Thinking About the Development of Offshore Wind Farm in Northeast China

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Abstract. The wind energy is the new developed energy on a large scale, and the offshore wind energy resource in in northeast China is abundant, which has great value of development. This paper not only states the meaning of offshore wind farm through introducing the planning location of offshore wind farm and the general information of wind energy, but also discuss the environmental problem brought by project from the view of birds and marine fishery resources. What is more, it offers a proposal about further strengthening study on its resource impact and provides a reference for offshore wind farm in northeast China.

1. Background
Among different types of renewable energy, offshore wind energy ranks among the top in terms of technology readiness, large-scale development possibility, and prospects for commercial development[1]. Featuring constantly evolving technologies, increasing unit capacity, and significantly decreased operating cost, offshore wind power generation needs no land resources, and thus has become a new field of wind resource development with great potential and promising development prospects[2][3]. At the national level, the National Development and Reform Commission has set the goal of building offshore wind farms providing $1000 \times 10^4$ kW wind power, including $500 \times 10^4$ kW installed wind power by 2020.

On the one hand, China boasts abundant offshore wind resources, and on the other hand, China’s coastal areas, which are economically developed, have a high demand for electricity. In such a context, developing offshore wind resources will play an important role in satisfying power demand, improving energy structure, reducing environmental pollution, coping with global climate change, and promoting sustainable and healthy economic development. As of the end of 2013, China had installed 112 offshore wind turbines, with total installed capacity reaching $29 \times 10^4$ kW. By the end of 2015, grid-connected wind power capacity had reached $12,900 \times 10^4$ kW[4].

In northeastern China where wind resources are abundant, onshore wind farms have appeared at a rapid speed, but offshore wind farms are still in its infancy. Actually, the offshore area of Dalian, especially of Zhuanghe and Huayuankou, has rich wind resources which encourage the development of wind power resources. Given this, Dalian has been actively promoting the construction of wind farms, responding to the state’s call of developing renewable energy resources, and promoting local social and economic development at the same time.
2. Planned Offshore Wind Farms in Northeastern China

The offshore area of Dalian City, Liaoning Province is the main target of wind farm construction in northeastern China. It’s planned to build seven wind farms with a total installed capacity of 2.2 million kW at two sites. Among the seven planned wind farms, Zhuanghe Wind Farm III is now under construction upon approval, and other farms are in the process of feasibility assessment or environmental impact assessment.

Table 1. Statistical Table of Recommended Offshore Wind Farm Locations

| Wind farm name                | Water depth: 5m~30m (Year of construction: 2011~2015) | Water depth: 5m~30m (Year of construction: 2016~2020) | Remarks |
|------------------------------|-----------------------------------------------------|-----------------------------------------------------|---------|
|                              | Distance from the shore (km) | Depth of water (m) | Area (km²) | Installed capacity (kW) | Distance from the shore (km) | Depth of water (m) | Area (km²) | Installed capacity (kW) |         |
| Site I                       |                                     |                                   |           |                           |                                     |                                   |           |                           |         |
| Huayuankou Wind Farm I       | 12                                   | 5~14                              | 65        | 300,000                   |                                     |                                   |           |                           |         |
| Huayuankou Wind Farm II      | 12                                   | 5~12                              | 65        | 300,000                   |                                     |                                   |           |                           |         |
| Zhuanghe Wind Farm I         | 12                                   | 7~14                              | 46        | 200,000                   |                                     |                                   |           |                           |         |
| Zhuanghe Wind Farm II        | 18                                   | 10~20                             | 64        | 300,000                   |                                     |                                   |           |                           |         |
| Zhuanghe Wind Farm III       | 22                                   | 12~22                             | 65        | 300,000                   |                                     |                                   |           |                           |         |
| Zhuanghe Wind Farm IV        | IV1                                  | 31                                | 19~26     | 77                        | 350,000                              |                                     |           |                           |         |
| Zhuanghe Wind Farm IV        | IV2                                  |                                    |           |                           |                                     | 40                                | 25~30     | 44                        | 200,000  |
| Zhuanghe Wind Farm V         | 32                                   | 18~27                             | 56        | 250,000                   |                                     |                                   |           |                           |         |
| Total                        |                                     |                                    |           |                           |                                     |                                   |           |                           | 2,000,000 |
|                             |                                      |                                    |           |                           |                                     |                                   |           |                           | 200,000  |

