

Teaching Sustainability in High Schools:
Module 1 (Focus on Grade 10)
Lessons 1-4

Sustainability and Really Cool
Technologies (Energy, Water, Waste)

Teacher Supplement

Developed by:



Funded by:



Student Supplement for Module 1: *Sustainability
and Really Cool Technologies (Energy, Water, Waste)*

Developed by:



Funded by:



In collaboration with the Sustainable Living Challenge



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Project Leader: Mr Karlson 'Charlie' Hargroves, TNEP Director

Principle Researcher: Dr Cheryl Desha, TNEP Education Director

TNEP Researcher: Ms Annabel Farr, TNEP Research Associate

This document is available electronically, and supports a subject supplement for students. Enquires should be directed to: Mr Karlson 'Charlie' Hargroves, Co-Founder and Director, The Natural Edge Project

<http://www.naturaledgeproject.net/Contact.aspx>

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Table of Contents

| | |
|---|-----------|
| Introduction – Using this Supplement | 4 |
| Overview | 4 |
| Structure of the Teacher Supplement | 5 |
| Structure of the Student Materials | 5 |
| Additional Support for Teaching Education for Sustainability | 6 |
| 1: Sustainable Development - the Opportunity of Our Lifetime | 7 |
| Educational Aims | 7 |
| Alignment with National Curriculum | 7 |
| Activity 1 – Investigation: Learning from Easter Island | 8 |
| Key Learning Point:..... | 8 |
| Resources: | 8 |
| Teacher Preparation: | 8 |
| Activity Description:..... | 8 |
| Sample Answers: | 8 |
| Handout – Learning from the Past | 10 |
| Activity 2 – Discussion: Understanding Climate Change through the Media | 11 |
| Key Learning Point:..... | 11 |
| Resources: | 11 |
| Teacher Preparation: | 11 |
| Activity Description:..... | 11 |
| Summary Activities and Homework Ideas..... | 12 |
| 1. Research Task and Essay Question..... | 12 |
| 2. Mind Map | 13 |
| 3. Short Answer Questions | 14 |
| 2: Energy - Powerful Solutions for Getting off Oil..... | 15 |
| Educational Aims: | 15 |
| Alignment with National Curriculum | 15 |
| Activity 1 –Debate: How can we create a fossil-fuel free society? | 16 |
| Key Learning Point:..... | 16 |
| Resources: | 16 |
| Teacher Preparation: | 16 |
| Activity Description:..... | 16 |
| Handout – How can we create a fossil-fuel free society? | 17 |
| Activity 2 – Demonstration: Building as Termites Do! | 18 |
| Key Learning Point:..... | 18 |
| Resources: | 18 |
| Teacher Preparation: | 18 |
| Activity Description:..... | 19 |
| Student Handout – Building as the Termites Do! | 20 |
| Summary Activities and Homework Ideas..... | 21 |

| | |
|---|-----------|
| 1. Essay | 21 |
| 2. Mind Map | 22 |
| 3. Short Answer Questions | 23 |
| 3: Water - Solutions that Protect Our Most Valuable Resource | 24 |
| Educational Aims | 24 |
| Alignment with National Curriculum | 24 |
| Activity 1 – Discussion: 99 Bottles | 25 |
| Key Learning Point:..... | 25 |
| Resources: | 25 |
| Teacher Preparation: | 25 |
| Activity Description:..... | 25 |
| Activity 2 – Experiment: Intercepting the Water Cycle | 26 |
| Key Learning Point:..... | 26 |
| Resources: | 26 |
| Teacher Preparation: | 26 |
| Activity Description:..... | 26 |
| Summary Activities and Homework Ideas..... | 27 |
| 1. Essay | 27 |
| 2. Mind Map | 29 |
| 3. Short Answer Questions | 30 |
| 4: Waste - Smart Solutions Towards No-Waste Lifestyles | 31 |
| Educational Aims | 31 |
| Alignment with National Curriculum | 31 |
| Activity 1 – Discussion: Up Scaling Recycling Efforts | 32 |
| Key Learning Point:..... | 32 |
| Resources: | 32 |
| Teacher Preparation: | 32 |
| Activity Description:..... | 32 |
| Activity 2 – Experiment: Landfills and Leachate..... | 33 |
| Key Learning Point:..... | 33 |
| Resources:..... | 33 |
| Teacher Preparation: | 33 |
| Activity Description:..... | 33 |
| Student Handout – Landfills and Leachate | 34 |
| Summary Activities and Homework Ideas..... | 35 |
| 1. Essay | 35 |
| 2. Mind Map | 36 |
| 3. Short Answer Questions | 37 |

Introduction – Using this Supplement

Overview

Are you a high school science, biology, chemistry, or physics teacher who wants to discover relevant and practical activities that engage students in sustainability in your classroom? This teacher supplement will help you address national curriculum requirements with regard to education for sustainability, and will also show how sustainability can provide context for Science, Technology, Engineering and Maths (i.e. STEM) curriculum.

This Teacher Supplement provides teaching and assessment ideas for the student supplement, to support the use of these materials to address the requirement for education for sustainability in the national curriculum. It also aims to increase interest in STEM through an interesting and current topic area. The teacher resource has been funded by Engineers Australia (QLD Division), as a companion to the existing 12 lessons (Grade 12, Senior Chemistry and Senior Physics) that have been previously developed with funding from the Port of Brisbane as part of the Sustainable Living Challenge.

As the first of three modules in this series, this module contains activity ideas, student handouts, and summary activities and homework ideas for four lessons on sustainable development:

- **Lesson 1 – Sustainable Development: The Opportunity of our Lifetime.** This lesson provides a general introduction to the following three lessons on energy, water and waste. We begin by identifying a number of key challenges for the 21st Century, considering the definition of sustainable development. We also highlight the specific role technology plays in addressing climate change and sustainable development.
- **Lesson 2 - Energy: Powerful Solutions for Getting Off Oil.** This lesson provides an overview of the concept of ‘peak oil’, and introduces ways of reducing our greenhouse gas emissions and reliance on fossil fuels like oil as an energy source. We consider opportunities for using energy more efficiently in everyday places like our homes, and using different forms of fuel and technology as a power source for vehicles.
- **Lesson 3 - Water: Solutions that Protect Our Most Precious Resource.** This lesson provides an overview of the challenges that Australia and the rest of the world faces with maintaining our most precious resource: water. We consider various ways that water can be used more efficiently, how we can clean water more effectively, and how we can help major users of water, like agriculture, reduce their reliance on water.
- **Lesson 4 - Waste: Smart Solutions towards No-Waste Lifestyles.** This lesson introduces the significance of waste coming from our everyday practices and the extent to which waste to landfill impacts on the health of our society and the environment. We consider a number of benefits to reducing and eliminating waste, and we highlight some examples of what companies and governments around the world are doing to achieve ‘zero waste’ goals.

This curriculum draws on the text book: Hargroves, K. and Smith, M. (2006) *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century*, Earthscan, London. Teachers are encouraged to refer to this text for further explanation of related content, additional references and excerpts for use during training sessions. The text also has a supporting online companion at www.naturaledgeproject.net/NAON.aspx.

Structure of the Teacher Supplement

This 'Teacher Supplement' provides an activity pack for each of the four lessons described above. The content has been structured to enable a wide variety of teaching methods, from lesson-style teaching, to problem based learning. Teachers may choose to fully explore all of the material, or just take parts of the content as they support existing materials in the learning program. Each lesson supplement has the following structure:

- **Educational Aim:** This text is the same as in the student materials, defining the educational objective for each lesson. The teacher may use this as an introduction to the class.
- **Alignment to National Curriculum:** This text provides a summary of how the lesson aligns with the stated objectives of the Australian National Curriculum.
- **Activity descriptions:** Here we provide 2 activities for each lesson, spanning exercises that require minimal resources or expenditure, to activities that may need some funds and/or preparation. Occasionally there are also pre-prepared student handouts that can be photocopied or scanned, to assist with the lesson preparation.
- **Summary activities and homework ideas:** Here we provide a number of ideas for assessment under three popular types including essay topics, mind map opportunities, and short answer questions. We also provide some sample answers to assist with marking.

Structure of the Student Materials

This 'Sustainability and Really Cool Technologies' program has been designed as a base reference for Australian Science, Technology, Studies of Society and Environment (SOSE), and Business Education units and lessons on the challenges and opportunities in sustainable development. The student materials comprise four lessons. Depending on the students' existing knowledge base, Lesson 1 could be used as one lesson (perhaps with take-home reading), or alternatively it could be spread out over 2-3 lessons:

Each Lesson contains the following headings. It is intended that teachers can either use this structure directly, or be readily able to adapt it to their preferred class structure and format:

- **Educational Aims:** define the educational objective for each lesson. This text provides a snapshot of the key message.
- **Learning Points:** summarise key points to explain the message. This information can be transferred onto overhead or PowerPoint slides for teaching to the class. Alternatively, the points could be read out by students and discussed in a tutorial-style learning environment.
- **Brief Background Information:** This provides the teacher with a context within which to interpret the Learning Points. It also indicates the type of information contained in the recommended references and resources. This material often explains terminology in more depth, or provides background information to help further explain concepts in case students find the material difficult to understand. Note that the Brief Background Information should not be considered the only source of in-depth information – please also refer to the cited references.
- **Key References:** This list is essential as a summary of where key information has been sourced from, and where more information on related topics can be found.

- **Key Words for Searching Online:** This list is intended to encourage students to explore online resources related to the topic of interest (both specific information and more general topics of interest). Specific pages are noted where appropriate, although at times only the home page is listed for general reading and navigation of the site. A search of these key words will also list the most current material available on the topic of interest.

Additional Support for Teaching Education for Sustainability

In addition to the extensive reference list provided for each part in the 'Student Supplement' the following is a list of key resources for which teachers can use to access potential class activities:

TeachSustainability.com.au (<http://www.teachsustainability.com.au/>): A primary resource for teachers is the *TeachSustainability.com.au* web resource. An initiative of the Sustainable Living Challenge, this website is a resource sharing database to support Australian teachers who are exploring issues of sustainability in their classrooms. This database allows the open and free sharing of resources that have been developed or sourced by school teachers and educators.

