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The Evaluation of the Performance of the Vertical Axis Wind Turbine that Made with Waste

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Abstract

This research studied to evaluation of the performance of the vertical axis wind turbine that made with waste or plastic bins. The study was the relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank and the relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank. The results showed the relationship of A (m^2) and Q (m^3/s) that the size of the wind turbine blades increasing were A1 = 0.895 m^2, A2 = 1.790 m^2, A3 = 2.685 m^2, and A4 = 3.580 m^2, respectively, vertical wind turbine could more pumping. That was, the rate of pumping of vertical axis wind turbine was proportional to the size of the wind turbine blades as the equation was Q = 0.1152 (A) – 0.0555 with R^2 = 0.798 at the lowest average wind speed was 2.17 m/s and suction lift was 0.20 m. The result also showed the relationship of v (m/s) and Q (m^3/s) that the increasing of wind speed was proportional to the increasing of the rate of pumping as the equation was Q = 0.337 (v) – 0.3865 with R^2 = 0.89 at the wind turbine blades was 3.58 m^2 and suction lift was 0.20 m. In addition, the study also suggested the relationship of suction lifts of the piston (h) and the rate of pumping (Q) that the range of piston pumps decreasing were h4 = 0.85 m., h3 = 0.60 m., h2 = 0.45 m., h1 = 0.20 m., respectively, the vertical wind turbine could more pumping. That was, the rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping. Comparison the economic values of the use of the vertical axis wind turbine compared to the cost of pumping with the water pump in normal. The economic values were the cost of construction and energy use per unit of volume of water that was pumped by the pump. In general, the costs of pumping were the water pump and the oil and electrical power to the pump in a normal manner. The results showed the IRR was 14.24% per year, the B/C ratio was 2.42, and the payback period was 2.36 year. The result also showed the relationship of Q (m^3/s) and the volume of water (V: m^3) used to grow crops per day per rai. Three types of planting were sugarcane, cassava, and maize. The volume of water in sugarcane crop, cassava crop, and maize crop were 4.299, 6.776, and 4.346 m^3 per day per rai, respectively. The result also showed the maximum pumping rate of the vertical axis wind turbine was 0.561 m^3/s at the wind speed was 2.893 m/s, the

minimum of suction lift was 0.20 m, and the maximum size of the wind turbine blades was 3.580 m^2.

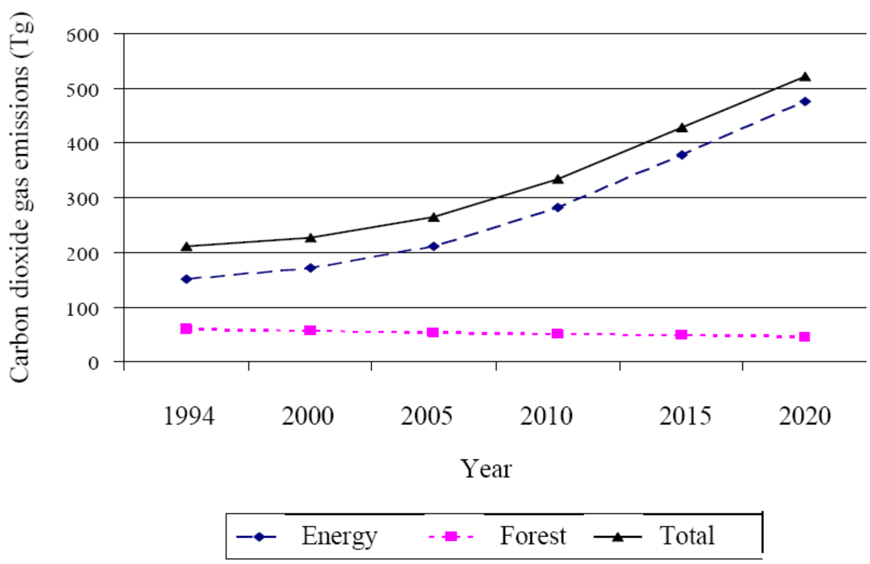
Keywords: Vertical axis wind turbine, Suction lift, Wind speed, Waste materials

1. Introduction

One of the environmental threats that our planet faces today is the long-term change in Earth's climate and temperature patterns due to global climate change, or the greenhouse effect. CO_2 and CH_4 from human activities are the most important greenhouse gases that are contributing to global climate change (IPCC, 1995). Electrical energy or fuel to pump water for farming produces CO2 and CH4.

