The Nuclear Industry in South Australia

An Environmental Perspective

A Study Guide for Middle School Teachers and Students

Including

Lesson Plans
Student Activities
NuclearSA web site information

Study Guide for Teachers

The NuclearSA website, http://nuclearsa.ccsa.asn.au/, and study guide have been developed by a group of concerned residents of South Australia with an interest in providing schools with accurate information on the nuclear industry. It aims to contribute to the development of a broad awareness of nuclear issues in young people within existing school curricula frameworks. NuclearSA is independent of industry and government and is funded by public donation.

The study guide draws upon information from a number of sources including the NuclearSA website. It presents factual information and offers classroom material to assist students in situating the nuclear industry in social and environmental contexts. Topics include:

- ❖ Nuclear weapons
- ❖ Depleted uranium weapons
- ❖ Nuclear waste
- ❖ Nuclear power
- ❖ Uranium mining
- ❖ The nuclear fuel chain
- ❖ Health and safety aspects of the nuclear industry
- ❖ Ionising radiation
- ❖ The enhanced greenhouse effect
- ❖ Ecological sustainability
- ❖ Ecologically sustainable energy supply and use.
- ❖ Cultural impacts.

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The Nuclear Industry in South Australia

Were you Aware?

- Many groups, including scientists, environmentalist and medical professionals, oppose the use of radioactive material.

- Companies with nuclear industry connections control most of the electricity industry in South Australia. None of these companies is Australian.

- There are over ten nuclear industry companies actively working in South Australia. Most of these companies are not Australian and are based in countries that have nuclear weapons.

- There are three companies mining uranium in South Australia. Two of these pump sulphuric acid into the ground to dissolve the uranium: they dispose of their nuclear waste into the underground water. Neither of these companies is Australian. Acid in-ground leaching of uranium is not used in the countries in which these companies are based. Neither company will rehabilitate the ground water after mining.

- Most of the nuclear waste that the Federal Government wants to bury in South Australia comes from its nuclear reactor at Lucas Heights in NSW.

- Most uranium mined in South Australia goes to countries with nuclear weapons.

- Uranium is used not only as a nuclear explosive in A-bombs and H-bombs but also in conventional weapons such as those used in the Gulf War and in the Balkan conflict.

- Although there are international agreements to prevent uranium mined in South Australia from being used in nuclear weapons it is impossible to prevent that happening.

- Uranium mined in SA will contribute to toxic nuclear waste, which will remain dangerous for tens of thousands of years.

- Nuclear reactors are very expensive to build and remove.

Some Areas for Study

The NuclearSA website (www.ccsa.asn.au/nuclearsa) provides background information for all the suggested classroom activities.

The activities are keyed to the SACSA Framework. Each one is accompanied by one or more letters (**F**, **Id**, **In**, **T** & **C**) that correspond to the Essential Learnings, followed by numerals that refer to entries in the SACSA Band Overview for the Middle Years.

The activities are intended for students in the Middle Years band. Many teachers working in this band use thematic approaches rather than the Learning Area approach adopted here. We therefore encourage teachers to select and modify the activities to meet the needs and interests of their students. As part of the on-going development of these materials activities and ideas used in classrooms will be posted on the NuclearSA website.

The section begins with an introductory activity intended to assist students to develop some answers to questions such as “What kind of future/career would I like to have?” and “What has this nuclear stuff got to do with me?”

Preliminary Activity

In considering the question "What kind of future/career would I like to have?" students draw up a time-line for their own life marking in major events up until the present.

They extend the time-line into one or more preferred futures showing what they think might be some key events which will need to occur if their futures are to be achieved.

1. Direct the students to create a series of time-lines to answer the question "What does the 'career' of uranium mined in South Australia look like?" You may suggest that they look at both of the 'forms' – or isotopes – of uranium, ie: U_{235} and U_{238}.

Several time-lines will be possible depending on whether the uranium enters a nuclear reactor and proceeds via a reprocessing facility for reuse in reactors, or for use in nuclear weapons, or is used in depleted uranium weapons. The time-lines should show how nuclear wastes arise and are disposed of.

2. Next, ask students to represent their time-lines to scale. If students imagine that their lifeline will be as long as that of their great grandparents they can then work out how many generations of their descendants will need to take responsibility for managing nuclear wastes.

