Energy

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Energy

Syllabus outcomes addressed:

Science understanding

Some of Earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

- considering what is meant by the term 'renewable' in relation to the Earth's resources
- comparing renewable and non-renewable energy sources, including how they are used in a range of situations

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155)

- recognising that potential energy is stored energy, such as gravitational, chemical and elastic energy
- investigating different forms of energy in terms of the effects they cause, such as gravitational potential causing objects to fall and heat energy transferred between materials that have a different temperature
- recognising that heat energy is often produced as a by-product of energy transfer, such as brakes on a car and light globes
- using flow diagrams to illustrate changes between different forms of energy

Science as a Human Endeavour

Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119) (ACSHE134)

Science Inquiry Skills

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126) (ACSIS141)

Task

Students work through a series of questions outlined below. This will involve watching some videos, working through some interactives and extracting material from written work.

By the end of this unit, students should have a better understanding of energy, its forms and what we use it for. The unit allows students to look at technologies and how they help us understand the workings of items.

QUESTION 1: What is energy?

This can be a confusing concept, as we know we need it, use it and can see what it does, but actually putting it in words can be a little tricky.

(Watch the following video: https://youtu.be/CW0_S5YpYVo)

1. Define Energy
2. Name some types of energy
3. State the conservation of energy

QUESTION 2: Where can we get it from?

Broadly speaking, we can get energy from 2 sources: renewable and non-renewable energy.

(Watch the following video: https://study.com/academy/lesson/what-is-a-renewable-energy-source-definition-example-quiz.html)

1. What makes something a renewable energy?
2. List advantages and disadvantages of renewable and non-renewable energy.
3. Why are renewable energy sources so important?

QUESTION 3: What do we use it for?

1. Make a list of what you use energy for.

QUESTION 4: Storage of Energy

Also known as *potential energy,* stored energy allows us to make sure energy is available whenever we need it. The energy that we use usually comes in the electrical form. We plug something in and it works. But how can we make sure it is always there when we need it? This is where storage devices come in.

1. Make a list of different ways that electrical energy can be stored

Different storage devices are needed because we use energy for such different things. Some batteries are needed to be long terms storage. They need to power a device for a long time without failing e.g. a watch.
This link allows you to see which battery is best for different situations.
Traditional batteries work on *chemical potential energy*.

But what if you want to want something to charge quickly and discharge quickly. Eg. To power the initial acceleration of a Ferrari.

QUESTION 5: Supercapacitors

What is a capacitor? It is basically a storage device. It works on electrostatic fields rather than chemicals. We can store energy in a capacitor in the form of *electrical potential energy*. A little like a battery, a capacitor doesn't produce electrons, only store them[1]. It also has another property that makes them really useful in some situations. They can release the energy that they store in a very short period of time.

(Watch the following video: https://youtu.be/DzLiaJsric4)

Capacitors are not a new invention. In fact in the 1700s a Leyden Jar was used to store energy. It was one of the first capacitors created and used in history. A lot has changed since then.

1. List as many devices as you can that use a capacitor.

QUESTION 6: What is Graphene?

Graphene is a material that has been used at the **CSIRO** in research to create supercapacitors.

(Watch this video: https://www.youtube.com/watch?v=-2fSL9ic6zk&feature=youtu.be&list=PLpU3sTjF-jzeH9GtmSmHmzNDTD_jGhITH)

1. What is graphene?
2. List some of its uses?
3. What property of graphene makes is so good for energy storage?

QUESTION 7: A day in the life of a CSIRO scientist

Dr Han and the team at the CSIRO are working on research with Vertically grown graphene.

Read a little about Dr Han.

What do you do?

I work at CSIRO as a research scientist.

How would you describe your particular area of Science?

My research area is nanomaterials for energy. This is a relatively new area of science. It emerged from the practical needs of using renewable energy to minimise the carbon footprint and climate change during the consumption of energy. It also arose from large interests in the development of portable electronics and hybrid electric vehicles. Nanomaterials, which are incredibly small materials, could outperform many traditional materials in enabling these energy-related applications.

What do you do during a typical day at work?

