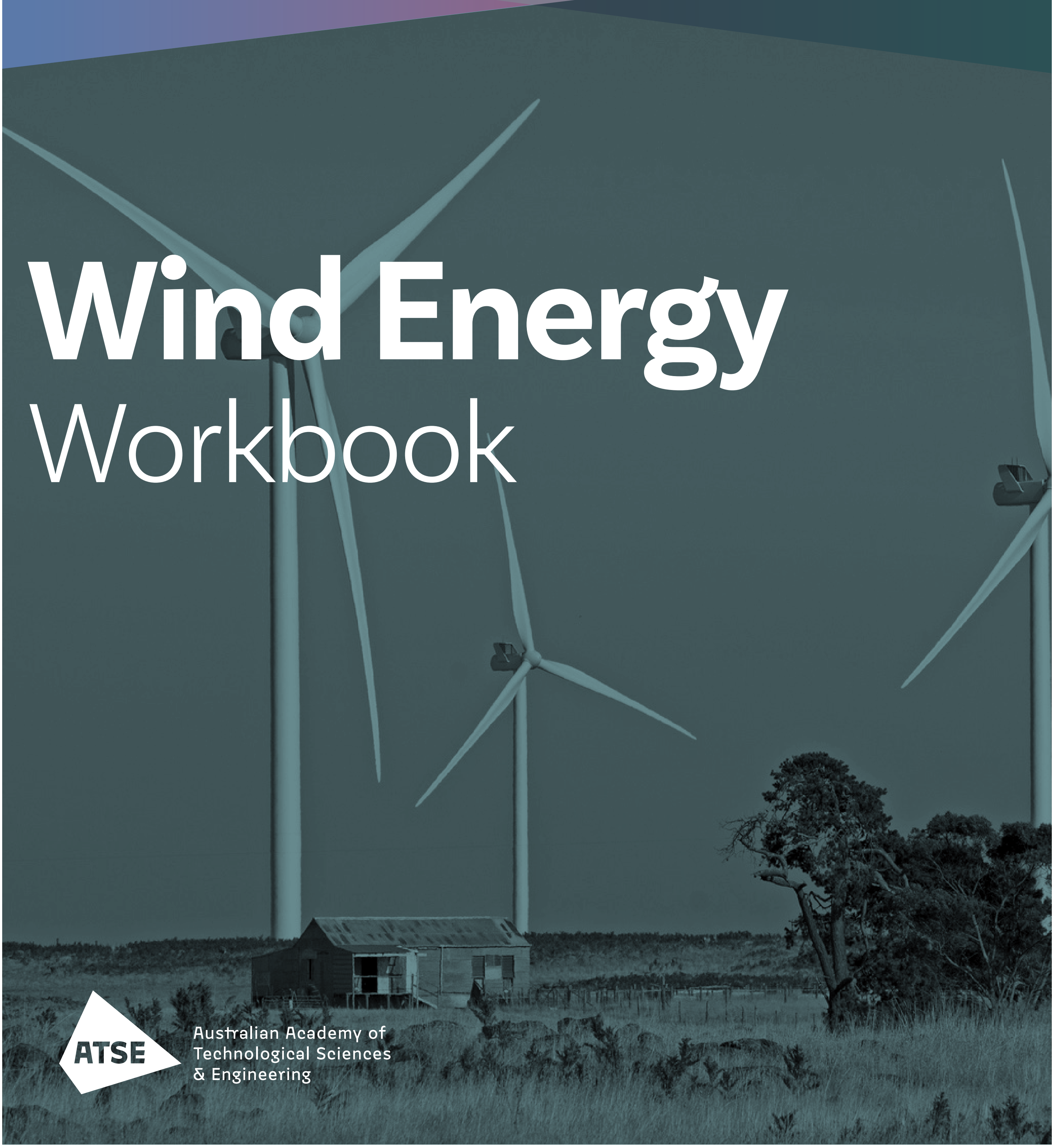
STELR

SCIENCE

8

Wind Energy

Workbook



ATSE
Australian Academy of Technological Sciences & Engineering

ATSE Fellow Fact File

Professor Paul Simshauser

AM FTSE

CEO | Iberdrola Australia

"Having the next generation of students engage with Australia's energy future is essential to the energy transition facing our country. This STELR resource introduces students to wind turbines through engaging, hands-on learning that builds an understanding of renewable energy concepts, and their real-world applications."

