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AEG 1505 Teaching Humanities
Assessment 2 - Integrated Unit

The Economics of Renewable and Sustainable Energy

Contents

Title

The Economics of Renewable and Sustainable Energy

VELS / Year Level

VELS Level 6, Year Ten

VELS Learning Focus, Dimensions and standards

VELS Learning Focus

Civics and Citizenship: Students evaluate the role of the Australian Government... through contexts such as government responses to environmental concerns such as global warming or other issues of environmental sustainability.

The Humanities - Economics: Students investigate the relationship between economic growth, ecological sustainability. They develop skills in using economic reasoning, including cost-benefit analysis, to research economic issues. They research economic problems.

The Humanities - Geography: Students investigate the interaction of human activities with the natural environment through a study of issues such as global warming and climate change... and air and water pollution. Students develop skills to evaluate the factors contributing to the development of these issues, identify strategies to address them and explore ways of managing them. They reflect on plans of action... considering the value positions underlying them, including a commitment to the principles of sustainability.

Information and Communications Technology: Students consistently apply commonly accepted ICT presentation conventions and use efficient procedures and techniques to… create quality information products that fulfil their purpose. Students expand their skills in locating information on websites. They refine their searching techniques to get more precise results.

VELS Standards

Strand	Domain	Dimension	Key elements of standards
Physical, Personal and Social Learning	Civics and Citizenship	Civic knowledge and understanding Community engagement	Students draw on a range of resources... to articulate and defend their own opinions about... environmental issues in national and global contexts. They... demonstrate their knowledge of a social or environmental issue and suggest strategies to raise community awareness of it.
Discipline-Based Learning	The Humanities - Economics	Economic knowledge and understanding	Students describe how markets, government policies... affect the economy, society and environment in terms of... the use of resources... and ecological sustainability.
Discipline-Based Learning	The Humanities - Economics	Economic reasoning and interpretation	Students use economic reasoning, including cost-benefit analysis, to research... and to clarify and justify values and attitudes. They plan and conduct investigations in order to research an economic problem. They use relevant economic concepts and relationships to evaluate economic... policies, and debate the costs and benefits of contentious economics-related issues of local, national or international concern.
Discipline-Based Learning	The Humanities - Geography	Geographic knowledge and understanding	They analyse... issues and... evaluate comprehensive policies, including those for sustainable use and management of resources. They use evidence based on their inquiries and geographical language and concepts.
Discipline-Based Learning	The Humanities - Geography	Geographical skills	Students accurately interpret information on different types of maps and photographs at a range of scales, and use map evidence to support explanations, draw inferences.
Interdisciplinary Learning	Information and Communications Technology	ICT for visual thinking	Students are efficient and effective in their use of appropriate ICT tools and editing techniques.
Interdisciplinary Learning	Information and Communications Technology	ICT for creating	Individually, and as team members, students apply a range of techniques, equipment and procedures that... maximise the accuracy, clarity and completeness of the information.

Synopsis

This unit will explore the economics of the environment, sustainable and renewable energy, carbon pricing models, and how students can raise awareness of these in the community. The unit will begin by exploring the students' current knowledge of and opinions about these topics. The students will participate in a range of activities using a number of teaching methods and learning styles, and by the conclusion of the unit students will reflect on their original opinions, and be able to justify how and why their opinions have changed or remained the same.

Students will look at the economic, social and environmental issues around energy production methods and have the opportunity to observe firsthand some examples via an incursion by CSIRO and an excursion to CERES Community Environment Park. The unit will cover not only economics, but will integrate geography, civics and citizenship as well as ICT. It is designed to expand and support students' critical thinking and analysis skills through the use of inquiry based and cooperative learning.

Focus Questions

- What is environmental economics and how does it differ from and link to financial economics?
- What is carbon pricing? Is it an appropriate method to address the national and global issues affecting energy production and the environment?
- What are the models used to address carbon pricing and why is it necessary for the government to impose this?
- What are the geographic and economic factors that affect renewable energy production?
- How can the community be engaged in and impact on issues of renewable and sustainable energy?