3. Finally, ask students to research in groups another aspect of technology that leaves 'residues' that subsequent generations of humans have to manage. Get each group to present their personal time-lines, those of the uranium and of other technologies with 'left overs'.

As a whole class, discuss or debate the extent to which it is fair for any generation to leave subsequent generations problems to solve - especially if the succeeding generations gain little or nothing from the original technology.

Arts

1. Working in groups students create and present an art work which deals with the issues associated with uranium mining or the nuclear industry as seen by members of a group (family, classroom, business etc) who otherwise get on well with each other but who have considerable disagreement over one or both of these topics.

(**F In 3.3**)

2. With a partner students search the Internet and in the school and community libraries for art works which present the advantages/usefulness of uranium mining or the nuclear industry. They find out how the artists' intentions were expressed in each work.

Students repeat the process for art works which are critical of uranium mining or the nuclear industry, and present in class a brief account of which works in each group they found most/least convincing and why.

(**T C 3.4**)

3. Having completed the above activities, students consider their own art works and describe the ways in which they show that the students have been influenced by – or are similar to/different from - art works from cultures other than their own.

(**Id T 3.6**)

Design & Technology

1. Smoke detectors may contain either radioactive or non-radioactive materials. Students investigate the difference between these two kinds of smoke detector in terms of their manufacture from raw materials, their installation and use, and their fate when the useful life of them or their components has expired. They develop a critique of each kind of device, and design and make an advertisement comparing and contrasting each kind, and making conclusions about the positive and negative aspects of each one.

Students research the meaning of the term 'cradle to grave analysis', and critique each kind of detector within that framework. They use this critique to make suggestions about improvements that could be made to smoke detectors.

(**F In 3.5**)

2. Working in groups, students research and record in flow sheet format several ways in which electricity can be generated. On these they highlight points in the flow sheets at which damage to humans or to other living things could occur, and they repeat this process showing where non-living things such as water and air systems could be affected.

Students develop a set of design criteria which they think would be important if those in charge of each of these ways of generating electricity were required to be, above all, concerned about the health of present generations, or of their great grandchildren.

After rating the different approaches to electricity generation against this list of criteria they present their findings to another group, being prepared to defend them.

(**F In 3.1**)

3. Using consequence wheels, concept maps or other graphic organisers students establish where materials dangerous to human or ecological processes occur in uranium mining and/or nuclear power generation. They research the strategies mining and reactor operators carry out to safeguard human and ecological health, and insert these into their existing outlines of the consequences of nuclear material mining and use.

Students set up similar ways of organising ideas to describe the dangerous events at nuclear facilities such as Roxby Downs, Three Mile Island, Chernobyl and Sellafield. They highlight the points at which strategies for safeguarding human and ecological health have been unsuccessful – or successful. They research the meaning of the term "fail safe", and discuss whether they think this kind of design is possible or not.

(**F In 3.6**)

4. Using a map of Australia students design and make a display to represent answers to the following questions:

(1) Where and how is Australia's nuclear waste stored, including in their research nuclear waste from mining, processing and using uranium?

(2) How long have these nuclear wastes been stored in Australia?

(3) What levels of danger do these wastes present to Australians?

Students describe how the technologies used for storing nuclear wastes in Australia have changed over the last 50 years. They critique these changes to determine the extent to which these technologies have improved, taking care to state what they think 'improvements' are – and why they think that. They work out ways of including this information on their map.

Students are asked to draw conclusions about the extent to which their critique suggests that the skills of designers have developed in this time, also considering what other factors, apart from the skills of designers, they think would determine whether nuclear waste disposal technologies were, in fact, improved.

(**T 3.2)**

5. Students research and present as a flow sheet the Synroc process for 'disposing' of nuclear wastes, including the financial costs.

Using questions such as the following they critique this process in terms of whether it is economically successful.

(1) How much has the Australian Government spent developing the process?

(2) How much has the Australian Government received from selling the process to the nuclear industry?

(3) Has this process been used on a commercial (rather than trial) scale anywhere in the world?

Students discuss and develop a list of criteria any process would need meet if it was to be ecologically and socially responsible, and rate the Synroc process against these criteria.

(**F In 3.6**)

6. Students are asked to consider the problems created when a society needs to store dangerous materials for tens of thousands of years.