Professor Paul Simshauser is a leading energy economist, with a remarkable record of achievement across government, academia and industry. He is professor at Griffith University's Centre for Applied Energy Economics and Policy Research, publishing widely on renewable electricity, energy hardship and climate policy.

He is also chief executive of Powerlink, Queensland's electricity transmission network operator. In this role, he is translating research into reality as he leads Queensland's transition to a low-carbon, clean-energy future, while ensuring positive social and economic outcomes.

His insightful research into important energy transition questions, and ability to navigate the commercial and political implications of his work, make him a trusted adviser to the Australian and Queensland governments.

What are some of the main factors we need to consider as we continue to adopt and develop new or enhanced ways of capturing and storing energy?

- **Economic:** each technology's cost and possible contribution to a reliable, affordable and efficient power system
- **Environmental:** ensuring technologies reduce emissions and are sustainable over the long term
- **Social:** managing impacts on communities through formal assessment and benefit frameworks
- **Ethical:** access to energy, responsible development, and long-term impacts across communities
- **Broad societal impact:** regulatory, safety, and lifecycle (design, operation, and decommissioning) to ensure planned technology deployments are accepted

AC9S8H03
Examine how proposed scientific responses to contemporary issues may impact on society and explore ethical, environmental, social and economic considerations

What are some of the main challenges you see in people's perceptions of new energy technologies and projects, and how can science communication address these challenges?

Challenges often arise from concerns about local impacts, environmental risks, and/or a lack of understanding of how a technology works or forms part of a broader portfolio of technologies. Science communication plays a critical role in addressing these challenges by providing clear, evidence-based information that helps improve understanding of technologies and their impacts. Ongoing engagement helps build trust and ensure decision-makers and stakeholders are armed with accurate, and accessible information.

AC9S8H04
Explore the role of science communication in informing individual viewpoints and community policies and regulations

ATSE STELR

SCIENCE | TECHNOLOGIES | NUMERACY | ENGINEERING | EXPERIMENTS












CONTENTS

15 years of inspiring students to pursue STEM careers

STELR is a STEM in schools initiative from the Australian Academy of Technological Sciences & Engineering

Hands-on kits
Purchase our STELR Energy kits that support this resource.
shop.stelr.org.au

STELR Science — Year 8 Wind Energy
Written and produced by the STELR team at the Australian Academy of Technological Sciences & Engineering.
www.atse.org.au/STELR

STELR
Australian Academy of Technological Sciences and Engineering
Level 2, 28 National Circuit Forrest ACT 2603
atse.org.au/stelr

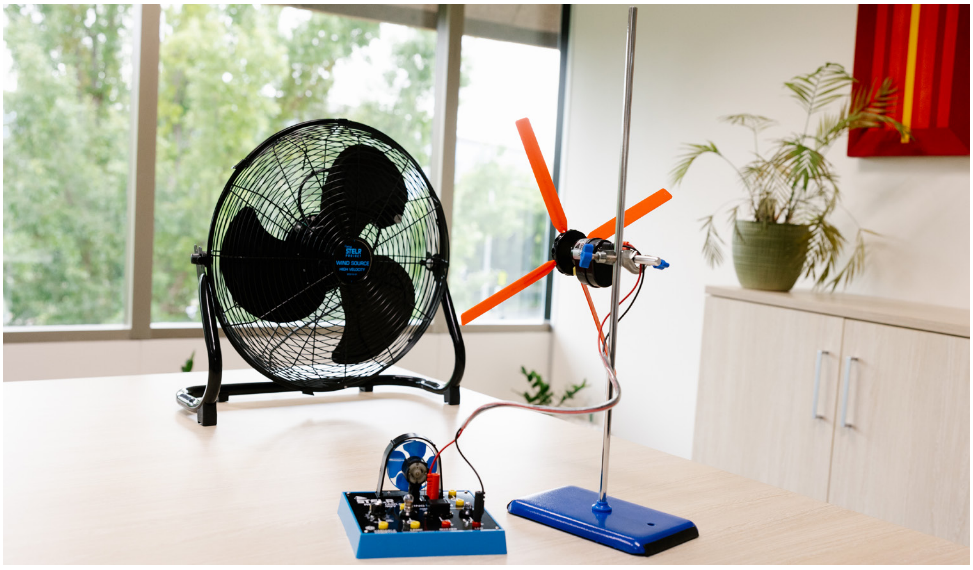
INTRODUCTION

Capturing kinetic energy from the wind is not a modern concept, with the first evidence of humans capturing energy from the wind coming from Ancient Egypt around 3200-3000 BCE where ancient peoples used sails to capture wind and power boats. Even windmills themselves are not modern concepts, with vertical-axis windmills used as far back as 7th-9th century Persia (modern day Iran) to grind grain and pump water for irrigation. In Australia, windmills have been used since the early 1800s for grinding grain, but also in rural Australia for pumping water from underground bores to support sheep and cattle stations in dry regions.

