Wind Power Generator for Small Scale Fish Processing Unit at Coastal Area in Aceh, Indonesia

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Abstract. This paper presents a wind power technology used to generate electricity for small scale fish processing unit. The units consist of ice machines, green house solar dryer, fish smoke house and utilities. A 10 kW wind turbine system were installed in 2010 at Lancang Paru village, Pidie Jaya. Total number of energy required for small scale fish processing unit are calculated. Initial test shown that wind power generator able to produce maximum power of 5 kW at 4 m/s wind speed. This wind turbine is enough to provide electricity for small scale fish processing unit.
Keywords: wind power, electricity, small scale fish processing unit

Introduction

On 26 December 2004, most coastal areas in Aceh, Indonesia, are devastated by the earthquake and tsunami disaster. During rehabilitation and reconstruction period, a lot of efforts have been made to restore community's economy in coastal areas. One of significant efforts is to develop a small-scale ice factory in order to increase value added of fish products from fisherman. The factory location is selected based on a number of fishermen who are still doing fisheries business in the affected tsunami coastal area.

The factory is operated under a group of fishermen management who gathers in a cooperative community group. By considering limited supply of electricity from national electricity provider (PLN), the ice factory use diesel fuel for electricity generation. Today, some of donated small-scale ice factory did not operate because the fishermen are not able to provide diesel fuel. This is due to the price of diesel fuel increased annually.

Utilization of free renewable energy is considered to be an alternative solution to solve the problems faced by groups of fishermen. This research is a pilot project of applied renewable energy to generate electricity to encourage development of small-scale fish processing units in remote coastal area. The pilot project was implemented in the Lancang village, Pidie Jaya, Aceh Province, Indonesia.

Similar project has been done by Gilau et al that performed an analysis for developing solar energy power plants, wind energy, and hybrid with a diesel engine for small scale ice-making machine in Eritrean coastal area Red Sea1. The reliability, ice productivity, and cost-effectiveness of each option were analysed. Based on data processing and ice production analysing, wind diesel hybrid powered system has achieve high ice productivity which is attributed to high wind speed resource.

SunWize Technologies of Kingston have installed a prototype of PV-hybrid ice-making system in the Northern Mexico fishing village2. The performance and reliability of the system investigated. Holz *et al.*, reported that the National Renewable Energy Laboratory has also investigated wind-electric for ice-making system3.

This paper focuses on evaluation and installation wind power electricity generator for small-scale ice-making machine in rural area. It started by calculating electricity demand to produce ice for keep maintain fresh fish each day. Measuring, recording and analysing wind speed to identify suitable site for wind turbine installation, then, selecting an appropriate type of wind turbine for electric generation small-scale ice plant.

Materials and Methods

Site project

The pilot project of small-scale fish processing unit powered by renewable energy located in the remote village in Aceh Indonesia. The village lay on 05.18' north latitude: 96.07' east longitude directly facing to northern Malacca Strait. The population of the fisherman villagers is 950 people. Mainly, villager works as farmer and fisherman about 5% to 75% of population, respectively. Figure 1, shows location of Lancang village, Pidie Jaya, Aceh Indonesia.