Teaching and Learning for a Sustainable Future (<http://www.unesco.org/education/tlsf/>): *Teaching and Learning for a Sustainable Future* web resource is an award winning internationally renowned training toolkit for those who want to educate for a sustainable future. It consists of over 100 hours (divided into 25 modules) of professional development for use in pre-service teacher courses, as well as the in-service education of teachers.

Education for Sustainability Portal (<http://www.aries.mq.edu.au/portal/index.htm>): Developed by the Australian Research Institute in Education for Sustainability (ARIES), the *EFS Portal* is a central source of information on education for sustainability. The site is designed for use by those who want to use education and learning based strategies to stimulate change towards sustainability. This includes community groups, local councils, government agencies, industry, non-government organisations, schools, colleges and universities.

Federal Government Resources: DEWHA, DCC and ORER:

- The Australian Government Department of Environment Water, Heritage and the Arts (<http://www.environment.gov.au/education/publications/index.html>) provides a range of resources that seek to develop sustainability skills, knowledge, values and behaviours.
- The Department of Climate Change website provides answers to frequently asked questions about Climate Change (<http://www.greenhouse.gov.au/science/index.html>).
- The Office of the Renewable Energy Regulator has been established to oversee the implementation of the Australian Government's mandatory renewable energy target. Their website has information on renewable energy options (<http://www.orer.gov.au/index.html>).

The Natural Edge Project – Engineering Sustainable Solutions Program (ESSP): Recognising that the engineering, scientific and design professions will play a significant part in moving society to a more sustainable way of life, together with the realisation that we have very little time to prepare, this program seeks to contribute open source peer reviewed education material to assist efforts globally to accelerate education for sustainability. All material is freely available, open-source and online, under a Creative Commons Attribute license: (<http://www.naturaledgeproject.net/ESSP.aspx>, see Curriculum & Course Content).

1: Sustainable Development - the Opportunity of Our Lifetime

Educational Aims

This lesson provides a general introduction to the following three lessons on energy, water and waste. Additional Readings are provided to introduce students to key topics, in case they do not have prior learning in these areas. This introductory package provides the context to sustainable development through identifying a number of key challenges for the 21st Century. We consider the definition of sustainable development to be where technologies, processes and practices can reduce our environmental impact while still meeting the needs of the world's growing population. We highlight the specific role technology plays in addressing climate change and sustainable development.

Alignment with National Curriculum

The activities and information presented in this lesson aligns to the National Curriculum cross curriculum priority 'Sustainability' which is concerned with the ongoing capacity of the Earth to maintain life:¹

Actions to improve sustainability aim to reduce our ecological footprint while simultaneously supporting a quality of life that is valued—the 'liveability' of our society. Sustainable patterns of living meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is both an individual and a collective endeavour often shared across communities and nations necessitating a balanced but different approach to the ways humans have interacted with each other and with their biophysical environment. Sustainability learning draws on and relates learning across the curriculum. It leads to students developing an overall capacity to contribute to a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.

Specifically, this lesson addresses the following items:

- ACSHE191 Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.
- ACSHE192 Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries
- ACSHE194 People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.
- ACSHE195 Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities.
- ACSHE230 The values and needs of contemporary society can influence the focus of scientific research
- ACSIS208 Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

¹ <http://www.australiancurriculum.edu.au>

Activity 1 – Investigation: Learning from Easter Island

This activity asks students to study the history of the ancient civilization on Easter Island. Students will be asked to identify a number of problems by reading a short history of the ancient civilization and then will draw comparisons between Easter Island and the planet today. A handout is provided with an outline of the Easter Island Story and some discussion questions

Key Learning Point:

There are many examples of ancient civilizations that have failed because they have developed unsustainably. Examining these failures can help our civilization avoid repeating such mistakes.

Resources:

- Lesson 1 Background Reading 1.1 ‘Learning from the Past – Easter Island Story’
- A detailed account of the Easter Island story can be found at:
www.mnforsustain.org/easter_island_diamond_j.htm.

Teacher Preparation:

- Study Background Reader 1.1, and consult online resources for further information on the Easter Island history.
- Make the Easter Island history handout available to students, electronically or in hard copy.
- Consider alternative presentation ideas based on available materials, such as butchers paper, electronic whiteboards and e-sticky notes.

Activity Description:

1. Ask students to read the Easter Island handout. Ask students, in groups, to discuss the following questions which relate to the key learning areas found in ‘Lesson 1 – Sustainability: The Opportunity of a Lifetime’ (these questions are also provided in the student handout):
 - a) What were some major problems in the Easter Island civilization?
 - b) Who was responsible for these problems?
 - c) How could the civilisations have avoided this outcome?
2. Ask students, in their groups, to consider the similarities between the Easter Islanders and the world today. Discuss the following:
 - a) Are there similar scenarios happening in the world today?
 - b) What lessons could the leaders of today learn from the downfall of ancient civilizations?

Sample Answers:

1a) What were some major problems in the Easter Island civilization?

From key Learning Points 2, 4, 6 of Lesson 1, we know that:

- Easter Island is essentially a ‘closed **system**’, much like a smaller version of planet Earth. The citizens’ behaviour within the system (cutting down the forests, hunting and fishing) eventually meant it became uninhabitable. We can see many similarities between the citizens of Easter Island and the population of the earth.

- The concept of an '**ecological footprint**' is easy to understand on a small scale like Easter Island. Every living thing on the island was supported by the resources of the island itself, for example the chickens that formed part of the citizen's diet needed to be fed by the grains that were grown on the island, which in turn needed land, sunlight and water to grow. Using these simple relationships, the amount of land needed to support each islander could be calculated (called a 'footprint'). When the citizen's needs became greater than what could be supported by the island's resources (ie, their combined 'footprints' were larger than the area of the island), stocks of resources (such as trees and food) began to decline, leading to the eventual downfall of the civilization.
- The Easter Islanders developed their civilization and used resources (for example, food, water and trees) at such a rapid rate that the island could not regenerate in time to provide for the next generation. This problem highlights the **definition of sustainable development** – 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'

1b) Who was responsible for these problems?

- Every citizen of Easter Island was responsible for their own consumption of resources – the way they used trees to build shelter, killed birds that spread seeds to sprout new plants, and cleared forest to make gardens. The leaders of the island may have been able to influence how their citizens used these finite resources.

1c) What could have been done to improve the outcome of these civilizations?

- Building on Key Learning Point 10, imagine if the islanders began to live in caves or discovered how to build durable stone shelters. This would have saved huge amounts of deforestation, which in turn may have preserved the islands biodiversity and allowed for more regeneration. This process of developing new techniques, ideas and inventions is called **innovation** and is an important part of driving sustainable development.
- The islanders cut down an enormous amount of trees to make ropes. Imagine if the islanders were able to make ropes that were thinner, stronger and used fewer trees. This would have at least enabled them to make more ropes out of the same amount of trees, if not even allowing the tree population time to regrow. This process is now known as '**resource productivity improvement**' or simply, doing more with less!

2a) Are there similar scenarios happening in the world today?

- Yes - all over the world, resource depletion is occurring at an alarming rate. Forests are cut down, fisheries exhausted, soils are increasingly salty and oil supplies are diminishing.

2b) What lessons could the leaders of today learn from the downfall of ancient civilizations?

- They could employ techniques such as '**resource productivity improvement**' to help reduce their impact on the natural world; they could educate members of the population so that everyone understood the impacts of their actions; and they could develop policy and legislation which help to conserve and protect the natural world for future generations.
- One critical advantage we have over the Easter Islanders is that we are now aware of the damage we are inflicting on our 'system'. We will never know if the Easter Islanders realized

that they were causing their ultimate demise with their unsustainable ways, but we can learn from their downfall by acting rapidly to turn around our own dangerous behaviour.

Handout – Learning from the Past

The following information is a brief overview of the Easter Island story, adapted from Jarrod Diamond's publication, 'Collapse – How Societies Choose to Fail or Survive'.²

Easter Island, with an area of only 64 square miles, is the world's most isolated piece of habitable land. It lies in the Pacific Ocean more than 3,200 kilometres west of the nearest continent (South America), and 2,200 km from even the nearest habitable island (Pitcairn). In just a few centuries, the people of Easter Island wiped out their forest, drove their plants and animals to extinction, and saw their complex society spiral into chaos and cannibalism.

Pollen records show that destruction of Easter's forests was well under way by the year 800, just a few centuries after the start of human settlement. Then charcoal from wood fires came to fill the sediment cores, while the pollen of palms, other trees and woody shrubs decreased or disappeared, and the pollen of the grasses that replaced the forest became more abundant. Not long after the year 1400 the palm finally became extinct, not only as a result of being chopped down but also because the now ever-present rats prevented its regeneration (of the dozens of preserved palm nuts discovered in caves on Easter, all had been chewed by rats and could no longer germinate). While the Hauhau tree did not become extinct in Polynesian times, its numbers declined drastically until there weren't enough left to make ropes from. By the time European explorers visited Easter Island, only a single, nearly dead Toromiro tree remained on the island, and even that lone survivor has now disappeared.

Every day newspapers report details of famished countries - Afghanistan, Liberia, Rwanda, Sierra Leone, Somalia, the former Yugoslavia, Zaire - where soldiers have appropriated the wealth or where central government is yielding to local gangs of thugs. As the risk of nuclear war lessens, we are no longer concerned about ending our existence with a big bang, and so there is nothing obvious to make us stop and think about our current course of development. With the gradual and incremental nature of climate change, the risk is now that we will just wind down, slowly, and end in a whimper. Corrective action is blocked by vested interests, by well-intentioned political and business leaders, and by their electorates, all of whom are perfectly correct in not noticing big changes from year to year. Instead, each year there are just more people and fewer resources on Earth.

