COST EFFECTIVE WIND TURBINES

INTRODUCTION

Wind turbines are used to produce power at various locations in Victoria. The Macarthur Wind Farm is a wind farm located in the south west, approximately 16km East of Macarthur and covers around 5,500 hectares and produces enough green energy to power around 220,000 Victorian houses every year . The cost per wind turbine to be built was around 3-4 million dollars.

The wind turbine does have its limitations. It relies on the strength , constancy and direction of the wind to produce power consistently.

DESIGN PRINCIPLE

The principle adopted for working out the optimum design was the cost effectiveness of the device. Initially this was quantified simply as the ratio power measured to the cost to build or how much energy you get relative to the cost to build the wind turbine.

The main theory used to investigate the renewable energy devices is the Power Law with watts. The unit of power is named after James Watt. Based on this law the energy produced by the wind turbines can be calculated from the voltages measured across the buzzer and the current measured flowing through the circuit connecting the buzzer and device.

AIM

The aim of this study was to identified the most power and cost effective design option for wind turbines. A series of experiments was used to determine the optimum number of blades and angle of blades for the model wind turbine.

PREVIOUS EXPERIMENTS AND KEY DISCUSSION

The year 9 carried out an initial set of experiments on model wind turbines. The following variables were considered :

- Wind (fan) speed
- Height of the wind turbine relative to the fan
- Distance from the wind turbine to the fan
- Size of the wind turbine blades
- Angle of the wind turbine blades
- Number of wind turbine blades

The two classes found a different blade angle to be the optimum:

- 10° for 9A
- 40^{o} for 9D

Power output varied inconsistently between 7mW to 82 mW.

As these test results were used as the basis for the individual experiments, the inconclusive tests should have been repeated and the variations in the variables increased. This information was important when conducting this current experiment.

DESIGN OF EXPERIMENT

Two sets of experiments were undertaken by students, one from 9A and one from 9D.

Some factors that were taken into consideration while designing the experiments were:

- the cost to build
- construction limitations in the arrangement of the in the centre of the wind turbine.

The variables used for the two experiments were:

Dependent Variable: Power produced by the windmill compared to the cost.

Control Variable: Wind turbine blade size, distance from wind source (fan), strength of wind (fan setting) height of turbine, angle of blades .

The control variables chosen for both experiments were:

Wind (fan) speed – **high**

Height wind turbine - **40 cm**

Distance from wind turbine to fan - **30 cm**

Size of wind turbine blades – **small**

The one control variable that differed was the angle of wind turbine blades:

- Student 1 Class A choose **10^{o}**
- Student 2 Class D choose **40^{o}**

The two students results were combined and analysed two ways:

- Angle of the blade as the independent variable with the number of blades (4) as a control variable
- Number of blades as the independent variable with the angle of the blades (10^{o}) as the control variable

SAFETY PRECAUTIONS

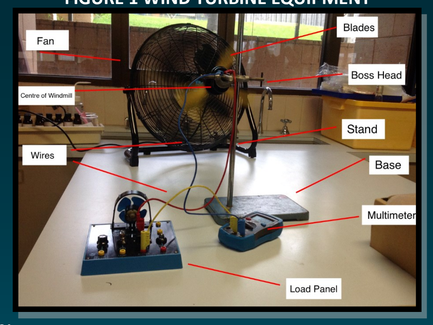
- Tie up hair to avoid getting hair caught in the fan
- Carry equipment with two hands
- Don't use burnt out wires
- Do not put hand in between blades while the wind turbine is spinning

EQUIPMENT

Shown in **Figure 1**

- Retort stand
- Boss head
- Wind generator
- Blades
- Fan
- Load station
- Wires
- Multimeter
- Power supply

FIGURE 1 WIND TURBINE EQUIPMENT



WIND TURBINE CONSTRUCTION

Step 1: The boss head was attached to the retort stand.

Step 2: The blades were attached to the wind generator and then attached to the boss head.

Step 3: Wires were used to connect the turbine to the load station.

Step 4: The multimeter was attached in series or parallel to measure the current or voltage of the circuit.

TEST METHOD

Step 1: The structure was built according to one of the designs.

Step 2: A picture was taken of the structure.

Step 3: The current was measured on a multimeter which was attached in series and then recorded.

Step 4: The voltage was measured on a multimeter which was attached in parallel and then recorded.

Step 5: The amount of power and the cost of the wind turbine structure was calculated.

Step 6: The power was divided by the total cost of the structure to calculate who cost/energy efficient it was.

Step 7: Steps 1-6 were repeated with the other designs.

