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 36km 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 deg-

PREVIOUS EXPERIMENTS AND KEY DISCUSSION
The year 9 carried out an initial set of experiments on model wind turbines. The variables used for the two experiments were:

- Number of blades
- Angle of blades

The two classes found a different blade angle to be the optimum. 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° was more cost effective than 40° because there was a greater surface area facing the wind so more power was produced.

The number of blades (control variable) used is four.

The experimental results with the angle of blade as the independent variable are shown in Tables 1 and 2. The angle of blades used is 10°. The results of the analysis are presented in Table 1 and Figure 2.

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:

- Independent 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
- Height wind turbine -40 cm
- Distance from wind turbine to fan -30 cm
- Size of wind turbine blades - small
- Angle of blade as the independent variable with the number of blades (4) as a control variable
- Number of blades as the independent variable with the angles of the blades (10°) 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

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.

| INDEPENDENT VARIABLE - NUMBER OF BLADES | 3 | 4 | 5 | 6 | |---|---|---|---|---| | (mW/$) | 0.2 | 0.3 | 0.4 | 0.5 |
| INDEPENDENT VARIABLE - ANGLE OF BLADES | 10° | 20° | 30° | 40° | |---|---|---|---|---| | (mW/$) | 0.2 | 0.3 | 0.4 | 0.5 |

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

- 10° for 9A
- 40° 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.

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

A random error was when 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 multimedia 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.

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° was more cost effective than 40° 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.

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° was more cost effective than 40° because there was a greater surface area facing the wind so more power was produced.

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

BIBLIOGRAPHY