If mere thousands of Easter Islanders with only stone tools and their own muscle power sufficed to destroy their environment and society, how can billions of people with metal tools and machine power fail to do worse?

But there is one crucial difference. The Easter Islanders had no books and no histories of other doomed societies. Unlike the Easter Islanders, we have past-information that can save us. Our main hope for our children's generation is that we may now choose to learn from the fates of societies like Easter's.

Discussion Questions:

- What were some major problems in the Easter Island civilization?
- Who was responsible for these problems?
- What could have been done to improve the outcome of these civilizations?
- Are there similar scenarios happening in the world today?
- What lessons could the leaders of today learn from the downfall of ancient civilizations?

² Diamond, J. (2006) Collapse: How Societies Choose to Fail or Survive, Penguin Books, UK.

Activity 2 – Discussion: Understanding Climate Change through the Media

In this activity, students will use print and online media as the basis for participating in a discussion about climate change and sustainable development

Key Learning Point:

Climate change and sustainability are often discussed in the media. Scientific background and reasoning should be used to engage in clear and focussed discussion about the causes and effects of, and the possible solutions to, these issues.

Resources:

- Lesson 1 Background Reading 1.2 ‘Understanding Climate Change’
- Print media, journals and online resources (such as blogs)

Teacher Preparation:

Teachers will require some general background knowledge of climate change and greenhouse gas emissions to be able to facilitate the class debate and question opinions that are presented without supporting evidence. This could include reading Lesson 1 Background Reading 1.2 ‘Understanding Climate Change’ for a general introduction to the language and concepts, and conducting some preparatory online research and through print media such as newspapers and journals, using the ‘Key Words for Searching Online’ section in Lesson 1.

Activity Description:

The aim is to encourage peer based learning, rather than simply presenting students with a huge amount of facts about climate change. The discussion may have to be managed so that facts remain accurate and all important points are raised in some form.

3. Choose one or more topics for investigation: The content discussed will vary depending on what information the students find. The following are examples of topics that could be targeted: global footprint, the rise of mega cities and the increase of urban dwellers, temperature rises and consequences, environmentally sustainable solutions, historical examples of populations who have destroyed their natural environment, understanding the language of greenhouse gas emissions, climate change scenarios, and the need for climate change mitigation and adaptation.
4. Ask students to find information: Ask students to find two or three articles, blog entries or commentaries, or other print media concerning the causes, effects and strategies to combat climate change. It may be helpful to give guidelines or directions (for example, avoid certain newspapers, investigate certain journals, search various online databases). Students might also be required to reference all facts that they use.
5. Create a forum for discussion: Once students have collected various articles, ask them to prepare a short talk (for example 3 minutes) about the issues raised in their articles (do they agree with the ideas expressed, do they think they are valid or important?). Some students may be ‘scribes’, recording main points on a whiteboard. Working around the class, students present what they have discovered about climate change, and with the assistance of the teacher, work to relate their article and opinion with the opinions already conveyed by other students.

Summary Activities and Homework Ideas

1. Research Task and Essay Question

This research task and essay question highlights the concept of innovation and requires students to identify innovative processes occurring today. In answering the questions posed below, students will be tested on their understanding of the concept of innovation for sustainable development, and their ability to write a well-structured essay within the word limit set by the teacher.

Essay Statement:

Discuss the concept of innovation for sustainable development. In your response, address the following:

- What is sustainable innovation?
- Why is innovation so important to prevent or reduce climate change?
- Provide an example of a sustainable innovation that is in use today, describing the industry it serves, how it is used and how it will prevent or reduce greenhouse gas emissions or climate change

Sample Answer:

Innovations that contribute to sustainable development that could be highlighted by students include: alternative energy technologies, hybrid cars, nanotechnology, and biomimicry. An example short essay is provided here:

An innovation is a new idea or invention that is developed into a product or service. Innovations are very important to slow the process of climate change, reduce our impact on the earth's resources and limit greenhouse gas emissions. Innovation can do this in a number of ways.

Some innovative technologies will assist in achieving sustainable development because they aim to create products or service that create fewer emissions, produce less waste or are reusable or recyclable. Other innovations will contribute to sustainable development because they are processes that achieve the same solutions with less resources or input. Sometimes this is known as 'resource productivity improvement'.

One of the areas with a lot of potential for innovation is in electricity generation. Within this industry, innovation is occurring that both improves the efficiency of electricity generation (reduces the amount of lost or wasted electricity) and changes the way we generate electricity.

For example, energy efficient technologies such as renewable fuels, solar cells, wind turbines have meant that it is now possible for some household to be completely self-sufficient, that is they do not depend on the electricity grid for any of their energy. Other buildings are able to use this technology to supplement their grid usage.

Increasing the use of renewable fuels other electricity generation technologies means that we can burn less coal to fuel traditional electricity stations. This will significantly reduce the amount of greenhouse gases released.

2. Mind Map

This mind map assessment item highlights the variety contributing factors to environmental degradation. In creating the mind map, students will be demonstrating their understanding of a variety of ways in which development can result in environmental degradation, and their appreciation of the interconnectedness of these issues. This exercise could be undertaken individually or in a group.

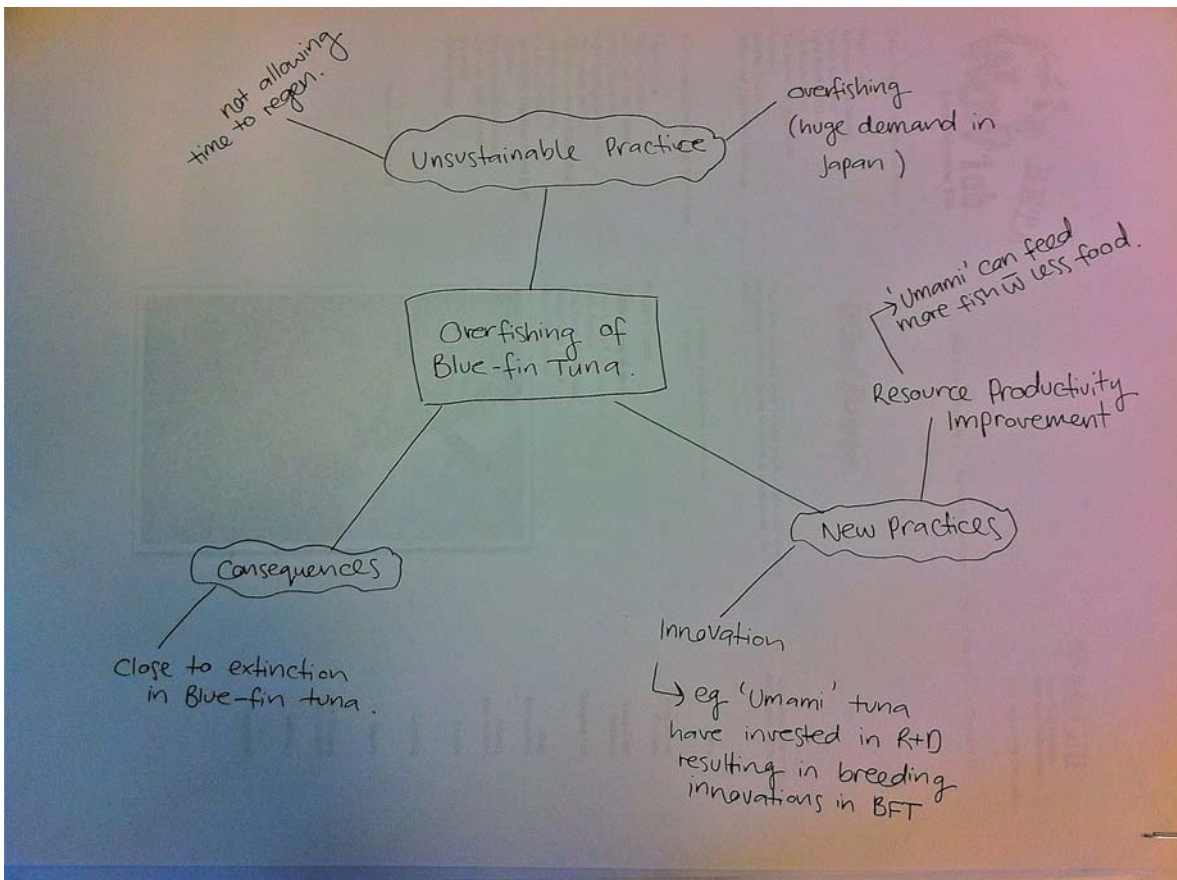
Mind Map Briefing:

After completing the in-class activity on the Easter Island story, your task is to consider a modern-day environmental issue that could be improved by studying Easter Island. You will create a mind map of your chosen issue, which includes:

- the unsustainable practices currently occurring;
- the consequences of not changing these practices; and
- two new practices that could be introduced.

Some example topics include: deforestation in the Amazon, desertification in Africa and Australia, overfishing in the East China Sea, and population growth (for example in Africa or Asia).

Sample Answer:



3. Short Answer Questions

Question 1: Describe the concept of an 'ecological footprint'. What unit of measure is used to determine a person's ecological footprint? List one product you used today and all the energy and resource costs associated with it.

Sample Answer: The ecological footprint is a way of measuring a person's individual resource use and energy consumption. It is measured by a 'global hectare', which is one hectare of space that supports the world's average productivity. It is useful because it shows the relationships between our lifestyles and the environment, and can help to identify hidden energy and resource costs that are often forgotten. For example: a t-shirt's footprint includes the generation of raw materials like cotton and the inks, manufacturing costs such as electricity and water use, and transportation costs to deliver the t-shirt to the shop where it is purchased.

Question 2: The planet's population faces significant challenges in the 21st Century. Describe a major problem and identify the reasons why it has become such a huge issue.

Sample Answer: Rapid population growth: The world's population is growing at a rate never before experienced. All these people need food, water, shelter and a basic quality of life. This is a major issue because we now understand that the world only has a finite amount of resources with which to supply the needs of all these people.

Question 3: What is sustainable design and why is so important to combat climate change? Identify a profession that would be able to really effectively use sustainable design.

