWEA is a member of IEA Wind China Working group (CWEA, 2019a). The research work and academic communication provide CWEA knowledge of China's OW industry, which helps CWEA cooperate and communicate with other OW stakeholders. Also, it also helps CWEA make decisions on OWA to proceed the convening process.

CWEA has gained credibility and influence from their active role in OW industry. In addition to the above activities, CWEA also organizes OW exhibition and high-level forum. For example, it held China Wind Power 2018, which was an international conference and exhibition for wind energy manufacturers (CWEA, 2019a). In 2019, CWEA co-held Global Offshore Wind Summit in Yangjiang with the support from Yangjiang government. Organizing these conferences means that CWEA has direct communication with major OW developers, which is different from the Carbon Trust's networks and influence in OW industry.

4.3 Context for OWA in China

The Chinese Government aims to peak its carbon emission by around 2030 (NEA, 2016a). In order to achieve the objective, the Chinese Government has formulated a "double-replacing" energy strategy: replacing coal with oil and gas and replacing fossil fuels with non-fossil fuels (NEA, 2016a). Therefore, renewable energy, including OW, plays a role in China's energy strategy to replace conventional fossil fuels. The Chinese Government has set objectives of wind energy that the electricity generation from wind energy reaches 420 billion kWh and accounts for 6% of total electricity production by 2020 (NEA, 2016b). Among wind energy, the installed capacity of OW energy was planned to reach 5 GW with 10 GW under construction (NEA, 2016b). Thus, developing OW is still a long-term development direction and priority in China's energy strategy.

Table 6 and Figure 8 illustrate the detailed information about OW capacity with different status in China. The total size of OW farms with different status reaches 134,740.75 MW. The capacity is much higher than the installed capacity of fully commissioned wind farms. The capacity of fully commissioned and partial generation OW farms in China just account for 4% of the total capacity. The under-construction wind farms account for 3%. Therefore, China's OW capacity will keep increasing in the few years because the fully commissioned, partial generation, and under-construction farms form a baseline of China OW development in the near term.

In addition to OW farms that are commissioned or being constructed, large ocean areas are ready to build OW farms, creating an enormous potential for China's OW development. Explicitly, the consent authorized OW capacity reaches 39,334 MW, accounting for 29% of total capacity; pre-construction OW capacity reaches 2,985 MW, accounting for 2% of the total capacity. Consent authorized OW projects and pre-construction OW projects mean that developers have already got project permission from the government and can start the projects whenever they have enough resources. These farms demonstrate a huge mid-term OW development potential. Besides, the capacity of development zone, concept/early planning, and consent application submitted OW projects reaches 83,668.5 MW, accounting for 61% of the total capacity, which means China has an ambitious long-term OW objective. Thus, with government support, China's OW energy has an enormous mid-term and long-term potential.

Table 6. Offshore wind capacity with different statuses in China.

Status	Explanation	Capacity (MW)
Development zone	An area or zone that the government has identified as being suitable for OW development. Normally, the developers are then invited for project proposals within the area.	46,150
Concept/Early planning	The pre-application stage that tasks are undertaken to establish the feasibility and design of OW projects.	35,918.5
Consent application submitted	The formal application has been officially submitted and is waiting for authority decision.	1,600
Consent authorized	Approval of application has been granted by the authorities, and developers can begin constructing if they decide to invest.	39,334.4
Pre-construction	The developer(s) have reached financial close/made a final investment decision. The project is moving towards offshore construction.	2,985
Under construction	The offshore construction is in progress, but no turbines are yet energized.	4,465.25
Partial generation/Under construction	At least one turbine has been energized and is feeding power to the grid. Part of the project is under construction.	1,769.8
Fully commissioned	The construction completed. The offshore wind farm is feeding power to the grid.	3,517.8[1]
Total	The total capacity of the above seven statues.	134,740.75

Source: Author. Based on the 4C Offshore wind farms database (4C Offshore, 2019a).

[1] The author is aware of that the fully commissioned capacity (3,517.8 MW) does not equal to the data (4,588 MW) used in Figure 2-1 from (IRENA, 2019). However, both data were collected from reliable sources. The data (3,517.8) in the Table 4-1 is the reliable detailed data of OW projects that the author could find.

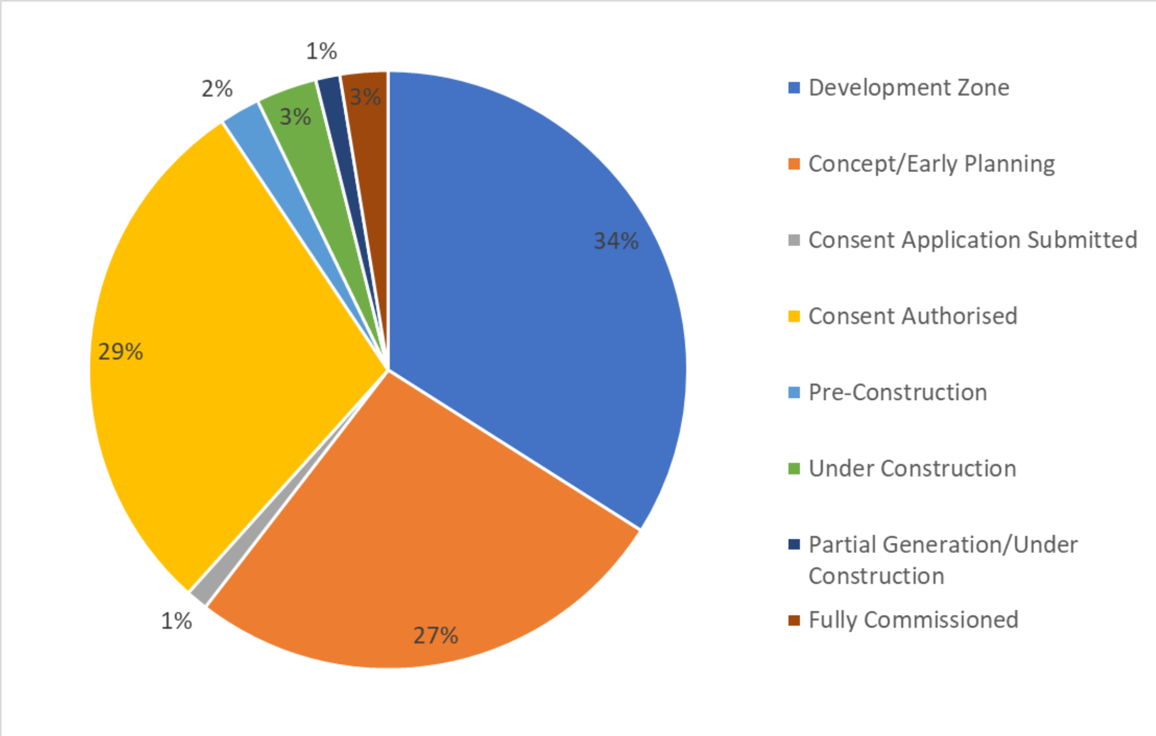

Figure 8. The percentage of OW projects with different statuses in China.

Source: Author. Based on the 4C Offshore wind farms database (4C Offshore, 2019a).

Combing China's strategy to develop OW and the potential based on the huge capacity of planed and consented OW projects, it is fair to estimate that OW energy in China will keep growing at a steady or faster pace. The OW developers in China have significant market potential. To realize the potential, the OW developers need to promote technical innovation and development to increase their competitiveness in the sector. Therefore, OWA, as an innovation collaboration, has its value for the OW developers in China.

4.4 Potential Partners in OWA in China

According to the OWA design, the major developers in China's OW sector are the vital participants. Therefore, it is crucial to identify and investigate the key OW developers. According to Figure 9, it is evident that two companies, Longyuan Power and SPIC, dominant China's OW market, owning 52% of installed OW capacity. Furthermore, Longyuan has the most abundant wind installed capacity in the world (Longyuan Power Group, 2019). These two companies relatively monopolize China's OW development. Other developers such as Guodian, CTG, Huaneng, CGN, and Luneng, own 6% or 7% of market share. In total, these seven companies own 83%. Besides, Guodian and Shenhua Group (a vast coal group) were reorganized into China Energy which has 51% of Longyuan's stakes. Therefore, China Energy owns 35% of market share. Overall, Longyuan and SPIC are dominant players, and Guodian, CTG, Huaneng, CGN, and Luneng are important players in China's OW sector. These companies are the key participants that Carbon Trust and CWEA need to convene. Table 7 summarizes the detailed information of these significant OW developers.

