Renewables – energy and efficiency

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Researching Physics

Higher

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Researching Physics Renewables – energy and efficiency

Contents

Advice to students

Page 3 Overview of the unit and activities

Page 4 Organising your work and carrying out the activities

Page 5 Assessment issues

Web-based research briefs

Page 6 Initial research activity - Renewables – how much do they contribute?

Page 7 Research activity 1 - Wind turbines – how do they work?

Page 8 Research activity 2 - Solar panels – how do they work?

Practical investigation briefs

Page 9 Practical activity 1 - Wind turbines – number of blades and power

Page 10 Practical activity 2 - Wind turbines – blade angle and power

Page 11 Practical activity 3 - Solar cells – angle of incidence and power

Page 12 Practical activity 4 - Solar cells – irradiance and power

Page 13 Notes for teachers and technicians

Higher Physics

Researching Physics Renewables – energy and efficiency

Overview of the unit and activities.

What is involved in the unit 'Researching Physics'?

Studying physics involves learning physics facts and concepts. It also involves developing particular skills. These include research skills, which may involve you in doing investigative experiments or researching information, perhaps from the internet. The aim of this unit is to help you develop these physics skills. You will learn some physics facts, probably in some depth, however it is the development of skills which is the focus of the unit.

What physics content will I be learning?

The context for your work is renewable sources of energy.
Our ever-increasing use of technology demands a huge supply of energy and we have devised many ways to supply this energy.
A lot of research is being undertaken to develop sustainable sources of energy, that is, sources that will not run out. These are **renewables**.
Hydroelectric, solar, wind and tidal power are examples of renewable energy sources. In this unit, you will carry out research and an investigation into solar or wind power.

What activities will I be doing?

There are three types of activities in the unit.

Undertaking literature based research is a hugely important skill. In this unit, this is best carried out as web-based research. It is easy to simply look up a single fact on the internet, but undertaking a more structured project is more complex. Sifting through what is often a large amount of data is demanding. Keeping track of what you are trying to find out is one of the most difficult parts of this type of research, and summarising what you have found, without merely cutting and pasting someone else's work is also challenging. There are several research briefs which can be used in preparation for your investigation.

Investigative practical work can be fun and challenging. Planning and designing experiments is often the hardest part of this work. Actually carrying out the experiment may be straightforward. The experiments you are likely to carry out in your investigation are not the kind where you can simply look up the results beforehand. There may be no right or wrong answers. What you find is what you find and your way of doing the experiment may not be similar to others in your class.

Scientific communication is hugely important. It does not matter how interesting or ground breaking your work is; if you cannot communicate your results then you have not completed your work.
Information from your web research and data from your practical work will contribute to an assignment that you will complete under supervised conditions. This assignment is assessed externally by the SQA. You can pass this unit without completing the assignment, but you cannot get an overall course award in Higher Physics without doing so.

Organising your work and carrying out the activities

How will I organise my work?

Some of the work you carry out in this unit will be in preparation for your research into solar or wind power. When you carry out the research activities themselves, it is likely that you will be responsible for organising your work.

You are required to produce a report on the results of a piece of web-based research, and you may produce a report of your practical investigation. You are strongly advised not to produce these “as you go along”. Rather, it is very good practice to maintain a diary, or record of work. This should record all your experimental results, ideas, problems you met, references and all the other day to day observations and data that you want recorded. The record of work is your record and as such it should be in a format that suits you. However, experience shows that students who organise their work for ease of reference are likely to be able to extract the information more easily and the resulting reports are likely to be easier to produce.

Will I do the same work as everyone else in my class?

This material includes a number of web-based research and practical investigation briefs. It is likely that students within the same class will be allocated different activities, depending on resources available and other classroom management issues.

What about teamwork?

It is probable that you will undertake some of the work as part of a group. Sometimes, within your team, you will be undertaking the same task and other times you will each focus on a different part of the task. In either case, it is important that discussion takes place. Agree the part that each member of the team will play and ensure that there is time to share the results of the work.