Sample Answer: Sustainable design is a practice of designing objects and environments (like cars, electronics, houses and larger buildings) to contribute positively to the surrounding environment and the future. For example, architects and engineers can ensure that the buildings (and other structures) they design and create use locally available materials, minimise the impact on the surrounding environment and minimize resource consumption through the life of the structure.

Question 4: Describe the concept of 'decoupling'. Note the difference between 'relative decoupling' and 'absolute decoupling'.

Sample Answer: Decoupling is a concept which relates to removing the linear relationship between 'economic throughput' / 'economic activity' and environmental degradation. Relative decoupling is where the rate of the environmental damage is less than then rate of economic throughput; however this means that rate the environmental damage could still be positive, it just has to be less than that of the rate of economic throughput. Absolute decoupling is where the rate of environmental damage is actually negative; i.e. each year there is less and less environmental degradation. These differences are important when trying to understand political agendas; parties who concentrate on relative decoupling rather than absolute decoupling are actually encouraging environmental degradation.

2: Energy - Powerful Solutions for Getting off Oil

Educational Aims:

The aim of this lesson is to provide an overview of climate change and 'peak oil', and introduce ways of reducing our greenhouse gas emissions and reliance on fossil fuels like oil as an energy source. In particular, we will consider using energy more efficiently in everyday places like our homes, and using different forms of fuel and technology to power vehicles.

Alignment with National Curriculum

The activities and information presented in this lesson aligns to the National Curriculum cross curriculum priority 'Sustainability' which is concerned with the ongoing capacity of the Earth to maintain life:³

Actions to improve sustainability aim to reduce our ecological footprint while simultaneously supporting a quality of life that is valued—the 'liveability' of our society. Sustainable patterns of living meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is both an individual and a collective endeavour often shared across communities and nations necessitating a balanced but different approach to the ways humans have interacted with each other and with their biophysical environment. Sustainability learning draws on and relates learning across the curriculum. It leads to students developing an overall capacity to contribute to a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.

Specifically, this lesson addresses the following items:

- ACSHE191 Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.
- ACSHE192 Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries
- ACSHE194 People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.
- ACSHE195 Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities.
- ACSHE230 The values and needs of contemporary society can influence the focus of scientific research
- ACSIS208 Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

³ <http://www.australiancurriculum.edu.au>

Activity 1 –Debate: How can we create a fossil-fuel free society?

There are many perspectives on developing an economy that does not rely on fossil fuel, because there are so many options to consider. In this activity, students will be allocated one particular option and will work in a team to argue a case for or against the development of this as part of the solution.

Key Learning Point:

There are many options for developing an economy that does not rely on fossil fuel. Rather than relying on one ‘silver bullet’ solution, we need to consider the role of each option in the future.

Resources:

- ‘Brief Background Information’ provided in Lesson 2 ‘Energy Powerful Solutions for Getting off Oil’
- Depending on the time available to cover this topic, we recommend viewing *An Inconvenient Truth*. Hosted by ex-Vice President of the United States, Al Gore, this documentary provides a dramatic and serious introduction to climate change. The documentary explains in easy-to-understand terms the latest scientific evidence of global warming and its potential impacts on our civilisation. To learn more about the documentary or to preview the trailer, visit www.climatecrisis.net.

Teacher Preparation:

- Depending on the level of understanding about this topic, teachers may want to do some preparatory research, following up on the references provided in ‘Brief Background Information’ in the student materials.
- Students should be given time to prepare for the activity, and class time should be allocated for the actual debate.

Activity Description:

1. Divide students into teams of two to three. Provide each team with one of the following topics (taken from Figure 2.2. ‘Brief Background Information’ of the student materials): Efficiency, Transport Mode Shifts, Pricing/ Taxes, City Design/ Lifestyle, Other Petroleum Fuels/ Gas/ Tar-Sands, Other Fuels, Deprivation.
2. Give each team member a role – scientist, economist or politician. Alternatively, you may like to allow students to pick their own role based on their personal interests.
3. Instruct the groups to prepare a case for their option to reduce reliance on fossil fuel, within their allocated role. For example, a group may be investigating the option of ‘Efficiency’ (i.e. making everything more efficient), with its members considering the science behind this option, economic reasons for doing so, and political considerations.
4. After allowing sufficient preparation time, ask the groups to – in turn – present their considerations for their option being able to assist society become ‘fossil-fuel free’.
5. After each presentation, or after all of the presentations, bring the various topics together by reconsidering Figure 2.2. ‘Brief Background Information’. Highlight the complexity of the transition, and the many opportunities available within the transition.

Handout – How can we create a fossil-fuel free society?

In this exercise, you will be allocated to a team (2-3 students per team). Each team will then be allocated an option from the figure below (also in your student materials). Within your team, you will then need to choose a perspective for each team member – a scientist, economic or politician.

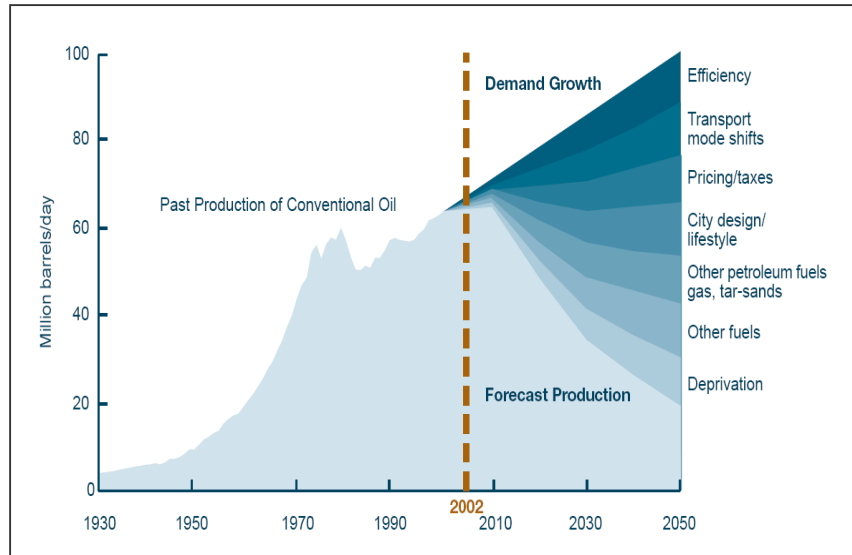


Figure 1. Dependence on Fossil Fuels

Source: Robinson, B. (2002)⁴

Within these roles, and for your option, you will need to prepare a short presentation to deliver to the class. Your presentation should have a central argument, supporting evidence, and a real life example or 'case study' to help explain your position. The following table contains some guiding questions for each 'role' in your team:

| Role | Points to Consider |
|------------|---|
| Scientist | <ul style="list-style-type: none"> – Is this option scientifically feasible? – What improvements need to be made to the existing technologies? – How will the energy be stored? Is this practical? – How can the energy and fuel be distributed? – What are some other technological and scientific considerations? |
| Economist | <ul style="list-style-type: none"> – What types of costs would be involved (for example, infrastructure costs, research costs etc)? – What are the benefits of this option? – What organisations might be against this option? |
| Politician | <p>What are some reasons to/to not progress this option. Consider:</p> <ul style="list-style-type: none"> – meeting greenhouse gas emission level targets – national security (for example current reliance on Middle East for oil) – Why might politicians want to support/ oppose the option? – Is the option safe? For whom is it safe? For whom is it not safe? |

⁴ Robinson, B. (2002) *Global Oil Vulnerability: the Australian Situation*, sustainability background paper, State Sustainability Strategy CD-ROM, Department of the Premier and Cabinet, Perth.

Activity 2 – Demonstration: Building as Termites Do!

In this activity, students will discover the idea of 'biomimicry' by exploring the principles behind the Eastgate Complex – a new building modelled on a termite mound. They will learn the importance of developing energy efficient buildings and practical ways to do so. A brief demonstration of the science underlying one of the physical processes (convection), used in the Eastgate Complex, will engage all types of learners.

Key Learning Point:

Biomimicry is an effective way of reducing our energy usage and levels of greenhouse gas emissions. We can learn lots of cool things from nature which can be used to design more sustainable things!

Resources:

- 'Case Study – Building as the Termites Do!' provided in Lesson 2 'Energy Powerful Solutions for Getting off Oil'
- For more information on biomimicry, termites and the Eastgate Complex, see <http://inhabitat.com/building-modelled-on-termites-eastgate-centre-in-zimbabwe/>
- Materials: 1 large, sturdy box, with approximately A4 size opening; two toilet rolls; one medium candle; one pair of scissors; cello tape; tissue paper; tongs; and 1 box of matches.
- Alternatively, this demonstration can be found online, at a variety of science education websites. A good one is <http://www.youtube.com/watch?v=OmeCxZ8l0SY>

Teacher Preparation:

- Read the case study provided in Lesson 2 'Energy Powerful Solutions for Getting off Oil'
- For more background information on the principals behind 'biomimicry' and the importance of design to produce energy savings, refer to <http://science.howstuffworks.com/environmental/life/evolution/biomimicry.htm>.
- For brief background information regarding convection currents, see <http://en.wikipedia.org/wiki/Convection>.
- Prior to the lesson, construct the demonstration activity, as follows:
 - a. Turn the box so the open face is in front of you.
 - b. Cut two holes with the same diameter as the toilet rolls in the top face of the box, about 20cm apart.
 - c. Push the two rolls through the hole and place the candle inside the box, below the roll on the right.

During the demonstration, when you light the candle, you will be heating the air above it. When smoke is created above the roll on the left, it will be pulled through the box as shown in the following figure due to convection currents.