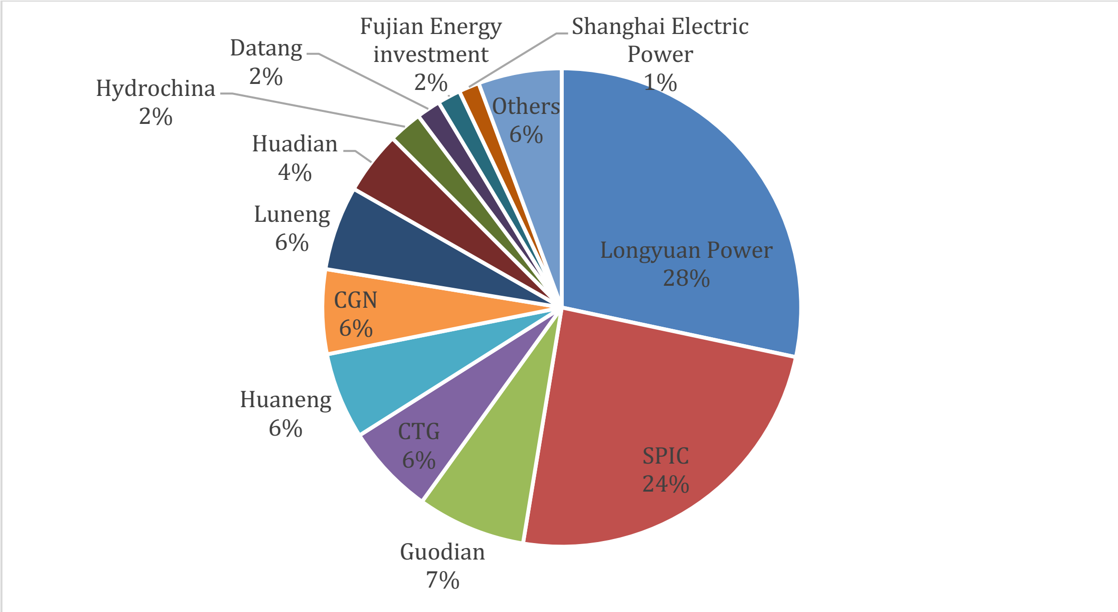

Figure 9. The market share of fully commissioned OW capacity in China.

Source: Author. Based on the 4C Offshore wind farms database (4C Offshore, 2019a).

4.4.1 Interdependence

In China, all significant OW developers have the same background that they are all state-owned or state-controlled. Among the companies listed in Table 7, Longyuan is the only publicly listed company. China Energy, a giant SOE, holds 57.27% of Longyuan's stakes (Longyuan Power Group, 2019). Therefore, although Longyuan is publicly listed, it is still state-controlled. Except for Longyuan, other companies are all entirely state-owned. Besides, Guodian and Shenhua Group, which was a massive coal and power company, merged into China Energy (Xinhua Net, 2017). China Energy holding both Longyuan and Guodian has 35% of China's OW installed capacity. Thus, in China's OW sector, a small number of SOEs form a close circle that controls OW development.

The market situation that Longyuan and SPIC dominant China's OW development is a consequence of political arrangement rather than market and technology competition. Longyuan that has the most abundant installed capacity of wind energy is the first company that was established specifically for wind energy (Longyuan Power Group, 2019). SPIC who has largest photovoltaic power generation is a demonstration company of smart energy construction determined by the State-owned Assets Supervision and Administration Commission (SASAC) (SPIC, 2019). The political arrangement of renewable energy in China provides the two companies political support, resources, and market advantages on OW development. Therefore, they have few interdependences with other relatively small developers in the OW sector.

As SOEs, the OW developers face little financial pressure as they own substantial financial resources and have banking privileges. Based on the companies' total assets, revenue, and profits in Table 7, we can understand that these OW developers own vast financial resources. Besides, due to their SOE identities, OW developers can easily get loans from state banks (Karltorp, Guo, & Sandén, 2017). Owning considerable financial resources and privileges, these OW developers are not as cost-sensitive as private companies (Interviewee F, 2019). The low level of financial pressure reduces a company's reliance on other companies.

In addition to political support and financial resources, another factor limiting the interdependence between OW developers is that they are in the same position on the OW value chain. Most companies compete rather than cooperate. For example, most commissioned OW projects were developed by a single company. OW developers usually work with manufacturers on their supply chains (Interviewee A, 2019). Besides, due to the declining of the Feed-in Tariff (FiT) of OW, the developers accelerate OW farm construction and therefore compete fiercely on OW turbines and construction facilities (Interviewee E, 2019), which is also discussed below.

In sum, substantial financial advantages, political support, and competition on the value chain result in a low level of interdependence among OW developers. The low level of interdependence constraints the motivation of the OW developers to collaborate and participate in the OWA.

Table 7. The detailed information of major OW developers in China.

Company	Ownership	Installed OW capacity (MW)	Financial data in 2018 (RMB, billion)			Description	Data source
			Total assets	Revenue	Profit or net-profit [2]		
China Longyuan Power Group Corporation Limited (Longyuan)	China Energy owns 57.27% stakes; H shareholders in Hong Kong Stock Exchange owns 41.56%; Guodian Northeast Power Co.,Ltd. owns 1.17%	996.5	56.6	26.4	Net-profit: 4.9	Longyuan is the earliest specialized company to develop wind power, with more than 300 onshore and offshore wind farms in China.	(Longyuan Power Group, 2019)
State Power Investment Corporation Limited (SPIC)	State-owned.	853.4	1080.3	226.4	Profit: 10.8	SPIC was established in May 2015. It was reorganized and established by the former China Power Investment Corporation and National Nuclear Power Technology Corporation. It owns nuclear, thermal, hydropower, wind, and photovoltaic power generation types. It is the largest photovoltaic power generation enterprise in the world. It is the demonstration	(SPIC, 2019)

[2] The "profit" includes profit and net-profit because some companies used the term "net-profit", and some companies used "profit".

						enterprise of smart energy construction determined by SASAC	
China Guodian Corporation (Guodian) >> China Energy Investment Corporation (China Energy) [3]	State-owned. In 2017, the Chinese Communist Party Central Committee and State Council approved that Guodian and Shenhua Group were merged and reorganized to a new company, China Energy.	258	1800	542.3	Net-profit: 50.9	China Energy has eight business segments including coal, thermal power, new energy, hydropower, transportation, chemical industry, environmental technology, and industrial finance. It is the world's largest coal production company, thermal power generation company, and wind power generation company (partly as China Energy holds Longyuan).	(China Energy, 2019)
China Three Gorges Corporation (CTG)[4]	State-owned	214.5	700.9	278.6	Profit: 14.4	The strategic mission of CTG is to serve the development of the Yangtze River economic belt, play a major role in Yangtze River protection, and provide fundamental service for the area. It is the world's largest hydropower operation company and China's largest clean energy company.	(CTG, 2018)

[3] The information in this row is about China Energy.

[4] The data of CTG is for 2017 because CTG has not published their 2018 data.

China Huaneng Group (Huaneng)	State-owned	205.5	1073.3	278.6	Profit: 14.4	Huaneng focuses on thermal power. Huaneng mentioned that electricity generation is its core, and coal is the base.	(Huaneng, 2019)
China General Nuclear Power Corporation (CGN)	State-owned	201	660	98		CGN was formally registered in September 1994. It constructs and manages a number of clean energy projects such as nuclear power, wind power and solar energy.	(CGN, 2019)
Luneng Group[5] >> State Grid	Completely owned by State Grid, which is also a SOE.	200	3932.5	2562.7	78	State Grid's business area covers 26 provinces, covering more than 88% of China's land area. It provides power supply service for over 1.1 billion people. State Grid ranked 2nd on Fortune Global 500.	(State Grid, 2019)

Source: Author.

[5] The report of Luneng Group cannot be downloaded. Therefore, the information of this row is State Grid, the parent company of Luneng Group.