Image: Australian windmill in Cowra, NSW (Source: Wikimedia Commons)

Today, we still use wind energy for many of these things, but by far the most widespread use of wind energy in modern society is the generation of electricity. If you wish to transform the energy from the wind into electricity, you want machines that do this as efficiently as possible – at least, within your cost limits.

Many factors contribute to the efficiency of wind turbines, including their size and location, the number being used together, and their design features such as blade size, shape, angle or number of blades. You can explore a number of these factors and their impact on how well the wind turbine captures and transforms wind energy into electricity using the STELR Wind Energy Kit.



ACTIVITY 1

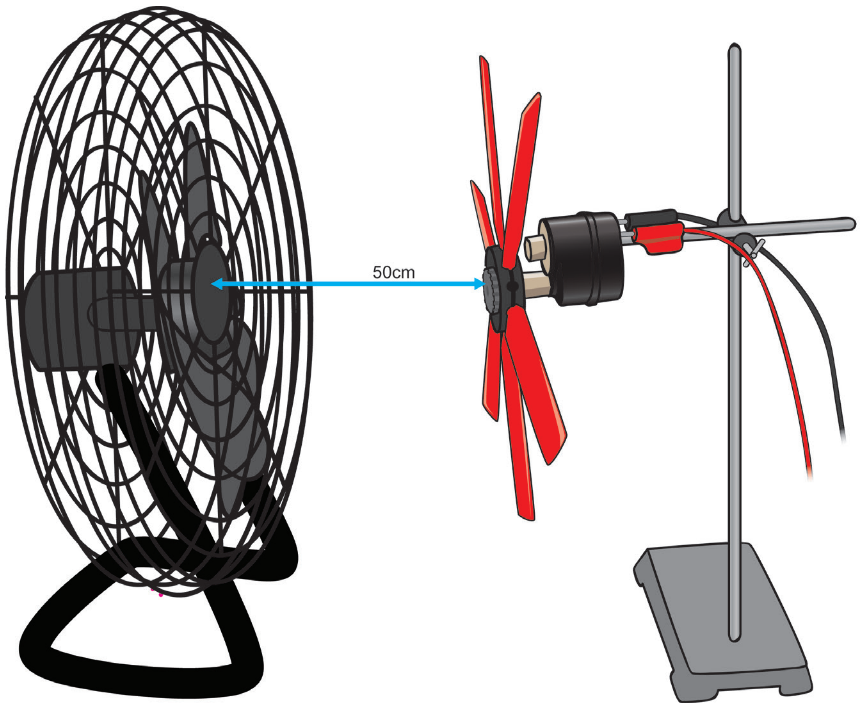
Investigating blade angle

What you need

- STELR testing station
- 1 x STELR multimeter
- Sets of red, blue and yellow blades
- Turbine hub
- STELR model wind turbine
- Connecting leads
- High-speed electric fan
- Tape measure
- STELR hub protractor

What to do

Set up the wind turbine and high velocity floor fan 50cm apart - **do not change the distance**. Secure the STELR wind turbine to the retort stand and make sure that the hub is fitted tightly in the lower socket of the hub.



Inquiry question

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

Question 1.1

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. **This will be your hypothesis**.

Explain why you think this.

TESTING TWO BLADES

Use **TWO** red blades, which are 15 cm long. Make sure the blades are tight in the hub of the turbine and are both at 45° to the face of the hub by using the STELR protractor to measure their position.