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Researching Physics Renewables – energy and efficiency

Assessment issues

What do I have to do to pass this unit?

As you work on this unit, you will carry out activities which develop your skills in undertaking research in physics.
Two of the activities contribute to the unit assessment. To be awarded the unit, you need to demonstrate that your work is of at least the required standard in each of the two types of activity.
The two types of activities are:

- Undertaking web based research
- Carrying out investigative practical work - you need to take an active part in planning and carrying out an investigation.

Do I need evidence?

For the web based research, you should ensure that you retain evidence that your work is of the required standard. Each year SQA will ask to see the evidence from a number of candidates. This process is easiest to manage if your evidence is stored in an e-portfolio. You can store text based work, together with pictures, web pages, and any other material which you wish to present as evidence. If you do not use an e-portfolio, you should ensure that your evidence can be easily accessed.

What about assessment in the Higher Physics exam?

The Higher unit - Researching Physics is available as a free standing unit. It is also a required unit for a course award in Higher Physics. There will not be any questions in the Higher Physics course assessment which specifically relate to the topic of this unit. However, there will be questions in the course assessment which relate to the skills that you have developed in the unit. The following are the skills which may be assessed in the course assessment:

- Selecting information from texts, tables, charts, graphs and diagrams,
- Presenting information in a variety of forms,
- Processing information,
- Planning and designing an experiment,
- Evaluating experimental procedures,
- Drawing conclusions and making predictions based on evidence provided.

Higher Physics

Renewables – energy and efficiency

Initial Research Activity

Renewables – how much do they contribute?

Research Brief

Modern society is energy hungry. Our use of technology demands a huge supply of energy and we have devised many ways to supply this energy. Fossil fuels, including coal, oil and gas, provide a significant proportion of our energy requirements in this country. However, these energy sources are not sustainable. There is a limited supply of fossil fuels and we will eventually run out of them. Although the supplies of nuclear fuel can potentially last much longer, they too will eventually run out.
A lot of research is being undertaken to develop sustainable sources of energy, that is, sources that will not run out. These are **renewables**.
Hydroelectric, solar, wind and tidal power are examples of renewable energy sources.

In this initial research activity you will find out some background information about wind and solar power.

In carrying out your research you should answer the following questions.

- How much energy is used in the UK – on average, per hour/day/week?
- What proportion of energy is currently produced from non-sustainable sources?
- What proportion of our energy requirements could be provided by solar and/or wind power?
- How much does it cost to produce energy from each of the different sources? Remember to take into account capital costs as well as running costs.
- What are the environmental issues related to solar and wind power?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

If you work as part of a team that produces one report, you should include a short statement at the end of the report that indicates which part of the work you were responsible for.

Higher Physics

Renewables – energy and efficiency

Research Activity 1

Wind turbines – how do they work?

Research Brief

Wind turbines are a common sight in our countryside and in some inland sea areas. We usually see them from some distance but when they are viewed from up close, it is perhaps surprising how big they are.
Modern wind turbines are sophisticated machines. Their blades have been very carefully designed for optimum performance and the electrical generator is made to be as efficient as possible.

In carrying out your research you should answer the following questions.

- Wind turbines are often built in inaccessible places. How do they get there?
- What is the relationship between the speed of the wind and the energy produced by a wind turbine?
- What are the minimum and maximum wind speeds that can generate useful energy?
- The shape of wind turbine blades is quite complex. How are they designed for optimum performance?
- What is the efficiency of a wind turbine? (i.e. useful energy output as a proportion of energy input)
- How is the rotation of the blades converted into electrical energy?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

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Higher Physics

Renewables – energy and efficiency

Research Activity 2

Solar panels – how do they work?

Research Brief

A solar cell (or photovoltaic cell) is a device that converts light energy directly into electrical energy. A solar panel is a group of solar cells used to convert sunlight into electrical energy. Solar panels are now quite commonly seen on the roofs of buildings where a proportion of the electricity used within the building is produced by the solar panel.