4.4.2 Relationship between the OW developers

The following discusses the elements that influence the prior ties or relationships between the OW developers. The elements include the evolution of China's power sector, the power that the authorities have to directly influence OW developers, and the competition and cooperation between the developers.

The evolution of the power sector

The background information of China's power sector is helpful to understand the relationship between OW developers. Before 2002, China's electricity sector is monopolized by the State Power Corporation (SPC) that controlled over half of the power generation assets and almost all electricity transmission and distribution assets (Wang & Chen, 2012; Xu & Chen, 2006). At the end of 2000, SPC owned RMB 1.8 trillion (the US $213billion) assets (Xu & Chen, 2006). As a monopolist in the power sector, SPC faced criticism like high cost and low efficiency (Xu & Chen, 2006). The monopoly situation hindered the development of China's power industry: the lack of investment in power generation and grid infrastructure caused that power sector could not meet the increasing demands led by economic growth; power grids were weak, and people in rural areas could not get access to electricity; power grids were so unstable that they could not handle disasters and accidents (Zeng, Yang, Wang, & Sun, 2016). Reforms was needed to solve these problems to meet the increasing electricity demand in China.

In 2002, the central government issued a market-oriented reform. The reform aimed to develop power market by separating government orders and business function and promoting fair competition between utilities (Wang & Chen, 2012). One key policy of the reform was dismantling SPC into several companies: its power assets were mainly distributed into five companies (Huaneng, Datang, Huadian, Guodian, and China Power Investment Corporation) that were called the Big Five; its transmission and distribution assets were distributed into State Grid and China Southern Power Grid (Wang & Chen, 2012; Zeng et al., 2016).

Although the SPC was dismantled, the newly established companies do not fully compete in China's electricity market. The utilities got assets that distributes in different areas so that they have competitive advantages in some areas. For example, Guodian's assets are mainly in Northern China, Eastern China, and Yunnan, Guizhou Provinces, and China Power Investment Corporation's assets are mostly in Northeastern China, Jiangxi, and Henan Provinces (Xu & Chen, 2006). Except for the Big Five dismantled from the SPC, the other two OW developers, CTG and CGN, were established especially for hydropower and nuclear power respectively, and they have advantages in the two specific technical areas. Due to the advantages in some geographic and technological areas, the market competition in the power sector is not as intense as in a free market.

The influence of authorities

Some authorities have a close relationship with the OW developers. The National Development and Reform Commission (NDRC) is responsible for making macroeconomic policies and therefore has a significant influence on China's economy. NDRC has two sub-departments that directly influence OW developers. First, the Department of Price determines and releases electricity tariff that directly affects the utilities' revenues from OW farms (Liu, 2018). Although OW developers can negotiate the electricity tariff, it is the Department of Price that makes final decisions on the tariff. Second, the National Energy Administration (NEA) that is also under NDRC has the power to make energy development strategies, plans, policies, and standards (NEA, n.d.). Specifically, NEA is responsible for approving, consenting, and reviewing energy investment projects, including OW projects (NEA, n.d.). In addition to the NDRC system, the State-owned Assets Supervision and Administration Commission (SASAC) represents the government as an owner of central-level SOEs, including the OW developers (Hu, 2018). SASAC oversees the performance of the OW developers and appoints high-level executives so that it plays a vital role in the strategies and operation of the OW developers (Hu, 2018). Furthermore, SASAC has incentives to influence the policymaking and chase economic-efficient policies to benefit the OW developers (Hu, 2018).

The authorities manage the relationship between OW developers through different approaches. First, the government can dismantle or merge companies. For example, because coal-fired power plants are the most prevalent electricity generation plants, and the market determines the price of coal, the power generation companies face volatile coal price and sometimes lack coal supply (Liu, 2018). To solve this problem, Guodian and Shenhua, which was the largest coal producer in China, merged into China Energy under the decision of the government (Xinhua Net, 2017). Second, the government can issue orders to determine and exchange the leaders of the utilities. For example, the government announced that the former president of State Grid was the new president of Huaneng (Xinhua Net, 2018). Thus, the Chinese Government can directly determine and change the relationship between OW developers.

Figure 10 summarizes the relationships between the key OW developers and government authorities. First, some developers were dismantled from the same company, the SPC. All the developers have the same owner, SASAC. SASAC oversees the operation of these developers and issues orders on company executive appointment. Two departments under the NRDC has a significant influence on the OW developers: first, the Department of Price sets electricity tariffs, directly affecting the profitability of OW projects; second, NEA issues national OW plans and policies.

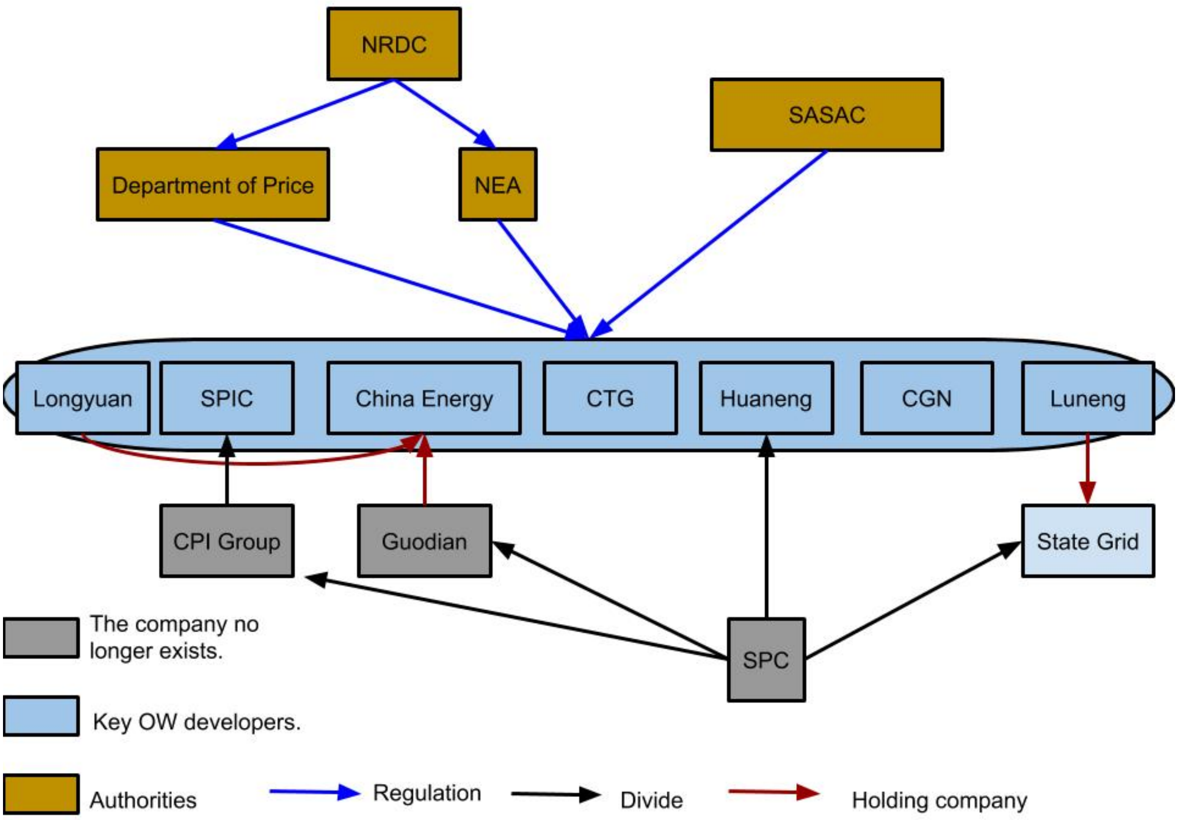

Figure 10. The market share of fully commissioned OW capacity in China.

Source: Author.

Competition and cooperation

The government policies and their significant influence on the OW sector limit the competition between the OW developers. First, NEA assigns power generation tasks to different utilities, which avoid the fierce competition of utilities in a specific field. For example, Datang and Huadian focus on thermal power; SPIC focuses on clean energy; Longyuan focuses on wind energy (Interviewee F, 2019). Second, the ownerships of OW projects are determined mainly by political negotiation between developers and local governments, which is like a black box. Although there may be a public and open tender process, the ownership of a project is determined even before the tender of the project is released (Interviewee E, 2019; Interviewee F, 2019). This phenomenon is partly because OW development requires vast capital investment and high technical expertise, and local governments do not have many alternatives while planning OW zones (Interviewee E, 2019). Since many OW projects have been consented, the developers do not need to worry that they do not have projects. Overall, the competition of the developers on OW projects is not fierce.