The prevention or solution of these problems is to reduce activities which cause the greenhouse gases. As the human population increases and deforestation occurs they eventually cause environmental problems and often preceded by severe natural disasters and the losses of human lives and environment. Ministry of Science, Technology and Environment reported the estimation of the amount of methane and carbon dioxide emitted by major sources in Thailand during 1994 - 2000 in the Environmental Situation Report as shown in Figures 1 (MoSTE, 2000).

Figure 1: The estimated amount of carbon dioxide gas emissions by all sources in Thailand during 1994-2020[(1)]



[(1)] **Note from:** Thailand's Initial National Communication under the United Nations Framework Convention on Climate Change. By MoSTE, 2000, Bangkok: MoSTE.

Thailand interested in developing renewable energy and more renewable energy. Wind energy is a renewable energy, clean energy and haven't impact on the environment. Wind energy can be used to produce renewable energy to electrical energy. Production of wind energy is cheaper than the cost of electricity from solar energy. Wind turbine technology is one of the factors in clean energy that are important and should be studied. The studies the relationship between the size of the wind turbine, the wind velocity, and the rate of pumping water. To be able to use wind power as a renewable energy that is appropriate for wind speeds in the area for the management of water resources in agricultural areas.

2. Methods

This research studied to evaluation of the performance of the vertical axis wind turbine that made with waste or plastic bins. The study was the relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank and the relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank.

2.1. The Study Area

The research area was located at 14° 58′ 16″ N, 102° 5′ 59″ E in the Vongchavalitkul University, meaunwai subdistrict, muang district, Nakhon Ratchasima province. The project research is in the area with an altitude of 200 meters above sea level.

2.2. Implementation of the Research

This research was studied in two periods of the year according to the wind direction in Nakhon Ratchasima. Wind direction in the province was under the influence of two types of monsoon winds that were northeast monsoon wind and the southwest monsoon wind. The northeast monsoon wind blows between October to February. The southwest monsoon wind blows between May to October.

Type of wind turbine used in this study was a type of vertical axis wind turbines and installed as shown in Figures 2. The vertical axis wind turbines are made from plastic bins that have been discarded. Plastic bins will be split in half and were used into the blades of wind turbines. The water piston made of PVC pipe at various suction lifts. The axis of wind turbines and the water piston were connected to the gear pump used for water pumping.

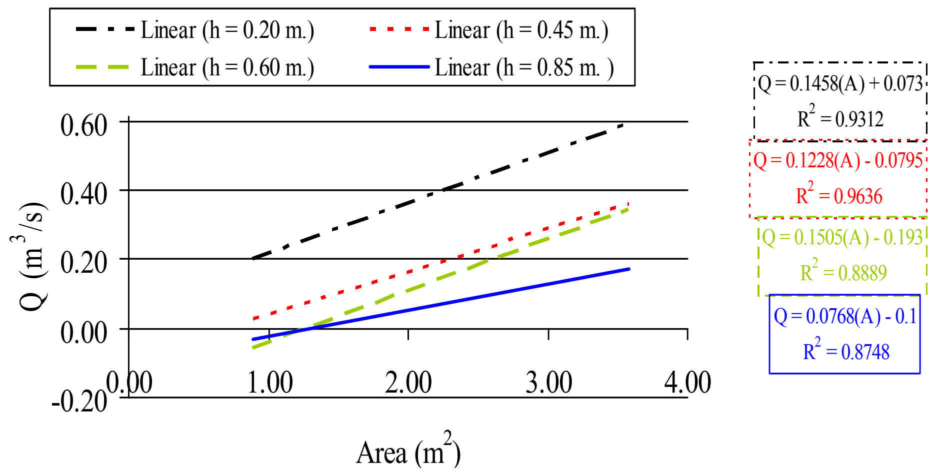
Figure 2: The vertical axis wind turbine

The study was the relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank. The research was conducted by changing the size of the wind turbine blade. The size of the wind turbine blades increasing were A1 = 0.895 m^2, A2 = 1.790 m^2, A3 = 2.685 m^2, and A4 = 3.580 m^2, respectively. The study was the relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank. The wind speed was measured using Anemometer. In addition, the study also was the relationship of suction lifts of the piston (h) and the rate of pumping (Q) that the range of piston pumps decreasing were h4 = 0.85 m., h3 = 0.60 m., h2 = 0.45 m., h1 = 0.20 m., respectively.

