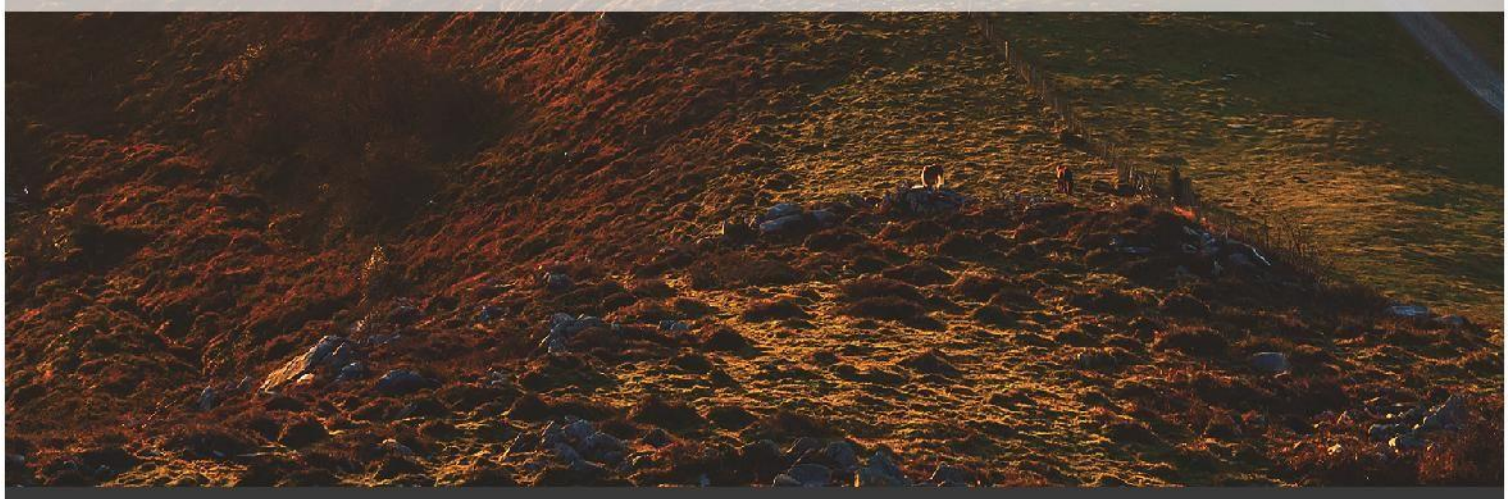
STUDENT BOOKLET

STELR

WIND ENERGY



NAME

CLASS

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Wind Energy was written and produced by the STELR project team.

Science and Technology Education Leveraging Relevance (STELR) is the key school education initiative of the Australian Academy of Technology and Engineering. www.atse.org.au

GLOBAL WARMING

The melting of Arctic ice is one consequence of global warming. It is, in turn, leading to other consequences, including more extreme weather in Europe and North America.

KEY QUESTIONS

- What is climate change?
- What causes it?
- What will climate change mean for the future?
- How will it affect people in other countries?
- Is there anything we can do about it?
- Should we be worried about the greenhouse effect?
- Is climate change really happening? What evidence is there?

Work Sheet 1: Global Warming Concept Map

Global warming is an issue that is frequently the subject of discussion and debate in the world today. In this worksheet, you will explore what you and your classmates already know about this hot topic.

Have a class discussion about each of the **Key Questions** for this lesson.

Question 1

Use your own knowledge and what you have learned from the class discussion to design a concept map that shows how various aspects of global warming are related to each other. Incorporate the following key words as well as any others you can think of into your concept map.

- Global warming
- Energy from the Sun
- Methane
- Ice cores
- Greenhouse gases
- The greenhouse effect
- The enhanced greenhouse effect
- The atmosphere
- Extreme weather events
- Refugees
- Flooding
- Carbon dioxide
- Balance
- Temperature
- Evidence
- Rising sea levels

Global Warming

Work Sheet 2: Global Warming Background

Now it is time to find out more about global warming.

Watch the following video titled **Global Warming: Cold Facts, Hot Science** and then answer the questions below.

https://www.youtube.com/watch?v=CKzxdly7DpY

Question 1

What is global warming?

Question 2

What is causing global warming?

Question 3

Why should we be concerned about global warming?

Question 4

How do you gather evidence for global warming?

Question 5

What can we do about global warming?

Question 6

Why should we be doing anything about global warming?

Question 7

Who do you think produced this video? Who is the intended audience? How would you improve its message?

Question 8

Write down any questions you still have about global warming.

ENERGY RESOURCES

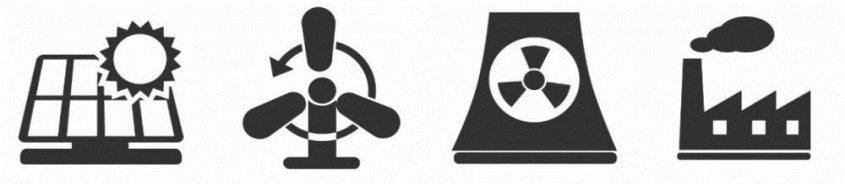
The 140 MW Woolnorth Wind Farm on the far north-west coast of Tasmania. Credit: Hydro Tasmania

There are many sources of energy. Each one has benefits but brings problems with it too. Which ones should we use and how do we get the best out of them?

KEY QUESTIONS

- What factors does society need to consider in choosing energy resources?
- What energy resources do we use today?
- What is a renewable resource?
- How can we compare the outputs of electricity power stations?

Work Sheet 3: Types of Energy Resources



The energy that we use can be divided into two categories: **renewable** and **non-renewable**.

Renewable energy is energy from sources that we can use without having to replenish it. For example, the wind will always blow with or without a wind turbine and the Sun will always shine light on a roof whether or not there is a solar panel there to convert it into electricity.

Non-renewable energy is from sources that once we use it up it is gone. These resources generally undergo a transformation, such as the burning of fuel, which is irreversible and removes them as available resources.

The table below shows some examples of each energy type. Put these energy sources into the most appropriate columns:

- Uranium
- Nuclear
- Tidal
- Wind
- Geothermal
- Biomass energy
- Natural gas
- Petroleum
- Food
- Diesel
- Oil

Renewable Energy	Non-Renewable Energy
Solar energy	Coal
Hydropower	Propane gas

Hint: If you are not sure whether an energy source is renewable or non-renewable, first discuss it with the person sitting next to you and if you are still unsure, try an internet search.

Work Sheet 4: Energy Resources Project

Getting started

Divide yourselves into groups of 3 or 4. Each group must select one energy resource to investigate. Use the STELR website and other websites. You are encouraged to contact experts in the field; where this is possible (websites will often include a *contacts* page where you can find the email addresses of the field experts that work there). You will then give a presentation about the energy resource to the class.

Each group should investigate a different energy resource. You may choose to investigate one of the energy sources that supplies your home - do you know where the energy to run your home comes from?

Suitable energy resources include:

- Solar panels for generating electricity
- Solar heating
- Solar thermal power stations
- Wind turbines
- Geothermal power stations
- Hydroelectric power stations
- Biogas for generating electricity and producing heat energy
- Petrol for transport
- A biofuel used for transport (such as bioethanol or biodiesel)
- Tidal power
- Wave power
- Nuclear power stations
- Coal-fired power stations
- Gas-fired power stations
- Coal seam gas

You need to find out

1. What is the science and technology behind the resource?

- How do you get energy from this resource? What devices are used?
- What are the main energy transformations and energy transfers that take place? Include a flow chart showing the energy transformations that occur.
- Is this energy resource renewable or non-renewable, and why?

2. How is the energy resource used?

- Is this energy resource used in Australia, and if so, to what extent? Is it a large-scale energy resource, or just used on a small scale? Where in Australia is it used – across most of Australia, or just in a small part of Australia?
- Is this energy resource used across the world and if so, to what extent? Which countries are the main ones using it? Is there a reason why some countries are using it and others are not?

3. What are the benefits and problems associated with this energy resource?

- What are the main advantages of using this energy resource? Will increased use of the resource help reduce global warming?
- What health and safety concerns are associated with this energy resource?
- What environmental concerns are associated with this energy resource?