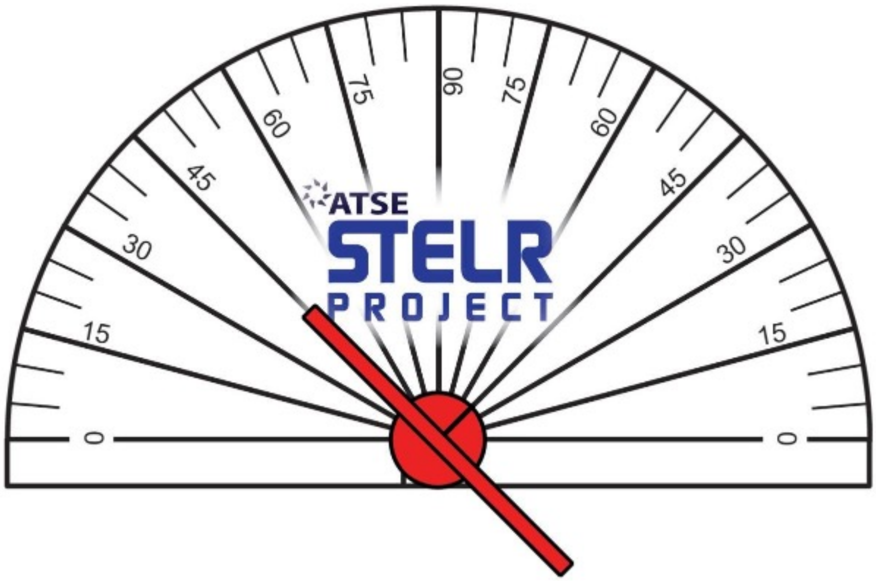
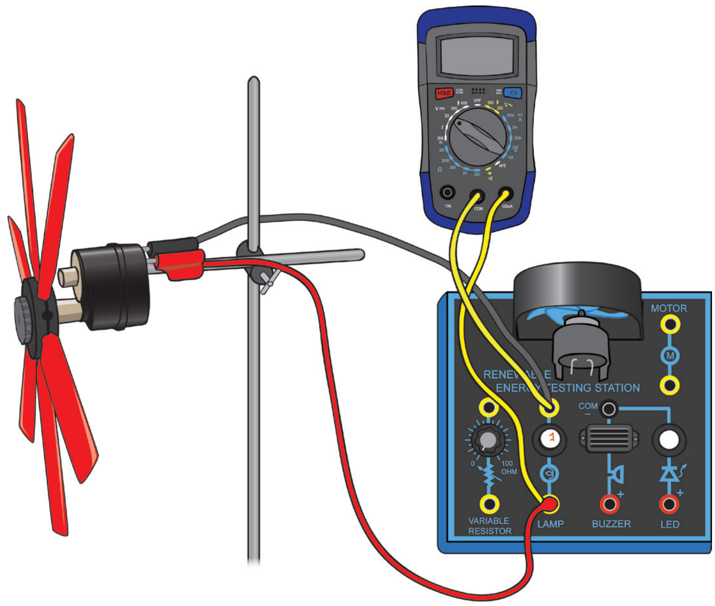
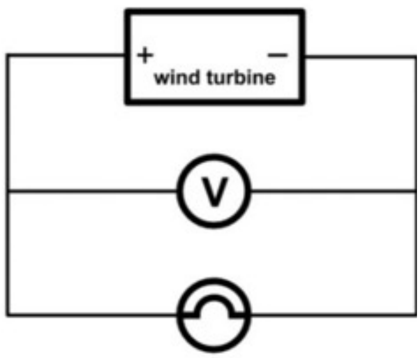


Figure 1 - Using the STELR protractor, place it around the base of the blade and look from the top of the blade down to measure the angle. The protractor should be lined up so that the bottom of the protractor is in line with the back of the hub

Setup

Set the wind turbine up in a circuit with the testing station by connecting the wires to the yellow connectors of the LAMP on the testing station. To be able to measure the voltage, you will then connect the multimeter into the cables you just connected from the wind turbine into the LAMP as shown below. This is called a **parallel circuit** and is the way to properly measure the voltage across the lamp on the testing station.