3. The Results and Discussion

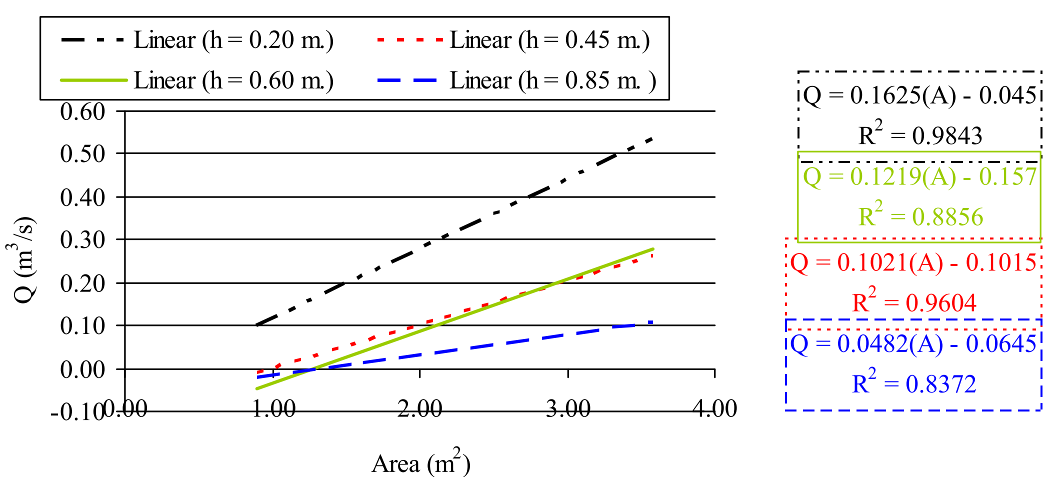
This research studied to evaluation of the performance of the vertical axis wind turbine that made with waste or plastic bins. The study was the relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank and the relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank. In addition, the study also suggested the relationship of suction lifts of the piston (h) and the rate of pumping (Q) that the range of piston pumps decreasing were h4 = 0.85 m., h3 = 0.60 m., h2 = 0.45 m., h1 = 0.20 m., respectively. The results showed the relationship of A (m^2) and Q (m^3/s) that the size of the wind turbine blades increasing were A1 = 0.895 m^2, A2 = 1.790 m^2, A3 = 2.685 m^2, and A4 = 3.580 m^2, respectively, vertical wind turbine could more pumping as shown in Figures 3-5. The rate of pumping of vertical axis wind turbine was proportional to the size of the wind turbine blades as the equation were Q = 0.1458 (A) + 0.073 with R^2 = 0.9312, Q = 0.1228 (A) - 0.0795 with R^2 = 0.9636, Q = 0.1505 (A) - 0.193 with R^2 = 0.8889, and Q = 0.0768 (A) - 0.1 with R^2 = 0.8748 at the average wind speed was 2.893 m/s and suction lift were 0.20 m, 0.45 m, 0.60 m, and 0.85 m, respectively as shown in Figure 3. The rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping.

Figure 3: The relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank in various suction lifts at the wind speed was 2.893 m/s