4. What does your community think about this resource?

- What are the views of members of your school and/or local community on the setting up and use of the energy resource to supply electricity or other useful forms of energy, especially if it were to be established nearby?

5. What is the likely future of the resource?

- Is the energy resource likely to be a useful and widely used energy source for Australia and across the world in the future? Why?

Question 1

Write any other questions you have related to your research here:

How to present your project

You should consider a range of ways of communicating your information that will capture the interest of your audience. Here are some examples:

- Digital images
- Diagrams, models, flow charts and maps
- Tables and graphs of data
- Website capture
- Video clips
- Posters
- Your own recordings of interviews and site visits
- PowerPoint presentation

Resources

.

STELR Renewable Energy
https://stelr.org.au/stelr-modules/renewable-energy/

Go to the web page and scroll to the bottom of the page for additional recources.

Make sure to include the presentation, presentation notes, draft notes, a bibliography, further questions, and any other draft or support documentation you produced during this activity. Don't forget to identify every document clearly so that your teacher knows its purpose.

WIND TURBINES

KEY QUESTIONS

- What energy transfers and transformations occur in a wind turbine?
- How do wind turbines deliver electrical energy?
- Is there a best design for wind turbines?
- Where does the wind blow most in Australia?
- What are the advantages and disadvantages of wind turbines?

In Australia, wind turbines are the fastest growing renewable energy resource.

There are over 80 wind farms with well over 2000 turbines. There are plans for many more. In 2016 wind farms produced 13,000 gigawatt hours (GWh) of electricity. That's a bit below the 18,000 GWh from hydroelectricity, and well behind the 162,000 GWh from coal.

How wind turbines work

Watch the video *How a wind turbine works*.

How a wind turbine works
https://youtu.be/57NFcXLd9BA

Question 1

Increasingly, wind farms are being built coupled with massive batteries that store electricity when the turbines produce more than is needed, and supply it when the turbines aren't producing enough.

Write in the boxes to complete the description of the transfers and transformations that occur when a wind turbine charges a battery. Use the following words:

electrical | transferred | kinetic | transformed | mechanical | transferred
transformed | chemical

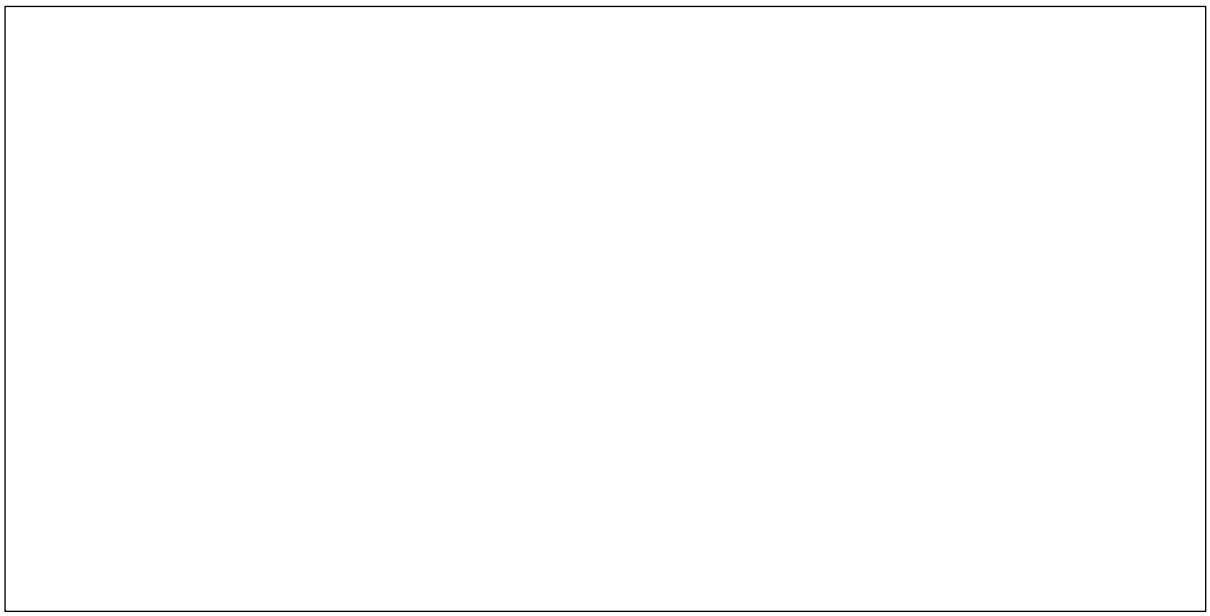
Wind has _____ energy. This energy is transformed, becoming _____ energy of the turbine. This is _____ along the main shaft to the generator where it is _____ into _____ energy. This energy is then _____ through cables to the battery where it is _____ into _____ energy.

Question 2

Wind turbines take about half of the wind's kinetic energy. Of that, most is converted into mechanical energy, with a little lost as heat and sound. Then, most of the mechanical energy is transformed into electrical energy, again with small losses to heat and sound.

Draw a Sankey diagram showing the transformations that occur. (Do not include the kinetic energy that remains in the wind).

- start with the wind energy and only show the final outputs
- then make the diagram longer by showing the mechanical energy stage



Where to put wind turbines?

Obviously, the best place to put a wind turbine is where it's windy. Turbines work best in smooth air flows, so they should be placed away from obstructions such as tall buildings or rugged landscapes, which break up the air flow. And the higher you go up the stronger the wind, so engineers make turbines as high as they can.

Some wind farms are built off-shore, in the ocean. These cost more, but winds are generally stronger and people don't object to them spoiling the landscape.

Where in Australia, on land or off the coast, are the best locations for wind farms?

Open the web site below and navigate to Australia. Where are the strongest winds now? If you click on a location the wind speed is shown in the box at the bottom left of the screen.

earth
https://earth.nullschool.net/#current/wind/surface/level/orthographic

Question 3

On the map below, in one colour:

1. draw circles around the three areas where the winds are strongest
2. beside the circles write in the top wind speeds in those areas
3. in the bottom left corner of the map, write in a map key:
    a. name the pen colour you are using,
    b. then beside it write 'Most wind' and the date

Write in small letters because you will soon add more information to the map.

Now, go to this website:

Australian Renewable Energy Mapping Infrastructure
http://nationalmap.gov.au/renewables/#share=vYUobz

(Click 'I agree' to see the map. You'll see better if you move the opacity slider to 100% once you're in, too).

This map shows the average wind speeds 100 m above the ground all around Australia – dark blue areas have the lowest average speeds and red areas the highest. To get accurate readings, zoom in and click on a location – the average wind speed there is displayed in a text box.

Question 3 continued...

Now, using another colour, add the following to the map above:

1. circle the three areas with the highest average wind speeds
2. beside the circles write in the average wind speeds at those locations
3. add to the map key:
    a. name the pen colour
    b. write 'Highest average wind speeds'

Question 4

Compare the wind speed data today with the average wind speed information in your map:

1. Did the areas that you circled overlap at all? Explain.
2. How do the wind speeds today compare to the averages for the areas?

Question 5

Wind turbines need average wind speeds of 6 m/s or more to operate effectively.

Looking at the average wind map, approximately what proportion of Australia has enough wind to support wind turbines?

- ☐ Less than 25%
- ☐ Between 25% and 50%
- ☐ Between 50% and 75%
- ☐ More than 75%

Question 6

Discuss

If wind speed was the only factor involved in deciding where to build wind farms, we would put them in the areas where the average wind speeds are highest.

Looking at the wind map, can you think of reasons why these might not always be good places for wind farms?

Advantages and disadvantages of wind power

Discuss

There are many factors to consider when deciding how we should produce electricity. Some are listed in the table on the next page.

1. In small groups, discuss how wind power stands with respect to each factor, and then summarise the main points you decide on. Sometimes there might be several points relating to a factor.
2. On the basis of the points you've made, rank wind power as good (Y), bad (N) or somewhere in the middle (–).