Activities

Activity One

Think Pair Share

Students are given an introduction and a brief overview of the new unit, The Economics of Renewable and Sustainable Energy. The teacher will also provide an outline of some of the activities the students can expect to participate in, including an incursion and an excursion.

Students undertake two Think Pair Share activities, one at the beginning of the unit and one at the end of the unit. This will serve as a preface to the unit, and also a guide for both the teacher and the students to informally assess the progress of their learning.

Beginning:
At the introduction of the unit students are asked to think about the issues of renewable and sustainable energy and carbon pricing, and to reflect on the economics of each. In pairs students discuss their thinking and compare information and opinions. Students then share this with the whole class.
The teacher will record the students' input and with students consultation and assistance make a poster summarising this, to be displayed on the classroom wall for the duration of the unit.

End:
At the end of the unit the poster will be placed on the board (or central learning space) and the contents reviewed. Students are asked to think about what they have learned over the course of the unit and reflect on if their opinions have changed at all based on their learnings, and why. In pairs students discuss and compare their thinking and reasons, if applicable. Students then share their reflections with the class.

Activity Two

Economics of the Environment

Students read an excerpt about Economics of the Environment (based on the text *Economics* 4th Edition by McTaggart, Findlay and Parkin) and answer a series of comprehension questions about the reading material. The questions cover a range of lower and higher order thinking principles and the activity is designed to be a starting point into the different issues that are involved in environmental economics. Students will be expected to discuss and share their answers in the class setting once completed, facilitated by the teacher. This will assist students in consolidating their own understanding, and give them practice arguing their opinions where appropriate, as well as giving the teacher an overview of the students' grasp of the material.

Handout with questions attached as Appendix One.

Activity Three

Incursion - Energy Without CO_2

Students will participate in an incursion run by CSIRO titled "Energy Without CO_2", which is designed around Levels 5 and 6 of VELS. The session will run for sixty minutes and will cover global warming and the consequences of greenhouse gas emissions as well as providing an introduction into alternative sources and methods of energy production.

Students are encouraged to fully participate in and enjoy the session, but also advised to make note of the content as the information will be useful for the remainder of the unit.

Immediately after the session the teacher will facilitate an informal debrief, and solicit from students their reflections on what they saw, what they learned, whether the session invoked any particular feelings (bored, saddened, inspired), whether the students considered it to be a valuable experience and why or why not. Students will also be given some class time to write down any notes or reflections they feel may be useful for the upcoming activities.

Activity Four

Research project - energy production methods

Having attended the incursion and gained some information and ideas about sustainable and renewable energy, the class will complete an investigation of the different kinds of energy production methods. This will include all forms of energy production, from current fossil fuel and 'clean' fuel technologies to renewable energy sources. The activity will begin with a mind-map or brainstorm, soliciting a list of the different kinds of energy production methods. The students should come up with: coal, natural gas, nuclear, hydroelectric, solar, and wind. These will form the basis of the class investigation. Students may come up with other renewable and non-renewable forms (biomass, biofuel, geothermal etc.).

Students will be assigned to working groups of between three to five students depending on class size. Groups will vote on the energy production methods they would prefer to research, and will be allocated a method accordingly. Within the group students must research the economic, social, and environmental impacts and benefits of the energy production technique they have been assigned. Students should identify the factors that contribute to costs and benefits, stakeholders and how they are affected, production output levels and the current proportion of total energy consumption in Australia. Students may use library resources and online resources. They will be encouraged to consult the media in order to find current discussion of public opinion on the various issues involved.

Groups will be expected to present their research in either a poster or booklet format. These will be displayed around the classroom and will serve as resources for the class for the remainder of the unit, and as such will need to be referenced appropriately. The poster or booklet will be assessed (rubric contained in the assessment section).

Activity Five

Renewable energy and geography

Continuing on from the concepts covered in Activity Four, students will now investigate renewable energy production sites in Victoria and identify the environmental and geographic features that make those locations suitable.