In design teams they brainstorm ways in which people are warned to stay away from dangerous materials or practices in present societies. They categorise these ideas into those suitable to last without maintenance for ten thousand years, and those not suitable to last, unmaintained, for a similar period of time. Students present these opinions for a class discussion intended to arrive at the most useful approaches to this design problem. As a class they develop a set of criteria for the necessary characteristics of the long-term waste repositories to be designed.

Each team selects/is allocated one or more of the approaches considered to be suitable. They develop design outlines for suitable artefacts and processes to warn humans away from or prevent their access to long-lived dangerous materials such as nuclear wastes. Each team creates a scale model of such a repository, and a brief statement setting out the reasons why their designs will effectively solve the problem. They share the models and statements in class, and rate the suggestions of each group against the criteria developed earlier.

Students might further develop a critique of their own designs, and of the processes they went through as a team and whole class – and then discuss these in class. A summary of ideas proposed as solutions to this kind of problem by a multidisciplinary team can be found at:
http://www.halcyon.com/blackbox/hw/wipp/wipp.html

(F T 4.3)

English

(activities under development)

1. Students imagine they are living near Chernobyl at the time of the nuclear disaster. They write a diary covering the week before and the week after the disaster.

2. Students research material for and organise a class debate on the topic “South Australia should have a nuclear power station.”

3. Students write a story describing a typical day in their life – without sunlight.

4. Students research the term ‘legal fiction’ as used by Vandana Shiva, a scientist trained as a nuclear physicist who now opposes the use of nuclear energy. Beginning with the words ’waste’, ‘waste disposal’ and ‘away’ (as in “throwing waste away”) students develop a dictionary of legal fiction (a legal fictionary?)

Health and Physical Education

(SACSA connections being reviewed)

1. Students construct a poster and accompanying brochure using Marie Curie's experience to advertise the safety precautions needed to ensure worker and consumer protection for different uses of radioactive materials.

2. The concept of 'half-life' is used to describe the rate at which radioactive materials decay. Students find out what this means for uranium, and for some of the things left after nuclear power stations have ceased their useful life. They might explore the notion further by seeing if it could be used to describe other things that 'decay', such as physical fitness, and SPEED OF REACTION TIME.

3. Students research questions such as "How long will radioactive wastes from uranium mining remain dangerous?" and "What about the radioactive wastes from the world's nuclear reactors which will be powered by South Australian uranium?" They use examples such as the times that Aboriginal people and non-Aboriginal people have been in Australia to discuss terms like short-lived and long-lived radioactive isotopes.

They proceed to consider questions like: Where is the largest volume of nuclear waste produced? Where is the most radioactive nuclear waste produced? Has any of this nuclear waste been permanently and safely disposed of - if so, where and how?

Having, in the first part of this activity, used the time-scale of Aboriginal people's occupation in Australia to develop a relative scale to do with length of life of nuclear wastes, they consider what scales or indicators they could develop to express the human and environmental implications of the amounts of nuclear wastes they determined above.

4. Direct students to research as many different ways of producing and conserving electricity as they can. They are then to analyse each in terms of their impact on the health and wellbeing of individuals and communities. Make sure students consider the multi-dimensional nature of 'health' ie: the physical, ecological, social, spiritual, and emotional dimensions.

Now ask students to compare the alternatives and rank them from the healthiest to the least healthy. Stress to the students that reasons for their rankings are to be discussed and provided.

On the basis of the above research students are to prepare a report that argues for healthy ways of obtaining the services provided by electricity. Present the report to groups in the school community eg. via a school assembly, student meetings, the school newsletter, and local newspapers.

5. The history of the nuclear industry is also a history of community resistance and social activism. Ask students to gather as much information as they can about one such case outlining: the health issues from which the social action developed and; the ideas, processes, and tactics used by the community, alliance or organisation.

Students are to comment on the success of the social action and offer reasons for its success or lack of success.

Ask students to use their knowledge of collective action for social change gained from this activity to consider a health issue in the school community and develop a community action plan for healthy social change.

6. Students research how standards for exposure to ionising radiation have changed since 1934. They are asked to consider in pairs, and discuss in groups, questions such as “Are radiation health standards likely to keep changing?” and “What, if anything, will be the consequences of further changes to the standards?”

7. Students enquire from their dentist how much ionising radiation (in milliSieverts) they receive in a typical dental X-ray. They also ask the X-ray technician and the appropriate State Government department.