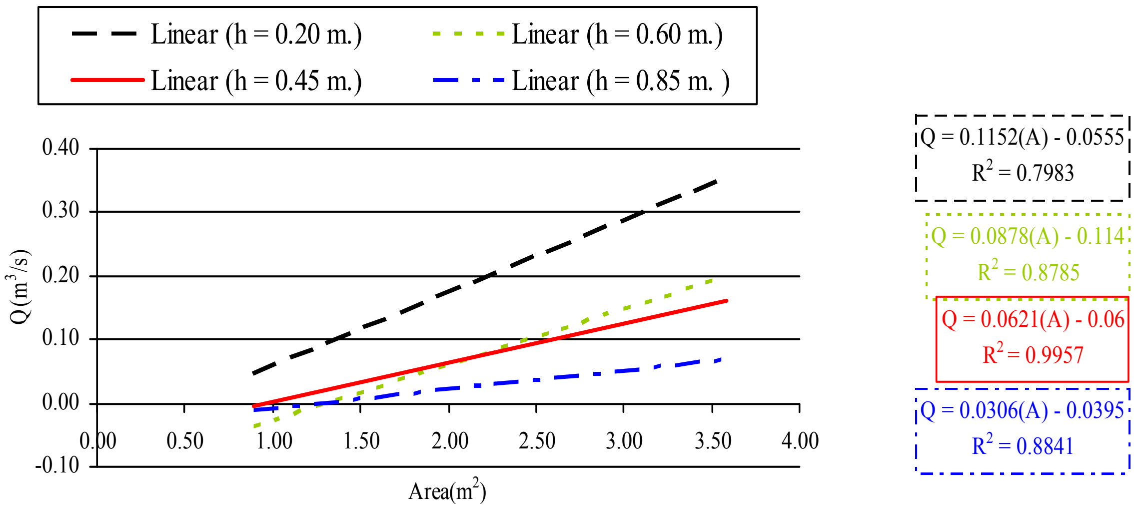
The rate of pumping of vertical axis wind turbine is proportional to the size of the wind turbine blades as the equation were Q = 0.1625 (A) - 0.045 with R^2 = 0.9843, Q = 0.1021 (A) - 0.1015 with R^2 = 0.9604, Q = 0.1219 (A) - 0.157 with R^2 = 0.8856, and Q = 0.0482 (A) - 0.0645 with R^2 = 0.8372 at the average wind speed was 2.573 m/s and suction lift were 0.20 m, 0.45 m, 0.60 m, and 0.85 m, respectively as shown in Figure 4. The rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping.

Figure 4: The relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank in various suction lifts at the wind speed was 2.573 m/s



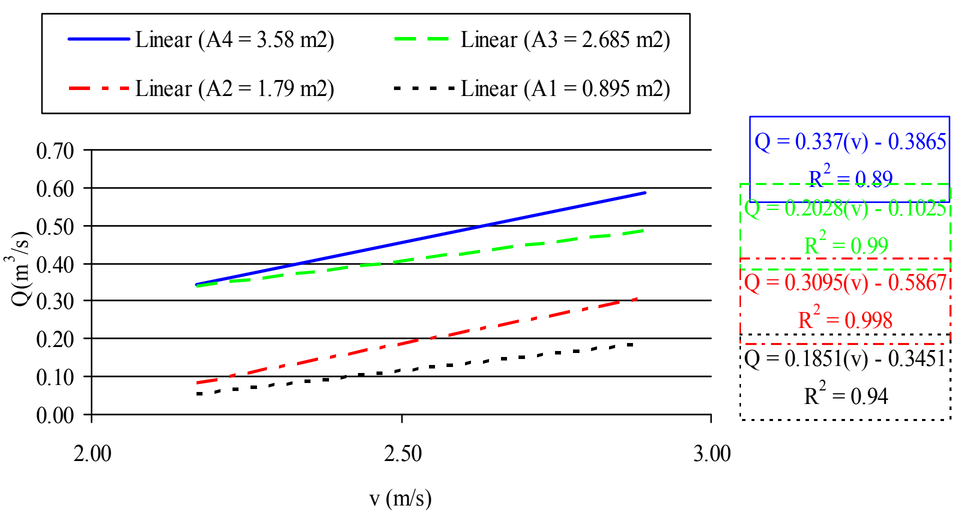
The rate of pumping of vertical axis wind turbine is proportional to the size of the wind turbine blades as the equation were Q = 0.1152 (A) - 0.0555 with R^2 = 0.7983, Q = 0.0621 (A) - 0.06 with R^2 = 0.9957, Q = 0.0878 (A) - 0.114 with R^2 = 0.8785, and Q = 0.0306 (A) - 0.0395 with R^2 = 0.8841 at the average wind speed was 2.170 m/s and suction lift were 0.20 m, 0.45 m, 0.60 m, and 0.85 m, respectively as shown in Figure 5. The rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping.