Students may use the Sustainability Victoria list of Renewable Energy in Victoria (http://www.sustainability.vic.gov.au/www/html/2087-renewable-energy-in-victoria.asp) as a starting point, but will be expected to utilise various techniques in order to complete their investigation, including different types of maps (topographical, synoptic etc) whether print or online, online mapping technology such as Google Maps, and information they obtain in their research. A large map of Victoria will be displayed on a pinboard in the classroom, and students will be able to consult it as a reference as well as marking the sites they have investigated with different coloured pins depending on energy production method.

As well as ascertaining why the locations of the renewable energy production sites are significant and suitable, students should consider and record the problems associated with those locations in terms of mass energy production, for example the distance of the site from densely populated areas (and therefore the majority of energy consumers).

Students will be working individually, but it is expected and preferred that they will collaborate with other class members to support and guide each other. The teacher will also be available to support and guide as necessary, and informal assessment will be conducted as the teacher circulates throughout the room. At the conclusion of the session the teacher will bring the students together and as a class discuss their findings and the implications for the use of renewable energy.

Activity Six

Carbon pricing models

This activity will begin by reviewing students' knowledge of economic concepts such as market models and free trade, laws of supply and demand - this should be a review, and can be treated as an opportunity for informal assessment of prior learning. Once the teacher is confident that students are comfortable with these concepts, the class will move on to the topic of carbon pricing models.

Students will be asked to share their knowledge of economic measures currently in place (or being debated) to regulate carbon emissions. These can be written on the board or work surface as a brainstorm or mind map, and will provide a starting point for the remainder of the class.

The teacher will have prepared three blank poster sheets and displayed them on a surface that they can be written on. Students will be required to cooperatively research three different models of carbon pricing, and as a class will fill in the posters with this information. The three models are: 1) emissions charges, 2) taxes or levies, and 3) marketable permits. Students will work on laptops or use books and materials previously gathered by the teacher to find out how these different models work, and what economic theories can be identified as underpinning these models. Students should attempt to find an example where the models have been used in other countries.

Once these are complete, a fourth poster will be added. Students will research what Australia's current carbon emissions policy is, which of the three models it most closely follows, and what kind of reduction the government expects to achieve by instituting this policy. They will also research which industries or sectors contribute the greatest levels of carbon emissions.

At the conclusion of the activity, students will put away research materials and laptops and come together as a class. The teacher will facilitate a discussion on whether they believe the current policy on carbon pricing is appropriate and/or effective in Australia, why it may or may not be successful, how it might be made more successful, and which model they believe would work better or best. Students will be encouraged to justify their opinions with reasoned arguments, and to foster a spirit of lively, respectful debate.

Activity Seven

Excursion - CERES

Students will participate in an excursion at CERES Community Environment Park (Centre for Education and Research in Environmental Strategies). The excursion will be a half-day experience involving two programs, both of which are linked to Levels 5 and 6 of the VELS.

The first program is titled "Renewable Energy" and will allow students to interact with real renewable energy production mechanisms or working models. This should act as a good follow up to their previous learning, putting a physical, practical face on the renewable energy methods they have researched and learned about and allowing the students with more hands-on learning styles to really solidify their understanding. Part of this activity will be observing the working solar energy facility that the centre uses to generate power, and discussing the challenges that exist in implementing renewable energy.

The second program is titled "Australia 2030 Trail" and will challenge students to use all the knowledge they've acquired, make educated decisions and see the consequences of those decisions play out in Australia's future in terms of economy, society and environment. This will ideally broaden their critical thinking skills and give them a better understanding of the kind of thinking and decision making that has national ramifications.

A debrief will follow the excursion once back at school, with the teacher facilitating class discussion about the excursion. The discussion should cover not only what the students enjoyed or didn't enjoy, but draw out their thoughts on the Australia 2030 Trail activity and what they learned from it, if they would change some of the decisions they made based on the outcome, what they thought worked well etc. This will lead into the final activity.

Activity Eight

Research project and proposal - community engagement

This activity is designed to get the students to take their learning from the unit as a whole and apply it to the wider world, with a real focus on community engagement. In groups, students will undertake a research project and proposal. The topic is based around what the students can do to promote sustainable energy; at home, at school, and in the community. This will be a multi-period activity. The proposals will be assessed (rubric contained in the assessment section).