8. Students research the sources of ionising radiation that are claimed to be beneficial to some people. They try to find out where such materials are made, and from where Australia gets these materials – and which could be made in a less dangerous manner or imported.

Now ask students to research the health costs and benefits of using ionising radiation to detect and treat cancer eg. mammography with X-rays or body scanning with technetium 251 (Tc-251), and to treat cancer, eg. with radioactive cobalt-60 (Co-60). They should include all affected people (medical technician, patient, miner, nuclear reactor technician, transport worker, nuclear waste disposal worker, scientists, people who live near the nuclear reactor or nuclear waste disposal site, etc) in their analysis.

Students are to represent the results of their research by using maps and time-lines.

Language/LOTE

(activities being developed)

1. Students make as long a list as they can of words in other languages for: atom, ion, electron, nuclear, radiation, waste, bomb, health, cancer, sun, wind, energy, environment.

2. The following countries are known to have nuclear weapons: USA, France, Russia, UK, China, Israel, Pakistan, and India. Students find the countries on a map of the world, and draw or stick red dots on to the map to show them. On the same map they use black dots to show which of these countries have nuclear reactors.

3. South Australia exports uranium to France, USA, and the UK. Students use thread or tape to connect the places where uranium is mined in South Australia to each of these countries.

4. Students share research to establish answers to the question "What were the last two countries to detonate nuclear weapons?" They research the cultures of these countries, and look for answers to questions such as: "Are these countries close to each other? Are relations between these countries good?"

5. Students conduct research in order to answer questions such as "Which is the only country to have dropped nuclear weapons on the people of another country? What were the circumstances under which this happened? Are these circumstances likely to re-occur?"

6. Students conduct research to answer the following question: "Which country used South Australia as a source of uranium for its nuclear weapons and as a place to test those weapons?"

On a map of South Australia they locate the place where uranium ore was mined, the place where the ore was processed, and the place in where the weapons were tested, and connect these places with thread or tape.

Students find out what happened to the waste from these nuclear weapons tests, and represent this on their map.

Mathematics

1. How long do radioactive materials 'last'?

All materials, objects, things and so on are made of tiny particles called atoms. All atoms are made up of electrons and a nucleus containing protons and neutrons. Some atomic nuclei are unstable. That is, they break down – by giving off some of the very tiny particles of which they are made. Because they give off some of their particles – or radiate them - these atoms are said to be radioactive. Some nuclei break down faster than others. They are said to be highly radioactive.

The radiation given out by radioactive atoms when they break down is called ionising radiation because it is capable of creating charged particles (or ions) from uncharged particles such as atoms and molecules.

The atoms left behind after radioactive breakdown are eventually stable, that is, not radioactive.

Radioactive materials are dangerous to living things because ionising radiation can damage living cells causing cancer and other diseases. Highly radioactive materials are more dangerous than less radioactive ones.

To provide a way of describing how long it takes radioactive atoms to decay scientists invented a measure called the half-life. This is the time that it takes for half of the atomic nuclei to decay. That is, half of the nuclei have become another kind of nucleus. So, if the half-life is 20 years, and we start off with a piece of material containing a million of the particular nuclei, there will only be half a million of the nuclei in the piece of material after 20 years. The rest of the nuclei in the piece of material will be another kind of nucleus – which might be either radioactive or non-radioactive depending on the nuclei we started with.

Using plasticine blocks of known size, or coloured squares, or squared paper, or …… students make a series of graphs showing how long it will take for the number of radioactive atoms to decay to $1/8^{th}$ of their original number if the nucleus has a half-life of 30 years. They repeat this for another nucleus with a half-life of 100 years. For each of these nuclei they estimate what fraction they think will be left after 300 years, and check it by using their graphs.

They consult the NuclearSA website to find out the half-lives of some radioactive nuclei that are called "short lived" and some that are called "long-lived", and use their graphs to show what happens to them. All of this could be entered into a spreadsheet to make and test predictions about the length of time that it takes radioactive nuclei to decay to other atoms. Note that the new nuclei may themselves be radioactive with a completely different half-life to that of the original nuclei.

(**F 3.3)**

2. How much ionising radiation can you take?

When people work with radioactive materials – for example, in mining, transporting, processing, using, reprocessing and disposing of them (see the sections on 'The Nuclear Waste Cycle') – it is important to make sure that they are not exposed to ionising radiation that damages their cells. Obviously, it is more likely that more damaging amounts – or 'doses' - of radiation will be received if people are handling highly radioactive materials.