A typical day for me to work at CSIRO starts from sitting in the office and checking the latest research publications from the websites of some of the major journals, such as Nature and Science. This is also a good time for me to think ideas, plan experiments and gather resources needed for these experiments.
At 10.30 am tea break, I will chat with some of my team members in the cafeteria and check their progress on previous experiments and/or projects.
At 11.00 am I will go to laboratories to conduct my planned experiments. Primarily these experiments include the plasma-synthesis of vertical graphene, the electrochemical deposition of nanomaterials, and the testing of electrodes made of the nanomaterials.
At 12.30 pm Lunch time I will be at the cafeteria. Again, this is a good opportunity to exchange with colleagues on any new discoveries or ideas.
From 1.30 to 3.30 pm, I will go back to my office and continue reading scientific papers. Sometime I will work on writing manuscript draft. Preparing a manuscript requires a lot of editing and proofreading which could take substantial time before it can be submitted to journals.
From 3.30 pm to 5 pm, this is the time I usually spend to supervising and/or project administrating duties. I would sit with students, managers and colleagues in a more formal way to discuss the project progress. I would also report to my line manager any discoveries or project milestones delivered.

How did you become interested in this area of science?

I became interested in energy technology since PhD, when I was working on the synthesis and application of nanomaterials. At the completion of my PhD, it turned out clear that using nanomaterials for energy technology is very promising and I shall spend more time on it.

What are some of the key characteristics that are important for a person to succeed as a research scientist?

My personal opinion of becoming or succeeding as a scientist include:

- Passionate about science. Always be curious about discovering new things and be willing to spend time on it.
- Persistence. Science requires broad as well as deep knowledge in designing the experiments and explaining the observations. Therefore, one has to read a lot of both legacy and cutting-edge research articles.
- Collaborating with others. Nowadays science becomes more interdisciplinary than ever. A good scientist will talk to colleagues, mentors, students and collaborators to exchange ideas and foster new research opportunities.
- Learn from mistakes. Often scientific experiments fail at the first try. Hold a strong belief on yourself and keep trying. Of course, you do need to learn from the mistakes and make improvements next time.

Why is your research important?

My research is important because it will solve one of the biggest challenges in our society, Energy. If we are able to use clean energy to replace the fossil fuels, our earth and environment will become much more friendly and sustainable.

What are the possible real world applications.

Renewable energy grid; portable electronics; hybrid electric vehicles; implantable biomedical devices; etc.

Do you have an analogy to help me understand your work?

One of my mentors had used a very good analogy for batteries and I am going to rephrase here:
Storing renewable energy is like we store fruits and vegetables in the fridge – they will become ‘on-demand’ and a lot more convenient to use.

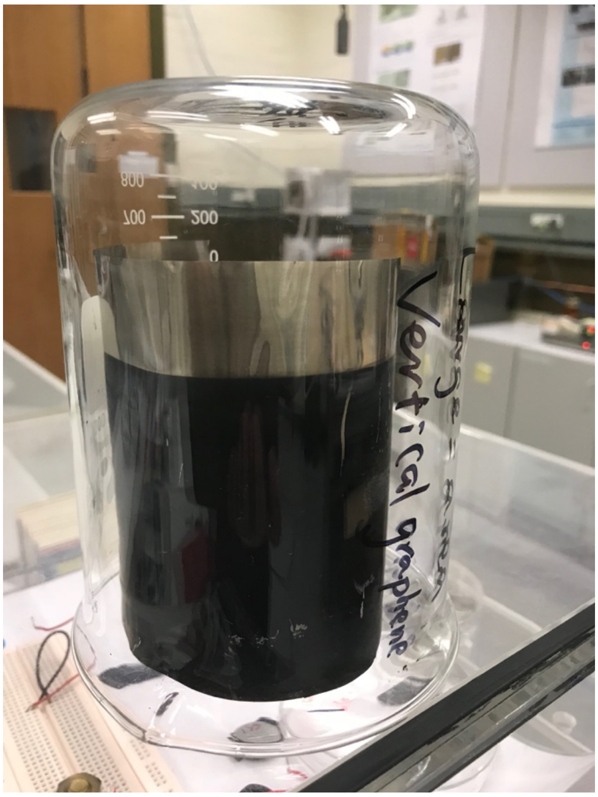
What is your favourite aspect of your research?

The moment that your experiments actually show you the results exactly you expected!

What is the coolest thing about your work/research?

Flexibility. One of the great things about working at CSIRO is that you have a lot of flexibility and it is relatively easy to achieve a life-work balance.

What does it look like?