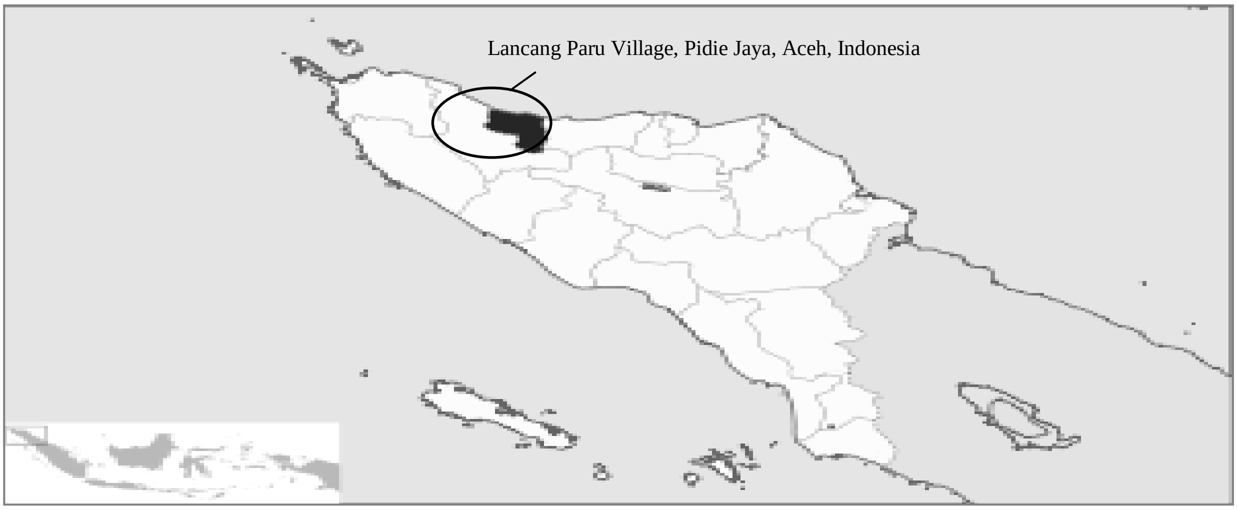

Figure1. Pidie Jaya district map.

Electricity demand

In order to collect data about quantity of fishing ships, fishing trips and ice demand per day, a technical survey has been conducted. From the data, it found that total numbers of fishing ships are 25 units which are classified in 20 units fishing ships with weight capacity up to 200 kg fish/trip and 5 units of fishing ships with weight capacity around 400-600 kg fish/trip. Commonly, the fishermen in Lancang village go to fish only 20 trips/months a year. In a year, they can fish within seven months. The average of total amount of ice is required for the first type of fishing ships is 300 kg ice/day and 150 kg ice/day for second type fishing ships. So, based on data observation total amount of ice demand about is 9.000 kg/months (300 kg/day).

Based on this purpose, a unit of ice machine (ice cube) with production capacity 300 kg ice/day has been purchased. Large amount of heat capacity is determined by the energy required to cool water from the initial temperature to a temperature To = 0 °C, and then cooled to ice temperature Ti = -5 °C, which can be written in the form of equation 1.

$$E = m/t \times (Cp_{-water} \times (T_a - T_o) + h + Cp_{-ice} \times (T_o - T_i) \quad \ldots\ldots\ldots.1$$

Measurement of potential wind energy and wind turbine selection

A wind assessment system was installed at selected project site to ensure the wind speed is suitable for wind turbine location in October 2010. The assessment system consists of a tilt-up tower with 18 meters height, instrument, sensors and accessories. The wind data was analysed to ensure that collected data was suitable for the period of December 2010. Then, wind data was recorded again from January to August 2011. The wind performance data recorded are processed and analysed using HOMER Software5. There are some criteria that have to be fulfilled for type and size selection of wind turbines. This power is include required to generate electricity for small-scale ice processing unit. Various types of wind turbines in the market are considered based on power curve provided by manufacturer. Theoretically, wind power is proportional to the area of wind turbine swept. The cube of wind speed and air density are varies by the altitude6.

Wind speed

The average speed of wind flow monthly is observed and recorded. The minimum average of wind speed should be determined and the maximum wind speed should be identified. Moreover, average of monthly wind speed should be calculated. To determine the temporal distribution of wind speeds and various frequency of wind directions the wind rose graph has been used. According to obtained data shows that wind flow direction is in North East and South West direction. It indicates that wind speed and wind energy achieved at South West more than at other direction.

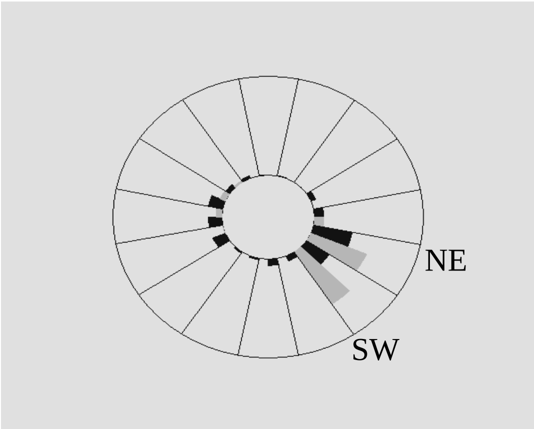

Figure 2. Wind direction and distribution

Wind Speed Frequency Distribution (%)

The calculated data is tabulated in wind speed frequency distribution graph as shown in figure 3. It shows the frequency of wind speed occurred at 5 m/s or 12 %. Generally, wind turbines produced today have a cut-in speed at 3 m/s. So, based on the data from the wind measurement results, it can be concluded that wind turbine power to generate electricity for small-scale ice factory can be in this selected village, Aceh Indonesia.