The cooperation between OW developers is also rare in China. It can share the financial risks of an OW project that several utilities jointly develop the project. However, the installed capacity of jointly developed OW projects is 749.4 MW, accounting for 21% of fully commissioned capacity. Large OW developers are unlikely to develop OW projects with other companies. Usually, companies that have just entered the OW sector jointly develop OW projects with large developers, and these large developers often acquire small enterprises (Interviewee E, 2019). Therefore, the key OW developers have few cooperation experiences such as joint development.

In sum, the key stakeholders have prior ties and understand each other well. Some of them were dismantled from the same company, SPC. Further, the key OW developers identified above have the same owner, SASAC, who can give direct orders to the developers. The close relationship between the developers means they are unlikely to conduct uncooperative behavior in collaboration because they may be punished by SASAC, which is beneficial to forming collaboration. NEA can influence the developers through OW development plans and policies. Also, the government can change the relationship between companies through merge or leader exchange. Although the current cooperation and competition between the key developers both remain at a relatively low level, the significant impact of the authority on the developers means if the government issues a collaboration decision and provides incentives, the developers are likely to participate in the collaboration.

4.4.3 Industrial and technical characteristics

The following discusses the features of Chinese OW industry and technology that affect the motivations of OW developers to collaborate. The features include OW technical convergence, innovation uncertainty and culture, and the industry entry barrier.

Technical convergence

The OW industry is a complex system requiring knowledge from multiple disciplines. Figure 11 shows the process of an OW project, SPIC Binhai North H2 400 MW Offshore Wind Farm, which is the biggest fully commissioned OW farm in China. The first step of the project was investigation and project plan, including wind measurement, wake effects measurement, and geotechnical site investigation. Second, based on the investigation result and project plan, the developer began farm construction, including facilities installation (foundations, cables, and sub-generators) and grid connection. Third, after the wind farm connected to the grid system, the

OW project entered the operation and maintenance stage that is challenging as the ocean environment can cause difficulties for operation and maintenance activities. Fourth, after a certain period of operation, the developer needs to decommission the farm and ensure that the environment of OW farm area after decommissioning is the same as before the construction of the farm. Although the developers subcontract some tasks rather than implement the tasks by themselves, they are deeply involved in these steps, requiring a high level of knowledge and skills within multiple disciplines. Therefore, the high level of technology convergence in OW development provides incentives for the developers to collaborate to solve the challenges of OW knowledge and technology.

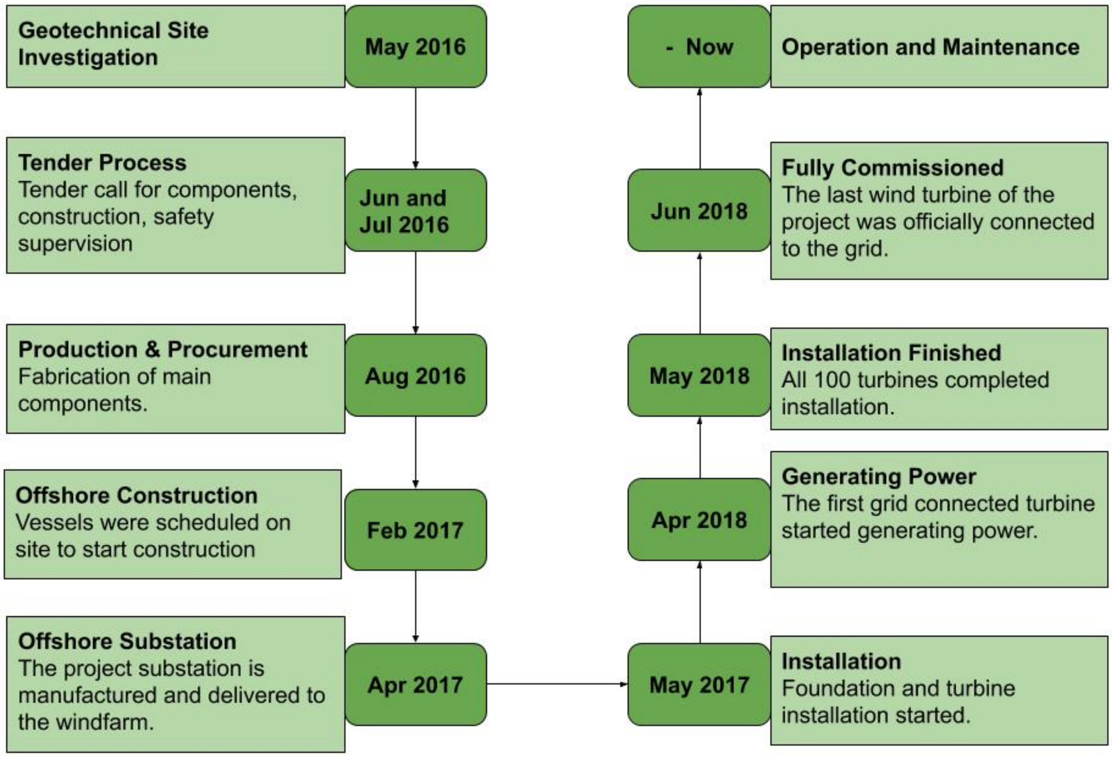

Figure 11. The process map of SPIC Binhai North H2 400 MW OW farm.

Source: Author. Based on the data collected from 4Coffshore.

Innovation uncertainty and culture

The uncertainty of OW development has been decreasing. Although a high level of technical convergence brings uncertainty, China's OW sector has passed through the initial stage and entered into a steady development stage (Interviewee A, 2019). With technological development, innovation uncertainty has also been declining. Technological innovation and development are still needed to reduce the lifecycle cost of OW projects further. However, as mentioned above, the developers can easily get loans from state banks (Karltorp et al., 2017). Furthermore, the OW developers may get financial support when facing financial crises. For example, when the Big Five's debt was climbing because of the increase of coal price, SASAC and the Ministry of Finance provided cash for these companies to help them overcome the crisis (Hu, 2018). Therefore, under today's policy framework of loan and financial support, the major OW developers unlikely go bankrupts. Although innovation still faces uncertainty, the fact that the developers do not need to worry about the financial crisis and bankruptcy reduces the uncertainty faced by the developers.

Innovation culture among OW developers also affects their commitment to and motivation for innovation collaboration. Carbon Trust wants to establish an OWA to deliver breakthrough innovation that can bring significant benefits to the whole industry. However, Chinese developers tend to focus on near-term innovation that can quickly provide benefits and be used by their projects soon (Interviewee C, 2019). Therefore, the long-term prospect advocated by Carbon Trust maybe not that attracting for OW developers.

Entry barrier

We mentioned above that big SOEs monopolize China's OW market. For domestic private utilities and foreign-owned utilities, the entry barrier to enter China's OW sector is extremely high. First, OW development requires vast investment and knowledge which most private utilities in China do not own. Second, resources, information, and security restrict foreign-owned companies to enter China's OW industry (Interviewee E, 2019). Currently, there is only one foreign invested OW project. EDF Group acquired about 35% stakes of Dongtai 4 and 5 projects that are still under construction (Shao, 2019). China Energy owns the left 65% stakes, higher than the stakes held by EDF Group (Shao, 2019). Besides, the concern that China has maritime disputes with neighbors is also a significant obstacle (Interviewee E, 2019). In the East China Sea, China has territorial disputes with Japan; in the South China Sea, China has territorial disputes with Vietnam and the Philippines (Council of Foreign Relations, 2017). The US's security commitments to Japan and the Philippines make the situation more complicated (Council of Foreign Relations, 2017). The unstable relationship between mainland China and Taiwan also leads to that the government does not want to share the information with foreign companies. Thus, in the near term, China's OW industry will still be dominated by current players, and other companies are unlikely to enter the industry.