(Credit: SWoodward)

A carbon covered surface. But if we look closely at it we can see the intricate structure. How close? Scanning electron microscope close.

QUESTION 8: Which microscope do you use?

This interactive goes through different types of microscopes and their uses.
https://www.sciencelearn.org.nz/embeds/12-which-microscope

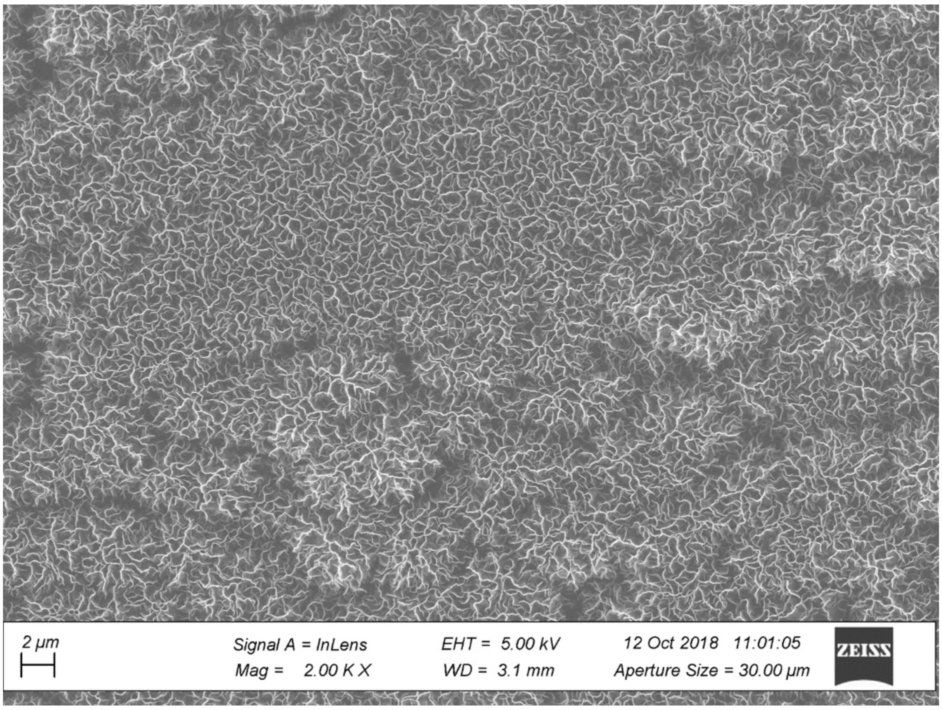
Complete the following table (The first one is completed for you)

Microscope name	**What specimens can be seen?**	**How small can it see things?**
Stereo or light microscope	Living things. Surface of the sample without disrupting the sample	Approx 2000x (school : 40-400 x)

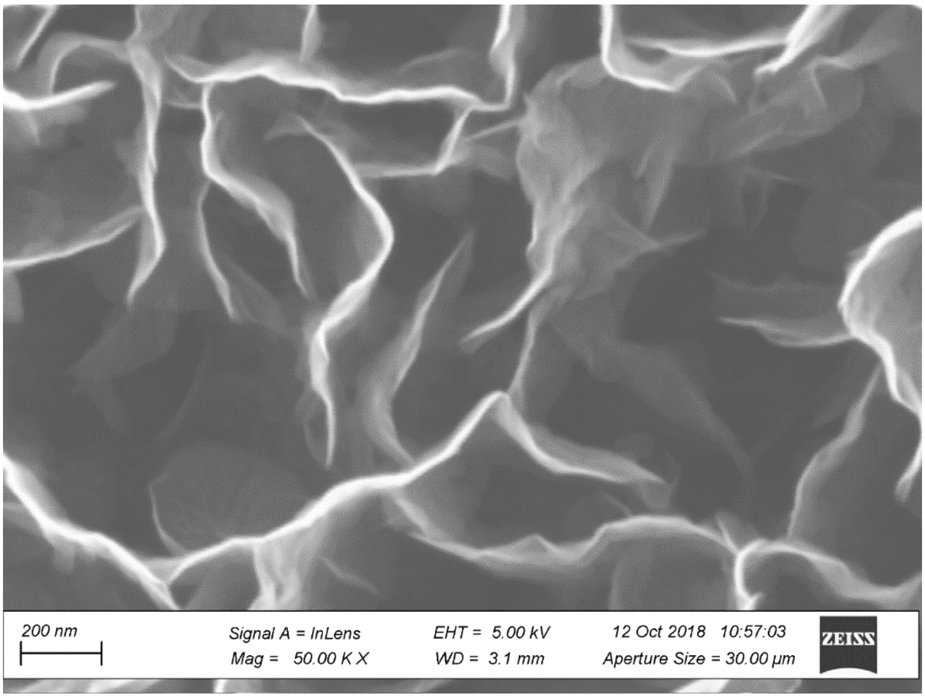
What is a scanning electron microscope?
https://www.youtube.com/watch?v=uQ1gClkCbIQ