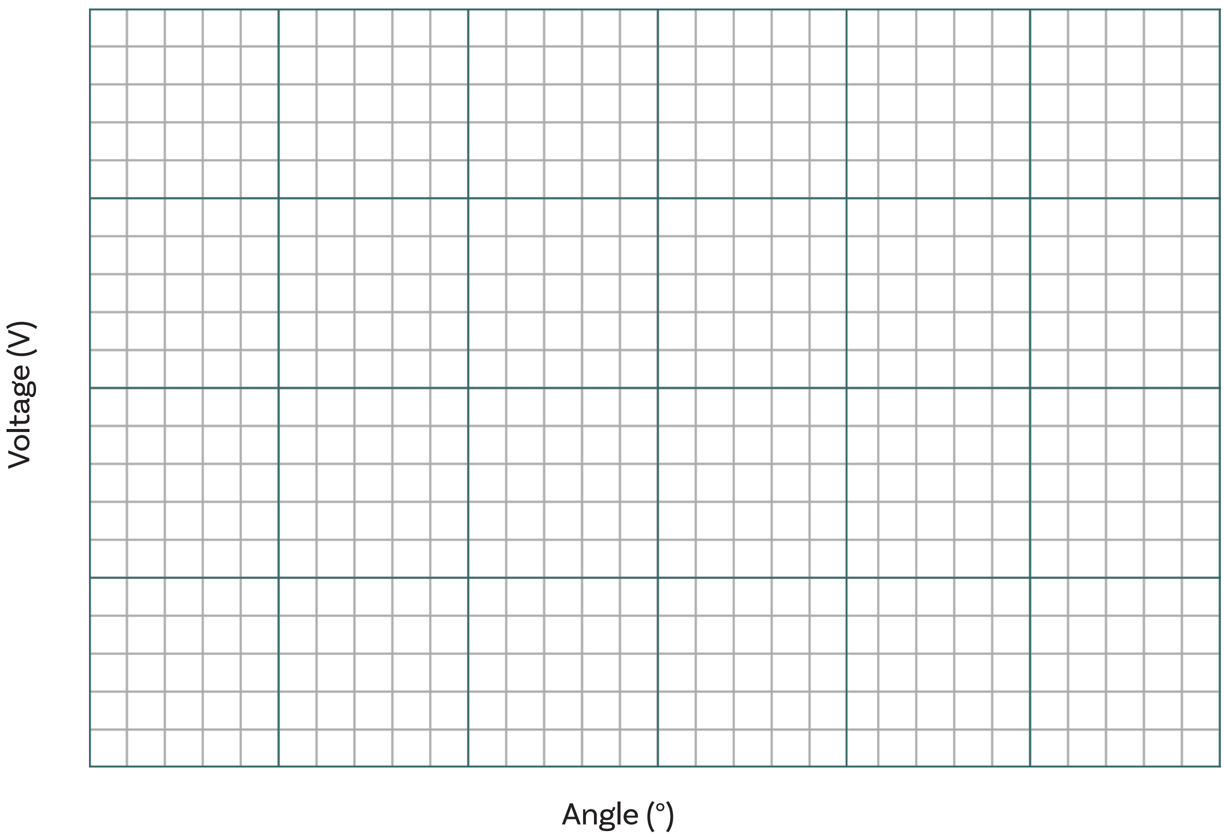
Question 1.2

Turn the fan onto the highest setting, measure the voltage for the fan blades set at 45° and record your results in the table below. Adjust the angle of the blades and repeat this step of measuring and recording the voltage for each of the angles in the table.

Angle of Blades	Voltage produced (V)
0°	
15°	
30°	
45°	
60°	
75°	
90°	

Question 1.3

Draw a graph of the voltage produced at different angles of the blades



Question 1.4

What do you think would have happened to the voltage produced by the turbine if the fan had been set at the medium setting instead of the high setting?

Question 1.5

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

Question 1.6

Identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 1.7

List the variables that you kept the same when you performed the investigation.

Question 1.8

In conclusion, what is the best angle for two blades on a wind turbine to generate the most voltage?

ACTIVITY 2

Investigating blade length

What you need

- STELR testing station
- 1 x STELR multimeter
- Sets of red, blue and yellow blades
- Turbine hub
- STELR model wind turbine
- Connecting leads
- High-speed electric fan
- Tape measure
- STELR hub protractor

What to do

Set up the wind turbine and high velocity floor fan 50cm apart - **do not change the distance**. Secure the STELR wind turbine to the retort stand and make sure that the hub is fitted tightly in the lower socket of the hub.