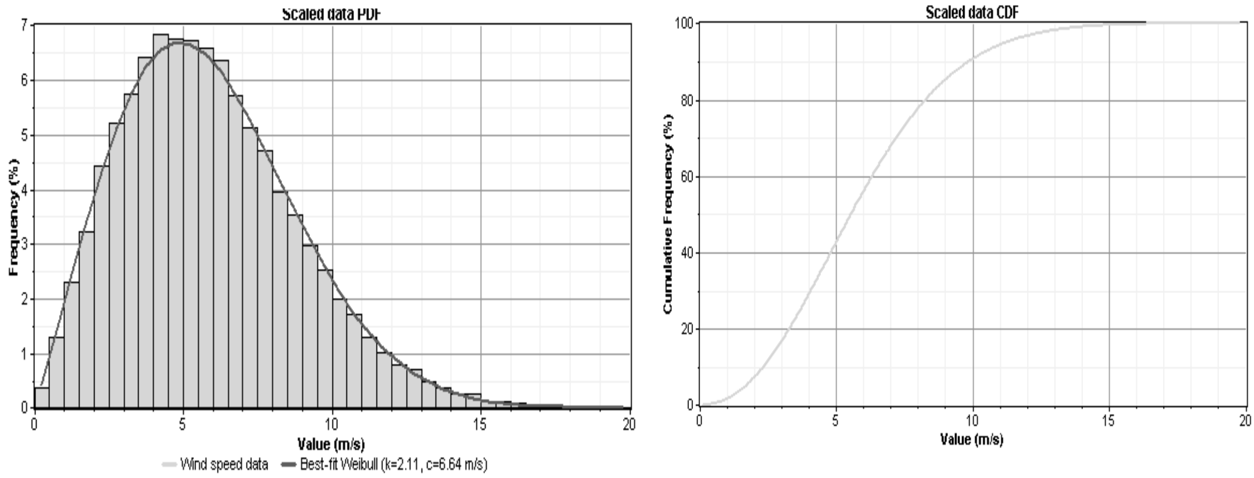

Figure 3. Wind speed frequency distribution

Results and Discussion

Wind speed result

The average speed of wind flow monthly is observed and recorded as shown in figure 4. The minimum average of wind speed was determined 4.8 m/s in September 2011 and the maximum wind speed was identified 7.0 m/s in October 2011. The average of monthly wind speed was calculated 5.88 m/s.

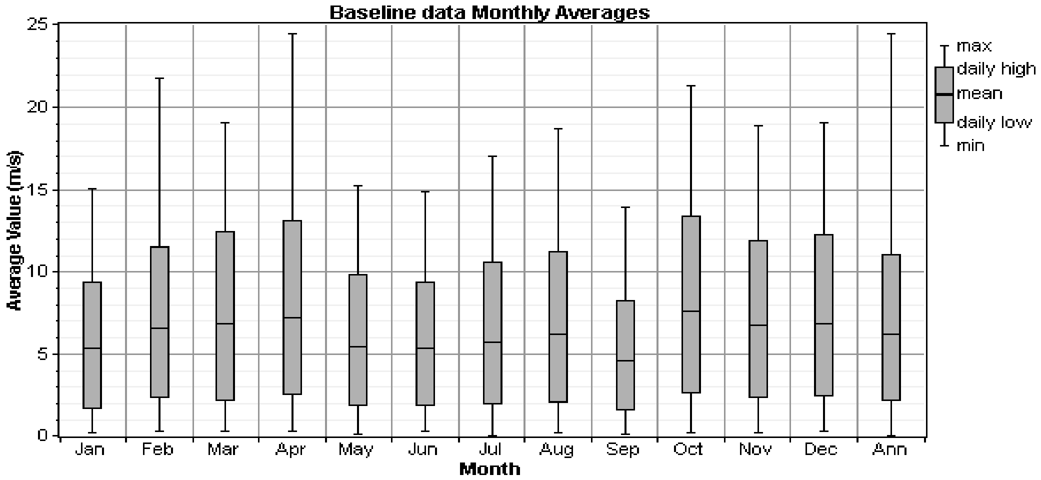

Figure 4. Monthly averages of wind speed

Wind turbine for generating electricity

According to equation (1), to produce 300 kg/day ice by initial temperature (Ti) 28 °C requires a total amount of power 1.636 kW. Nevertheless, in practical there are many factors affecting ice factory process such as heat load to agitator, insufficient isolation, material use of heat or cold transfer device, air blowing to attain clear ice and opening gate on reload ice and refill water due to climates condition . Generally, ice factory in Indonesia considers adding 30% of their production capacity from calculation to handle extra load. The amount of power capacity is 1.636 kW x 1.3 = 2.127 kW.