Scientists have developed a measure called the 'maximum allowable dose' (MAD), the amount of ionising radiation received per year that causes an amount of damage to a person that is considered by international authorities to be an acceptable risk. This is described in terms of a unit called milli-Sieverts (said 'milli – seeverts'), shortened to mSv. Students can check the NuclearSA website to find out what one mSv is equal to.

As scientists understand more about radioactive materials, including how dangerous they are, they have found it necessary to revise the MAD downwards. That is, the more we know about radioactive materials the more dangerous scientists believe they are. On the average, the MAD has been halving every 12 years or so. Students could graph what this looks like by using the same procedures as they used in activity 1 in this section. There they were showing what happened to a physical entity. Here they would be graphing what has been happening to an idea! If they do this, they might try to predict how long it would take the 1991 MAD of 20mSv to become 5mSv – and then check it on their graph(s).

As a way of understanding the significance of this dose, students could find out how many mSv a person receives in a dental X-ray or in a chest X-ray. They discuss what they think will be the MAD in 2003, 2015, 2027, 2039, and 2051 if the trends that they have investigated continue.

Students are asked to discuss how they think the nuclear industry could use their graph on a poster claiming that safety was improving. Or would it be safety standards that were improving? They can also discuss how critics of the nuclear industry might use the same graph in a poster advertising their idea.

(F C 3.2)

3. How much do we know about how safe radioactive materials are?

When uranium mining, under the guise of exploration, started at Roxby Downs in 1982 the Maximum Permissible Dose (MPD) for the workers was 50mSv per year. In 1991 the MPD was set at 20 mSv a year. Using these values and their predictions of the MPD for 2003, 2015, 2027, 2039, and 2051 students could work out how much ionising radiation could legally be received by a worker receiving a MAD each year for a period of employment of ten years from 1982, 1992, 2022, and 2042. This should enable them to discuss the differing 'conditions of work' for people employed at Roxby Downs from the beginning of its operations, during the life of the mine, and concluding with the last decade of mine operation. Roxby Downs is expected (scheduled) to cease operation in 2051. Students discuss what this activity suggests about the safety of uranium mining.

By looking at the information contained in "The Nuclear Waste Cycle**"** students produce a list of other situations in which worker safety might have been compromised by our changing definition of what is "safe".

They consider how they could represent this information graphically with a minimum amount of text.

(**F T 4.2)**

4. Spilt? Lost? Disappeared? Gone? Where? How much?

In January 2002, a liquid containing a variety of dissolved chemicals was accidentally released from the pipes carrying it around the uranium extraction plant at the Beverley uranium mine. During the accident 62,000L of solution were spilt. Students find out the volume of an Olympic sized swimming pool, and that of an average sized backyard swimming pool. They make some measurements that enable them to calculate the volume of their classroom, and use these volumes to work out how many times – or to what extent - the spill would have filled all of the 'containers' listed above. They represent that graphically.

There were 220g of uranium dissolved in every 1000L of solution (220 ppm). So in 62 times this – that is 62,000L – there are about 13.6 kg of uranium. 99.3% (or about 13.5 kg) of the uranium has a half-life of 4.5 billion years. The remaining (0.1 kg or 100 gms) uranium has a half-life of 713 million years.

Students represent those quantities graphically using different scales.

In January 2002 it was announced that 440,000L of mining waste had accidentally escaped from a tank at the Roxby Downs uranium mine. There was 1kgm of uranium in each 1000L of this mixture (1000 ppm). Students repeat the processes they undertook in 4.1 – and represent these amounts on a map of South Australia showing the uranium mining sites.

Students consult the NuclearSA website and other links – including press reports, and press releases from those in support of mining at Beverley and Roxby Downs, and from those against it - to find out where all that uranium 'went', how dangerous these events were, and what procedures have been put in place to try to avoid these events happening again. The nuclear industry claims that these spills were not dangerous. Students are asked to consider what we need to know in order to check this claim, and to ascertain whether this information has been provided by the nuclear industry.

Students research the other leakages, or other 'accidents', that have happened at uranium mines in South Australia – or Australia – and represent these on timelines. They also research which of these accidents were immediately announced by the mining companies involved, and which were made public by other people.