Factor	Discussion – how is wind power with respect to this factor?	Y, N or –
Carbon dioxide		
Renewability		
Cost		
Pollution		
Environment		
Reliability		
Suitable locations		
Community acceptance		

Alternative technologies

Below are a series of trial blade shapes designed to test how efficiently they can convert wind energy into electrical energy.

Question 7

Design and draw an idea for an alternative blade shape that you could try out in the laboratory.

Wind Turbine Investigations

If you want to transform the energy in the wind into electricity, you want machines that do this as efficiently as possible – at least, within your cost limits.

There are many factors that contribute to the efficiency of wind turbines, such as the materials used and the height of the towers. Some factors you can test with the STELR wind turbine. The following experiments test:

1. what is the best angle for the turbine blades,
2. what is the best number of blades, and
3. what is the best length of blade to use.

Your teacher will tell you which experiment or experiments to do.

Summary

Summarise your findings from the three experiments. First for blade angle:

Number of blades

Blade length

Prac 1: Angle of Blades

Introduction

In this activity you will be investigating the effect that the angle of the blades has on the power output of the STELR wind turbines. The set up for the circuit is in Figure 1.

TIP: the hub for the wind turbine can be loosened for easy attachment of the blades by turning the large blue screw.

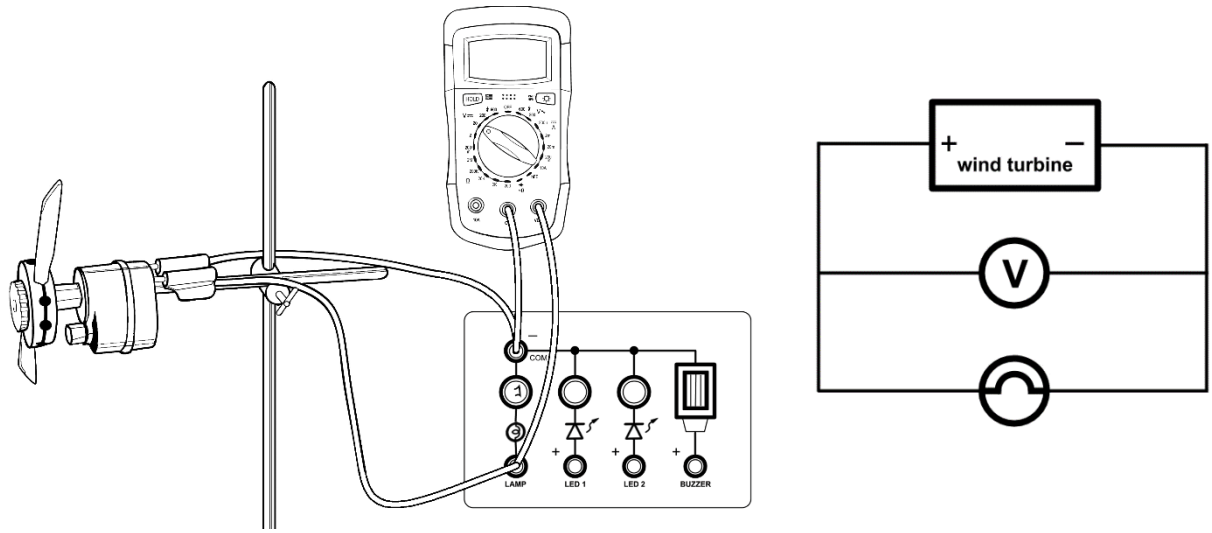


Figure 1. The set up

Inquiry Question

What is the best angle for the blades on a wind turbine hub to produce the biggest voltage?

Hypothesis

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you change the angle of the blades. Explain why you think this.

Materials

- STELR testing station
- 1 x STELR multimeter
- 2 x 150 mm (red) turbine blades set into a hub
- STELR model wind turbine
- Connecting leads
- Three-speed electric fan
- Tape measure or metre ruler
- STELR hub protractor

Risk Assessment

Complete the following risk assessment for this practical investigation.

	What might be the risks?	What precautions will we take?
If the blades are not inserted firmly into the hubs, they may fly out at a high speed whilst the turbine is spinning.		
A fast-spinning electric fan will be used in this experiment.		

Procedure

Part A – Testing with two blades at 45º.

1. Make sure the two blades are tight in the hub of the turbine and are both at 45º to the face of the hub, like those in Figure 2 below.

Secure the model wind turbine to the retort stand, as shown in Figure 1.

Make sure that the hub is tight on the motor drive shaft and you are using the correct socket to attach the hub.

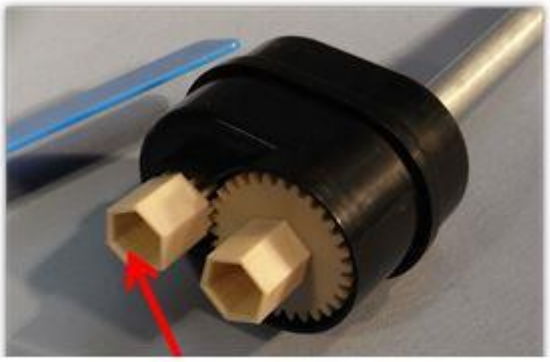


Figure 2. These blades have been set into the hub at the same angle (45^0).

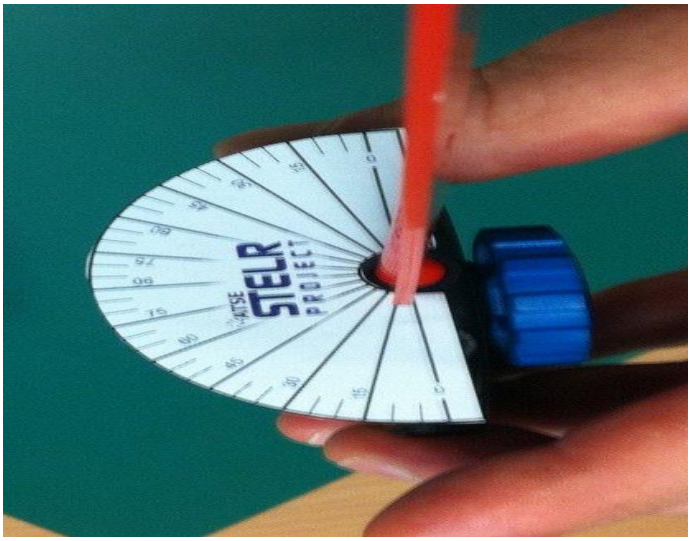
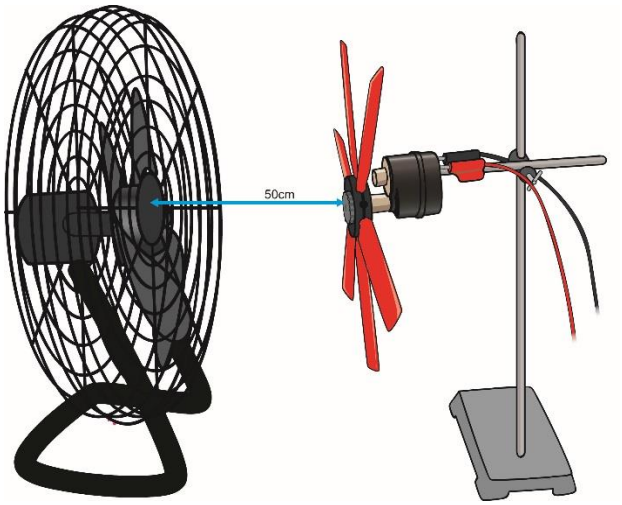


Figure 3. Using the STELR protractor to set the blade angle

2. Connect the circuit as shown in Figure 1. Connect the cable from the wind turbine across the lamp on the test station. Then connect the multimeter across the lamp.

3. Place the three-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine. **Secure the wind turbine retort stand to the lab bench (with masking tape, for example).** Do not turn on the fan yet!



Do not change the distance between the fan and the turbine over the course of the experiment!

4. Raise or lower the turbine on the retort stand so the centre of the wind turbine's hub is at the same height above the bench as the centre of the fan's hub.