Inquiry question

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

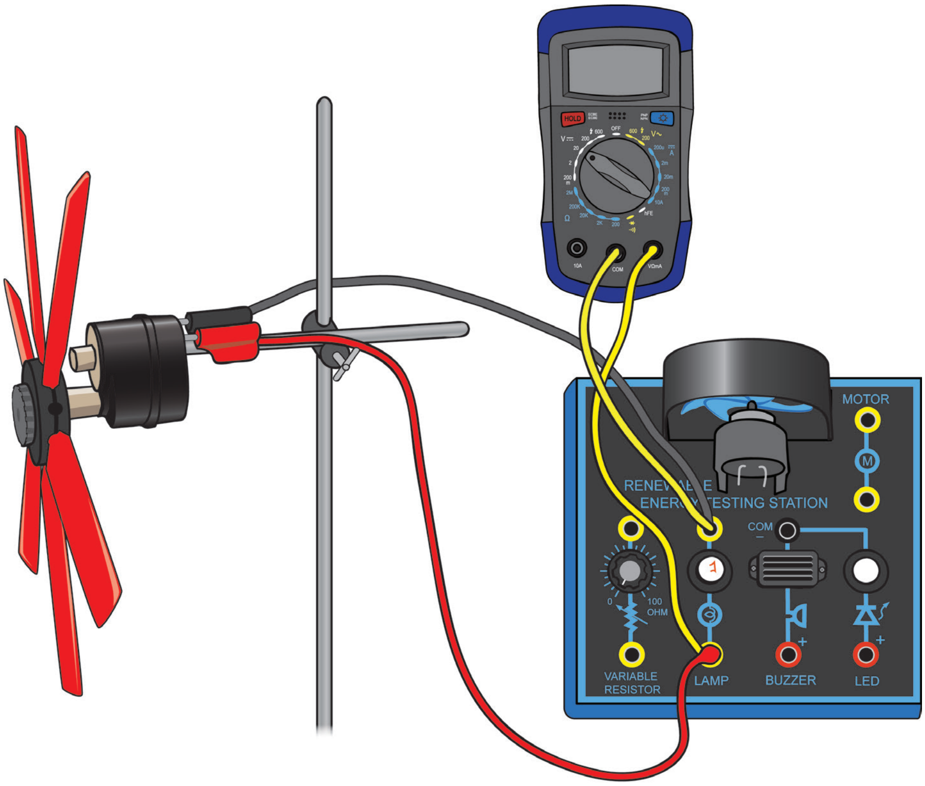
Question 2.1

What blade length do you think will give the biggest voltage? **This will be your hypothesis.**

Why do you think this?

SETUP

Set the wind turbine up in a circuit with the testing station and multimeter the same as you did in Activity 1. Install 2-4 blades on the hub **spaced evenly around the hub** and set them to the optimum angle you found during Activity 1. Make sure you keep the number of blades and angle of blades consistent in each experiment, you are only changing the size of the blades used. Don't mix and match.



Question 2.2

Turn the fan onto the highest setting, measure the voltage for each of the three sizes of fan blades and record your results in the table below

Blade colour	Blade length (cm)	Voltage produced (V)
Yellow	7.5	
Blue	10.0	
Red	15.0	

Question 2.3

Draw a graph of the voltage produced at different lengths of the blades

Voltage (V)

Blade Length (cm)

Question 2.4

How reliable do you think your results are? Discuss.

Question 2.5

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

Question 2.6

In conclusion, what is your answer to the inquiry question that this investigation explores?