Figure 5: The relationship of the size of the wind turbine blades (A) to the rate of pumping (Q) from shallow wells or water tank in various suction lifts at the wind speed was 2.170 m/s



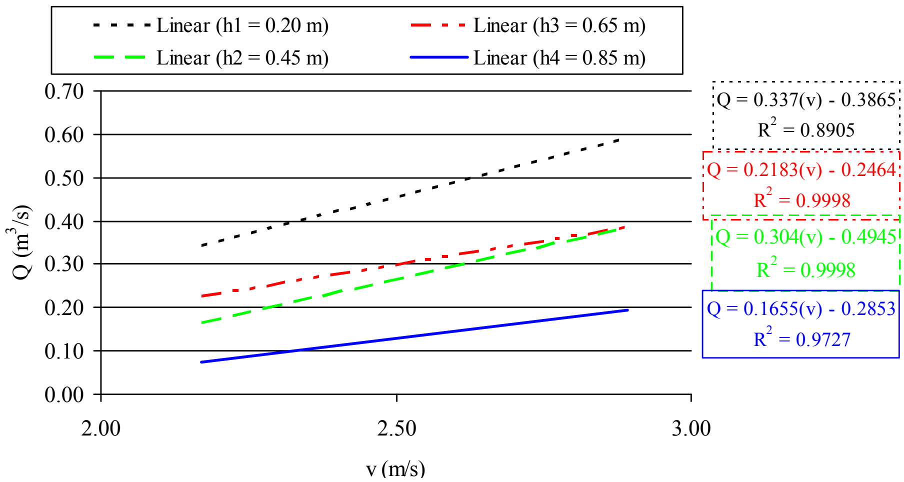
The result also showed the relationship of v (m/s) and Q (m^3/s) that the increasing of wind speed was proportional to the increasing of the rate of pumping as the equation were Q = 0.337 (v) – 0.3865 with R^2 = 0.89, Q = 0.2028 (v) – 0.1025 with R^2 = 0.99, Q = 0.3095 (v) – 0.5867 with R^2 = 0.998, and Q = 0.1851 (v) – 0.3451 with R^2 = 0.94 at the size of wind turbine blades were 3.58 m^2, 2.685 m^2, 1.79 m^2, and 0.895 m^2, respectively at minimum of suction lift was 0.20 m as shown in Figure 6.

Figure 6: The relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank in various size of the wind turbine blades at the minimum of suction lift was 0.20 m



The study were the relationship of the rate of pumping (Q), wind speed (v), the size of the wind turbine blades (A), and suction lifts of the piston (h). The results showed the rate of pumping of vertical axis wind turbine was proportional to the size of the wind turbine blades, and wind speed. The result also showed the rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping or suction lift as shown in Figures 6 and 7. The result showed the relationship of v (m/s) and Q (m^3/s) that the increasing of wind speed is proportional to the increasing of the rate of pumping as the equation were Q = 0.337 (v) – 0.3865 with R^2 = 0.8905, Q = 0.304 (v) – 0.4945 with R^2 = 0.9998, Q = 0.2183 (v) – 0.2464 with R^2 = 0.9998, and Q = 0.1655 (v) – 0.2853 with R^2 = 0.9727 with suction lift were 0.20 m, 0.45 m, 0.60 m, and 0.85 m, respectively at the maximum size of wind turbine blades was 3.58 m^2 as shown in Figure 7.

Figure 7: The relationship of wind speed (v) to the rate of pumping (Q) from shallow wells or water tank in various suction lift at the maximum size of the wind turbine blades was 3.58 m^2



This research also studied to evaluation of the performance of the water management by the vertical axis wind turbine. The result also showed the relationship of Q (m^3/s) and the volume of water (V: m^3) used to grow crops per day per rai. Three types of planting were sugarcane, cassava, and maize. The volume of water in sugarcane crop, cassava crop, and maize crop were 4.299, 6.776, and 4.346 m^3 per day per rai, respectively as shown in Table 1.