Other considerations in selection wind turbine for electricity generation did in the Lancang village as a pilot projects are electricity demand for utilities such as lightening, fish dryer, fish cleaner and extending electricity demand in future. Therefore, wind turbine with power capacity 10 kW is selected for this purpose.

The 10 kW wind turbine is directly driven by rotor blades without any other additional equipment. The whole wind generator system consists of six parts including a generator body (including rotor blades, gearbox, direction-regulating DC Motor and dogvane), yaw shaft, tower, controller, inverter and energy storage system as shown in Figure 5. Technical specification of 10 kW wind turbine used for generating electricity in Lancang village presented in Table 1.

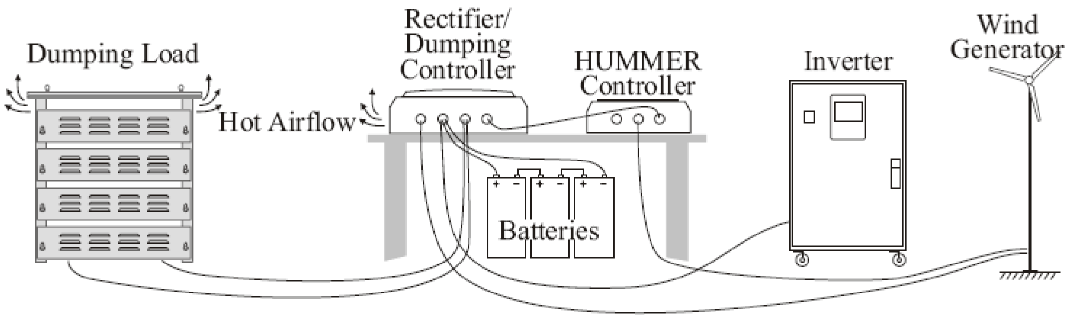

Figure 5. The 10 kW wind generator turbine system6

Table 1. Specification of 10 kW wind turbine.

Rated power (kW)	10
Maximum output power (kW)	15
Charging voltage (V)	DC 240 V
Blade quantity	3
Rotor blade diameter (m)	8
Start-up wind speed (m/s)	3
Rated wind speed (m/s)	10
Generator output	Single-phase frequency conversion AC
Rated charging current (A)	41.7
Tower height (m)	15
Storage energy system	Battery 12 , V 250 Ah, 20 pieces

A 10 kW electricity powered wind turbine has been installed on October 2011. The picture of the wind turbine is presented in figure 6. The preliminary test to determine turbine performance including electrical power, current and voltage have been conducted.