ACTIVITY 3

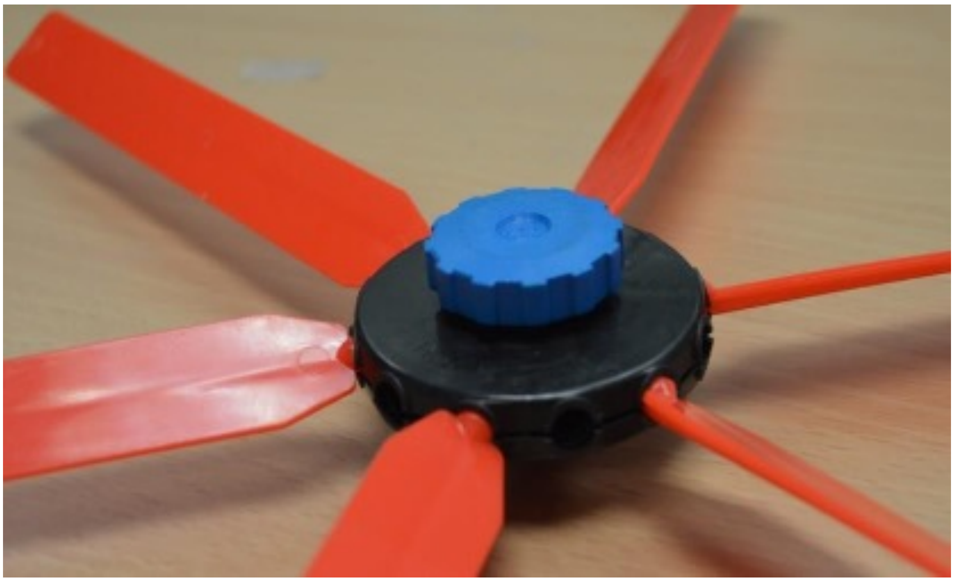
Investigating number of blades

What you need

- STELR testing station
- 1 x STELR multimeter
- Sets of red, blue and yellow blades
- Turbine hub
- STELR model wind turbine
- Connecting leads
- High-speed electric fan
- Tape measure
- STELR hub protractor

What to do

Set up the wind turbine and high velocity floor fan 50cm apart - **do not change the distance**. Secure the STELR wind turbine to the retort stand and make sure that the hub is fitted tightly in the lower socket of the hub.



Inquiry questions

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

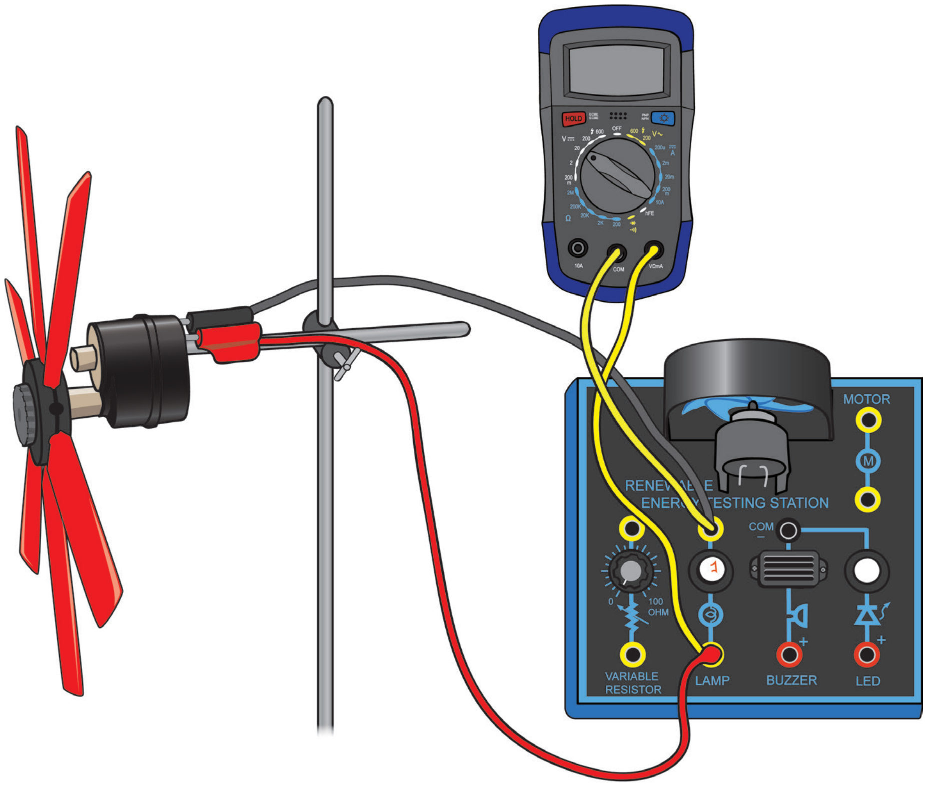
Question 3.1

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you change the number of blades. **This will be your hypothesis.**

Explain why you think this

PART A - TEST WITH SIX BLADES

Make sure the six blades are tight in the hub of the turbine and are all at 45° to the face of the hub, like those in previous activities. Set the wind turbine up in a circuit with the testing station and multimeter the same as you did in Activities 1 and 2.