4.4.4 Buyer's power

If there is a significant buyer for the electricity generated by OW farms, the buyer's attitude to the price and innovation will affect the OW developers. In China, the buyers for OW electricity are two grid companies, State Grid which owns grid assets covering 26 provinces and 88% of China's land area (State Grid, 2019) and China Southern Power Grid (CSPG) which owns grid assets covering 5 provinces (CSPG, 2017). The two state-owned grid companies monopolize China's electricity transmission market. They own most of the power exchange centers where electricity trade takes place (Liu, 2018). The grid companies obtain the revenue from the gap between the tariffs for electricity generators and end-users (Andrews-Speed, 2018). Therefore, the grid companies have incentives to reduce the transmission tariff that they need to pay to electricity generators.

However, like mentioned above, it is the Department of Price under NDRC rather than grid companies determines electricity transmission tariffs and end-user tariffs. In China's power sector, utilities submit the economic indexes to NDRC before they build a power plant, and then NDRC negotiates with the utilities to determine the on-grid tariff (Zeng et al., 2016). Since both generation companies and grid companies are state-owned, the government tend to set relatively high on-grid tariffs and electricity tariffs to make sure that these companies can obtain profits (Zeng et al., 2016). To promote the development of OW, the government has set a FiT of RMB 0.85 Yuan/kWh to make sure that OW utilities have stable revenues. Although the FiT mechanism provides incentives for utilities to develop OW projects, it also means that the developers do not face high price pressure from buyers at least in the near term. The government issued a new policy about the change of OW on-grid tariff after 2021. However, the policy leads to a negative impact on significant innovation in OW sector, which is discussed in 4.5 Policy section.

4.5 Government Policies for OWA in China

The above mentions that the government can directly change the relationship between OW developers. This section explains how government policies from different authorities cause incentives or obstacles for the collaboration behaviour of OW developers. The policies include SOE and power sector policies, electricity transmission tariff policies, and innovation policies.

4.5.1 SOEs and power sector policies

As mentioned above, major OW developers are all state-owned or state-controlled (e.g., Longyuan). Therefore, this sub-section discusses SOE policies and electricity sector policy together. For the electricity sector, to solve the overcapacity problem faced by electricity generators, the Chinese Government issued a document to start a market-oriented reform in the electricity sector. According to the policy, the government aims to cultivate independent market entities and encourage competition in the electricity generation side (The State Council, 2015). More OW developers and market competition can promote the motivation of utilities on technical innovation, and thereby the OWA in China can become more attractive for the developers.

However, the SOE policies issued by the Chinese Government can lead the power sector reform toward another direction. After President Xi Jinping came to power, a popular slogan of SOE reform was "make SOEs bigger and stronger", meaning that the free market competition is not the objective of the SOE reform. There are two key features of President Xi's SOEs reform. The first feature is increasing the leadership of the Chinese Communist Party (CCP). One SOE policy document mentioned that "insisting the Party leadership and strengthening the Party building are unique advantages of SOEs" (The State Council, 2017). Therefore, the SOEs will continue enjoying privileges in China's economy and lacking motivations to innovate to strengthen their competitiveness. The second feature is promoting mergers and acquisitions that directly relates to the "bigger and stronger" objective. Facing disordered competition and overcapacity problems, the Chinese Government encourages mergers and acquisitions to increase industrial concentration and acquire critical technologies, core resources, well-known brands, and market accesses (The State Council, 2016a). One representative example in the power sector is Goudian and Shenhua merged and reorganized China Energy, which was mentioned above. The merger and acquisition policies are directly controversial to the market-orientation reform of the electricity sector and newer than the electricity reform policy. Overall, the "bigger and stronger" SOE reform direction will help OW developers have more advantages and privileges, and thereby market competition will decrease. The decrease of market competition reduces the motivations of OW developers for innovation collaboration.

4.5.2 Electricity transmission tariff policies

Currently, OW developers enjoy the FiT policy that the transmission tariff of OW is RMB 0.85/kWh, much higher than the transmission tariffs of coal power or hydropower. However, to promote competition, NDRC published a document in 2019 to remove the OW FiT. According to the document, for the OW project consented before 2018, the generation plant can continue enjoying the FiT of RMB 0.85/kWh if the plant connects to grid system by the end of 2021; the generation plant will take guidance tariff that will be lower than RMB 0.85/kWh if it connects to grid system after 2022 (NDRC, 2019). Since provincial governments and OW developers both want to take advantage of the current FiT, provincial governments consented many OW projects to promote OW development in their areas. Meanwhile, the OW developers want to complete as many OW projects as they can before 2021 to enjoy the current FiT

(Interviewee E, 2019). The motivations of provincial governments and OW developers can partly explain why the consent authorized OW projects reach as high as 39,334 MW (Table 6) because provincial governments and OW developers both want to take advantage of current FiT. On this issue, provincial governments and OW developers are partners, and NDRC is on the other side. To complete the consent authorized projects, the OW developers will compete with each other on the supply chain, including turbines, foundations, and vessels (Interviewee E, 2019). For the OW developers, the current priority is construction rather than long-term innovation, which reduces the attractiveness of the OWA model aiming to promote technical change.

4.5.3 Innovation policies

The Chinese Government has set high-tech innovation as a critical strategy to upgrade China's economy. On the central government side, the government intends to build more innovative industrial clusters in which the key enterprises play the role of leading innovation and demonstration, and SMEs participate (The State Council, 2016b). The government emphasizes promoting innovation collaboration but focuses on the collaboration between upstream and downstream companies, companies and research institutions. Besides, the government intends to establish an assessment system for the technical innovation performance of SOEs in which R&D investment and innovation performance are KPIs (The State Council, 2016b). Besides, the government tries to issue policies that provide more incentives for SOEs for their innovation outcomes (The State Council, 2016b). However, the government does not explain how they will implement these incentive policies in detail. Considering the lack of detailed policies, it is skeptical whether the assessment system and incentive policies can effectively promote SOEs' innovation capacity.

On the local government side, the local government's innovation policies focus on infrastructure and manufacturing. To establish an OWA in China, CWEA intends to persuade Yangjiang government to support the OWA idea. Choosing the Yangjiang government is because Yangjiang has expressed their ambitions to develop an OW industry base. The Yangjiang government has issued several policies to develop the OW industry. For example, Yangjiang government encourages OW companies to set up research and innovation institutions such as engineering laboratories in Yangjiang (Wang, 2019). Besides, the Yangjiang government tries to open OW technology demonstration area and innovation information platform (Wang, 2019). More importantly, Yangjiang government has established the Yangjiang Offshore Wind Power Industry Development Fund with a total investment of RMB 12 billion and the first phase of 1.987 billion (Wang, 2019). However, the OW companies mentioned that they had not received any money from the fund, and they do not know how the fund functions (Interviewee C, 2019). The fund is still at a very early stage. The initial motivation of Yangjiang government is to develop its OW industry and upgrade its economy. The government has not explained the policies about how they attract OW developers and promote their collaboration.

Overall, the Chinese Government does not provide strong incentives for OW developers to collaborate on innovation. First, although the government issued market-oriented reform on the electricity sector, the "bigger and stronger" objective of SOEs reform with merger and acquisition policies will keep the market situation that some central SOEs monopolize the OW development. The monopoly is not beneficial for collaboration since the OW developers lack motivations for innovation collaboration. Second, the change of FiT has pushed the OW developers to set their priorities on construction rather than long-term innovation. Third, although the government has emphasized the significance of innovation collaboration, the government has not issued policies about promoting the collaboration between OW developers.

4.6 Resource Needs for OWA in China

Human resources and financial resources are significant to form an OWA in China. Establishing OWA requires human resources with expertise on offshore wind. In the OWA, the primary mechanism to promote innovation is holding international competitions to solve urgent challenges faced by OW developers. Therefore, the practitioners at the OWA need to have in-depth OW knowledge about pressing challenges and latest innovations. The knowledge provides a basis for the staff on project design and management in the OWA. Meanwhile, the OWA management team needs to have strong communication ability. Because the management team needs to carry out internal communication with OW developers to determine the objectives, principles, and projects of the OWA. Besides, the management team needs to communicate with external stakeholders such as OW innovators and manufacturers. Thus, forming OWA requires human resources with considerable expertise on OW and strong communication ability. Currently, Carbon Trust has OWA management skills, and CWEA has in-depth OW knowledge and communication skills with other OW stakeholders, providing a basis for OWA formation.