Students develop ways of representing this property of accidents – that is, the amount of time it takes for them to be made public and how this occurs - on their timelines. If they have time they could extend this investigation to include accidents and their reporting in all activities of the nuclear industry – that is, processing, reprocessing and transport of all nuclear materials, and storage of wastes – for the nuclear facilities around the world.

(T C 3.2)

5. Will SA Great be great – for great-grandchildren?

Students consult resources to find out what fraction, or percent, of electricity generation in the world was provided by nuclear reactors last year. They do the same for electricity generated by wind turbines and solar cells. They consult information for ten years ago and represent the trends this data shows. They consider how these three methods compare and contrast with each other in the trends shown. They develop ideas about what the situation will look like if these trends continue for the next ten years and for the next 100 years.

Students develop a list of factors that might cause these trends to stay the same, or to change in favour of one or other of these three methods of electricity generation. They compose a letter to their great-grandchildren about what they hope things will be like for them – that is in about 75 years.

(**F C 3.11)**

6. Who minds the store?

Students are asked to imagine that Aboriginal Australians had been users of nuclear power when the earliest recorded cave paintings were made in Australia possibly 60,000 years ago. They develop ideas about how much of a 10kg load of nuclear reactor waste material we would now be required to manage if their 'waste disposal' methods were of the same kind as those proposed today? They consider if a generation of humans gives rise to the next in about thirty years how many generations will have been minding that 'store' of nuclear waste – and how many more generations will need to do so before (the remainder of) the original 10kg load of waste does not need to be managed?

They find out what the term 'intergenerational equity' means. In a small group situation they discuss the score out of 10 they would give to the nuclear industry in their role as a judge at the International Equity symposium in 60,000AD. They record and share some of the reasons for their score, and repeat the exercise for the invention of democracy, cigarettes, free schooling, and so on. They tabulate and make a poster of their score sheet, with brief reasons.

(**In F 4.3)**

6. How confident can you be?

On the last page of the student material in this kit there is a set of tabulated information titled "Generating Electricity in South Australia". It contains no numbers but provides information in a comparative and qualitative way.

The authors of this material believe that there are many aspects of electricity generation that it is difficult to describe accurately by numerical, or quantitative data.

For example, it is reasonably simple to provide the cost of, say, building and maintaining a large wind turbine. It is also reasonably straightforward to predict the amount of energy available in the relatively predictable seasonal pattern of wind strength occurring at any one site for a wind farm. However, it is difficult to provide a figure for the average amount of energy available from wind generators – and therefore its cost - given the widely different sites at which they might be built. Similarly, it is reasonably simple to estimate the cost of building and maintaining a nuclear reactor of known generating capacity. However, the cost of managing the reactor's wastes, over the time periods for which management will be necessary, is very difficult to calculate.

Using The NuclearSA website and other sources students research the factors which will have an impact on the 'cost effectiveness' of one or more means of generating electricity. Because this is quite a complex task it will be useful for them to work in small groups with each one considering only one or two means of generating electricity. It might be important to arrange full-class meetings occasionally to make sure everybody is interpreting results in similar ways.

Students are asked to categorise their results so that they separate factors for which a quantitative estimate can be confidently made from those where the figures are more 'rubbery'. They include in their categorisation factors that reduce and those that increase the costs. They acknowledge factors for which quantitative values are rarely found because, for example, there is a sense of aesthetics involved. An example in South Australia and elsewhere in mid-2002 has been resistance by some residents to the placement of wind farms in areas where the wind turbines can be seen from their houses. That has a quantitative element related to real estate value that might be possible to cost out. Doing so for the aesthetic value of the views available from a piece of real estate is much more problematic.

Whenever they find numbers quoted students could try to find out what the range is for the number(s) given, and/or whether the numbers need to be given with a +/- 10% or similar kind of notation.

Students share their results as a class. They design and put into effect a survey of their class members – and perhaps another class to whom they make guest presentations – to find out how people rank the various means of generating electricity. They will need to discuss the criteria for ranking. For example, they might use 'cost per unit of electricity' as the criterion for one ranking – and 'whether I'd like to work in this industry' as another – and so on.