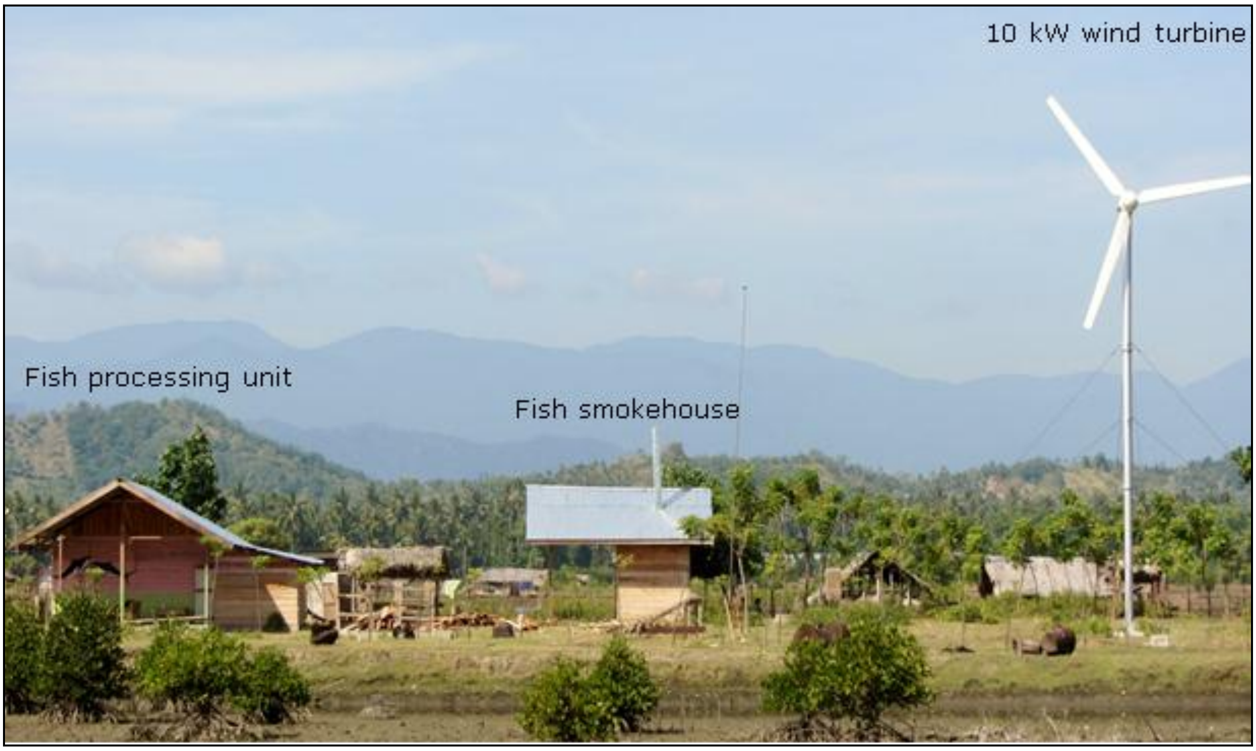

Figure 6. The Small Scale Processing Unit Generated by 10 kW wind turbine.

Based on testing result that shown in figure 7, wind turbine started at 3m/s wind speed giving electricity power 10.000 watt, voltage 280 V and electricity current 36 A. It shows that electricity power directly increase proportional to raise of wind speed which is achieve of the peak at 14-15 m/s generating maximum electricity power up to 16,823 kW, voltage 305 V and electricity current 48 A.

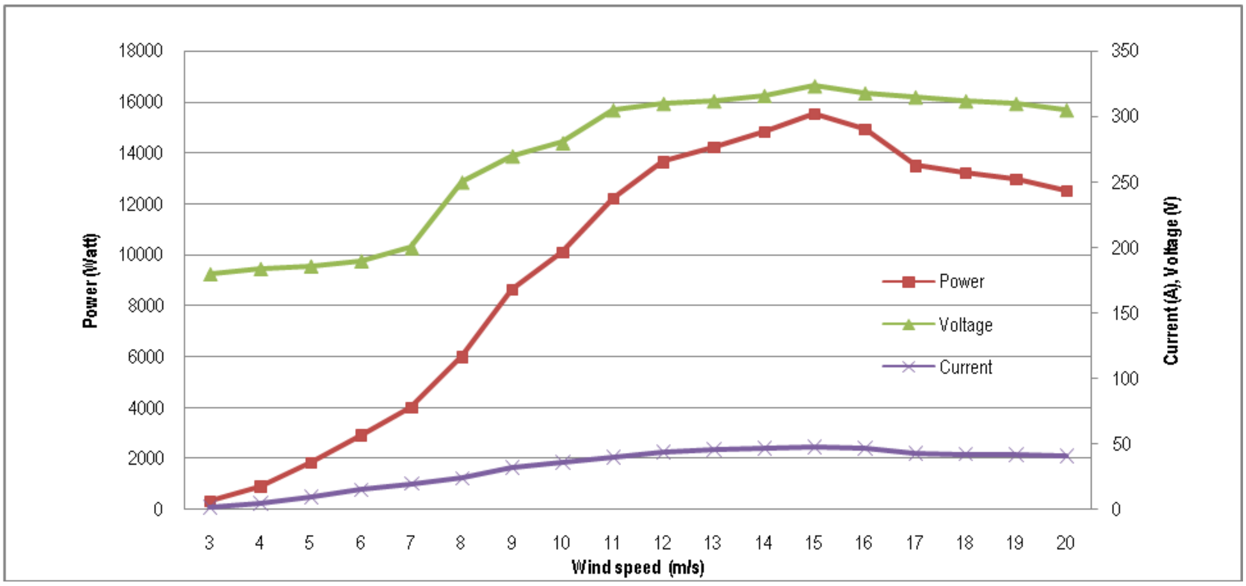

Figure 7. Curve of electricity power generated by 10 kW wind turbine

Conclusions

Preliminary test presents that the wind generator can produce electrical power up to 5 kW. Since, this wind turbine is quite enough to provide electricity for small-scale ice factory processing. Hopefully this work can contribute to for policy maker that implementation of renewable energy in rural area.

Acknowledgements

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