Question 3.2

Turn the fan onto the highest setting, measure the voltage for each of the three sizes of fan blades and record your results in the table below. **It's important to make sure the blades are spaced evenly around the hub.**

Colour of blades	Number of blades	Voltage produced (V)
Yellow	6	
Blue	6	
Red	6	

PART B - TEST WITH OTHER NUMBERS OF BLADES

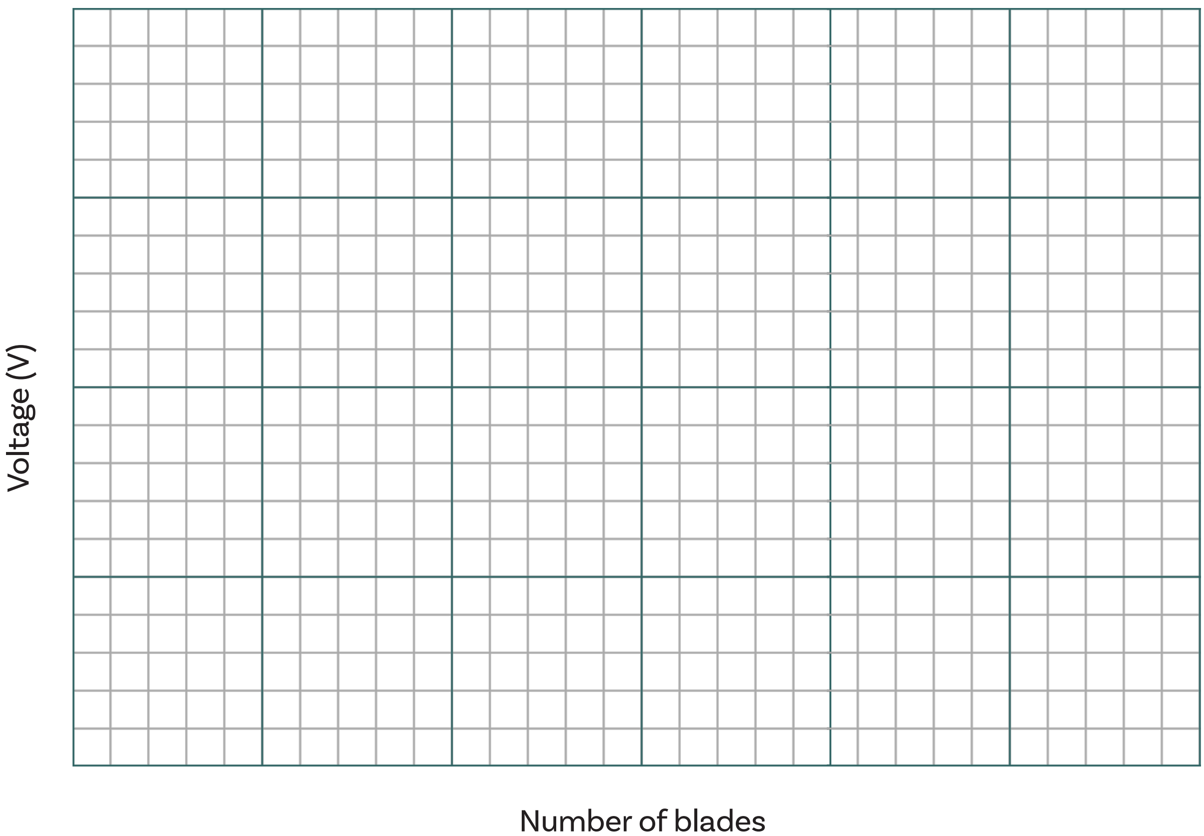
Question 3.3

Repeat your experiments for the range of different blade sizes and record your results in the table below. Ensure you keep all blades at 45°.

Number of yellow blades	Voltage produced (V)	Number of blue blades	Voltage produced (V)	Number of red blades	Voltage produced (V)
2		2		2	
3		3		3	
4		4		4	
8		8		8	
10		10		10	
12		12		12	

Question 3.3

Combining these results with the results found in question 3.2, graph all your findings on the graph grid below.



Question 3.4

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 your prediction was or was not correct.

Question 3.5

List the variables that were kept the same as you performed each investigation.

Question 3.6

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

Question 3.7

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

Question 3.8
Suggest two reasons why large wind turbines usually have three blades.

CONCLUSIONS

What are your answers to the three inquiry questions?

Inquiry question 1
What voltage can be delivered by a STELR model wind turbine operating with six blades?

Inquiry question 2
What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?

Inquiry question 3
How many blades give the greatest voltage?