The Near-Shore Wind Resource Assessment and Power Generation
at Huasai, Nakhon Si Thammarat, Southern Thailand

Jompob Waewsak1,*, Chana Chancham1 and Y. Tirawanichakul2

1 Solar and Wind Energy Research Unit, Department of Physics, Faculty of Science
Thaksin University (Phatthalung Campus), Phatthalung, 93110, Thailand

2 Department of Physics, Faculty of Science, Prince of Songkla University (Hat Yai Campus), Hat Yai, Thailand

*Corresponding author: jompob@tsu.ac.th

Abstract – Wind resource assessment is a crucial step in wind farm development phase prior to
implement the project because the wind power plant project requires high capital investment.
Consequently, to minimize project risk, high accuracy wind resource assessment is required. This
paper attempts to assess the near-shore (1 k.m. away from the shoreline and 20 km along the coast)
winds resource at Huasai district in Nakhon Si Thammarat province of southern Thailand. Wind speed
at hub height of a large scale wind turbine generator, i.e., 80 m, was extrapolated using the 10-min.
recorded interval that was observed onshore. Wind speeds at 20 m, 30 m, and 40 m were observed in
2008 and were used as model input. The micro-scale wind resource map over the target area was
predicted using WAsP computational model for either horizontal or vertical extrapolation. The annual
energy production of a wind farm under VSPP scheme (< 10 MW), which produced by 7 different
models of 1.5-2 MW large scale wind turbine generator, was investigated using WAsP 9.0 computer
program. The plant load factor was also computed in order to compare the performance of different
wind turbine generator technologies. Risk analysis due to wind resource uncertainty was also taken
into consideration. Results showed that the mean wind speed was in the range of 6.2-7.8 m/s. The
annual energy production was in the range of 5.5-7 GWh/year corresponding to the plant load factor in
the range of 22-32%. Results from this investigation deliver the recommendation that the 60-90 m wind
speed measurement especially exact at the target area are further steps in micro-siting wind resource
assessment for near-shore wind farm development.

Keyword: Annual Energy Production, Capacity Factor, VSPP, Wind Energy, Wind Farm
1. Introduction

Energy Policy and Planning Office (EPPO) has launched the strategic plan of renewable energy with the commitment of the use of wind power throughout the country with minimum installed capacity 800 MW [1]. Consequently, the search of potential wind resource either onshore or offshore is the main and importance task during the early stage of project development. The use of secondary data or information focusing on wind energy resource like high resolution wind map or wind atlas or micro-siting results provided by many academic institutions in order to minimize cost of wind power project development. However, due to the wind power project requires the high initial cost, thus, the accuracy and confident of long-term wind data is needed. Furthermore, the micro-siting wind resource with the measurement of wind speed and direction at hub height of a large scale wind turbine generator, i.e., 80-100 m for the present wind turbine technology is necessary for project financing.

The wind map developed by the Department of Alternative Energy, Development and Efficiency (DEDE), Ministry of Energy indicated that the high potential wind resource located along the coast of southern Thailand and at some high elevation areas. In 2007, the micro-siting wind resource in southern Thailand has been done by DEDE [2]. Later, in 2009, the micro-siting of 18 wind monitoring stations supported by the National Research Council of Thailand (NRCT) was presented [3]. It was found that in some typical area, the wind energy is relatively high and sufficient for wind power by the 1.0-2.0 MW wind turbine generators. Most of the good windy sites located along the coast of Nakhon Si Thammarat and Songkla provinces. Apart from shore, the offshore wind resource is higher than onshore in general. This is due to the low roughness length of wave height. However, the development of offshore wind power plant depends on many factors like offshore wind resource, water depth, geotectonic information, public acceptance and the permission of the use of offshore area. The project cost is another key factor for decision making by the investor. Therefore, the wind speed measurement at hub height and at the location where the wind turbine generator will be installed is the main activity during the feasibility study which should be accomplished in order to minimize risk of the project due to wind speed uncertainty.

For the pre-feasibility study, the use of secondary measured wind data for investigating the possibility of the wind power project is reasonably accepted. Consequently, this paper attempts to assess the near-shore wind resource using onshore observed wind data together with WASP 9.0 computer software.