5. Set the multimeter to the *20* setting on the V scale.

6. Have the teacher check your circuit. When your teacher has given permission, turn the fan on to the highest setting

7. Once a steady reading is obtained, record the current and voltage in *Results Table 1* below.

8. Turn off the fan and return the voltmeter to the OFF position.

Keep the set-up without altering it, ready for part B

***Results Table 1* – Part A – Testing the blades at 45º.**

Voltage (V)	Brightness of the globe

Part B – Testing with other angles.

1. Carefully detach the hub from the turbine's motor drive shaft.

2. Use the protractor to set both blades at 10°. Tighten the screw if necessary so the blades are firmly held again. Insert the hub and blades back onto the bottom turbine shaft, as shown in Figure 1. Make sure that the hub is tight on the shaft.

3. Reset the voltmeter to the *20* setting.

4. Turn the fan onto the highest setting and once a steady reading is obtained, record the voltage in *Results Table 2*.

5. Repeat Steps 1 and 2 for the blades set at different angles. Record your results.

6. Pack up according to your teacher's directions.

***Results Table 2* - Part B – Testing with other angles.**

Copy your results for 45º from Table 1. Enter your other results into this table.

Angle of turbine blades	Voltage (V)	Brightness of the globe
45º		
10º		

Discussion

Did you have any practical difficulties in performing Part A (testing with the blades at 45º) of the experiment? If so, how did you resolve them?

In Part A, what do you think would have happened to the voltage and brightness of the globe if the fan had been set at the medium setting instead? If you have time, test if your prediction is correct.

Question 1

Was the prediction you made at the start of this experiment correct? Were you surprised with the results in Part B for this model turbine? Suggest a reason why the prediction was or was not correct.

Question 2

Did all the groups in the class agree on the best angle for the blades? If not, identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 3

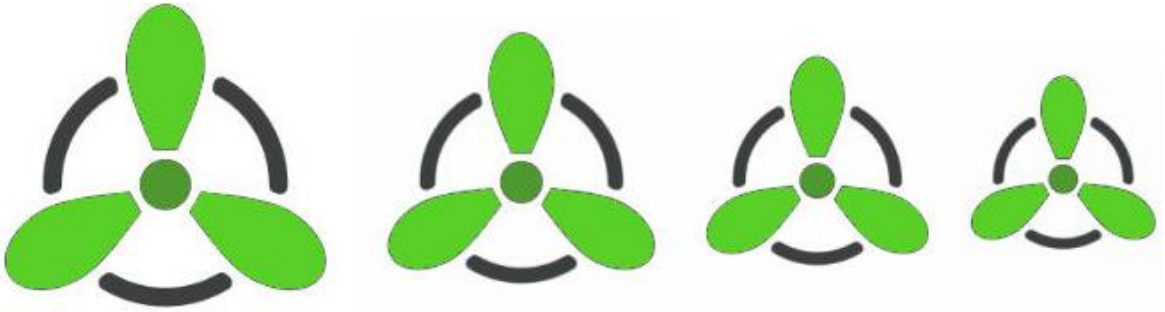
List the variables that were kept the same as you performed the experiment.

Conclusion

What is your answer to the inquiry question?

What is the best angle for the blades on a wind turbine hub to produce the highest voltage?

Prac 2: Blade Length



Inquiry Question

Which blade length, of the three lengths supplied, delivers the biggest voltage for the STELR wind turbine generator?

Hypothesis

What blade length do you think will give the biggest voltage? Why?

What you need

- Wind turbine
- Clamping hub
- 2 blades of each length (red, blue and yellow)
- Blade setting protractor
- Testing station
- Retort stand and boss head
- Connecting cables
- Multimeter

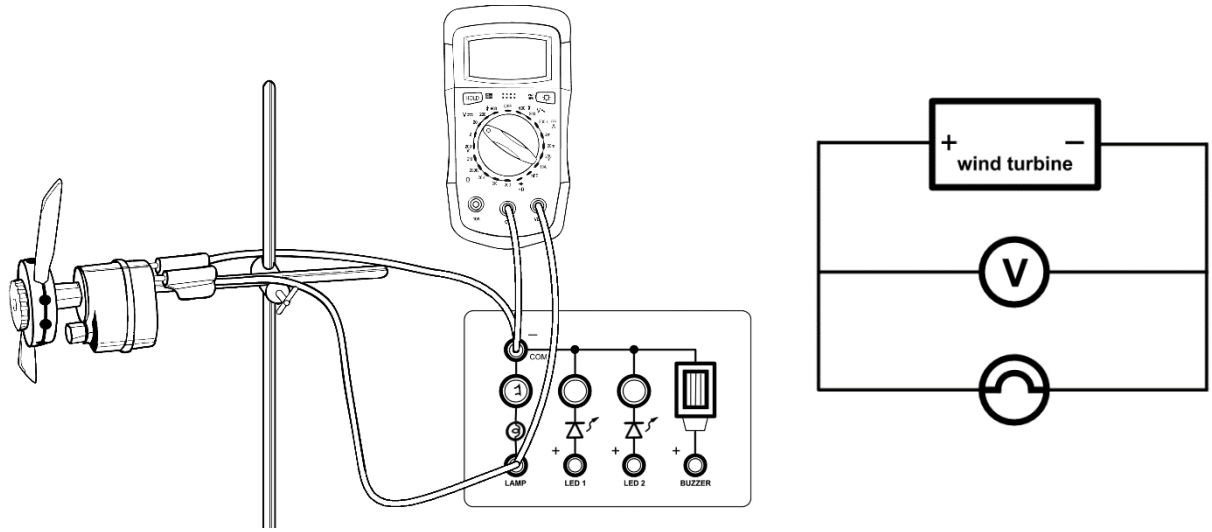


Figure 1. The set up

Method

1. Mount the wind turbine generator 50 cm from the fan using the retort stand and the boss head.
2. Connect the wind turbine generator across the lamp of the testing station.
3. Connect the multimeter across the lamp on the testing station.
4. Set the multimeter to the 20 V DC scale.
5. Attach two long blades to the hub and set at 45^{o}.
6. Connect the hub to the wind turbine generator.
7. Run the fan on high speed and note the brightness of the lamp and the voltage in the results table.
8. Repeat the process for the other blade lengths.

Risk Assessment

Think of two potential risks in this experiment and complete the following table:

The facts	What might be the risks?	What precautions will you take?

Results

Record your results in the table below.

Blade length (cm)	Brightness of the lamp	Voltage across the lamp (V)

Question 1

How reliable do you think your results were? Discuss.

Question 2

Did your findings surprise you? Can you suggest an explanation for what you discovered?

Conclusion

Of the three lengths supplied, what is the best blade length for the STELR model wind turbine?

Prac 3: Number of Blades

Introduction

In this activity you will be investigating the effect of different numbers of blades on the power output of the STELR wind turbines. The set up for this activity is shown in Figure 1.

Inquiry Questions

1. What voltage can be delivered by a STELR model wind turbine operating with 6 blades?
2. What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?
3. How many blades give the greatest voltage?

Hypothesis

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you reduce the number of blades. Explain why you think this.

Materials

- STELR testing station
- 1 x STELR multimeter
- 6 x 150 mm turbine blades set into a hub
- STELR model wind turbine
- Connecting leads
- Three-speed electric fan
- Tape measure or metre ruler