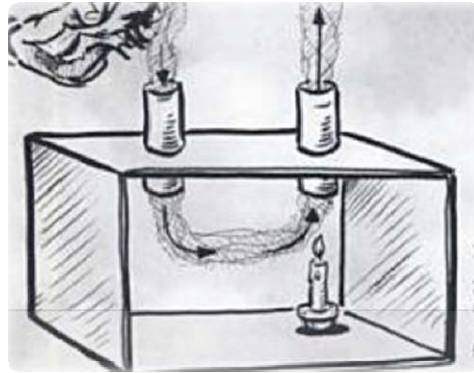


Figure 1 – Sketch of the demonstration

Source: “Teaching Green, the Middle Years” Grant. T (2010)⁵

Activity Description:

1. Provide a brief overview of the physics behind convection (see ‘Fundamentals’). Explain that this process can be used to cool buildings naturally without the use of energy-intensive air conditioning.

Fundamentals: When air is heated, the individual molecules move further apart, making air lighter and more buoyant. As this warm, light air rises, colder and denser air rushes in to take its place, creating an air current. In houses and other closed systems, this process is known as a convection current. In the biggest closed system of all, the earth, this process is called wind!

2. Perform the demonstration:
 - Light the candle in the box.
 - Holding some tissue paper with the tongs, light the end of the tissue so it creates smoke.
 - Hold the burning tissue over the left hand side roll and watch as the smoke is sucked through the box and through the roll above the candle.

⁵ Grant, T. and Littlejohn, G. (Ed) (2004) *Teaching Green – The Middle Years: Hands-on Learning in Grades 6-8*, Green Teacher, Toronto.

Student Handout – Building as the Termites Do!

Watch the demonstration by your teacher and read the following information. Then, use your knowledge of termites and convection to answer the questions below.

By identifying natural convection currents in buildings, we can regulate the temperature of the flow of air through buildings. By placing windows and doors in appropriate positions we can release or contain hot air to naturally heat or cool buildings in appropriate ways.

Figure 1 shows a cross section of a termite mound with the airflow direction indicated by the arrows. The cooler air enters the mound through the lower channels and the warmer air exits through the openings at the top of the mound. Figure 2 shows a cross section of the Eastgate complex in Zimbabwe. Can you see the similarities between the two?

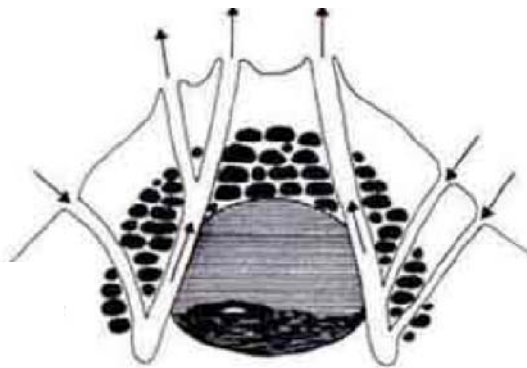


Figure 1: Airflow in a termite mound
Source: inhabitat.com (2010)

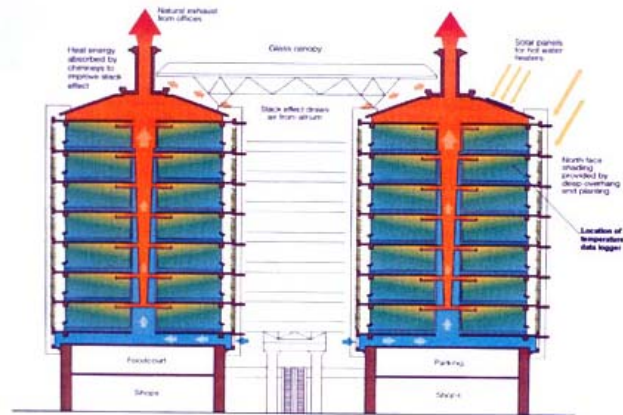


Figure 2: Airflow in the Eastgate Complex
Source: inhabitat.com (2010)

The material that termites use to build their mounds also helps to regulate the hot desert temperature inside their homes. By using lots of clay, the termites are able to protect their homes from fire. Some nest have even been found to contain a material called chrysotile, or white asbestos, a well known insulating material!

'Mimicking' the construction principles that termites have developed over thousands of years of evolution helps our buildings to use natural resources more efficiently. It reduces the need for air conditioning which produces greenhouse gases and uses fossil fuels.

The immediate advantages of the Eastgate complex are obvious – the building uses 10% less energy than the buildings next door, and can offer 20% lower rents to it's inhabitants!

Discussion Questions:

- How does this natural phenomena help to cool buildings?
- How have termites adapted this natural process to cool their mounds?
- What else have we learnt by studying termites mounds that can help to regulate temperatures inside buildings?
- How do these practices help to reduce oil dependency and greenhouse gas emissions?

Summary Activities and Homework Ideas

1. Essay

This essay question highlights the concept of innovation and requires students to identify an innovative way of saving energy. In answering the questions posed below, students will be tested on their understanding of the concept of energy efficiency, and their ability to write a well-structured essay within a word limit set by the teacher.

Essay Statement:

Considering the role of energy efficiency in helping to reduce society's reliance on fossil-fuel energy, write a short essay about an innovative technology that can reduce the amount of fossil-fuel based energy used in everyday life.

In your essay, you should describe the process, explain how it works to reduce energy consumption, and comment on the social, environmental and economic impacts (positive and negative) associated with this technology.

Some possible technologies that you could consider include:

- Using energy efficient light bulbs.
- Painting residential and commercial building roofs a white or lighter colour.
- Driving hybrid cars.
- Switching to solar hot water.
- Installing renewable energy technology (e.g. solar PV, wind turbines, geothermal power).

Sample Answer:

Some discussion points that demonstrate a systemic understanding of the technology and opportunities are outlined below for the example of driving hybrid cars:

- Hybrid cars use at least two different sources of fuel, usually petrol and an electric motor powered by a battery.
- They use sophisticated technology to reduce the amount of petrol required by using the energy that is required to slow the car down to recharge the electric motor.
- This significantly reduces petrol demand and hence reduces reliance on fossil fuels such as oil.
- The technology itself is effective at reducing energy consumption. However take up of the technology by the automotive industry has been relatively slow to date.
- Take up of the technology has also been mixed. For example, some manufacturers are using the technology to just improve the performance of large vehicles with large engines, rather than focusing on using the technology to drive smaller, lighter, more efficient vehicles.
- If the battery is rechargeable by connecting to an electricity, this may actually use fossil-fuel if the source of this electricity is from a coal-fired power station for example.
- Buying vehicles with hybrid technology is still quite expensive compared with cars using fossil-fuel based engines.

2. Mind Map

This mind map assessment item highlights the variety of inputs to providing goods and services that support our lifestyles. In creating the mind map, students will be demonstrating their understanding of the energy contributions to delivering something as simple as a cup of coffee, and their appreciation of the interconnectedness of these issues. This exercise could be undertaken individually or in a group.

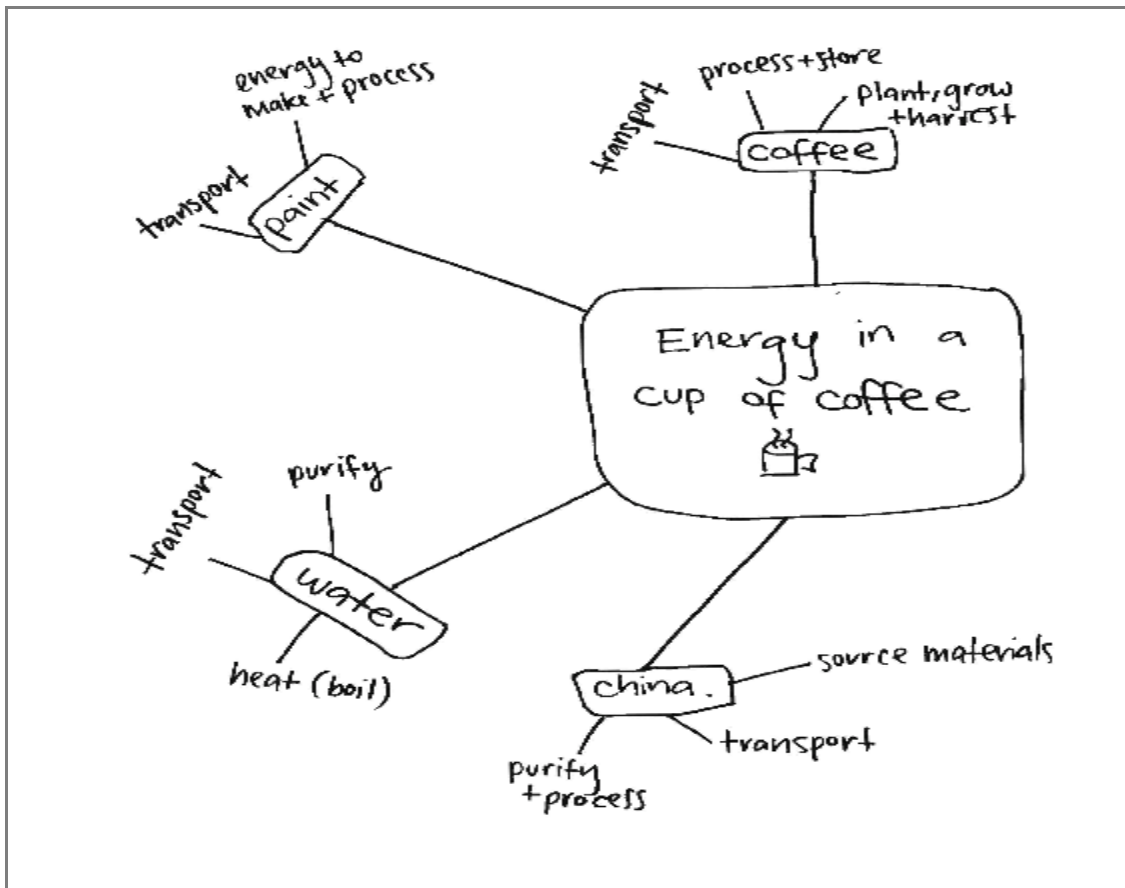
Mind Map Briefing:

Imagine a simple cup of coffee. In this exercise you will brainstorm all of the potential processes that are required to create that hot drink, in the form of a mind map.