In carrying out your research you should answer the following questions.

- Solar panels are expensive to produce. However, the cost has reduced in recent years. How expensive are they, and by how much have costs reduced?
- What is the photovoltaic effect?
- What is the relationship between the amount of sunlight falling on the solar panel and the electrical energy produced?
- Solar panels are normally installed on the roof of a building. How does the direction in which the roof faces, and the angle of the roof affect the energy output?
- What is the efficiency of a solar panel? (i.e. useful energy output as a proportion of energy input)
- What is the relationship between climate and the energy output of solar panels?

Answer the questions by carrying out research. It is probable that this is best undertaken using web-based research. You are advised to have completed an activity in which you consider the issues of undertaking web-based research. This may have been done during your work on other units in Higher Physics.

You may work individually or as part of a team.

Produce a report of your findings. This may be hand written, printed or electronic and saved in an e-portfolio.

If you work as part of a team which produces one report, you should include a short statement at the end of the report that indicates which part of the work you were responsible for.

Higher Physics

Renewables – wind turbines

Practical Activity 1

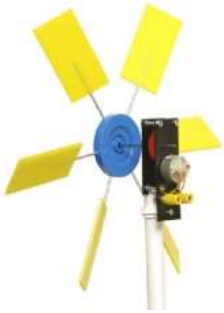
Number of blades and power

Investigation Brief

The blades used on modern wind turbines are very sophisticated (and expensive). Their shape is carefully designed to extract as much energy from the wind as possible. Many wind turbines have three blades and some have only two. You may see some with more than three.
A wind turbine is designed to transfer the kinetic energy of the wind to electrical energy.
Designers need to consider the number of blades they will use in their wind turbine.

The aim of this investigation is find how the number of blades affects the power output of a wind turbine.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you think is the relationship between the number of blades on the wind turbine and the power output?



Investigation Notes

You will need to use a model of a wind turbine that can be used with a different number of blades. An air blower or a steady wind can be used to make the wind turbine rotate. The power output will need to be measured.
Questions for consideration:
How strong should the wind or air flow be?
What is the maximum and minimum number of blades that can be used?
Should the wind turbine be connected to an electrical load?
How will you measure the power output?
Does the mass of the blades matter? Do you get the same results with blades that have a greater mass?
What will you do to control all the other variables in the investigation?
How will you present your findings?
What conclusions can you draw based on your results?

Higher Physics

Renewables – wind turbines

Practical Activity 2

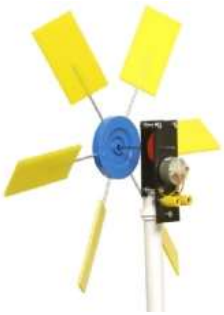
Blade angle and power

Investigation Brief

The blades used on modern wind turbines are very sophisticated (and expensive). Their shape is carefully designed to extract as much energy from the wind as possible. The angle that the blades make with the direction of rotation is called the pitch (sometimes called the angle of attack). A wind turbine is designed to transfer the kinetic energy of the wind to electrical energy. Designers need to consider the pitch (angle) of the blades they will use in their wind turbine to transfer the most energy.

The aim of this investigation is find how the pitch of the blades affects the power output of a wind turbine.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work. What do you think is the relationship between the pitch of the blades on the wind turbine and the power output?



Investigation Notes

You will need to use a model of a wind turbine that has blades that can be set at a different pitch. An air blower or a steady wind can be used to make the wind turbine rotate. The power output will need to be measured.
Questions for consideration:
How strong should the wind or air flow be?
How will you measure the pitch of the blades?
Should the wind turbine be connected to an electrical load?
How will you measure the power output?
What will you do to control all the other variables in the investigation?
How will you present your findings?
Why do the blades rotate when a wind blows on them? Think about the forces acting on the blades.
Why don't the blades keep accelerating? What determines the steady state rate of rotation of the wind turbine? Remember that air resistance increases when something moves faster through the air.
What conclusions can you draw based on your results?