QUESTION 9: How big are the vertical graphene structures?

1. Below are some images of the vertical graphene that was grown at the CSIRO. Use the scale to determine how big each structure is.



(Credit: CSIRO)



(Credit: CSIRO)

<u>QUESTION 10: How can this store energy?</u>

Once the graphene is grown, it is place inside a button battery. They end up looking exactly the same from the outside. This can be connected in a circuit in the same way as a battery.

(Credit: SWoodward)

<u>QUESTION 11: What can we use this technology for?</u>

There is a large range of applications from battery, fuel cell to solar cell. And less traditional applications still being explored.

QUESTION 12: How does a capacitor compare to a battery?

Potential Experiment

Risk Assessment – listed below are some considerations you will need to look at when doing this experiment.

Multimeter, digital (Deenergize and discharge the circuit completely before connecting or disconnecting a multimeter. Never apply power to the circuit while measuring resistance with a multimeter. Connect the multimeter in series with the circuit for current measurements, and in parallel for voltage measurements. Be certain the multimeter is switched to AC before attempting to measure ac circuits. Observe proper DC polarity when measuring DC. When you are finished with a multimeter, switch it to the OFF position, if available. If there is no OFF position, switch the multimeter to the highest ac voltage position. Always start with the highest voltage or current range. Select a final range that allows a reading near the middle of the scale. Adjust the) -

Resistor 100 ohm (Use: Heat prove mat. Use short period time. Verbal warning to students not to touch wires could be hot. Rubber soled shoes were worn at all times in order to minimise the risk of electrocution. Water and other conductive metals not associated with the experiment were kept away. Avoid touching bare wires/metal parts when attaching resistor terminals.) -

capacitor
http://www.idc-online.com/technical_references/pdfs/electronic_engineering/Capacitor_Capacitance_Hazards_And_Safety.pdf

Electrical leads (leads are constantly being moved and can eventually be damaged through wear and tear. In some cases damage to your leads may be visible (e.g. the insulation cracking or coming away from plugs). In other cases the damage may not be visible (e.g. with the damage being inside the lead). Visually checking and inspecting leads regularly is a good policy to follow. Except for those designed for use around wet environments, electrical appliances used near water are a serious shock hazard when they get wet. Don't drape leads over equipment or hot surfaces) -

Incandescent globe (The heat that is generated from even the lowest watt of incandescent light bulb is extreme. If a light bulb burns out you should wait a few minutes to change it out because you can burn your fingers. The current that runs through the coils inside the bulb generates heat that is transferred to the glass bulb because glass is a good conductor of heat.The glass that is used to make incandescent light bulbs is very thin, This helps the light to shine clearly through the bulb, whether it is a frosted bulb or a clear or colored bulb. Because of this it is extremely fragile and a very slight bump can cause the light bulb to break. The small shards of glass that fall from the shattered bulb can get into an eye, or be stepped on and difficult to remove. Additionally, if the light bulb breaks inside the socket it is dangerous to try to remove the light bulb from the fixture. A good method to remove such a bulb is to use a potato, push it hard onto the broken end of the bulb that is in the fixtur) -

battery AA holder (hazards unknown - item not on stock list) -

Battery, AA-size (Some Duracell alkaline batteries contain the Duracell Power CheckTM battery energy gauge which is a small conductive strip located underneath the PVC battery label that indicates the amount of charge in the battery. It is composed of minute quantities of conductive materials. Due to the small quantity of materials and their solid form, a health or environmental risk is unlikely.) -

