

## Offshore Wind Power in Vietnam: Lessons Learnt from Phu Quy and Bac Lieu Wind Farms

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### Abstract

While large offshore wind farms installed worldwide, Vietnam which is considered to have significant potential in both onshore and offshore wind energy, as well as being well planned wind farms but mainly located onshore. Although foreign investors who are interested and investing in Vietnam offshore wind farms, it has not been fully developed due to difficulties and challenges such as high investment rate, slow land clearance, far from the connection point to the power grid, low purchased price... As a result, this would become less attractive to the investors. This article will give a brief overview of Phu Quy wind power project located on the island more than 120 km from the mainland and Bac Lieu nearshore wind farm. From which, lessons are drawn for reducing existing difficulties and challenges mentioned above and supporting more favorable development of Vietnam offshore wind farms.

**Keywords:** Offshore Wind Farm; Nearshore Wind Farm; Phu Quy Wind Power; Bac Lieu Wind Farm; Island Wind Power; Wind-Diesel Hybrid Power.

### Introduction

Located in the tropical monsoon area with a long coastline of more than 3,200km, Vietnam has southwest monsoon winds blowing in the summer with its East Sea average wind speed considered to be quite high. Hence, Vietnam has the promising potential of wind energy thanks to its geographic location. Annual average wind speed in coastal areas is 4 - 5 m/s; In the offshore islands such as Co To, Bach Long Vi, Ly Son, Truong Sa, Phu Quy, Con Dao..., it is possible to efficiently develop wind power with the average wind speed from 6 - 8 m/s per year [1-6].

Our southern coastal area covers approximately 112,000 km<sup>2</sup> with about 142,000 km<sup>2</sup> of 30 - 60m in depth has high potential for wind power development. Especially, the area of 0-30m depth from Binh Thuan to Ca Mau is about 44,000 km<sup>2</sup> with the average wind speed of 100m height reaching over 5-8m/s according to Phu Quy and Con Dao wind data. Currently, the first wind farm has been put in to operation with a capacity of 99.2 MW and implementation research is being implemented the third phase with the capacity expected to increase by 142 MW.

### The process of implementing projects

#### Phu Quy Wind Power Plant

Phu Quy Wind Power Plant is invested by PVPower RE - PVPower with a total investment capital of 335 billion VND. The plant was built in Long Hai and Ngu Phung communes in Phu Quy island district (Binh Thuan province), with an average annual electricity production of 25.2 million kWh. Although the project was officially inaugurated on January 24, 2013, it has been in commercial operation since July 2012 and has reached a milestone of 1 million kWh in December 2012. This is a combined operation model for wind-diesel hybrid systems with its capacity rate of 6 MW/3 MW. Phu Quy Wind Power Plant with a capacity of 6 MW, including 3 turbines, tower height is 60 m, 3 blades and rotor diameter is 80 m, cut-in wind speed is 3.5 m/s and the average wind speed of Phu Quy Island is 6.7 m/s so suitable for wind turbine operate well. Phu Quy Wind Power Plant is newly constructed and connected to the existing 22 kV grid of the island, which is unique and independent from the National Grid.

Phu Quy Wind Power Project is not only the largest wind power project on island in Vietnam, but also the first wind power project in Vietnam using wind-diesel hybrid power and now being well operated. The plant contributes to solve the shortage of electricity for residential as well as manufacturing use for more than 27,000 people on the island, ensuring the implementation of local economic development strategy, contributing to maintaining security and protecting the territorial integrity of the nation. Since its inception in late 2012, the plant has helped EVN reduce tens of billions VND in annual losses by reducing the amount of electricity generated by diesel to the grid with high operating costs. In addition, Phu Quy wind power plant also make it possible for EVN to increase electricity generation time on Phu Quy island from 16h to 24h daily and the island electricity price equivalent to its onshore price from 1/6/2014.

Phu Quy wind power project faces many difficulties and challenges both in the process of investment and operation. Although wind power projects usually require oversized and heavy lift cargo transportation, the infrastructure of Phu Quy port is quite rudimentary with the maximum weight 1,000 tones only. As Phu Quy Island experience wind/waves of level 6-7, over 1,000 tones ships carrying super-sized and super-weight equipment will be highly dangerous and unsafe when arrival at the port. The entire power production produced for local consumer, who have been supplied by EVN's 3 MW diesel generator. Therefore, the installation of up to 6 MW of wind power was in excess of the actual need. The connection implementation process encountered many difficulties because of its specific characteristics and there is no similar system in the world. As a result, the issue is how to ensure the stability of the grid when converting the wind power source (6 MW) which is greater than 3 MW diesel generator to the island independent grid of 22 kW (not connected to the National Grid) and the operation process between wind and diesel power ensuring safety, stability and efficiency. Another difficulty is the calculation of economic efficiency between PVPower - wind power investor and EVN - diesel power and distribution system investor, setting the rate of power generation between the wind turbines and the diesel generator ensuring the interests of the parties, the demarcation of control and the handling of incidents between wind and diesel.