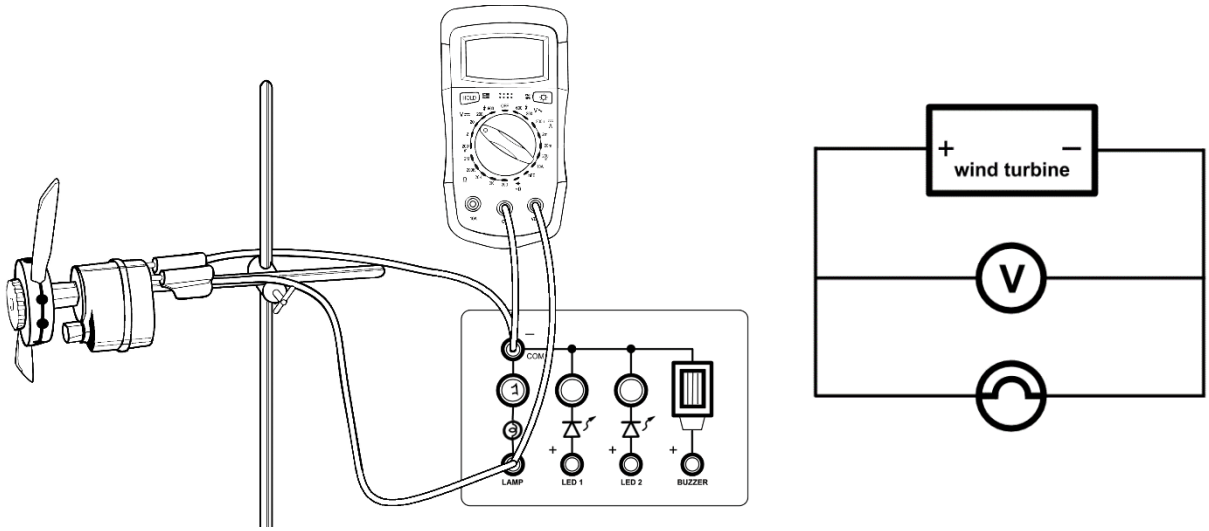


Figure 1. The set up

Procedure

Part A – Testing with six blades:

1. Make sure the six blades are tight in the hub of the turbine and are all at 45^0 to the face of the hub, like those in Figure 3 below. Then set up the model wind turbine in the stand, as shown in Figure 1. Make sure that the hub is tight on the motor drive shaft and that you are using the bottom shaft, as shown in Figure 1, which means the model wind turbine will be ungeared.

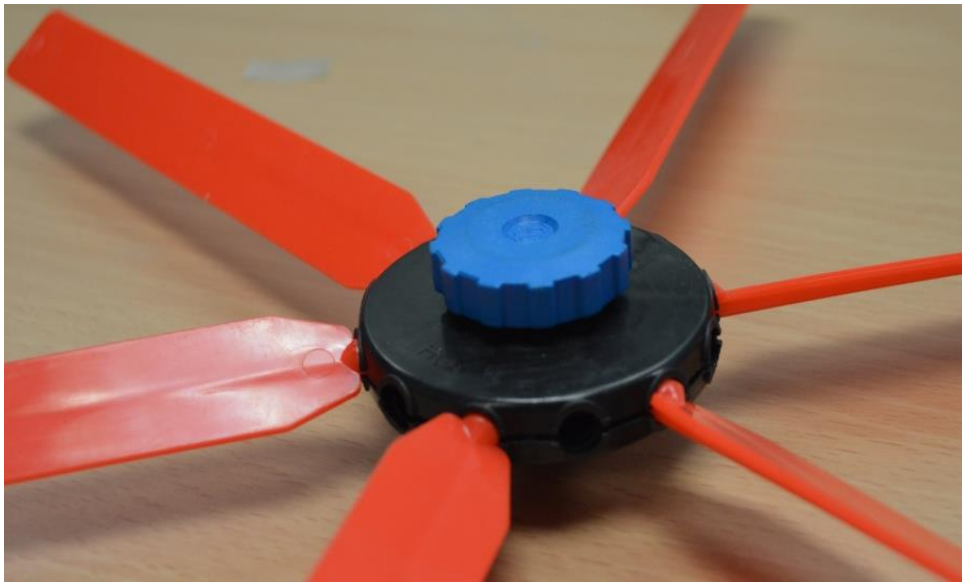


Figure 2. These blades have been set into the hub at the same angle (45^0).

2. Connect the circuit as shown in Figure 1, with the plugs inserted into the LAMP sockets of the STELR testing station.

3. Place the three-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine, as shown in Figure 3. **Do not turn on the fan, yet!**

Do not change the distance between the fan and the turbine over the course of the experiment!

4. Raise or lower the turbine on the retort stand so the centre of the wind turbine's hub is at the same height above the bench as the centre of the fan's hub. The two hubs should be in a direct line with each other, as in Figure 3.

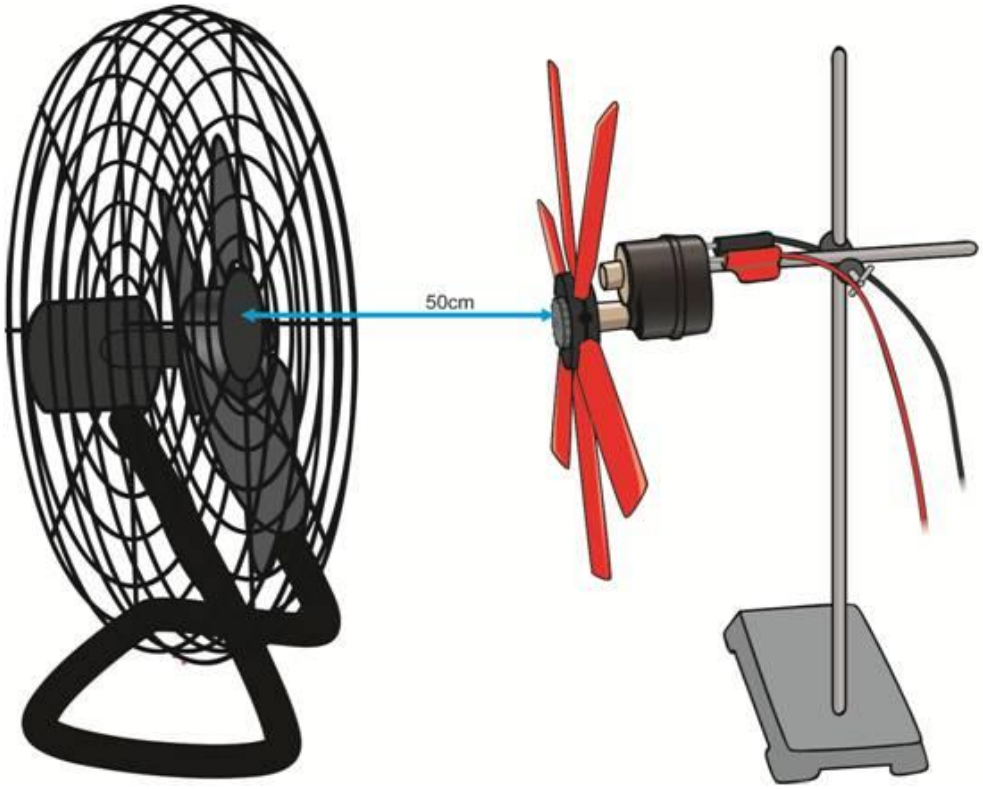


Figure 3. The correct relative positions of the fan and the turbine

5. Set the voltmeter to the 20 setting. (This allows a maximum reading of 20 V.)

6. Have the teacher check your circuit. When your teacher has given permission, turn the fan on to the highest setting.

7. Once a steady reading is obtained, record the voltage and brightness of the lamp in Table 1 below.

8. Turn off the fan and return the voltmeter to the OFF position.

Keep the set-up without altering it, ready for part B.

Part B – Testing with other numbers of blades:

1. Carefully detach the hub from the turbine's motor drive shaft and loosen the blades a little by turning the screw that holds them firmly in place.

2. Add six more blades to the hub so you now have 12 blades equally spaced, still set at 45°. Tighten the screw so the blades are firmly held again, insert the hub and blades back onto the bottom turbine shaft, as shown in Figure 1. Make sure that the hub is tight on the shaft.

3. Reset the voltmeter to the **20** setting.

4. Turn the fan onto the highest setting and once a steady reading is obtained, record the voltage and brightness of the lamp in Table 2.

5. Repeat Steps 1 and 2, for four, then three, and then two evenly spaced blades in the hub, still all set at 45°. Record your results in Table 2.

Results

Question 1

Table 1 – Part A: voltage and brightness with six blades.

Voltage (V)	Brightness of the lamp

Question 2

Table 2 - Part B: voltage and brightness of the lamp for a wind turbine with different numbers of blades.

Copy your results for six blades from Table 1. Then enter your results for 12, four, three and two blades.

Number of turbine blades	Voltage (V)	Brightness of the lamp
12		
6		
4		
3		
2		

Discussion Questions

Question 1

Did you have any practical difficulties in performing Part A of the experiment? If so, how did you resolve them?