3. Overview of Offshore Wind Resources in Northeastern China
The above-mentioned wind farms are located in the East Asian monsoon region where SSE, S, SSW, NNW, N and NNE contribute to over 60% of the wind energy in most of the project area, and the figure even stands above 80% in some areas.

Data collected by No. 1 anemometer tower near the sites show that the annual average wind speeds at 85m, 90m, and 100m are 6.86m/s, 6.88m/s and 6.92m/s respectively which indicate annual average wind power density values of 351.3W/m², 354.6W/m² and 360.7W/m². Data collected by No. 2 anemometer tower show that the annual average wind speeds at 85m, 90m, and 100m are 6.61m/s, 6.64m/s and 6.67m/s respectively, indicating annual average wind power density values of 310.6W/m², 313.5W/m² and 318.9W/m². Data collected by No. 3 anemometer tower show that the annual average wind speeds at 85m, 90m, and 100m are 7.20m/s, 7.22m/s and 7.26m/s respectively, and the associated annual average wind power density values are 422.0W/m², 425.9W/m² and 433.3W/m².

Generally speaking, offshore wind resources in northeastern China are abundant enough for the construction of wind farms.

4. Main Resource and Environmental Problems Related to Wind Farm Construction

4.1. Effects on birds

A number of islands (e.g. Shicheng Island and Haiwang Nine Islands in Zhuanghe) 20 km west of Zhuanghe Wind Farm III act as the breeding grounds of endangered species black-faced Spoonbill, and Class II protected species yellow-billed Egret and pelagic cormorants.

Wind farms will mainly affect the aforesaid birds in two ways. Firstly, wind farms will drive away cormorants. Secondly, the construction of wind farms will increase the number of species in the project area which indicates more food for birds. Besides, static facilities like booster stations will provide perching places for abundant bird species like gulls, changing the original avian community structure which mainly manifests as increased activities of gulls.

1) Construction of wind farms will generate suspended solids, waste water, waste oil, solid wastes, as well as noise pollution and light pollution which will affect the eyesight of birds diving to prey, such as cormorants. However, thanks to the deep water and low population of birds in the project area which is relative large, birds can easily find alternative areas to prey. Therefore, the project’s effects on birds diving to prey are minor. It’s worth noting that solid wastes generated during construction are likely to be eaten by birds, leading to their death due to poisoning or indigestion. Noise will also affect birds. However, since the effects of mechanical noise are limited within a 100m radius in the daytime and an 800m radius at night, and the offshore area around the project sites is much larger, noise will actually have a minor effect on birds flying by (which will keep away from noise) and birds on the breeding grounds.

2) After the wind farms are constructed, the arrays of large turbines may pose a threat to birds flying low at night during migration. Measured data show that the sound power level of a single turbine falls in the range of 85～100dB, and since most water birds are highly sensitive to moving things and noise which acts as warnings, they will keep away from noise when flying by.

4.2. Effects on fishing

The two construction sites, which are mostly 16–26m in depth, have been acting as fishing areas for a long time, especially for the fishing of spawns during the spring flood period, and Spanish mackerel during the winter flood period.