Table 1: The relationship of Q (m^3/s) and the volume of water (V: m^3) used to grow crops per day per rai

Crops	Maize	Cassava	Sugarcane
Crop yield (kg/rai)	1,000	5,000	14,500
Coefficient of water consumption (Kc)	0.93	1.45	0.92
Croping time around (day)	49	330	330
Water consumption (ET: m^3/day/rai)	4.346	6.776	4.299
Water consumption per round (m^3/cycle/rai)	212.95	2,236.0305	1,418.723

Note: - Average water consumption of the reference crop (ETp) = 4.673 m^3/day/rai
- Average water consumption of sugarcane, cassava, and maize (ETp) = 4.659 m^3/day/rai

This research also studied the comparison the economic values of the use of the vertical axis wind turbine compared to the cost of pumping with the water pump in normal. The economic values were the cost of construction and energy use per unit of volume of water that was pumped by the pump. In general, the costs of pumping were the water pump and the oil and electrical power to the pump in a normal manner. The results showed the IRR was 14.24% per year, the B/C ratio was 2.42, and the payback period was 2.36 year as shown in Table 2.

Table 2: The comparison the economic values of the use of the vertical axis wind turbine compared to the cost of pumping with the water pump in normal

The economic values	Performance of the vertical axis wind turbine
Internal rate of return (IRR)	14.24% per year
B/C ratio	2.42
Payback Period	2.36 year

Note: Total costs of the vertical axis wind turbine production was 20,031 baht per head
Save electricity to pump water was 8,496 baht per year
The benefits derived from the use of wind turbines was 9,696 baht per year
Average depreciation per year was 4,006.20 baht

4. Summary and Concluding Remarks

This research studied to evaluation of the performance of the vertical axis wind turbine that made with waste or plastic bins. The study were the relationship of the rate of pumping (Q), wind speed (v), the size of the wind turbine blades (A), and suction lifts of the piston (h). This research also studied to evaluation of the performance of the water management by the vertical axis wind turbine. This research also studied the comparison the economic values of the use of the vertical axis wind turbine compared to the cost of pumping with the water pump in normal.

The results showed the relationship of A (m^2) and Q (m^3/s) that the size of the wind turbine blades increasing were A1 = 0.895 m^2, A2 = 1.790 m^2, A3 = 2.685 m^2, and A4 = 3.580 m^2, vertical wind turbine could more pumping were 0.201 m^3/s, 0.305 m^3/s, 0.486 m^3/s, 0.530 m^3/s, and 0.561 m^3/s, respectively. That was, the rate of pumping of vertical axis wind turbine was proportional to the size of the wind turbine blades as the equation was Q = 0.1152 (A) – 0.0555 with R^2 = 0.798 at the lowest average wind speed was 2.17 m/s and suction lift was 0.20 m. The result also showed the relationship of v were 2.170 m/s, 2.573 m/, 2.893 m/s and Q were 0.323 m^3/s, 0.530 m^3/s, 0.561 m^3/s, respectively that the increasing of wind speed was proportional to the increasing of the rate of pumping as the equation was Q = 0.337 (v) – 0.3865 with R^2 = 0.89 at the wind turbine blades was 3.58 m^2 and suction lift was 0.20 m. In addition, the study also suggested the relationship of suction lifts of the piston (h) and the rate of pumping (Q) that the range of piston pumps decreasing were h4 = 0.85 m., h3 = 0.60 m., h2 = 0.45 m., h1 = 0.20 m., respectively, the vertical wind turbine could more pumping. That was, the rate of pumping of a vertical axis wind turbine was inversely proportional to the distance of the piston pumping. Comparison the economic values of the use of the vertical axis wind turbine compared to the cost of pumping with the water pump in normal. The economic values were the cost of construction and energy use per unit of volume of water that was pumped by the pump. In general, the costs of pumping were the water pump and the oil and electrical power to the pump in a normal manner. The results showed the IRR was 14.24% per year, the B/C ratio was 2.42, and the payback period was 2.36 year. The result also showed the relationship of Q (m^3/s) and the volume of water (V: m^3) used to grow crops per day per rai. Three types of planting were sugarcane, cassava, and maize. The volume of water in sugarcane crop, cassava crop, and maize crop were 4.299, 6.776, and 4.346 m^3 per day per rai, respectively. The result also showed the maximum pumping rate of the vertical axis wind turbine was 0.561 m^3/s at the wind speed was 2.893 m/s, the minimum of suction lift was 0.20 m, and the maximum size of the wind turbine blades was 3.580 m^2.

Wind energy can be used to pump water for agriculture by using the vertical axis wind turbine. However, when the demand for water in large quantities. Wind turbine pump is not enough to meet the demand because it depends on the wind speed. This problem could solve by increasing the number of wind turbines to meet the demand for water.

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