### Bac Lieu Wind farm

Bac Lieu Wind farm Project invested by Cong Ly Construction - Trade and Tourism Company Limited (Cong Ly Company) is located in Vinh Trach Dong commune, Bac Lieu city, Bac Lieu province. The project, which is the second grid project in Vietnam and is the first

project in the Mekong Delta, was started in September 2010. After 48 months of construction, the wind power plant in Bac Lieu has completed and put into operation 62 wind turbines, connectors and generators connected to the national grid. On 17/1/2016, the Bac Lieu wind farm was officially inaugurated in the coastal accretion zone of Vinh Trach Dong commune, Bac Lieu city, Bac Lieu province. The plant has a designed capacity of 99.2 MW, including 62 wind turbines rated at 1.6 MW with a gross electricity output of about 320 million kWh per year. The project covers an area of 500 hectares with total investment capital of 5,217 billion VND. The rotor diameter is 84m, wind tower height is 80m and the turbine weighs about 155 tones.

Currently, Bac Lieu wind farm is the largest one in Vietnam with a capacity of 99.2 MW, and the biggest coastal wind farm of Vietnam connected to the national grid. The coastal area of Bac Lieu has relatively good wind speed (average 6.5 - 7.2 m/s, peak season up to 10 m/s) and receives the main wind directions. According surveys by world organizations, Bac Lieu has the potential to develop wind power at around 300-500 MW. Bac Lieu wind power currently creates many jobs and making fundamental changes in future. This is a motivating contribution to the economic restructuring and the growth model reform, not only in Bac Lieu but also in the whole Mekong Delta region. Moreover, the Bac Lieu wind farm also combines planning investment in ecotourism and aquaculture development to make good use of coastal water surface, create mutual development, harmony and sustainability between modern industry and agriculture, tourism - services, as well as create majestic beauty and freshness of Vietnam's rural south. Bac Lieu wind power has created confidence of clean energy projects construction in the area with high potentials like Mekong Delta.

Bac Lieu wind farm is the first wind power project in Vietnam as well as in Asia, of which turbine masts are constructed on coastal mudflats with relatively complicated terrain and geology, affected by severe weather with storms, big waves, strong wind and unstable tide regime. The whole process of construction and installation carried out on the sea is highly dependent on weather conditions and strict requirement for labor safety. It is impossible avoiding unforeseen issues during the construction process because of the project large-scale capacity, massive capital investment, complex new technologies as well as inexperienced domestic contractors in constructing and installing wind turbines on the sea. The 110 kV transmission line with a total length of approximately 17 km make it difficult for land compensation, clearance and the current price of electricity equivalent to 9.8 UScent/kWh is not attractive enough for investors.

## Lessons learnt

### Site selection survey

The lack of understanding of the island terrain and its infrastructure also has a negative impact on the project investment efficiency. PVPower RE had spent nearly one year (from 26/11/2010 to 15/09/2011) to implement all stages of site clearance, land compensation and transportation of construction equipment (excluding the construction period). Meanwhile, the original plan to complete the project is 4 months only. The inaccurate survey, assessment and forecast of Phu Quy load demand leads to the choice of wind power capacity 6 MW which is superfluous and does not take full advantage of the three wind turbines capacity.

In order to implement Bac Lieu wind power project, Cong Ly company had directly carried out the wind measurement for one year. With the characteristics of a 54 km long coast, stable wind speed at average 7 m/s, homogeneous geology and hardly affected by storms and earthquakes, Bac Lieu Wind Power Project was constructed in the the highest wind potential area of the Mekong Delta. The construction site is a coastal area in Vinh Trach Dong Commune, which is flooded by high tide. Almost all the onshore areas of Bac Lieu province are used for aquaculture or salt production. Therefore, not only a huge site clearance cost should be covered but also farmers would lose land for cultivation if the project is constructed onshore. However, the construction site in the flooded area at high tide caused the project to be delayed for several months and cost a lot of money to be able to transport barges equipment and crane for installation.

The site selection survey which is very important and greatly affected the construction as well as operation process, therefore needed to be fully assessed to quantify all potential risks and difficulties.