Higher Physics

Renewables – solar cells

Practical Activity 3

Angle of incidence and power

Investigation Brief

Solar panels that are used to produce electrical energy are made of groups of solar cells. The properties of a solar panel can be investigated by using a single solar cell.
Solar panels are usually mounted on the roof of a building, to keep them out of the way and to position them up high so that they receive at much sunlight as possible. The roofs of most buildings slope so that the solar panels are mounted at an angle to the sunlight.
The position of the sun in the sky also changes during the day so that the angle the sunlight makes with the solar panel.
For both these reasons, the angle that the sunlight makes with the solar panel is rarely at ninety degrees.

The aim of this investigation is to use a solar cell and a light source to investigate how the electrical energy produced by the solar cell depends on the angle the incident light makes with the solar cell.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work.
What do you predict will happen to the energy output as the angle of the incident light changes?

Investigation Notes

You will need to measure the energy output of a solar cell.
A suitable light source will be required.
Questions for consideration:
How intense should the light source be?
How will you ensure the intensity of the light source remains constant?
Should the solar cell be connected to an electrical load?
How will you measure the energy output of the solar cell?
How will you measure the angle that the incident light makes with the solar cell?
What will you do to control all the other variables in the investigation?
What can you do to reduce the uncertainties in your measurements?
How will you present your findings?
What conclusions can you draw based on your results?
What is the mathematical relationship between the angle of the incident light and the energy output? (You may find it useful to draw a diagram, perhaps simplified so that it shows a side view only.)

Higher Physics

Renewables – solar cells

Practical Activity 4

Irradiance and power

Investigation Brief

Solar panels that are used to produce electrical energy are made of groups of solar cells. The properties of a solar panel can be investigated by using a single solar cell.
Solar panels are usually mounted on the roof of a building, to keep them out of the way and to position them up high so that they receive at much sunlight as possible.
The power of electromagnetic radiation that falls on each square metre of a solar panel is called the irradiance (measured in Wm^{-2}).
The irradiance incident on a solar panel changes as the position of the sun changes in the sky and as clouds pass in front.

The aim of this investigation is to use a solar cell and a light source to investigate how the electrical energy produced by the solar cell depends on the irradiance incident on the solar cell.

Discuss how you will carry out the investigation.
Write your plan in your record of work.
You should also include an hypothesis in your record of work.
What do you predict will happen to the energy output as the irradiance changes?

Investigation Notes

You will need to measure the energy output of a solar cell.
A suitable light source will be required.
Questions for consideration:
How intense should the light source be?
How will you measure the irradiance of light incident on the solar cell?
Should the solar cell be connected to an electrical load?
How will you measure the energy output of the solar cell?
What will you do to control all the other variables in the investigation?
What can you do to reduce the uncertainties in your measurements?
How will you present your findings?
What conclusions can you draw based on your results?

Further notes:
The relationship between irradiance, intensity, brightness and illuminance is complex. You should not get too concerned about the differences. However, you may like to consider that most light meters measure brightness in lux, which is one lumen per square metre. This is used to measure the intensity of light as perceived by the human eye. It is weighted at each wavelength according to how the eye perceives the brightness. Irradiance weights all wavelengths equally.
You may recall that irradiance depends on the distance from a light source. However, you may also recall that the formula assumes the light comes from a point source.

Wind turbines

A number of model kits are available that are suitable for the investigation. The SEP wind turbine 211-010 and the wind turbine kit from IDS Education (PH1000240) are shown.
The number of blades and the pitch of the blades can be varied with each.
A 1 k resistor is suitable as a load and the power output can be determined by measuring voltage and current.
A steady “wind” can be used with an air blower.
An extension to the first investigation is to make the blades heavier. It then becomes that much more obvious that simply doubling the number of blades does not double the power output.
The variation of blade angle with power is somewhat more complex than might be thought at first. Students may have difficulty explaining why there is an optimum angle for highest power output.