Question 2

Was the prediction you made at the start of this experiment correct? Or were you surprised with the results in Part B for this model turbine? Suggest a reason why your prediction was or was not correct.

Question 3

Did all the groups in the class agree on the best number of blades? If not, identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 4

List the variables that were kept the same as you performed the experiment.

Question 5

Were there any variables, other than those mentioned above, that might have affected the result that were not controlled? If so, state what they were and describe what effect they could have had on the results.

Question 6

Do you think the results would have been the same if the set of blades had been shorter than the set you used in this experiment? Discuss.

Question 7

Do you think the results would have been the same if the blades had been set at a different angle than the angle used in this experiment? Discuss.

Question 8

Suggest why large wind turbines usually have three blades.

Conclusion

What are your answers to the three inquiry questions?

1. What voltage can be delivered by a STELR model wind turbine operating with six blades?
2. What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?
3. How many blades give the greatest voltage?

Prac 4: The Best Wind Turbine

Introduction

In this investigation you will design, conduct and report on an experiment into getting the most energy from a wind turbine. Who can get the lamp to shine most brightly? Who can generate the biggest voltage?

You can use the blades provided, or make your own shapes. How will you connect them to the turbine hub?

When you have completed the investigation you can communicate your findings by completing the report below.

Before you commence your investigation and start collecting data, make sure that your teacher has checked your materials, method, risk assessment, variables and draft data table.

Inquiry Question

What is the best set-up for getting the most energy using the STELR model wind turbine?

Identify the Variables

Question 1

What things can you change on the turbine that might change the output from the wind turbine?

Question 2

What will your dependent variable be, that is, the one you are going to measure during the experiment?

Question 3

Which variables will you have to keep constant in order for your investigation to be fair and valid?

Equipment

Make a list of the equipment you will need to carry out your investigation.

Method

In numbered points, write a step by step procedure that can be followed in order to carry out this investigation. Include steps that show how to:

- set up the independent variable so that it can be varied
- measure the dependent variable
- control the variables other than blade length
- set up for reliability of data

Risk Assessment

Question 4

Complete a risk assessment of your procedure by completing the following table. Number the risk factors and use new lines to keep the facts and their corresponding risks and precautions aligned.

The facts	What might be the risks?	What precautions will be taken?

Do your experiment

Question 5

Keep records of what you did and of your results.

What did you change to get more voltage from your model wind turbine?

Discussion Questions

Question 6

How reliable do you think your results were? Discuss.

Question 7

Did your findings surprise you? Can you suggest an explanation for what you discovered?

Question 8

What are the implications of your findings for commercial wind turbines? Discuss.

Question 9

If you had the opportunity, what further investigation would you carry out to build on what you learned from this investigation?

Conclusion

Summarise the conclusions drawn by the class overall and hence answer the question: "What is the best set-up for getting the most energy using the STELR model wind turbine?"

Work Sheet 5: Wind Turbines and Electricity

Wind turbines are a renewable energy technology because they use wind to make electrical energy that we can use in our everyday lives.

Figure 1. Rows of wind turbines and electricity cables (L). Capital Wind Farm near Canberra (R).

Is the energy transformation in a wind turbine efficient?

Wind rushes across the blades of the wind turbine and pushes on them so that they start turning. Up to half of the kinetic energy from the wind is converted into the mechanical energy of the turning blades. The turning blades produce a little heat due to friction as well as sound energy, but most of the mechanical energy is transformed into electrical energy.

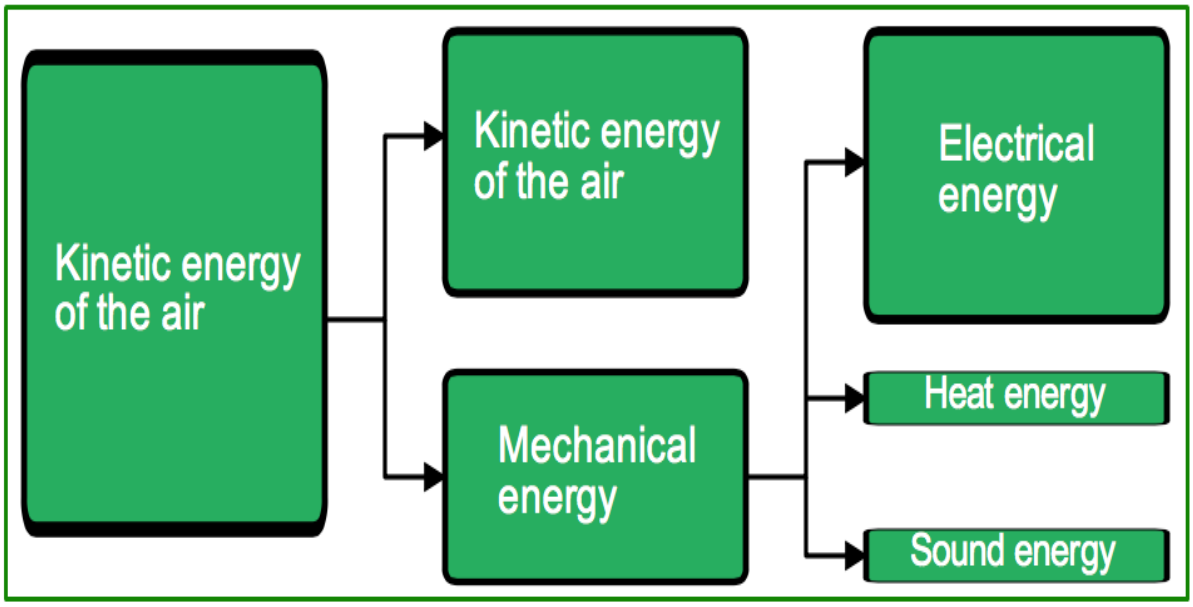


Figure 2. Energy transformations in a wind turbine.

Modern wind farms convert nearly 50% of the energy in the wind into electricity. In comparison, brown coal power stations convert about 25% of the energy in coal into electricity.

How do wind turbines work?

- Moving air pushes against the blades of the turbine, making the turbine spin.
- When this happens, some of the kinetic energy of the moving air is being transformed into the mechanical energy of the spinning blades.
- The shafts and the gears inside the gear box transfer energy from the turbine to the generator.
- The generator transforms mechanical energy into electrical energy.
- Some of the original kinetic energy supplied by the wind is ‘wasted’ as it is transformed into heat energy and sound energy within the turbine.

Examine the image of the inside of a wind turbine in Figure 3.

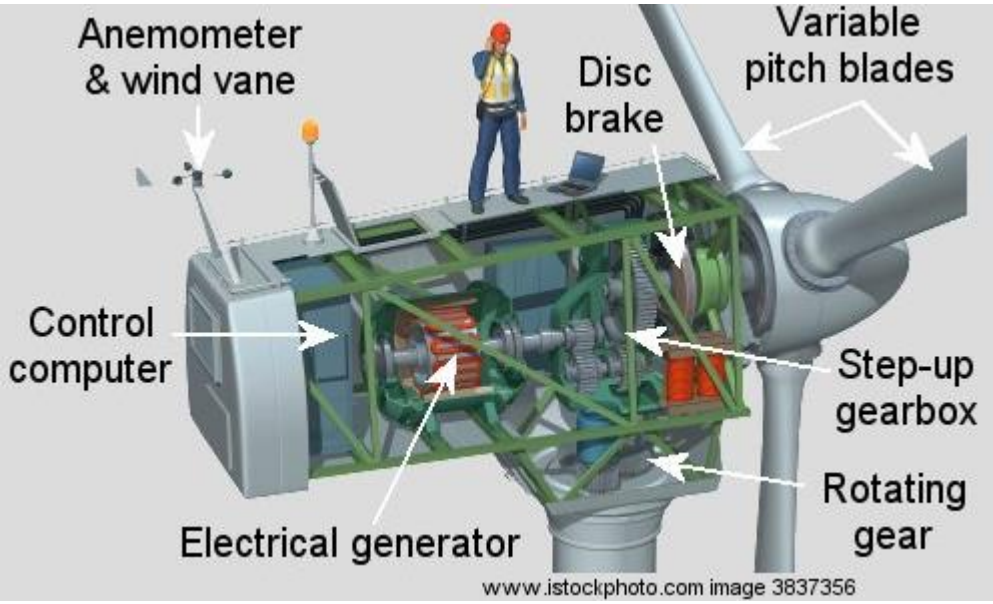


Figure 3. The parts of a wind turbine.