Forming OWA also requires initial funding. Implementing projects and supporting promising innovation proposals need financial investment. As a consulting company and an industrial association, Carbon Trust and CWEA do not have financial resources for the OWA. In the UK, the Scottish government and the industry together provided funding for the OWA. In China, CWEA wants to persuade the Yangjiang government to provide funding. Choosing Yangjiang is because the Yangjiang government has announced to establish the Yangjiang Offshore Wind Power Industry Development Fund, and OWA may be an interesting idea for the government. However, the fund is at a very early stage, and CWEA is still waiting for Yangjiang's response for supporting the OWA. The OW developers are unlikely to provide funding at this stage without government support first. Thus, Carbon Trust and CWEA still face difficulties of seeking funding source, which is a crucial challenge for the two conveners.

5 Discussion

Based on the above analysis, this section discusses some key issues that are especially relevant to the research objective and RQs.

5.1 Feasibility for an OWA in China

RQ 1: What is the level of feasibility of forming a collaboration similar to the OWA model in China?

Currently, the feasibility of creating an OWA in China is low. The idea of forming an OWA faces obstacles from the conveners, stakeholders, and policies. The below provides detailed answers for each sub-question, particularly the barriers from the three perspectives.

RQ 1.1 Do the conveners have sufficient credibility and resources to convene potential partners?

The Carbon Trust has interests in initiating and managing an OWA in China. Carbon Trust wants to spread its successful experience of managing OWA in the UK. China is an attracting market for spreading the OWA model because OW energy has enormous development potential in near-term and long-term in China. To realize the potential, OW technology needs to reduce the cost further to compete with other energy sources. Technical innovation and development are necessary for reducing the cost. Thereby, the OWA idea has value and attraction in China's OW industry as it can support the common innovation needs of the developers and support promising innovative solutions.

To form the OWA, Carbon Trust needs to convene relevant stakeholders to participate. However, the convening is limited by the Carbon Trust's credibility and influence in China's OW sector. The limited credibility is caused by the lack of project experience, technical knowledge, and communication with the OW developers. First, Carbon Trust has considerable OW project experience in the UK but has done few significant OW projects in China. Second, as a small office, Carbon Trust Beijing Office lacks experts who understand both OW technology and China's OW industry context. Although Carbon Trust has an OW team in London, the technology and knowledge support from London OW team cannot adequately fill the knowledge gap in Beijing Office. For the OWA, what the London OW team can provide is the OWA management experience, which is essential for the OWA management in China. Third, Carbon Trust has established a relationship with some research institute but has few direct interactions with the OW developers in China. Fourth, due to its identity as a relatively small foreign company, it is difficult for Carbon Trust to cooperate with huge Chinese OW developers and receive trust from government authorities. Because of the above limiting factors, Carbon Trust can hardly convene potential partners by it alone. Therefore, choosing CWEA as a convening partner is an important tactic to make up Carbon Trust's shortcomings.

As an industrial association, CWEA plays an active role in China's OW industry. CWEA has gained credibility from its various work in China's OW sector. First, CWEA has undertaken several projects under the commission of government authorities, through which CWEA has established a close relationship with the authorities. Second, CWEA knows OW energy through its research work on China's OW industry and academic communication with other organizations. Third, CWEA has organized several OW conferences through which CWEA has established a relationship with significant OW developers and manufacturers in China. Thus, CWEA has sufficient credibility and knowledge so that it is qualified for convening other potential partners. One problem may be that CWEA does not have as strong motives for OWA as Carbon Trust does, which is why Carbon Trust should do keep a close relationship with CWEA and push CWEA on the OWA program.

The Carbon Trust and CWEA as two conveners for the OWA have human resources but lack a clear source of funding. Carbon Trust's OWA management skills and experience and CWEA's OW knowledge and networks provide human and knowledge basis for launching an OWA in China. However, Carbon Trust and CWEA do not have a clear plan for the funding. A possible source is the government, but there is a dilemma to get the financing. Because obtaining government funding may require that OW developers join the OWA first because financing a very initial project may be too risky from the government perspective; however, without a stable government funding first, the OW developers may not join the OWA. Thus, Carbon Trust and CWEA have adequate human resources but lack financial resources to form an OWA in China.

RQ 1.2 Do potential partners have strong motivation to participate in the collaboration?

In China's OW industry, Longyuan and SPIC are leading developers, and some utilities are important developers. For these developers, several factors have constraint their motivation to participate in an OWA in China.

A low level of interdependence. The low level of interdependence is highly determined by the identity of the developers that all of them are SOEs. These developers have substantial financial resources, strong political support, and are at the same position on the value chain of the OW industry. Particularly, all key developers own substantial financial resources and enjoy privileges from the state banking system. Thereby, the financial resources and privileges make the developers have low incentives to collaborate to reduce financial pressure. Second, these developers have political missions to develope different types of energy (e.g., wind for Longyuan and renewable energy for SPIC). Shouldering these missions, they get political support from the Chinese central government, which makes the developers have privileges in the competition with other developers in the OW market. Third, unlike upstream and downstream companies in the supply chain, the developers are at the same position on the value chain and compete directly with each other. Although they face similar technical challenges that is the rationale of the OWA, the competition between the developers on the same field make the collaboration difficult as they do not want to share much information with competitors. Overall, the low interdependence between the companies reduce the necessaries for collaboration.

Low sensitiveness to innovation risks and practical innovation culture. Developing OW farms is complicated with a high level of technology convergence. However, since OW industry has entered a steady development stage, the innovation risks are declining. Besides, because the government provides financial support when the developers face fiscal crisis, the developers with substantial financial resources are not that sensitive to innovation uncertainty. On the innovation culture side, the Chinese OW developers prefer innovations that can deliver quick outputs and be applied to their projects soon. For example, for the innovation on wind measurement, the OW developers may ask if the new method can be used in their recent projects. The preference of near-term outputs is opposite to the objective of OWA that is to deliver universal and breakthrough innovations. Thus, the low sensitiveness to innovation risks and the innovation culture preferring quick returns reduce the attractiveness of the OWA in China.

High entry barrier. If more utilities enter China's OW industry, the existing developers will have more motivations for innovation collaboration because new developers can challenge their operation in the OW sector. The competition from new companies is not a concern of the OW developers because the entry barrier for OW development in China is much high. First, the massive investment cost requires companies to have massive capital so that small companies usually cannot enter into the market. The state-owned OW developers that have sbstantial financial resources and not highly cost-sensitive can bid so low that private companies cannot compete in project tendering (Karltorp et al., 2017). Meanwhile, the Chinese Government is unlikely to allow many foreign-owned utilities to enter the OW industry due to concerns over maritime data and security. Therefore, the existing OW developers will not face significant challenges from other companies.

The current priority of the OW developers on construction. Due to the decrease of FiT and introduction of competitive allocation, provincial governments and OW developers collaborate to promote the increase of OW projects in the near-term. To encourage OW developers to construct OW farms within their areas, the provincial governments have consented many OW projects. Owning these OW projects, the OW developers want to complete the consent authorized OW projects as soon as possible to enjoy the high FiT. Therefore, the developers put their priorities on construction rather than innovation. Focusing on OW farm building means that the developers compete with others on construction facilities (e.g., vessels) and equipment (e.g., wind turbines), which further reduces their collaboration motivations. Since the change of government policy determines this factor, it is also explained in the next sub-section.

RQ 1.3 What incentives and disincentives do government policies provide for forming OWA?

The main incentive provided by the Chinese Government is emphasizing the significance of technical innovation. The government has issued some policies to encourage innovation, especially the innovation capacity of SOEs. The government also stresses the necessity of collaboration between upstream organizations and downstream organizations on supply chains. The innovation policies do not specifically mention innovation collaboration between similar type companies like OW developers. Furthermore, the following policies constrain the innovation collaboration between OW developers.

SOE reform with the objective of "bigger and stronger". The current Chinese administration is committed to developing "bigger and stronger" SOEs instead of implementing market-oriented reform. To achieve the "bigger and stronger" objective, strengthening Party building is a crucial approach. Besides, some developers have acquired small upstream companies and merged other utilities with the order or support from the government. Becoming "bigger and stronger" means the OW developers will have more power and advantages in the industry and thereby have less motivation to collaborate with other organizations.