Nekton like fish is very mobile, and thus will swim away from pollutants. Therefore, increased suspended solids generated during the construction will not seriously affect marketable fish living in and around the sites, except that their distribution will be affected to some extent. Besides, construction activities may divide or even destroy the habitats of fish, posing threats to the ecosystem and commercial fish. During the construction, shipping activities will become much more frequent, and water quality will decrease. And even after the construction, the damaged ecological environment will take time to recover. As a result, fishing activities cannot be carried out during this period of time. According to administrative regulations concerning ocean utilization, offshore wind farms do not exclude non-related activities, which means the utilization and protection of fishery resources, such as
fishing and reproduction, are allowed in offshore wind farms. However, to ensure the safe operation of wind turbines, ships, regardless of their types, are forbidden to anchor or fish around the foundations and near cables. As a result, the fishing and fish farming areas will be greatly reduced, causing loss to involved parties to some extent.

In accordance with the Provisions on the Protection of Submarine Cables and Pipelines (Decree No. 24 of the Ministry of Land and Resources of the People's Republic of China), activities such as sand excavation, drilling, piling, anchoring, clubbing, bottom trawling, netting, fish farming and other activities that may pose threats to the safety of submarine cables are forbidden within a 50m distance away from cables.

A large number of submarine cables are required by the project, and according to the 50m limit requirement, only some small areas in the two sites can be used for fish farming and fishing. This means decreased available fishery resources, fishing time, and fishing areas. Therefore, the construction of the wind farms will have a big impact on local fishermen.

However, from another point of view, prohibition of fishing and fish farming will actually help the conservation of fishery resources in the project area. Special reports on the effects of underwater noise and electromagnetic radiation indicate that noise and electromagnetic radiation generated during the construction will have a minor effect on fishery resources. Therefore, the project will, to some extent, promote the rational utilization of fishery resources.

5. Suggestions on Wind Power Development

5.1. Feasibility studies on the construction of offshore wind farms shall be carried out actively.
In northeastern China where wind resources are abundant, onshore wind farms have appeared at a rapid speed, but offshore wind farms are still in its infancy. Actually, the development of offshore wind resources plays an important role in satisfying electricity demand, improving energy structure, reducing environment pollution, coping with global climate change, and promoting the sustainable and healthy economic development of northeastern China. In the current context where renewable energy resource development is encouraged by the government, relevant parties should seize this opportunity, actively promoting the construction of wind farms in northeastern China. To do so, feasibility studies shall be carried out to find out how to avoid areas subject to frequently occurring sea-ice hazards and areas home to intensive resources such as migrant birds, so as to minimize economic loss caused by sea-ice hazards, and the damage of project construction to fishery and birds, thus promoting the development of offshore wind resources in northeastern China in a sustainable way.

5.2. Fishery resource conservation in the project area shall be studied.
Underwater test results indicate that noise and electromagnetic radiation generated during construction will have a minor impact on fishery resources. Although the project will reduce fish farming and fishing area; on the other hand, a fishery resource conservation area will come into being naturally, playing a positive role in promoting the rational utilization of fishery resources. In addition, fishery resource conservation studies may be carried out in the project area.

5.3. Effects of project construction on birds shall be studied.
Since there are important bird habitats around the planned sites, it’s suggested to further study the possible effects of the project on birds of different species and birds having different migration routes during the construction period and operating period, so as to avoid threats to birds in the course of developing clean energy resources.

6. References
[1] Shihao Jiang, Kai Liu and Jichao Bian 2014 How Blue Economic Zone Promotes the Development of the Low Carbon Economy J. Marine Information. 3 32-35
[2] Li Xu, Feng Li and Hongbing Peng 2015 Relationship between Offshore Wind Power Development and the Environment in China: A Study J.China Population, Resources and Environment. 1 135-38
[3] Yanrong Zhou, Wei Zhang and Qiang Song 2015 An Analysis of the Status Quo of Global Offshore Wind Resource Development and Problems Concerning Sea Area Utilization J. Ocean Development and Management. 1 135-38

[4] Baiqiong Liu, Min Xu and Qing Liu 2015 Main Problems Concerning China’s Offshore Wind Resource Development and Suggested Solutions J. Ocean Development and Management. 3 7-12