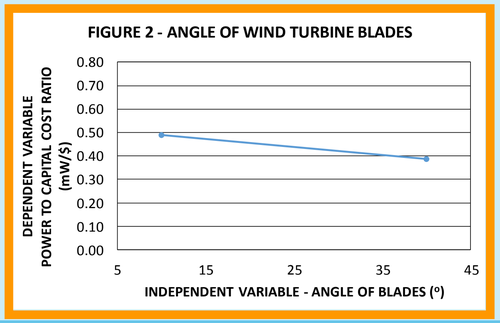
ANGLE OF BLADES RESULTS AND ANALYSIS

The experimental results with the angle of blade as the independent variable are shown in **Tables 1.** The number of blades (control variable) used is four. An estimate of the cost of each wind turbine was also made. The cost effectiveness was estimated by the ratio of the power output to the capital cost. The results of the analysis are presented in **Table 1** and **Figure 2 .**

TABLE 1 - RESULTS AND ANALYSIS FOR ANGLE OF BLADE

INDEPENDENT VARIABLE BLADE ANGLE	DEPENDENT VARIABLES				
	I1 (mA)	V1 (V)	P1 (mW)	WIND TURBINE CAPITAL COST ($)	P1/COST (mW/$)
10^{o}	22.90	3.10	70.99	145	0.49
40^{o}	18.72	3.00	56.16	145	0.39

FIGURE 2 - ANGLE OF WIND TURBINE BLADES



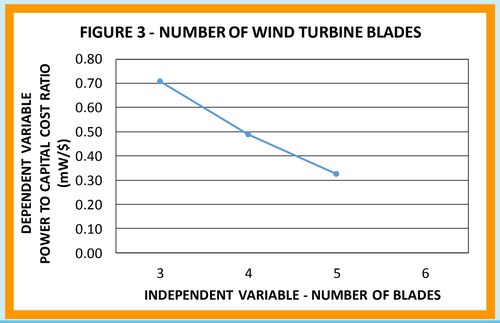
NUMBER OF BLADES RESULTS AND ANALYSIS

The results of the number of blades (independent variable) are shown in **Tables 2.** The angle of blades used is 10^{o}. The results of the analysis are presented in **Table 2** and **Figure 3.**

TABLE 2 –RESULTS AND ANALYSIS FOR NUMBER OF BLADES

INDEPENDENT VARIABLE NO. BLADES	DEPENDENT VARIABLES				
	I1 (mA)	V1 (V)	P1 (mW)	WIND TURBINE CAPITAL COST ($)	P1/COST (mW/$)
3 BLADES	23.90	3.70	88.43	125	0.71
4 BLADES	22.90	3.10	70.99	145	0.49
5 BLADES	22.40	2.40	53.76	165	0.33

FIGURE 3 - NUMBER OF WIND TURBINE BLADES



SYSTEMATIC ERRORS RESOLVED

A systematic errors made in the experiment were related to faulty buzzer, wires and multimeter. The faults were found and the equipment replaced.

RANDOM ERRORS RESOLVED

A random error was that sometimes the blades didn't start spinning so the current or voltage couldn't be recorded. This error was then resolved by one person in the group gently pushing the blades to get it going. The numbers on the multimeda were not recorded until around 10 seconds after the blades were spun . Another random error that was encountered was that occasionally the angle of the blades would change as they spun. This was solved by changing the circular part of the wind turbine that the blades were connected to. The new one held the blades tighter so that they could not move out of place.

RANDOM ERRORS UNRESOLVED

Some of the measurements of current and voltage were very low and it is expected that some errors such as incorrectly reading the meter or not waiting until the current was at its peak have occurred.

CONCLUSION

The most cost effective wind turbine design had three blades which were set at 10^{o} because it was the cheapest and produced the most energy with 0.63 mW/$.

DISCUSSION

The 3 blade wind turbine design was most cost effective for the several reasons.

There were less blades making it :

- Cheaper
- Lighter (less weight allows the wind to spin the blades around faster and produce more power)

The three blades were evenly distributed around the centre of the motor because they were not directly opposite each other.

It is expected that 10^{o} was more cost effective than 40^{o} because there was a greater surface area facing the wind so more power was produced.

FURTHER INVESTIGATION

Further testing is required to improve the design with regards to the other variables. Particular attention should be given to the angle of the wind turbine blades. Greater care should be taken both carrying out the experiments and in choosing the range of tested within each variable.

FURTHER ANALYSIS

Both the maintenance and the life of the wind turbine should be included in the costs.

If further investigation was carried out then the energy cost to build the wind turbine could be calculated so that they energy ratio (the energy returned as a ratio to the energy used to construct the structure) could be discovered and the design improved.

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