(In 3, or 4)

Society and Environment

1. Provide students with copies of the following from the NuclearSA website: "Were you aware?" the "Test your knowledge" quiz and the "They didn't tell me that" crossword. Ask students to list and review the ideas about the nuclear industry contained in the above. Some have greater implications than others for humans and the Earth. They research the ideas and values surrounding one or more of these 'facts'. In small groups students categorise them into 'low level implications', 'medium level implications' and 'high level implications'.

Students share their analyses with their peers, and respond to what they hear as 'constructively critical' friends.

(**In T 3.12**)

2. Working in groups, students investigate the environmental, social and economic consequences of various methods of providing the services usually supplied by electricity in the home. They prepare a display in which each group presents a poster or brochure setting out the advantages of one of these methods as an advertising or PR agency might do. After the groups have been reorganised each one prepares an advertisement setting out the views of opponents to that energy service provision.

(**In F T 4.5 4.6**)

3. Uranium mining in South Australia has always been strongly opposed by environmentalists and citizens' groups.

Students research ways in which the nuclear industry and the South Australian Government have responded to these concerns. They discuss in groups the extent to which these responses effectively addressed the concerns raised.

(**T C 3.12**)

4. Students are asked to choose one of South Australia's uranium mines (Honeymoon, Beverley, Roxby) and find out how the mine was opposed. They make a poster display illustrating what human rights the mines' opponents believed were being abused.

(**T C 3.8 3.9**)

5. Students research how the nuclear industry tries to meet environmentally friendly goals. They consult local environmental agencies of government and community to find out how well they believe those goals are met. Students prepare, display and defend a chart showing areas of agreement and disagreement.

(**C F 4.11**)

6. The Federal Government is planning a shallow burial pit for storing low-level nuclear waste (the National Radioactive Waste Repository) near Woomera in South Australia.

Students seek to establish who is supporting this proposal and who is opposing it – and their reasons for doing so. They research the views of Australian, state & local governments and politicians. They develop ways of measuring the extent to which these views are presented in the media and display their results.

(**F C 4.3 4.8**)

7. Uranium mines in Australia are on lands of significance to indigenous peoples. Students investigate whether this pattern is true for exportable minerals (including uranium) and indigenous peoples in other countries. They consider what conclusions they can draw about the similarities/differences in the experiences of indigenous peoples around the world, including their sense of identity as provided by their ability to control what happens on lands of importance to them.

Students summarise their findings on a Peters' projection of the world.

(**In Id 3.8 3.9**)

8. Students investigate some of the jobs and careers in the renewable energy industry and set up a school/class Expo at which each class/group presents a display showing the employment possibilities, the extent of government support of the industries, the consequences to environments and communities from the support of such industries – and ways in which their school experiences are preparing them to study towards working in those industries.

(**F T C 4.11 4.12**)

Science

1. People in affluent countries such as Australia and the USA consume more electricity per person than people in most other countries.

Students make an audit of their class/school use of electricity. They develop cooperative strategies for reducing electricity use – and an outline of reasons why reducing electricity use is important. They implement and monitor their success with the strategies, remembering to design and implement a series of rewards for themselves as they attain success!
Energy audit support materials may be available from Departments of Energy and for Education.

Students consider how they could extend this activity to their homes. They discuss and implement strategies to find out what national, state and local governments are doing to reduce electricity consumption.

(**In T 4.3**)

2. Often our use of electricity is not essential. That is, we use it to support our image or our sense of what it's fashionable to own, rather than providing for what we need. For example the appliances left on stand-by so we can turn them on with a remote control contribute to our high electricity use. Electricity conservation is the equivalent of producing more electricity. Students work out, graph and display how much electricity people could 'find' if they used electricity only for essentials.

(**T C Id 3.3**)

3. Radioactive substances give out ionising radiation. Students develop ways of finding out more about ionising radiation, particularly trying to answer questions such as: "What is alpha ionising radiation? What effects can it have on living tissue? Why is it so dangerous to workers in the nuclear industry? What materials or procedures are used to help protect them?"

Using a chart or other form. students illustrate how the atomic/molecular structures of biological materials make them susceptible to damage by ionising radiation, and how those of protective materials provide them with the ability to protect living tissues.

(**T C 3.7**)

4. One of the key figures in research on radioactivity was Marie Curie. Students research the work of Marie Curie and the cause of her death. As a class they research and make a gallery display of scientists who have been injured or killed as a result of the kinds of scientific work they were carrying out.