The change of the FiT of OW energy. To reduce cost and push the OW developers to improve their performance, NDRC introduced a policy that the OW projects consented before the end of 2018 have to connect to grid systems by the end of 2021 if these developers want to enjoy the FiT of 0.85 RMB/kWh. Affected by this policy, the local governments have consented many projects in a short time in 2018 as they want to develop OW in their areas. The OW developers own many consent authorized projects and will focus on completing the projects by the end of 2021. Therefore, the change of the FiT caused a problem that the OW developers set their priority on construction. Also, with the priority on the construction, OW developers prefer near-term innovations that can be used in their projects soon rather than breakthrough innovations.

5.2 Collaboration barriers in China's power sector

RQ2: What are barriers for the utilities in China to collaborate on a platform like OWA?

The utilities themselves, the potential competitors, and the government cause the barriers for Chinese utilities to collaborate. First, the major utilities in China are SOEs that have strong economic and political advantages. On the political side, the utilities get company missions directly from the government, i.e., it is the government that makes high-level decisions about what the utilities should do. For example, Longyuan has the largest OW installed capacity partly because it was established specifically for wind energy. The government assesses the performance of utilities on developing renewable energy as some companies have the responsibility to develop renewable energy. The utilities can directly get projects from the government even though there may be an open and public tender, which is partly because the state-owned utilities have close relationships with and broad network within the government. On the economic side, the utilities have huge financial resources and enjoy privileges from the state banking system. Furthermore, the government injects cash to the utilities when they face financial crisis so that the utilities will never bankrupt under the current system. The economic and political advantages make the utilities can earn money without putting many efforts on breakthrough innovations.

Second, the utilities face little competition from foreign-owned companies and Chinese private companies. Foreign-owned companies face many limitations on entering China's power market as the government sees the power sector as a critical area for state security and set a high entry barrier. For example, the maritime security concerns make the Chinese Government unlikely to allow foreign-owned utilities to enter the Chinese OW market. Foreign-owned companies can only enter the Chinese power market through partnering with Chinese utilities. It is difficult for Chinese private enterprises to compete with SOEs. Holding substantial financial resources, the state-owned companies bid unprofitable projects to improve the market share, which is impossible for private enterprises to do (Karltorp et al., 2017). Therefore, the significant utilities do not face competition pressure from international companies and Chinese private companies. Because of the scale economy and the lack of competition, the state-owned utilities do not face high pressures to improve their performance and competitiveness through innovations continuously.

Third, the government policies on SOEs reform reduces the possibility of collaboration between the utilities. The government tries to make the utilities "bigger and stronger" through acquisition and merger. After acquisition and merger, the newly established companies will have fewer motivations to collaborate because their dominant positions in the power sector will be strengthened. It will be more difficult for relatively small organizations like Carbon Trust and CWEA to convene the giant state-owned utilities.

6 Conclusion

The OWA is a program idea that aims to creates a collaboration platform to prioritize the common innovation needs of OW developers in China and support the promising innovation proposals that can meet the innovation needs. The feasibility of forming an OWA in China is low due to the barriers from three perspectives.

First, the Carbon Trust and CWEA as two conveners together have sufficient knowledge and skills to manage that is helpful to persuade the OW developers to participate in the OWA. However, the funding for the OWA is highly uncertain, and both Carbon Trust and CWEA do not have a clear and detailed plan for the financing.

Second, the major OW developers who are vital participants of the OWA have low motivations for the OWA because of four factors. (1) The developers have a low level of financial, market, and technical interdependence so that collaboration is not highly necessary for them. (2) The innovation uncertainty of the OW industry is declining, and Chinese OW developers prefer innovations that can be quickly applied into their OW projects, which is controversial with the innovation idea promoted by the OWA that is to help universal and long-term innovation needs. (3) The high entry barrier of China's OW market means the OW developers in China will not face the challenge from new competitors, which reduces the motivations of OW developers for improving competitiveness and performance through innovation. (4) The key OW developers have set their priority on project construction so that they can take advantage the FiT of OW energy that will be canceled after 2021.

Third, the government policies further reduce the motivations of OW developers for innovation collaboration due to the acquisition and merge in the power sector and the cancellation of the FiT. Thus, for the OWA idea, the conveners lack clear funding plans; the stakeholders have low participating motivations for the innovation collaboration; the government policies create disincentives.

The Chinese Government plays a particularly significant role in forming an OWA in China. First, the government holds a huge influence on the OW developers via energy policies from NEA and SOEs policies from SASAC. Second, the government is a possible and realistic funding source for the OWA. Therefore, forming an OWA in China may be feasible if the government provides funding and encourages the developers to collaborate. However, the features in China's OW sector, such as relative monopoly, lack of interest in breakthrough innovation, and construction priority, make the OWA challenging to sustain.

This thesis makes three contributions to the body of literature. First, applying the collaboration theories, this thesis provides a case study on the advantages and disadvantages for innovation collaborations in China's OW industry. Since developing and deploying renewable energy is the key to combat climate change, understanding how to promote innovation through collaboration is of significance. Second, this thesis provides a detailed review of the performance, relationship, and innovation behavior of state-owned utilities in China. Unlike existing literature focusing on macro data or manufacturing ability, this thesis discusses the innovation collaboration at the developer level. Third, this thesis not only focuses on the OW developers, but also offers a systematic review of foreign-owned companies (i.e., Carbon Trust), industrial associations (i.e., CWEA), SOEs (i.e., the OW developers), and the government authorities in China's OW sector.

One key limitation of this thesis is that the author did not obtain information from government officers. It is because the author did not find possible interviewees in the government, and government officers usually do not want to talk with external people. This thesis also did not interview staff at the OW developers who are responsible for innovation or collaboration, and their opinion would be beneficial for this thesis topic.

6.1 Recommendations

Targeting at the barriers identified in this thesis, the Chinese Government can implement the following policies to promote innovation collaboration on renewable energy.

- Create a fair utility market. The government should stop giving political and economic privileges to state-owned utilities as the privileges reduce their motivations for innovation. The government should also avoid giving administrative orders such as acquisition and merger to affect the operation of utilities.
- Create an open utility market. Foreign-owned companies and Chinese private companies should be encouraged to enter China's utility market. The fair competition from foreign-owned companies and Chinese private companies can create pressure on state-owned utilities to improve their performance, which is beneficial to the social interest.
- Issue policies to prevent the negative impact of canceling the OW FiT. The central government decided to cancel the OW FiT to push the OW developers to reduce costs. However, provincial governments have consented many projects, and OW developers try to complete as many projects as possible before 2021 to take advantage of the FiT. Focusing on construction is not suitable for the sustainable development of the OW industry and may cause overcapacity problems. Therefore, the government should issue policies to solve the possible problems.
- Support innovation collaboration platforms. The government should encourage innovation collaboration between the same type of companies like the OWA idea and co-innovation centers.

Having the successful OWA experience in the UK and facing the vast OW market potential in China, Carbon Trust should keep pushing the OWA idea in China through the following methods:

- Keep working with CWEA on the OWA. For Carbon Trust, CWEA is a necessary partner on the OWA program. Carbon Trust should enhance communication with CWEA.
- Strengthen the promotion of the OWA model. Carbon Trust should use different opportunities (e.g., international conference and workshops) to promote the successful experience of the OWA, which can help more public authorities and OW developers understand the program.
- Enhance communication with government authorities and OW developers in China. Carbon Trust can develop projects with OW developers to increase their credibility and influence.

For future studies, it is valuable to research the innovation behavior and collaboration behavior of the utilities in China. Since most critical utilities in China are SOEs, it is significant to compare the difference between state-owned utilities and private utilities on technical innovation. Also, the scholars can look into the relationship, such as cooperation and competition between the state-owned utilities in China.

