News Article for RISUD Strategic Focus Area (SFA) Scheme

	Name	Department
1. **Principal Investigator**:	Yang Hongxing	BSE/PolyU
2. **Name of SFA:**	Offshore Wind Power Generation	
3. **Project Title:**	Development of 3D Wind Turbine Wake Models for Energy Efficiency Improvement of Offshore Wind Power Generation Systems	

4. **Second Year Progress/Achievement**

Through close collaborations among the team members in this reporting time period, we have made very good progress towards the completion of this research project. Most of the proposed targets have been achieved. Seven SCI journal papers and two conference papers have been published from this project. The output of this project has also been presented as a keynote speaker by Prof. Yang in the 1st International Chinese Conference on Energy and Built Environment (19th to 22nd July 2019, Chengdu, China). The progress is mainly reflected from the following four aspects:

(1) Completed the wind field experiment.

The onsite wind farm experiments were conducted in Shiren Wind Farm in Zhangjiakou, Hebei Province, China. Two lidars were rented to measure the wake effect at the wind farm. One experiment takes two wind turbines into account to measure the upstream-and-downstream patterns. One of the measured periods is shown here as an example, i.e. at 8:33am on 5th March 2019.

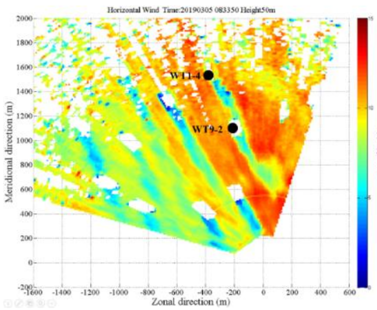

Figure 1 PPI scanning result in the plane at hub height.

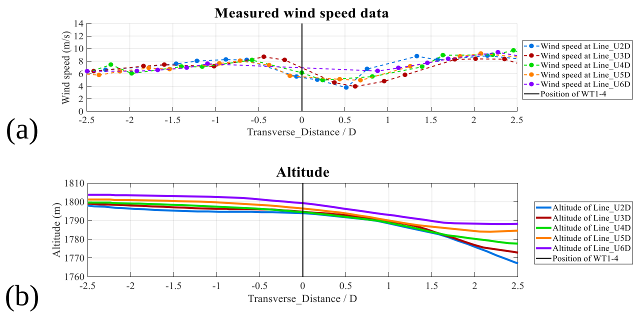

Figure 2 (a) Measured wind speed; (b) Altitudes in the crosswind direction. (behind 1-4)

The wind speed data was filtered based on the analyzing lines. The measured wind speeds and the altitudes in the corresponding lines are shown in Figure 2. From the results, the largest deficit of wind speed was in the near-turbine zone. The range of the wake-influenced area varied among different crosswind lines. The wake width increased gradually in the downwind direction. The terrain slope and local obstacles are the main reasons that the wake distribution was asymmetry about the centerline.

(2) Validated the 3-D wake models with the experimental data.

The 3-D wake models have been validated from two aspects by the onsite measured results. One is to compare the model with the wind speeds of a single wind turbine in vertical direction. Another one is to compare the model with the wind speeds of multiple wind turbines in horizontal direction. Some of the typical results are demonstrated below.

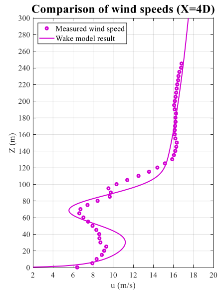

Figure 3 Comparison in vertical direction.

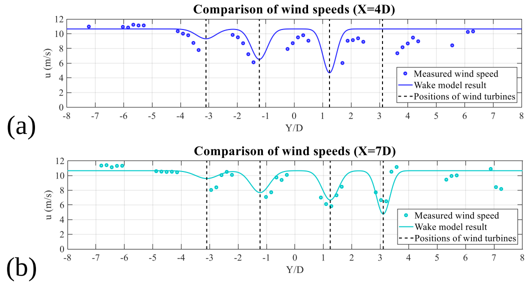

Figure 4 Comparisons in horizontal direction

To sum up, the 3-D wake model has a good overall prediction for wind deficits influenced by multiple wind turbines. Some complicated situations exist in the complex-terrain wind farm, which makes the wake model not accurate in some positions. More factors should be considered in the wake model in the further study.

(3) Analysed seismic behaviour of offshore wind turbines.

The DTU 10 MW offshore wind turbine (OWT) was modelled and simulated. The OWT has a monopile foundation. The seabed soil was particularly modelled to take into account the soil-pile interaction. Figure 5 describes the displacements at the tower top. The maximum horizontal displacements at the tower top are smaller than 0.90 m for all seismic waves except the Kobe earthquake. The maximum value of Kobe wave reaches 2.33 m at 28.51 s.

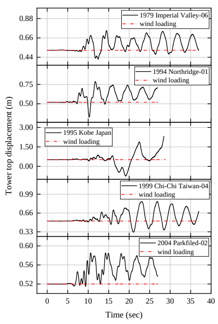

Figure 5 Tower top displacement time histories

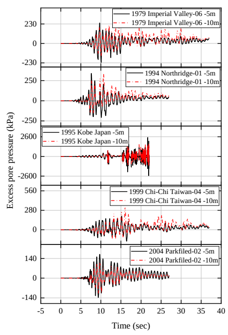

Figure 6 Excess pore pressure time histories of soil

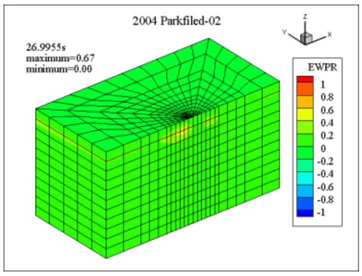

Figure 7 Excess pore pressure ratio of soil domain after the earthquake

As the PGAs of selected ground motion is relatively small, the OWT could operate properly during the earthquake. However, for the Kobe earthquake wave, the dynamic response would experience a dramatic variation in the last stage, which means tower collapse might occur.

(4) Examine the soil liquefaction risk under seismic loads

To assess the liquefaction potential of OWT in a liquefied site, the excess pore pressure (EPP) and excess pore pressure ratio (EPPR, which is defined as the ratio of excess pore pressure to the initial effective stress) are employed. The time histories of soil nodes at different depths and liquefaction areas are shown in Figure 6 and Figure 7 respectively.

The study concludes that the liquefaction potential of OWT under wind and earthquake coupling loading exists. The EPPs do not dissipate after the earthquake, and the liquefaction depths reach 5 m under some seismic waves. More attention should be focused on the liquefaction problem in the design of OWT, especially in earthquake-prone regions.