There are a number of ways that you might categorise the topics, for example by source (coal, oil, electricity, wind, solar...), material (ceramic, paint, coffee) or by process (manufacture, transportation...). Components of the mind map will also need to include things like:

- The energy needed to grow or extract the raw resources
- The energy needed to transport the raw resources and finished product
- The energy needed to make the cup of tea or coffee

Sample Answer:



This mind map could be developed further in considering the specific energy use for a certain type of coffee, produced in a certain location for example.

3. Short Answer Questions

Question 1: We use oil for almost everything. List two different ways that you have already used oil today. We haven't always been so dependant on oil however. Historically, what else have we used as an energy source?

Sample Answer: Many students will have used oil in their transportation to school – car, bus, train. Students will also have used electricity at some point, which requires oil to produce. However, there are many products, such as plastics, chemicals and Styrofoam that requires oil! Before the industrial revolution, there were many different forms of fuel – wood, wind, candle wax, whale oil to name a few.

Question 2: One of the best ways to reduce the use of fossil fuels and greenhouse gas emissions is to improve energy efficiency (using less energy to provide the same service). Consider your own home - where are some areas you could improve it's energy efficiency? Which ideas can be introduced after a house is built (retrofitting)? What ideas need to be implemented before building begins (redesign)?

Sample Answer: Most houses can be more efficient. Potential ideas include:

Retrofitting:

- install energy efficient appliances (for example, washing machine, refrigerators, front loading washing machines, induction cook-tops)
- use energy efficient lighting such as compact fluorescent light bulbs
- turn off lights and appliances when going out, turn appliances off at the power point

Redesigning:

- Design houses to reduce the amount of heat lost in winter or cooling lost in summer (e.g. avoid west facing walls) – this will reduce the amount of electricity needed for heating or cooling.
- Install wall and roof insulation
- Design houses to take advantage of natural lighting during the day

Question 3: Energy that comes from natural resources that can be naturally replenished is called 'renewable energy'. List three different kinds of renewable energy and explain which one you think will be most efficient.

Sample Answer: Renewable energy includes solar power, wave power, tidal power, hydro power, geothermal power and wind power. All renewable energies have advantages and limitations, and different situations will be better suited to different forms. An entirely renewable economy would depend on many different kinds of energy.

3: Water - Solutions that Protect Our Most Valuable Resource

Educational Aims

The aim of this lesson is to provide an overview of the challenges that Australia and the rest of the world are facing with maintaining our most precious resource: water. This lesson will introduce various ways we can use water more efficiently, clean water more effectively, and help major users of water, like agriculture, reduce their reliance on drinking-quality (i.e. potable) water.

Alignment with National Curriculum

The activities and information presented in this lesson aligns to the National Curriculum cross curriculum priority 'Sustainability' which is concerned with the ongoing capacity of the Earth to maintain life:⁶

Actions to improve sustainability aim to reduce our ecological footprint while simultaneously supporting a quality of life that is valued—the 'liveability' of our society. Sustainable patterns of living meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is both an individual and a collective endeavour often shared across communities and nations necessitating a balanced but different approach to the ways humans have interacted with each other and with their biophysical environment. Sustainability learning draws on and relates learning across the curriculum. It leads to students developing an overall capacity to contribute to a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.

Specifically, this lesson addresses the following items:

- ACSHE191 Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.
- ACSHE192 Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries
- ACSHE194 People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.
- ACSHE195 Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities.
- ACSHE230 The values and needs of contemporary society can influence the focus of scientific research
- ACSIS208 Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

⁶ <http://www.australiancurriculum.edu.au>

Activity 1 – Discussion: 99 Bottles...

Well, actually only three! In this activity, students will discuss the impact of three bottles of water from different sources.

Key Learning Point:

Water is a precious resource that comes from many different sources. Some sources have less impact than others, some are cleaner and safer, and some have specific uses. All are important!

Resources:

- Brief Background Information document in Lesson 3: ‘Water: Solutions that Protect Our Most Precious Resource’
- Materials: 3 labelled beakers/ jars of water (1 store-bought, 1 tap water, 1 grey water *previously used water – from washing machine or shower for example*).

Teacher Preparation:

- Study the brief background information in Lesson 3.
- Prepare to discuss the sources of the water. This may include some online research to determine the source of the bought bottled water.
- Set out the bottled water so students can view the three jars/ beakers.

Activity Description:

1. Discuss with the students the following questions, drawing a mind-map on the board to keep track of the discussion:
 - a) Where has the water come from?
Such as a dam (which dam?), a spring (where? Nationally or internationally?), a washing machine or dishwasher, a tank, a shower?
 - b) How is this water going to be used?
To the tap, an appliance, a human body, the garden?
 - c) Would you drink it? Why or why not?
Because it is clean? Sealed? Treated?
 - d) How did it get here?
By truck, pipeline, tap, tank, rain?
 - e) What are the environmental costs of this bottle of water?
How was the plastic bottle made? How was the dam made? What chemicals are in the water? How does this affect where it is going?
 - f) What are the energy sources that went into this bottle of water?
Transportation energy, treatment energy, energy to build dams, pumping energy...
2. Ask students about common perceptions of the properties of recycled water versus the reality. Is it safe to drink? Why are some people opposed to the idea of recycled water? Are these claims true?

Activity 2 – Experiment: Intercepting the Water Cycle

Most students will have learnt about the water cycle in primary school, however students may not be aware of the many different ways to capture water. In this activity, students are introduced to the process of evapo-transpiration and will – in teams – construct a device to collect some water that would normally evaporate directly to the atmosphere.

Key Learning Point:

Water is precious and to be able to provide fresh water to the world's population we must be innovative about the collection and storage of water.

Resources:

- This experiment builds on the concept of capturing evapo-transpiration, discussed in the 'Case Study: Collecting Water like the Namibian Beetle' in Lesson 3: 'Water: Solutions that Protect Our Most Precious Resource'
- Materials (per group of 4 students): 1 painting drop sheet per group – from hardware or grocery store; 1 roll of thick tape per group (such as duct tape or packing tape); a patch of green grass (the grass must be green!); and 1 bucket per group.

Teacher Preparation:

- Depending on existing knowledge levels, teachers may want to review the hydrological cycle (many resources are available online, google 'what is the hydrological cycle?')
- This activity requires a hot, sunny day, so some checking of weather forecasts may also assist.

Activity Description:

1. Provide each team of students (approximately 4 students per team) with a roll of tape and a drop sheet.
2. Instruct students to place the sheet over a patch of grass (approximately 1m²) and tape around the edges, effectively taping the edges to the grass. Leave the sheets for at least an hour, preferably more. If the sheets will not be disturbed, they can be left overnight as well.
3. Carefully pull the sheet off the grass, trying not to disturb the droplets which have formed on the surface. Gently shake the sheet over the bucket to collect the water droplets.
4. The amount of water collected will not be enormous but significant. Depending on the time and availability of measuring devices, the students could weigh or measure the volume and compare this with the area of grass covered.
5. Ask the teams to discuss the following questions, which can then be reported back to the group as a whole:
 - a) How much water did you collect? Was it significant? How could you make it more effective or obtain more water from your device?
 - b) Is this similar to any other types of water collection/purifying technique?
 - c) How does this capturing process compare with energy-intensive processes such as desalination, and distillation?

Summary Activities and Homework Ideas

1. Essay

This essay question highlights the concept of innovation and requires students to identify an innovative way of saving energy. In answering the questions posed below, students will be tested on their understanding of the concept of energy efficiency, and their ability to write a well-structured essay within a word limit set by the teacher.

Essay Statement:

Analyse the use of recycled water in Australian capital cities. Use the internet to research current water recycling methods, techniques and volumes, as well as case studies. Provide at least two arguments for your opinion and use examples to illustrate your point.

Sample Answer 1:

Possible arguments to support the use of recycled water in Australia⁷

- Water is a precious resource, yet less than 15% of Australia's urban and industrial wastewater is recycled. Water recycling is a socially, environmentally and economically viable solution to help utilise our water resource more efficiently.
- About 12% of Australia's water is used for household and manufacturing purposes with a large percentage ending in the reticulated wastewater stream. In total, some 2 000 GL of this water is thought to be recoverable.
- Recycled water is very safe when guidelines are followed and it is used for the intended purpose. Recycled water undergoes high standards of treatment to ensure it is fit for its intended purpose. There are standards that apply for its use.
- Recycled water can be used for almost any use, as long as it is treated to a level to make it fit for that intended purpose (i.e. fit-for-purpose) from a health and environmental perspective
- Recycling our water can offer substantial benefits to our society including:
 - Reduction of nutrient and contaminant loads into oceans and rivers
 - Providing more drinking quality water for domestic uses by substituting drinking quality water with recycled water for irrigation of agricultural crops and amenity horticulture
 - Reducing demand and stress on freshwater resources such as the groundwater and rivers by providing alternative water supplies
- There may also be benefits to agricultural and amenity enterprises through
 - Guaranteed water supply
 - Supply of water quality underpinned with a comprehensive water quality assurance program
 - Security for investment in agricultural enterprises
 - Recycling of valuable nutrients

⁷ Recycled Water in Australia, <http://www.recycledwater.com.au/index.php?id=47>, accessed 06/03/11

- Some examples of water recycling include:⁸
 - Abu Dhabi: Abu Dhabi's freshwater supply is produced by desalination of seawater. All of Abu Dhabi's wastewater is treated to open-access recycled water standards. The recycled water is delivered back to the city for irrigation of public parks, roadway landscaping and fodder farms. This has allowed Abu Dhabi to develop a garden city despite high temperatures and minimum rainfall.
 - Sydney Olympic Park: A water recycling scheme at Sydney Olympic Park supplies up to 7000m³/d of recycled water for irrigation of sporting fields and open space areas and for toilet flushing in the sporting venues.

Sample Answer 2:

Australian cities should be promoting the increased use of recycled water. Recycled water is a valuable resource, but in Australia only about one percent of all the water used is currently recycled. Water recycling is an important initiative and provides many benefits to society and to the environment.