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Appendix I Chinese OW projects

Project name	Construction Starts	Owners	Capacity MW (Max)
Donghai Bridge 100 MW offshore wind power demonstration project	20-Mar-09	China Datang Corporation, Shanghai Green Energy Co., Ltd, CGN Wind Energy Limited, China Power New Energy Development Company Limited	102
Suizhong 36-1 Oil Field Turbine	25-Jun-07	China National Offshore Oil Corp(CNOOC) (中国海洋石油有限公司)	1.5
Longyuan Rudong Intertidal Trial Wind Farm	15-Jun-09	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	32
DDHI Composite Bucket Foundation Test Project	30-Sep-10	DaoDa Heavy Industry Group Co. Ltd (道达海洋重工股份有限公司)	2.5
Jiangsu Rudong 150MW Offshore (Intertidal) Demonstration Wind Farm - phase II	2-Jul-12	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	50
Jiangsu Rudong 150MW Offshore (Intertidal) Demonstration Wind Farm - extension	1-Nov-12	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	50

Xiangshui Intertidal Pilot Project - Goldwind GW3000kW + DEC FD119A	1-Sep-11	China Three Gorges Corporation (中国长江三峡集团公司)	6
Xiangshui Intertidal Pilot Project - Shanghai Electric - SEC2000	1-Oct-09	China Three Gorges Corporation (中国长江三峡集团公司)	2
Hydropower Rudong Offshore Wind Farm (intertidal) 100MW demonstration project - phase 1	5-Jul-12	Sinohydro Renewable Energy Co.,Ltd(中国水电建设新能源开发有限公司),DongDian New Energy(江苏东电新能源)	20
Fujian Putian City Flat Bay - 50MW	1-Mar-15	Fujian Energy Investment Co., Ltd.(福建中闽能源投资有限责任公司)	50
Dafeng (Shanghai Electric) Intertidal Demonstration Turbine	1-Jan-09	China Power New Energy Development Company Limited (中国电力新能源发展有限公司),B.I. Energia	2
Guodian United Power 6MW Prototype (onshore)	6-Nov-12	Guodian United Power Technology Co., Ltd.(国电联合动力技术有限公司)	6
Longyuan Rudong Intertidal Trial Wind Farm -Extension	2-Jul-12	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	49.2
Jiangsu Longyuan Chiang Sand H1 300MW	1-Jan-17	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	300

Zhongmin Fujian XEMC Test Turbine(Nearshore)	30-Mar-12	Fujian Energy Investment Co., Ltd.(福建中闽能源投资有限责任公司)	5
Rudong Offshore Wind Farm Demonstration Project - Expansion Project (200MW)	25-Nov-14	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	200
Longyuan Jiangsu Dafeng (H12) 200MW (Concession)	25-Nov-16	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	200
Jiangsu Luneng Dongtai 200MW Concession	16-Jan-16	Shandong Luneng Group (鲁能集团有限公司)	200
Longyuan Putian Nanri Island I - 400MW Project - Demonstration - 16 MW	7-Jan-14	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	16
Shanghai Lingang Demonstration - 2	5-Nov-15	Huaneng Renewables Corporation Ltd (华能新能源股份有限公司),Shanghai Green Energy Co., Ltd,Shenergy Company Ltd (申能集团)	100.8
SPIC Jiangsu Dafeng H3 300MW	28-Dec-17	State Power Investment Corporation (SPIC) (国家电力投资集团)	302.4
SPIC Binhai North H1 100MW	3-Oct-15	State Power Investment Corporation (SPIC) (国家电力投资集团)	100

Huaneng Rudong 300MW - South	30-Apr-16	China Huaneng Group HK Ltd.(中国华能集团香港有限公司),Huadian Power International Corporation Limited (华电国际电力股份有限公司)	146.4
Guodian Zhoushan Putuo District 6 Zone 2	31-Jul-16	GD Power Development Co.Ltd (国电电力发展股份有限公司)	252
Donghai Bridge Offshore Wind Farm Phase II (Extension) project	27-Sep-11	China Datang Corporation (中国大唐集团公司),China Guangdong Nuclear Power Group (中国广核集团),China Power New Energy Development Company Limited (中国电力新能源发展有限公司),Shanghai Green Energy Co., Ltd	102.2
Xiangshui Intertidal Pilot Project - Goldwind - GW 100/2500	1-Oct-09	China Three Gorges Corporation (中国长江三峡集团公司)	2.5
Xiangshui Intertidal Pilot Project - Shanghai Electric - W2000M-93-70	1-Oct-09	China Three Gorges Corporation (中国长江三峡集团公司)	2
SPIC Binhai North H2 400MW	10-Feb-17	State Power Investment Corporation (SPIC) (国家电力投资集团)	400
Xiangshui Demonstration	17-Apr-15	China Three Gorges Corporation (中国长江三峡集团公司)	202
Jiangsu Rudong 150MW Offshore (Intertidal) Demonstration Wind Farm - phase I	17-Jun-11	China Longyuan Power Group Corporation Limited(龙源 电力 集团 股份有限公司)	99.3

CGN Rudong Demonstration	8-May-15	China Guangdong Nuclear Power Group (中国广核集团)	152
Hydropower Rudong Offshore Wind Farm (intertidal) 100MW demonstration project - phase 2	1-Oct-14	Hydrochina Corporation (中国水电工程顾问集团首页)	80
Huaneng Rudong 300MW - North	30-Apr-16	Huadian Power International Corporation Limited (华电国际电力股份有限公司),China Huaneng Group HK Ltd.(中国华能集团香港有限公司)	156
Zhuhai Guishan Hai Demonstration - phase 1	8-Sep-16	China Southern Power Grid (中国南方电网),Guangdong Electric Power Investment Co., Ltd. (广东电力投资有限公司),Guangdong Electric Power Development Co., Ltd (广东电力发展股份有限公司),Mingyang(Guangdong) Wind Power Industry Group Co.,Ltd (广东明阳电气集团有限公司),Guangdong Guangye Assets Management Co., Ltd. (广东省广业资产经营有限公司),GD Power Development Co.Ltd (国电电力发展股份有限公司),Datang International Power Generation Co., Ltd. (大唐国际发电股份有限公司),Guangzhou New Energy Development Co., Ltd. (广州发展新能源有限公司),China Three Gorges New Energy Co., Ltd. (中国三峡新能源有限公司)	120
Huaneng Rongcheng Power Prototype Demonstration Project(Onshore)	7-Dec-09	Huaneng Renewables Corporation Ltd (华能新能源股份有限公司)	6

Appendix II Interview questionnaire

Interview guide 访谈大纲（For Carbon Trust Staff）

1. The OWA design

1.1 What is the current status of offshore wind energy development in China in the view of Carbon Trust? 在Carbon Trust眼里，中国发展海上风电的现状和前景是怎样的？

1.2 What is the motive to develop a OWA in China? 为什么Carbon Trust希望创建中国版的海上风电加速器？背后的动力是什么？

1.3 What are the issues that need to be solved through the collaboration? 通过创建海上风电加速器，Carbon Trust是希望解决什么行业问题？

1.4 In Carbon Trust’s eyes, what is the structure of the collaboration in China? 中国海上风电加速器的模式是怎样的？

1.5 Compared to the OWA model in the UK, what are the adjustments of the OWA in China? 相比于英国的海上风电加速器模式，中国版的海上风电加速器会有什么针对性的调整？

2. The attributes of CT as a convener

2.1 How do you assess the credibility of CT in the eyes of other stakeholders? 在你看来，Carbon Trust在中国海上风电行业的可信度或者说影响力是怎样的？

2.2 If Carbon Trust initiates and manages the China OWA, does CT have adequate resources or skills to make it work? CT有没有足够的资源或者说能力建设和运行中国版海上风电平台？

3. Collaboration partners

3.1 In a program proposal sent to Yangjiang government, offshore wind suppliers, developers, and agencies are included. How did you choose these potential partners? 在发送给阳江市政府的海上风电联合行动2025的材料中，选定了公共机构、开发商和设备商等参与到海上风电加速器。 这些潜在的参与者是怎么选定的？

3.2 What is the relationship between Carbon Trust and the potential partners? Carbon Trust跟这些潜在参与者的关系是怎样的？

3.3 Do the issues make sense to potential partners and give them an incentive to reach an agreement? 对于潜在的合作伙伴，他们有什么动力加入到这个海上风电加速器模式。

3.4 What are the barriers for potential partners to join the collaboration? 对于潜在的合作伙伴，他们参与海上风电会遇到什么阻碍？

4. Resources

4.1 Who may provide funding for the project? 谁会为这个加速器项目提供资金？

4.2 How is the relationship between Carbon Trust and offshore wind innovators? 在英国的海上风电加速器中有许多独立的研发机构获得支持。Carbon Trust与中国类似的研究机构有没有联系？

4.3 What is the reasonable timetable to form the accelerator? 成立海上风电加速器有没有一个预定的时间表？