Watch the following video of the construction of a wind turbine. Then answer question 1.

VIDEO https://www.youtube.com/watch?v=a09vHnVrBi0

Question 1

Write a series of instruction steps to show how the parts are put together to build the wind turbine. Use the correct terms for the different parts of the wind turbine, as shown in Figure 3 above.

The following animation shows how energy is transferred and transformed in a wind turbine.

https://www.youtube.com/watch?v=cCCcd_AOiT8

Question 2

Complete the following description of how wind can be used to charge a battery.

Wind has _____ energy, which is transferred into rotational _____ energy of the turbines. The generator then transforms this energy into _____ energy, which is then transferred to a battery where it is transformed into _____ energy for long term storage.

Did you know?

The only reason that wind has kinetic energy is because air has mass. In fact, it has so much mass that every square metre on the surface of the Earth has *ten tonnes* of air sitting above it. That's about the weight of three elephants!

Question 3

Where might energy be lost or wasted as wind energy is converted into electrical energy?

What affects the amount of electrical power produced?

Factors affecting the amount of electrical power produced by wind turbines include:

- The speed of the wind
- The number of blades
- The length of the blades
- The shape of the blades
- The pitch (angle) of the blades to the wind
- The use of gears
- The type of generator used

Other Technical Issues

- The broad topography of the Earth's surface can affect how windy a region is. Some sites will be more exposed to the wind than others.
- A good site might have a 35% capacity factor – this means that the turbines will produce 35% of their capacity on average over a year.
- In many countries, most wind turbines are constructed off-shore, usually because people do not want them on the land. This is much more expensive, and presents problems such as corrosion by seawater and additional greenhouse gas emissions from transport.

Work Sheet 6: Wind Turbines and Birds

Introduction

Many people answer questions with their 'gut' feelings. They often have little or no evidence to back up their opinions. A true scientist, however, will only express an opinion on an issue if they have worked through a process called critical thinking.

In this activity, you will use critical thinking to examine an important issue about wind farms and their effect on bird populations.

Figure 1. Photograph courtesy of The Age

What is critical thinking?

Critical thinking does *not* mean the same thing as criticism (finding fault with something). Instead it means examining something very carefully in order to understand and improve it.

Critical thinking is an essential tool used by people in many disciplines, including science.

The process of critical thinking includes:

- Finding out relevant facts.
- Thinking about how and why something occurs.
- Reflecting on what the possible consequences might be.
- Considering how it fits in with the wider picture.
- Identifying any biases or prejudices that might be operating, including your own.

The case of the rare orange-bellied parrot

Figure 3. The rare orange-bellied parrot

In 2006 a large wind farm proposal in Victoria was halted by the then Australian Federal Minister for the Environment, Senator Ian Campbell, based on concerns for the rare orange-bellied parrot, which was claimed to have a flight path through the proposed site.

Senator Campbell stated: "On the basis of the information that has been presented to me on the orange-bellied parrot, I have decided not to approve the Bald Hills wind farm. I understand that this will be a disappointing outcome for the proponents of the wind farm but it is very clear to me from reading this report that every precaution should be taken to help prevent the extinction of this rare bird."

This sparked a huge public debate. The 52 turbine wind farm had been approved by the Victorian Government two years earlier.

In an interview on the ABC, the then Victorian Planning Minister, Rob Hulls, referred to a report into the collective impact of wind farms on some of Australia's threatened bird species, on which Senator Campbell's decision was based. He claimed that the senator's decision was politically based and ignored the evidence presented in the report. Hulls said, *"The actual report says that not a single orange-bellied parrot was observed near the*

proposed Bald Hills wind farm. At best, scientists found a few historic records of sightings and a couple of potential foraging sites 10 to 35 kilometres away."

Now, go to this Article:

The Age – Fury over wind farm decision

https://www.theage.com.au/national/fury-over-wind-farm-decision-20060406-ge22x1.html

After a few months, the decision was overturned. Yet many members of the public were angry that the wind farm was able to go ahead. They still believe that birds cannot see turbine blades when they spin, and are harmed by flying into them.

Is their opinion justified?

What to do

Step 1: Find out the facts

Search the internet and other sources to investigate the answers to the following questions. It may be helpful to restrict your research to sources in the US or in Australia to obtain this information. *Some possible websites are listed below.*

Web resources

Following is a list of some useful websites to help answer these questions. You might also find other sources. It is always advisable to use websites from reliable sources, such as government websites, recognised scientific organisations such as the CSIRO, acknowledged experts in the field, and respected news services such as the ABC and the BBC. (You might like to think about why this is advisable.)

- Information published by the Ontario Ministry of Agriculture and Food
- Wikipedia entry
- Data from walkinginfo.org
- How Stuff Works article

As you complete your investigation, each time you access an information source, add it to the table in question 16.

Question 1

For a typical 1 MW (megawatt) or bigger wind turbine in a wind farm, how many times on average do the blades rotate each minute? How high are the blades above the ground? What is their width and height?

Question 2

How many birds die each year from flying into buildings?

Question 3

How many birds die each year after being hit by a car?

Question 4

How many birds are killed each year by cats?

Question 5

How many birds are killed each year by wind turbines?

Question 6

How many pedestrians die each year in road accidents?

Question 7

Use this space to make research notes or record more questions.

Step 2: Think critically

Question 8

Should cars be banned because they accidentally kill pedestrians, birds and other animals such as kangaroos, foxes and rabbits? Are there any places where cars are banned?

Question 9

Should cats be banned? Are there any situations where cats are banned?

Question 10

Should some wind turbine farms be banned?

Question 11

Have your answers to these questions been influenced by your personal experiences or by the opinions of other people? How?

Question 12

What might be the consequences if no-one was allowed to have a car or to keep pet cats?

Question 13

What other facts might have helped you understand why the Minister made his decision?

Question 14

Is it likely that if this ban had been continued, the orange-bellied parrot would be saved from extinction?

Question 15

What might be the consequences if wind turbines were banned in Australia?

Question 16

Use the table below to collate a bibliography of the sources you have used when carrying out your research.

Author	Date	Title	Publisher

Question 17

What have you learnt by completing this activity?

Step 3: Summarise your opinion

Question 18

What recommendations would you have made to Senator Campbell at the time of his decision if you had known what you know now about the environmental impact of wind turbines?

Work Sheet 7: Case Study of the Waubra Wind Farm

KEY QUESTION

- Do wind turbines make people ill?

In 2009 a new wind farm near the town of Waubra, in rural Victoria, sparked heated debate about the effects of wind turbines on human health. Were the turbines making people ill?

In this activity you will watch two videos presenting different positions on the debate and then discuss them. There are questions below to guide your discussion.

Remember, in discussions:

- be respectful and let people have their say
- provide reasons for what you say
- it's OK to change your opinion when someone gives good reasons

Video 1

The ABC television current affairs program, Hungry Beast, produced the first video.

Wind Turbines (Hungry Beast)
https://youtu.be/Ck36mlkMeLU

What are your impressions after watching this video?

Question 1

The producers of this video weren't attempting to give a balanced overview of the issue at Waubra – they only set out to present the situation for two people.

Never-the-less, do you think the presentation is fair and even-handed, or do you think the producers were trying to manipulate viewers to take a particular view? Explain.

Question 2

After watching the video, do you have a view about the safety of the wind turbines at Waubra? Explain your reasons.

Video 2

The second video, *The way the wind blows*, was produced by an independent citizen, Neil Barrett, a former energy economist with the State Electricity Commission of Victoria. This is just a part of the video.

The way the wind blows
https://youtu.be/65xD7eZ4xHk

Question 3

As with the first video, Barrett isn't attempting to present both sides of the issue, and he says that his 'attempts to understand the complainants issues have not been very successful.'