Water recycling involves treating wastewater for reuse in potable or non-potable applications. Water recycling utilises technologies such as reverse osmosis and microfiltration, but may also include biological systems such as constructed wetlands. The goal of each is to treat the water to a level that is suitable for reuse. Varying degrees of treatment may be required depending on the proposed use of the water and usually vary from secondary treatment to advanced tertiary treatment with disinfection. Optimal results are obtained when wastewater is treated to a level fit for its intended use to ensure community safety is upheld whilst also avoiding unnecessary treatment steps.

Recycled water may be used for a number of purposes, such as;

- irrigation
- aquifer recharge
- potable uses, such as showering and drinking
- non-potable uses, such as laundry and toilet flushing.

Recycling water provides many benefits to society and the environment. For example, recycling water helps to reduce our impact on the environment. It helps to reduce our demand on freshwater resources, which is particularly important in Australia where drought is common and freshwater reserves are already being overused.

Recycling water also helps to conserve drinking water and improve the reliability of our water supplies. Australians use on average 295 litres of water per person each day (Australian Government, 2006),⁹ but only a small fraction of this is for drinking. Recycled water could be used for non-potable purposes so that freshwater reserves are conserved for potable purposes.

⁸ IWA (2010) www.iwaterwiki.org/xwiki/bin/view/Articles/Urban accessed 06/03/11

⁹ www.environment.gov.au/soe/2006/publications/drs/indicator/335/index.html

2. Mind Map

This mind map assessment item highlights the variety of options to improve water efficiency, to support our lifestyles. In creating the mind map, students will be demonstrating their understanding of systemic opportunities for conserving water, and their appreciation of the interconnectedness of these issues. This exercise could be undertaken individually or in a group.

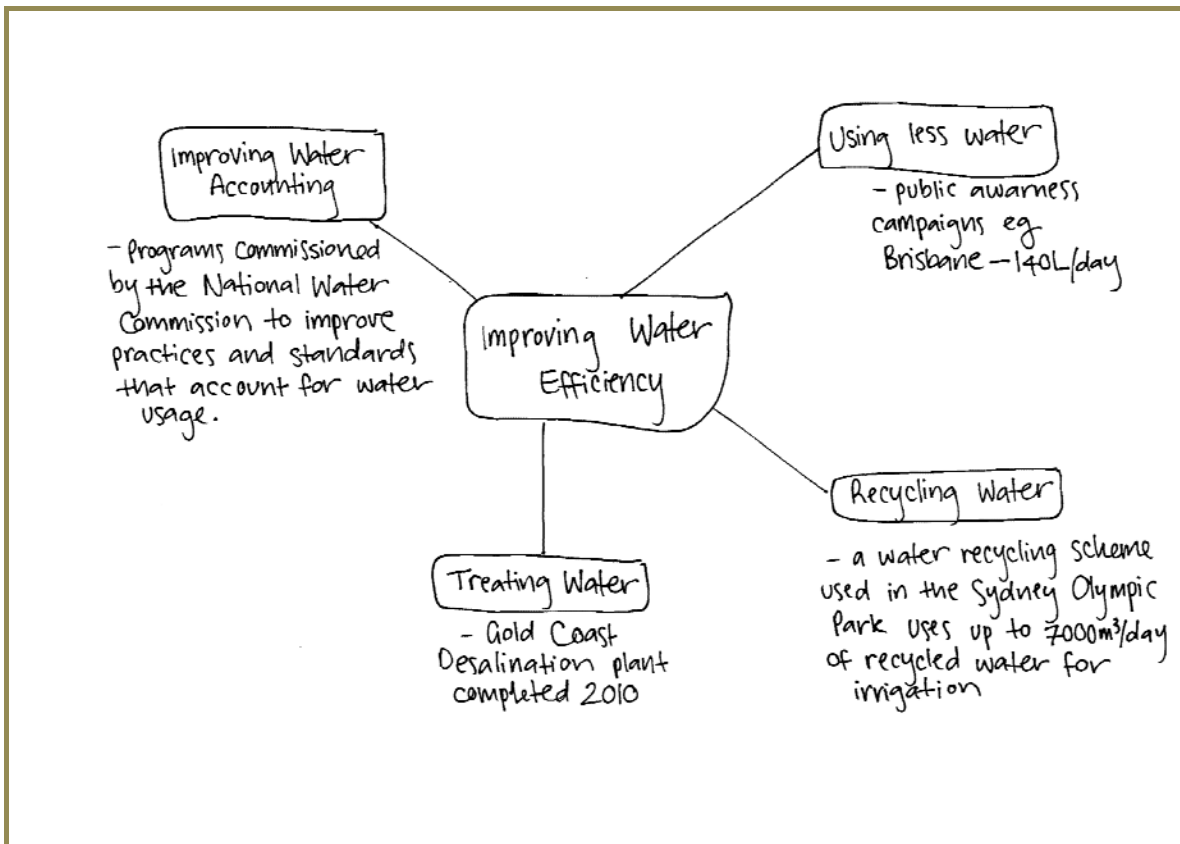
Mind Map Briefing:

Construct a mind map that outlines some opportunities to improve water efficiency, including the following key words. For each key word, consider examples that demonstrate this opportunity.

Key words to include in your mind map are: using less water, recycling and reusing water, storing water, and reducing the cost of treating water.

Sample Answer:

The following sketch begins the mind map process, but consider adding further extensions to the four boxes, with actual examples of opportunities. Then consider also linking opportunities between the boxes, showing how opportunities can connect.



3. Short Answer Questions

Question 1: Consider your own water usage. How do you use water directly? How do you use water indirectly? What are some major ways you could reduce your *dependence* on water

Sample Answer: Direct water use includes drinking, washing, cooking, showering etc... Indirect water use includes consuming food (which uses water to grow crops / raise cattle etc.), consuming electricity (where the electricity is derived from coal-fired power stations or hydro-electric power) etc. Ways to reduce dependence on water include:

- Utilising water efficient devices in the home and workplace
- Reusing greywater for non-potable purposes (e.g. gardening)
- Consuming goods which are less 'water intensive' to produce

Question 2: Knowing that water is becoming an increasingly precious resource, research some examples of countries and cities that have taken steps to use water more efficiently?

Sample Answer: In Melbourne the council has undertaken significant measures to educate the general public about water efficient practices and water restrictions. In Brisbane the residents reduced their water use to world's best practice in 2009 during the worst drought on record. Council has also built a multi-billion dollar water recycling scheme.

Question 3: Water is vital to sustain life. Yet many plants and animals live in dry and arid desert conditions. Research on such plant or animal and consider one way we could learn from it to collect, store or use water differently.

Sample Answer:

Cactus:

- Reduces water loss (cactus use their spines to provide shade and reduce evaporation).
- Uses the geometry of a sphere (highest possible volume with lowest possible surface area).
- Has insulating exteriors.

4: Waste - Smart Solutions Towards No-Waste Lifestyles

Educational Aims

The aim of this lesson is to introduce the significance of waste that comes from our everyday practices, and the extent to which waste-to-landfill impacts on the health of our society and the environment. This part will introduce the benefits of reducing and eliminating waste, and highlights some examples of what companies and governments around the world are doing to achieve 'zero waste' goals.

Alignment with National Curriculum

The activities and information presented in this lesson aligns to the National Curriculum cross curriculum priority 'Sustainability' which is concerned with the ongoing capacity of the Earth to maintain life:¹⁰

Actions to improve sustainability aim to reduce our ecological footprint while simultaneously supporting a quality of life that is valued—the 'liveability' of our society. Sustainable patterns of living meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability is both an individual and a collective endeavour often shared across communities and nations necessitating a balanced but different approach to the ways humans have interacted with each other and with their biophysical environment. Sustainability learning draws on and relates learning across the curriculum. It leads to students developing an overall capacity to contribute to a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations.

Specifically, this lesson addresses the following items:

- ACSHE191 Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community.
- ACSHE192 Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries
- ACSHE194 People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions.
- ACSHE195 Advances in science and emerging sciences and technologies can significantly affect people's lives, including generating new career opportunities.
- ACSHE230 The values and needs of contemporary society can influence the focus of scientific research
- ACSIS208 Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations

¹⁰ <http://www.australiancurriculum.edu.au>

Activity 1 – Discussion: Up Scaling Recycling Efforts

In this activity, students will learn about the importance of their individual recycling actions, in the larger community context of waste management.

Key Learning Point:

Individual acts of recycling really do help to reduce the amount of waste we generate and landfill space we occupy, as a community.

Resources:

- Materials (per group of 5 students): 3 whiteboard markers (black, red, green); a variety of colour pens; butchers paper/ A3 sheets of paper for brainstorming.
- Alternative materials, such as butchers paper, electronic whiteboards and e-sticky notes could also be substitute materials.

Teacher Preparation:

The teacher will need to prepare the room so that students can work comfortably in groups of three-five, with an area to write notes on an A3 size piece of paper. It may also be useful to review the types of calculations to be undertaken by the students.

Activity Description:

1. Create groups of 3-5 students within the classroom.
2. Ask the groups to do the following:
 - a) List a number of everyday objects that are commonly recycled, on one of their sheets of paper, using the black white-board marker.
 - b) Discuss which are easy to recycle, highlight these with the green white-board marker.
 - c) Discuss which require some effort to recycle and highlight these with the red white-board marker. Alongside these items, note down some of the key barriers to recycling?
3. Ask the groups to choose 1 item that some or all of the group didn't recycle in the past week. Ask students to imagine that their whole class didn't recycle that item for a whole year, and estimate how much waste this might create – a classroom, a truck, a football field?

Example calculation:

1 newspaper x 20 students = ½ bin of newspapers per day per class
½ bin of newspapers per day per class x 1 week = 3 ½ bins per week per class
3 ½ bins per week per class x 1 year = 182 bins per year
182 bins = about 1 entire class room, full of newspapers.

That's a lot of newspapers! Imagine if every class in your school didn't recycle newspapers. Imagine if every school in your suburb didn't recycle newspapers. Imagine if every suburb... well, that's a pretty good reason to recycle your newspaper!