2. Methodology

2.1 Wind measurement

Wind speed and direction were measured at Huasai district in Nakhon Si Thammarat province. The information of site location was shown in Fig. 1. The wind monitoring station consists of wind speed and direction sensors, a data logger, an ambient air temperature sensor, and a lightening arrester as shown in Fig. 2. Wind speeds and directions at 20 m, 30 m, and 40 m above ground level (AGL) were observed between January to December 2008 with 1 min sampling interval and 10 min recording interval. The monthly mean wind shear coefficient was analyzed based on observed wind speeds at three different layers. The wind speeds at 80 m, 90 m, and 100 m were then estimated by using a power law as described by Eq. 1. Where $V_r$ is the wind speed at reference height ($Z_r$), $\alpha$ is the wind shear coefficient (dimensionless).

$$V_z = V_r \left(\frac{z}{z_r}\right)^\alpha$$

Figure. 1 Site location of wind monitoring station.
Due to the accuracy of the extrapolating technique, the uncertainty of wind resource at 80 m, 90 m, and 100 m were considered by offsetting -1 m/s, -1.5 m/s and -2 m/s from the whole raw data. The observed wind climate of 1 year observed data at 80 m, 90 m, and 100 m were analyzed using Weibull distribution in order to investigate the Weibull parameters, i.e., k-shape and c-scale parameters as well as mean speed and power density.

2.2 Wind turbine generator

The annual energy output (AEP) was estimated using the extrapolated and offset wind resource in conjunction with WAsP 9.0 computer program. Therefore, it requires the spatial data of target area and the information of wind turbine generator like power curve. In this analysis, the 7 models of offshore wind turbine generator ranging between 1.8-3.0 MW capacities were used. The details of such model were presented in Table 1. The power curve of such model was also shown in Figure 3. The wind turbine generators were parked with the criteria of 5DX10D. The configuration of wind turbine generator parking was shown in Figure 4.
3. Results and Discussion

The near-shore wind resource assessment at Huasai, Nakhon Si Thammarat province, southern Thailand was presented. Results of the 1-year observed wind data analyzed by WAsP 9.0 computer programming will be presented in terms of Weibull distribution and wind rose, the annual energy production (AEP) and capacity factor (C.F.) of 7 wind turbine generator models.

Table 1. The specification of 7 different offshore wind turbine generators.

<table>
<thead>
<tr>
<th>Wind Turbine Generator Model</th>
<th>Rate Capacity</th>
<th>Installed Capacity</th>
<th>Hub Height</th>
<th>Swept Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.0</td>
<td>10</td>
<td>80</td>
<td>5,027</td>
</tr>
<tr>
<td>B</td>
<td>1.8</td>
<td>9</td>
<td>80</td>
<td>6,362</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
<td>10</td>
<td>80</td>
<td>6,362</td>
</tr>
<tr>
<td>D</td>
<td>2.3</td>
<td>9.2</td>
<td>80</td>
<td>5,333</td>
</tr>
<tr>
<td>E</td>
<td>2.3</td>
<td>9.2</td>
<td>80</td>
<td>6,793</td>
</tr>
<tr>
<td>F</td>
<td>2.5</td>
<td>10</td>
<td>100</td>
<td>7,854</td>
</tr>
<tr>
<td>G</td>
<td>2.0</td>
<td>10</td>
<td>80</td>
<td>5,945</td>
</tr>
</tbody>
</table>

3.1 Wind resource

The Weibull distribution and wind rose for the extrapolated wind speed at 80 m, 90 m and 100 m was showed in Figure. 5. The mean wind speed with 5 conditions i.e. offset 0 m/s, offset -1.0 alpha 1/7, offset -1.5 m/s and offset -2.0 m/s were in the range of 6.35-7.78 m/s, 6.68-8.11 m/s, and 6.86-6.32 m/s respectively that was showed the Figure 6.

Figure 4 The configuration of wind turbine generators parking.

Figure 5 Weibull distribution and wind rose of predicted wind at 80 m (upper), 90 m (middle), and 100 m (lower).

Figure 6 Wind resource at 80 m, 90 m, and 100 m as inputs of WAsP 9.0 analysis.
3.2 Annual energy production

The annual energy production (AEP) from different wind resource conditions and different wind turbine generations i.e. A, B, C, D, E, and F was in the range of 20.7-43.9 GWh. Regarding to the capacity factor, the near-shore Huasai wind farm was in the range of 25.7-43.9%. Finally, it was found that wind turbine generator model C, G and B could produce higher AEP than that of any other models. The details of AEP and corresponding capacity factor were presented in Figure 7-8.

4. Conclusion

The annual energy production from different wind resource conditions and different wind turbine generations i.e. A, B, C, D, E, and F was in the range of 20.7-43.9 GWh. The corresponding capacity factor was in the range of 25.7-43.9%. Finally, it could be concluded that wind turbine generator model C, G and B were suitable under wind condition of Huasai district, Nakhon Si Thammarat as they could produce the energy much higher than that of any other models.

5. Acknowledgment

The authors gratefully acknowledge the National Research Council of Thailand (NRCT) for providing wind data at Huasai district in Nakhon Si Thammarat province. The authors also acknowledge the Solar and Wind Energy Research Unit (SWERL) for the provision of research facilities and financial support.

Reference