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# Analysis of Ocean Wind Energy Density around Sulawesi and Maluku Islands with Scatterometer Data

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**Abstract**

The aim of this research was to optimize the utilization of Indonesian ocean wind energy potential especially around Sulawesi and Maluku Islands through mobile floating structure (MFS). The wind data used for analysis are scatterometer data for one year period which is from January to December 2008 collected by QuikScat satellite. Weibull distribution with two parameters was used to represent the wind model. Several methods were used to compute the distribution parameters which are linear regression method (LRM), maximum likelihood method (MLM) and moment method (MM). The obtained parameters are used to compute the energy density of the sea areas around the islands.


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*Keywords:* Energy density; mobile floating structure; ocean wind; scatterometer data; Sulawesi and Maluku Islands; Weibull distribution

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**Nomenclature**

| | | | |
|---|---|---|---|
| $a$ | slope of a straight line equation | **MLM** | maximum likelihood method |
| $b$ | intercept of a straight line equation | **MM** | moment method |
| $c$ | Weibull distribution scale factor | $n$ | number of wind data |
| **CDF** | cumulative distribution function | **PDF** | probability density function |
| $E_D$ | energy density | $v$ | wind speed |
| $k$ | Weibull distribution shape factor | $\psi$ | Digamma function |
| **LRM** | linear regression method | $\Gamma$ | Gamma function |
| $M_n$ | $n$-th moment of Weibull distribution | $\rho_a$ | air density |
| **MFS** | mobile floating structure | | |

## 1. Introduction

Indonesia has significantly abundant ocean wind energy potential, it is estimated that Indonesia has around 9.29 GW of wind energy potential [1]. However, World Wind Energy Association reported that only 1.4 MW or less than 0.1 % of this energy which has been explored and utilized by the end of 2012 [2]. Therefore, it is important to conduct a study to analyze the ocean wind energy in Indonesian sea areas in order to optimally explore its potential. For that purpose, the present study investigates the eastern Indonesia ocean wind energy density, especially around Sulawesi and Maluku Islands.

There are several ways to harvest the ocean wind energy, including the use of a mobile floating structure (MFS). The main advantage of this type of structure lies on its ability to move to other locations with higher wind energy density so that the energy harvesting process becoming more effective and optimal. This type of structure has also been assessed to be implemented in other countries such as in Japan using a concept of very large mobile offshore structure (VLMOS) [3,4]. However, in order to implement this type of structure, it is necessary to determine the monthly wind energy density of the particular sea areas. Therefore, the present study will focus on determining the wind energy density of the sea areas around Sulawesi and Maluku Islands.

In previous studies, data collected from meteorological stations operating around the islands are used to analyze the ocean wind energy potential on these sea areas [5,6]. However, because of limited access to daily data, the computation could not determine the energy density of sea areas every month. Consequently, the results can be considered to be less accurate and useful. Moreover, the previous results could not be used to analyze all sea areas around the islands because of the limited available data. Therefore, in order to obtain more accurate and comprehensive results, the presents study uses data collected by a satellite named Quikscat. The satellite uses scatterometer to measure the sea wind speed 10 m above sea surface [7] and provides daily, three-day averaged, and monthly data with accuracy of 0.25 degree earth grid. However, because of the orbital motion of the satellite, it did not perform measurements for all sea locations every day. Therefore, the present study will use three-day averaged data.

In order to represent the characteristics and distribution of the wind model, Weibull distribution with two parameters is used. This distribution has also been used to analyze energy density in other locations such as in Turkey [8], Brazil [9], China [10] and many other locations. The distribution is characterized by the probability density function (PDF) and the cumulative distribution function (CDF). These functions can only be determined after the Weibull parameters which are shape and scale factors, were obtained.

Obtaining these parameters is the most crucial part when adopting the Weibull distribution. Consequently, in order to obtain accurate and reliable results, the present study will implement three methods to compute these parameters which are linear regression method (LRM), maximum likelihood method (MLM) and moment method (MM). The computation results from these methods are compared and analyzed to investigate the accuracy of the methods.

Moreover, the obtained distribution parameters are also used to compute the probability density function (PDF) and the cumulative distribution function (CDF). After that, the energy density of each area can be determined