4. If there is time, ask students to try extending it to the school or suburb level. How much waste is generated at this scale?
5. Finally, ask the students to brainstorm some opportunities for addressing recycling within the school community, and discuss them as a class. This may be a catalyst to then begin an onsite program.

Activity 2 – Experiment: Landfills and Leachate

This hands-on activity shows students how to build a model landfill using common garden and household materials.

Key Learning Point:

Landfills are complex scientific systems. What we put into landfills affects all parts of the landfill and surrounding land through leaking liquids (i.e. leachate), leaking gases (i.e. off-gasing) and leaking contaminants (i.e. soil contamination). We can improve landfill use by properly designing the landfill, reducing the amount we put in, and sorting the waste before disposal.

Resources:

For each group of 3-5 students: 2 soft drink bottles; a selection of sands, gravels and clays (about a margarine container equivalent of each, which could be obtained from a hardware store or sourced from around the school); cling wrap; food colouring; 1 pair of scissors; and cello tape.

Teacher Preparation:

The teacher may wish to create a demonstration model to use with the class.

As a lead up to the experiment, the teacher can also discuss landfills with the students, with regard to the following questions for example: What goes into landfill? How does it get there? What happens to it? What are landfills made of? How do they hold onto the waste? What are the major risks to the surrounding environment? What is leachate?

Activity Description:

1. Create groups of 3-5 students.
2. Ask each group to cut one of their soft drink bottles in half, carefully pierce a hole in the cap of each bottle, insert the top of the bottle, lid down, into the bottom.
3. Ask each group to select a combination of materials with which to construct their landfill liner. This may be coordinated within the classroom, so that there are a variety of methods that can later be compared. Students then construct their landfill liner using three layers of materials, using the plastic wrap as a liner to the bottle.
4. Each group then makes some leachate in the second soft drink bottle by mixing some food colouring with water. This is poured over the landfill and the students are asked to observe and discuss what happens to the leachate when it is poured over the landfill.
5. Discuss with the class as a whole, for their landfill models:
 - a) How did the coloured water make its way through the landfill layers?
 - b) What colour is the leachate in the bottom of the container?
 - c) What has been collected by the water on its way through?
 - d) How does this model highlight what can happen in a real landfill with regard to 'leachate'?
 - e) Can we learn any lessons about landfill construction and operation?

Student Handout – Landfills and Leachate

Landfills are complex scientific systems. What we put into landfills affects all parts of the landfill and surrounding land through leachate and other environmental impacts. Onsite, potential environmental problems from landfill include:

- The pollution of surface or groundwater with contaminants from waste.
- The creation of nuisance odours and dust.
- The risk of property damage due to subsidence or the release of flammable or toxic gases.
- The release of pollutants into the atmosphere such as greenhouse gases.
- Wind can carry loose items of waste from the landfill which becomes litter!

Furthermore, as we continue to fill up existing landfill sites, we create the need to clear more land for new sites. This can further threaten remnant bushland and the flora and fauna living there. We can improve landfill use by reducing the amount we put in, sorting the waste and properly designing the landfill. Modern landfills are very different from the open ‘dumps’ of the past. A typical modern landfill is lined with a layer of clay and protective plastic to prevent the liquid waste (leachate) from leaking into the ground or ground water. A network of drains collects the leachate and pumps it to the surface where it can be treated. Ground wells around the landfill are used to monitor the groundwater quality and detect any contamination.

Activity Summary:

1. Take a plastic soft drink bottle and cut it in half.
2. Using a hammer and nails or the tip of scissors, punch a small hole in the cap.
3. Replace the cap and place the top half of the bottle, top side down, into the bottom half (see photos below).
4. Look at the materials provided by your teacher. Using your knowledge of landfills and liners, layer the various soils to make an effective landfill liner leachate capture system.
5. Create some ‘leachate’ by mixing water with food colouring. Pour it over your model landfill and watch to see if the leachate is able to pass through.
6. If some leachate does get through, what is its colour? What can you conclude from this experiment?



Summary Activities and Homework Ideas

1. Essay

This essay question highlights issues associated with waste management and requires students to reconsider the concept of waste. In answering the questions posed below, students will be tested on their understanding of the innovative waste management opportunities, and their ability to write a well-structured essay within a word limit set by the teacher.

Essay Statement:

The electronic goods industry is one of the biggest producers of hazardous waste materials in Australia. This waste, termed E-waste, contains over 1000 different substances, many of which are toxic, presents serious health and pollution problems. Many companies have begun to develop innovative ways to re-use waste, or are beginning to practice 'product stewardship' and product take-back policies. Some of these companies include: Fuji/Xerox, 'Close the Loop' (whose clients include HP, Canon, Epson, Brother and Panasonic), Apple, Sony, and NEC.

In this essay you will write about how one of these companies is rethinking the concept of waste, discussing two of their recycling and re-use innovations.

Sample Answer:

Some example points that should be introduced in this essay are outlined below for Fuji/Xerox:

- Fuji/Xerox are considered leaders in the field of environmental responsibility and encourage and practice product stewardship
- They have developed a number of key goals to ensure this continues
- These include setting targets for the number of parts that are remanufactured (aimed for 217 000 in 09/10) and introducing up to 50 new remanufacture programs
- They also aim to implement more robust product return measurement systems.¹¹

¹¹ Fuji Xerox Sustainability Policy (2011) www.fxasustainability.com.au/2010/report.php?chapter=4§ion=3.

2. Mind Map

This mind map assessment item highlights the variety of ways that waste is produced in creating the goods and services that support our lifestyles. Through this exercise, students will be demonstrating their understanding of the prolific nature of waste in society, and the many opportunities that exist to reduce waste and reuse resources. This exercise could be undertaken individually or in a group.

Mind Map Briefing:

One of the best ways to deal with waste is to prevent it becoming waste at all. By examining the chain through which a product passes before becoming waste, we can identify all the places where it may be able to be recycled.

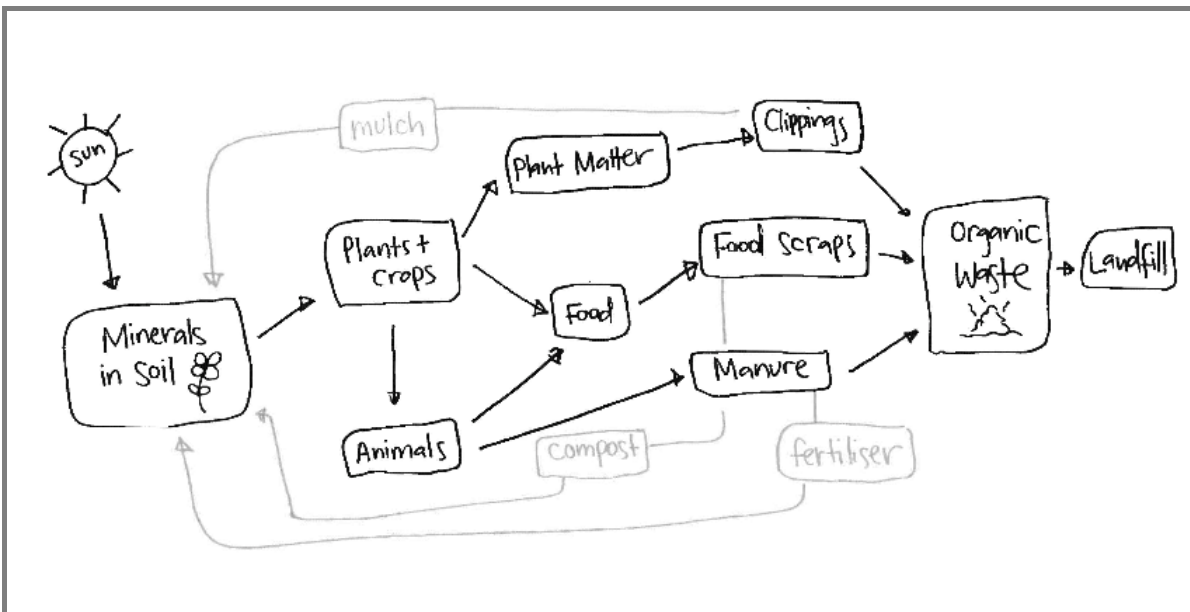
With this in mind, select one of the waste types below and develop a lifecycle mind map, indicating source inputs, products, waste destinations and connectors.

- Organic waste
- Electronic waste
- Hazardous waste

On this mind map, highlight areas where this waste can be converted into useful resources for other processes or products.

Sample Answer:

Here we provide an example mind map for organic waste, with possibilities for creating useful products from the 'waste' shown in gray:



3. Short Answer Questions

Question 1: List three practical ways an individual can reduce the amount of waste they generate.

Sample Answer:

- When purchasing items at the store consider: the amount of packaging the item has, whether or not it was made from recyclable materials and whether or not it is able to be recycled.
- Always separate wastes at the source into their different categories (before they go into the bin); especially organic waste which can go into the garden or a worm farm.
- Reuse items wherever possible. Either directly (e.g. glass jars as storage containers, old clothes as rags), or indirectly (e.g. giving unwanted goods to second-hand shops, family members or charities).

Question 2: Using your knowledge of landfill and leachate, list some major environmental problems that result from poorly designed landfills.

Sample Answer:

- Groundwater contamination
- Soil contamination
- Leachate leakage

Question 3: Define product stewardship and explain why it is so important in reducing E waste.

Sample Answer: Product stewardship is where all parties involved with any part of a products life-cycle actively takes steps to try and reduce that products life-cycle environmental impacts. For example, for manufacturers, designing products to be recycled more easily and with less toxic chemicals.

Due to the complex components of e-waste, extracting individual elements at the recycling centre can be near impossible. However, with product stewardship, these e-devices, at the manufacturing stage, can be *made* to be recycled; thereby making the recycling phase a more efficient process. They can also reduce the toxicity of the devices by using more environmentally friendly chemicals and elements, at the manufacturing phase.