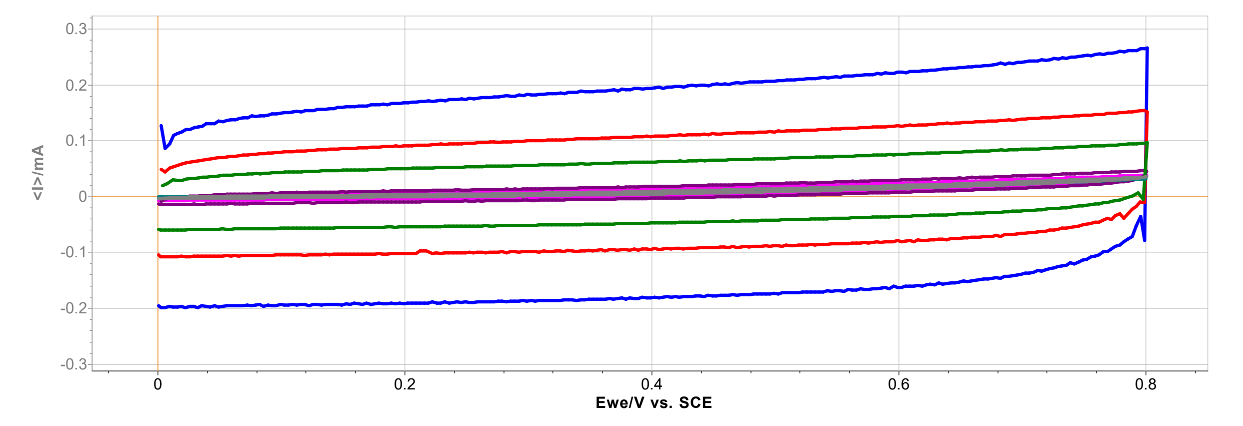
<u>Method:</u>

Connect a 1.5V battery to alight globe and record how the voltage changes over a period of time

Connect a capacitor to a 100ohm resistor and allow it to charge then discharge.

How does the speed of the voltage change compare to the that of a battery?

When testing the supercapacitor, the following graph was obtained as it charged and discharged.



(Credit: CSIRO)

1. What trends can you see?

This graph shows the capacitor as it charges, maintains the charge and then discharges.

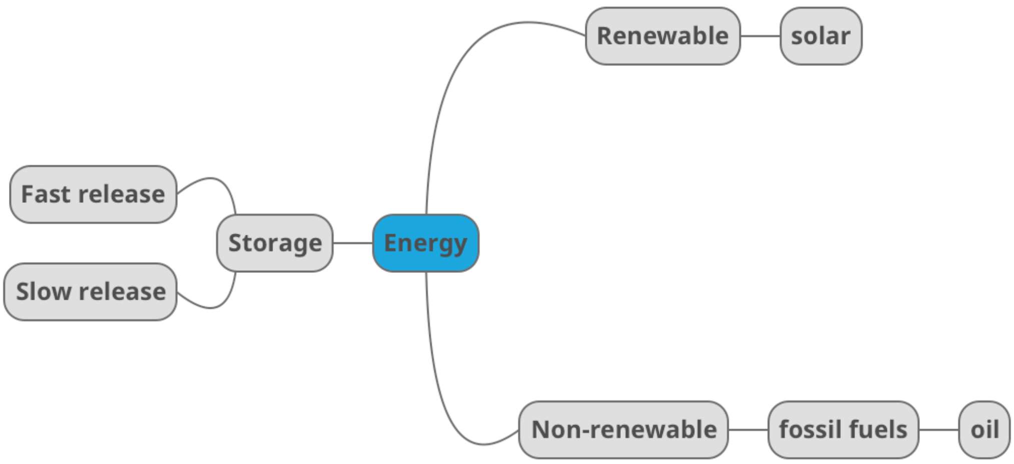
The vertical lines show the charging and discharging. As they are vertical, this shows it does so very quickly. The horizontal lines show the capacitor maintains constant charge in between.

A rectangle is ideal for a really good supercapacitor.

How did your capacitor compare?

QUESTION 13:   Mind Map

Below is the start of a mind map that puts together all the ideas that you have worked through. Continue to add to it.



(Credit: Made in Mind Meister)

Bibliography

https://www.mpoweruk.com/alternatives.htm

Source 1: https://electronics.howstuffworks.com/capacitor.htm

Ref: http://www.schoolphysics.co.uk/age16-19/Electricity%20and%20magnetism/Electrostatics/text/Capacitor_charge_and_discharge/index.html