Students use this material to contribute to their preparation for and presentation of a debate on the topic "The benefits of science outweigh the costs"

(**In C 3.7**)

5. Research the origins of the term "Ecologically Sustainable Development (ESD)". Develop a list of the characteristics that things (people, products, processes) would need to have in order to contribute to ESD.

Using this list organise a debate on the topic "Solar energy will contribute more to ecologically sustainable futures than nuclear energy"

(**F T C In 4.3**)

6. Students consult reference sources to ascertain what happens to the nuclear wastes from uranium mining.

Around the walls of the classroom they create a mural showing all of the points at which the nuclear industry produces radioactive wastes. They develop ways of noting on the mural at what points, and for how long, each kind of nuclear waste will remain dangerous to living things, and at what points, and for how long, each kind of nuclear waste will need to guarded by their grandchildren and later descendants so that dangerous materials cannot fall into the wrong hands.

Students discuss and decide to what extent they consider that the fate of nuclear wastes is an example of the ecologically responsible management of a product life cycle.

(**F In T C 3.8**)

7. Students research the leak of nuclear wastes from the tailings retention system at Roxby Downs, which was first reported in 1994. They investigate how the nuclear industry intends to manage mines so that these events do not occur in future – and what view of these precautions critics of uranium mining hold. They prepare a poster paper on the leaks, their environmental and cultural consequences and the opinions they have collected.

(**F 3.5**)

8. Students research the use of water by the Olympic Dam Project at Roxby Downs seeking to answer questions such as: "Where does the water come from? To whom does the water belong? How much is paid for the water? What happens to the water? What are the ecological and cultural impacts of its use? What opinions are there about the ecological and social justice of this?"

In groups they develop and discuss their views on this – and present them to another group.

(In 4.1)

Ionising Radiation:
the other story

Ionising radiation is unlike other forms of radiation because it converts neutral atoms and molecules into charged particles (ions). Heat, light, and sound, although forms of radiation, are not ionising radiation. They have no proper place in educational material on the nuclear industry. Inclusion of non-ionising radiation in literature on the nuclear industry serves only to confuse and to give a false sense of safety.

Like many harmful things, there is a minimum dose of ionising radiation that is difficult to avoid. This comes from cosmic rays and from small amounts of radioactive materials present in our environment.

It is in our best interest to minimise exposure to ionising radiation. If we assess that the benefit of increased exposure (as in an X-ray, or body scan) outweighs the risk, then it is our right to take the risk. Such risks must be taken voluntarily and knowingly. This is called informed consent.

Even for the medical uses of ionising radiation, consent is not always requested, and if it is, it is rarely informed consent. Try asking your dentist what dose (in milli Sievert) of ionising radiation you received during your last dental X-ray!

Frequently we receive additional doses of ionising radiation without direct consent, consent being given on our behalf by government. In many cases there is no perceptible benefit to balance the risk of such an exposure. In the case of the nuclear industry, financial benefit goes to the companies involved and to the workers in those companies but the risks are born by the population at large, which receives no tangible benefit from the industry. Those who object to being put at risk are ignored.

NuclearSA Website Map

http://nuclearsa.ccsa.asn.au/

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For Further Information Contact

Nuclear Information Centre:
The Conservation Centre
120 Wakefield St
Adelaide SA 5000 AUSTRALIA
(08) 8223 5155 fax: (08) 8232 4782

Useful Websites

❖ Anti-Nuclear Alliance of WA	www.anawa.org.au
❖ Australian Conservation Foundation	www.acfonline.org.au
❖ Australian and New Zealand Solar Energy Society	www.anzses.org
❖ Australian Peace Committee	www.peacecourier.com
❖ Friends of the Earth	www.foe.org.au
❖ Greenpeace	www.greenpeace.org.au
❖ Gundjehmi Aboriginal Corporation	www.mirrar.net
❖ Kupa Piti Kungka Tjuta	www.iratiwanti.org
❖ Medical Association for the Prevention of War	www.mapw.au.nu
❖ Mineral Policy Institute	www.mpi.org.au
❖ Nuclear Information Centre	www.ccsa.asn.au
❖ Sustainable Energy and Anti-Uranium Service	www.sea-us.org.au
❖ The Wilderness Society	www.wilderness.org.au
❖ Womens International League for Peace and Freedom	www.wilpf.org
❖ World Information Service on Energy	www.antenna.nl/wise

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