### Equipment and technical solutions

Phu Quy Wind Power Project is unprecedented in the world and its design, installation and operation of a combined wind/diesel hybrid power system with a total wind capacity of twice the total diesel capacity is considered to be very complex and special in the world. And the additional companion systems may need to be invested such as dumpload, backup battery otherwise the optimal operation would be difficult to achieve. Based on the wind parameters of Phu Quy island, 2 MW wind turbines are considered to be appropriate and the performance of which has been verified by specialized calculation software as well as actual operating conditions.

According to consultants, 1.5 MW or 1.6 MW turbine capacity is appropriate to wind characteristics of Bac Lieu province. The selection of 1.6 MW GE for Bac Lieu Wind Power is due to US-EXIM Bank funding conditions which also meets the technical requirements of the project. The favorable point that the Bac Lieu project acquired is that GE equipment was imported from a manufacturing branch in China, and therefore the importing time was shortened compared to the US or Europe.

Thus, it is necessary to select appropriate capacity as well as specialized equipment for offshore wind turbines which is suitable for the severe operating conditions of the marine environment and the tropical climate in Vietnam.

### Power system connection

Being built on the island, the connection to the power system of Phu Quy project is much more complex because its output is connected to the local grid instead of the national power transmission system. With the availability of 3 MW diesel generator system and low load demand, the combination of a diesel generator and a wind turbine in a hybrid system on Phu Quy Island is a problem for both PVN and EVN. Failure to find a common voice in power connection and generator planning made the operation progress of Phu Quy project extended more than 1 year (the installation already completed in October 2011, the connection application procedure basically completed in November 2012) and the economic efficiency of the project significantly reduced.

Bac Lieu project is the second grid-connected wind power project in Vietnam. However, the selected construction site which is 17 km from the 110 KW transmission grid made the cost of the project significantly increase (transmission line investment costs) and a negative impact on implementation progress of more than eight months late. In addition, the project which is located in submerged areas, has its implementation more complex with higher line charges than it does onshore.

The connection of wind power plants to the power system is often asynchronous with a prolonged time. Therefore, it is necessary to quantify all risks, difficulties and connection cost to reach agreement agree with EVN from the beginning for synchronous insurance and non-incurred costs.

### Lesson learnt from economics, finance and project management

All components used for installation of the Phu Quy Wind Power Project are imported from the Europe, including turbines, propel-

lers and even wind towers, the project required a huge cost for equipment investment (\$ 9.7 million/3 units for pre-tax equipment, equivalent to \$ 1.6 million/MW). In addition, having a very small scale compared to other approved projects with three wind turbines of total capacity 6 MW, the project is not eligible for equipment price incentives. The preparation of the project has not been well implemented in all aspects, such as selection of organizational structure, human performance, partners involved in the project, permission procedure for the implementation procedures. As a result, many problems have arisen during the project implementation leading to cost overrun. According to PVPower experience, preparation is considered to be very important and decisive factor to the success of the project.

The scale of the Bac Lieu project in the first phase is 10 turbines with a total capacity of 16 MW and the second phase raising up to 62 turbines with a total capacity of 99.2 MW. With this scale, the project has many advantages in terms of incentives for equipment price. Bac Lieu Wind Power Project started to operate 8 months behind schedule, mainly due to natural condition characteristics and economic situation affecting the contractor's construction capability. According to the company leaders, the project management process which is even highly appreciated is not supposed to be the cause of the delay. Thus, investors prioritize simple tasks in advance to save more time and manpower for other complex tasks. For the finance, with the guarantee of the t, Bac Lieu project has taken advantage of the preferential loans of the US Export Import Bank (US-Eximbank) for the development of renewable energy projects in the Mekong Delta. Total capital that the bank finances for the project can be up to 1.5 billion USD with the interest rate of only about 1%/year (For the first phase, Bac Lieu project has to invest and call for bank funding from Vietnam Development Bank with interest rate of over 8% per year). That is the ideal capital source for investment in wind power projects in Vietnam.

## Discussions and Conclusion

The electricity price of 9.8 cents/kWh for offshore wind is inefficient and unattractive to investors. Therefore, appropriate incentive mechanism is needed to develop offshore wind potential of Vietnam.

For a better development and effective investment in offshore wind projects, it is necessary to thoroughly survey the terrain, geology, power grids installation and connection with low cost for appropriate location selection and a minimum of one year for wind measurements. It is also important to calculate and select the most

suitable wind turbine capacity to best exploit the characteristics of the wind, as well as select wind turbines that are specifically designed for offshore installations, consistent with Vietnam hot and humid climate for cost savings of operating and maintenance.

Besides, searching for foreign preferential loans is necessary for the development of offshore wind power in Vietnam.

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