But how would you answer the same question as above: do you think the presentation is fair and even-handed or do you think Barrett is trying to manipulate viewers to take a particular view?

Question 4

Has watching the video changed your views about the safety of the Waubra wind farm? Why or why not?

Question 5

Each video presents a different position about the safety of wind turbines, but could it be that everyone is just stating what is the case for *themselves*, and that when this is made clear there's no real disagreement about facts?

Question 6

What further questions do you think could be investigated to help come to a final decision about the safety of the Waubra wind farm?

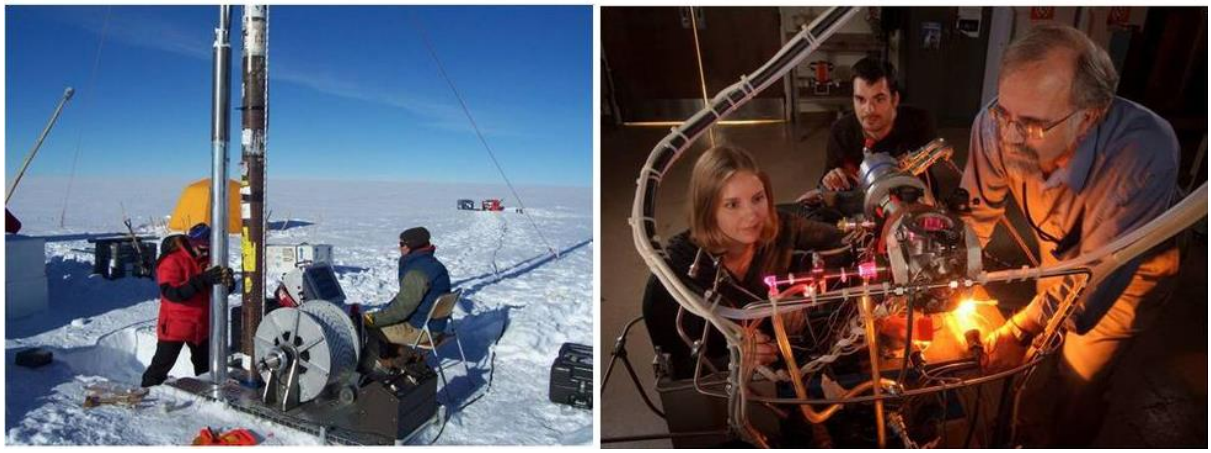
Self reflection

Question 7

Have you learned anything from the discussion of these videos, or perhaps even changed your opinion?

Describe how your knowledge or outlook has changed and the reasons for this, or why the points raised in the discussion didn't change your perspective.

HOW SCIENTISTS WORK



Scientists at work extracting (left) and analysing an ice core sample (right).

KEY QUESTIONS

- How do scientists go about designing their experiments?
- Which is more important for scientists –imagination or knowledge?
- Should scientists be allowed to conduct any experiment they want?
- Why should scientists' work be checked and evaluated?

Work Sheet 8: A Career in Renewable Energy

Introduction

There are countless careers to be had in renewable energies, more and more jobs are being created in the industry every year. These jobs range from working as a physicist in the Antarctic to communicating the latest scientific breakthroughs to the public.

The following video is a career profile on marine renewable energy engineer, Claire Legrand. Watch it before continuing with this activity.

http://www.stelr.org.au/career-videos/

Your task

In this activity you will be investigating the work of someone who works in renewable energy and write a career profile for that person. To do this you may use the internet, search science magazines, or even contact the person themselves - the choice is yours.

You can find sample career profiles of people working in the renewable energy industry on the STELR website.

Questions to Research

The information you find out should include, if possible, the questions in the left hand column of the following table. Use the right hand columns to keep track of your research information. Room has been left at the bottom for you to include any questions of your own.

	Question	Research Information	Reference
1	Name of the person being profiled		
2	Name of the organisation the person works for		
3	Brief description of what the organisation does		
4	Description of the position the person has in the organisation		
5	Subjects they studied at upper secondary school level		
6	Course(s) taken after leaving secondary school		
7	Duties involved in their job		
8	Why they chose this job		
9	The most enjoyable aspects of the job		
10	The challenges they face in the job		
11	How they think this job will change over the next decade		
12	Salary range of people working in this kind of job		

Your report

Include a variety of content such as images, a video, a written report, and so on. Present the findings of your report to your class before submitting it to your teacher.

Go to the Women in STEM website to get ideas about both written and video career profiles.

Women in STEM

https://stelr.org.au/womeninstem/

Use the space below to plan your report.

Career Profile: Angela Rozali

Senior Engineer – Renewable Energy

Who do you work for?

I work for AECOM in the Renewable Generation team of the Resources, Power and Industrial end market. AECOM is a global engineering consultancy firm that design, build, finance, operate and manage infrastructure projects for sectors such as power, transport, industrial, environment and buildings.

What does your job involve?

I'm focused on wind, solar and energy storage project development, which involves a range of activities such as climbing wind turbines, project management and energy generation modelling in PV systems. My job also involves energy advisory work, where we get to think big picture about the renewable energy industry such as understanding the impacts of distributed generation on the networks from a technical, regulatory and market perspective.

Why did you choose to work in the renewable energy industry?

Environmental sustainability is very important to me so working in the renewable energy industry aligned with my values because you get to actively transition Australia towards a low carbon future.

What do you enjoy most about your job?

I love seeing a renewable energy project get constructed and I particularly love climbing wind turbines because it's tough on the way up but the view from the top is always rewarding.

What has been one of your recent achievements?

At the beginning of the year, I was promoted to senior engineer so I'm thankful and proud that my achievements have been recognised.

What do you hope to do in the future?

In the future, I hope to be the lead owner's engineer for a wind farm project during construction. I've supported the owner's engineer role during development and construction on various wind farm projects but it would be great to have my own project.

What are some of the benefits that engineers have in their job?

Definitely the benefits are travelling and going out onto a construction site as well as attending professional development sessions like the Clean Energy Council's Wind Industry Forum.

What subjects did you study at the senior level of secondary school?

I studied French, Studies of Religion, advanced mathematics, advanced English, physics and chemistry in high school.

What training did you have to become an engineer?

Well, I actually studied chemical engineering and decided in my last year to become more mechanical to increase my chances of getting a renewable energy job so I took a few mechanical subjects and focused my thesis on solar thermal systems. Then, when I started in the AECOM Environmentally Sustainable Development team I was fortunate to have great mentors who taught me on the job how to interface with electrical, mechanical, civil, hydraulic and fire engineers on buildings projects which helped me transition into the Renewable Generation team.

How do you use mathematics in your job?

In my job, you need an understanding of where the sun is in the sky so I use a lot of geometry, Pythagoras' Theorem and trigonometry (I still use 'SOH CAH TOA' to remember the functions!). I also use mathematics with the help of excel spreadsheets to perform cost-

benefit analyses, to size up energy storage and solar systems, and to graph trends such as historical electricity prices.

What is your advice to students?

Give engineering studies a go because you learn life skills, which are applicable to a wide variety of jobs. You get more opportunities with an engineering degree so you have more choice of where you want to go even if it deviates from engineering. Some of my friends have gone to management consulting firms, banks, and even marketing.


ELLA GROSS
WATER DESIGN ENGINEER
JACI BROWN
MATHEMATICIAN & DIGITAL AGRICULTURE
NIKI ROBINSON
ENVIRONMENTAL ENGINEER & WATER REGULATION
SARAH LAST
BIOLOGIST, INVENTOR & ENTREPRENEUR
SHEENA ONG
RENEWABLES ENGINEER
SONJA BASSON
ELECTRICAL & ELECTRONIC ENGINEER
VANESSA RAULAND
SUSTAINABILITY & RENEWABLES ADVOCATE
ANJALI JAIPRAKASH
ROBOBIOLOGIST
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BIOPHYSICIST, INVENTOR & ENTREPRENEUR
MARIANNE FOLEY
FIRE SAFETY ENGINEER
PIA WINBERG
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VIDEO PROFILES OF WOMEN IN STEM CAREERS AND ENTREPRENEURSHIP
View them all at www.stelr.org.au/WomenInSTEM
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STELR
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