Once all groups have completed their proposals, one period will be allocated to presentations. The students will vote on which was the best proposal, and a winner will be decided. The class will then strategise what is the best method of implementing the winning proposal, and will make a formal submission to the school leadership group in order to have it approved and acted upon.

Students will receive a copy of the project expectations below, plus a copy of the assessment rubric.

Sustainable and Renewable Energy
Research Project and Proposal

Your task is to research what you can do to promote sustainable and renewable energy at school and in the community. In groups of four (three if approved by the teacher) you must draft and present a proposal for how you believe you can raise awareness about sustainable and renewable energy and effect change in the school or local community. You may choose to do this in economic terms (e.g. saving money), environmental terms (e.g. protecting the environment), social terms (e.g. improving quality of life), or a combination of these.

Some class time will be allocated for this assignment, but you will also be expected to work on it in your own time. You may choose the format of your report and/or presentation, bearing in mind that it is a major piece of assessment and will be marked. You will be expected to demonstrate appropriate use of ICT both for research and presentation. Referencing is essential.

The presentation should be between five to seven minutes in length, and may be in any suitable format. You may choose to simply speak, to use a powerpoint or Prezi, to make a video, to make a digital story; whichever format you believe best conveys your proposal.

As a class you will vote on which is the best proposal to try and take to the school leadership group and get implemented, so ensure that your presentation clearly demonstrates why your proposal is the best; explain, analyse, justify, convince.

Excursions

1. Incursion

VELS INTEGRATED UNIT INCURSION

Company Name: CSIRO Education Victoria
Contact Address: Graham Road, Highett VIC 3190
Phone Number: 03 9252 6387 / 03 9252 6410
Fax Number: 03 9252 6256
Email: education.vic@csiro.au
Website: http://www.csiro.au/Portals/Education/Teachers/Incursions-and-excursions/education-centres/Education-VIC/~/link.aspx?_id=ED6447E9983D4E2A8565C0163E836309&_z=z
Melways Reference: 77 E10
Cost: Minimum $520 (includes 2 sessions up to 60 participants per session)
Resources provided: One sixty minute session "Energy without CO_2"

1. *How does this incursion support students' learning in your unit?*

This incursion gives the students a hands-on introduction to the issues around energy production and alternative energy sources, which will appeal to students with a variety of preferred learning styles. It will provide a basis for further teaching and research in the unit.

2. *Which part(s) of VELS is this incursion is linked to?*

> Civics and Citizenship: Students draw on a range of resources... to articulate and defend their own opinions about... environmental issues in national and global contexts.

Students are beginning to gather information and formulate their own reasoned opinions.

> The Humanities - Geography: Students investigate the interaction of human activities with the natural environment through a study of issues such as global warming and climate change... and air and water pollution. Students develop skills to evaluate the factors contributing to the development of these issues.

Students are first exposed to these issues, and acquire a starting point from which to progress to further research.

3. *What is your expectation of this incursion?*

Students will gain an understanding on some of the problems faced by energy production, including effects on the environment such as global warming as well as being introduced to alternative methods of energy production. Students should gain some confidence in being able to name different methods of energy production and identifying some of the issues, knowledge that they will take into the next planned activity.

4. *What activities will the students do <u>during</u> the incursion?*

Students will spend sixty minutes being introduced to causes, consequences and solutions to global warming and accumulation of greenhouse gases in the atmosphere. Students will view some practical experiments about this, as well as examples of renewable energy.

5. *Describe any specific pre and post activities related to this incursion?*

The next activity in the unit (Activity 4) will use the information obtained in the incursion about different forms of energy production.

6. *Other comments*

Although this incursion will be more science oriented than economic, it will still provide a excellent introductory activity into the unit and will provide a valuable, concrete basis for students to continue to build knowledge on.

2. Excursion

VELS INTEGRATED UNIT EXCURSION

Company Name: CERES Community Environment Park
Contact Address: Cnr Roberts and Stewart Streets, Brunswick East VIC 3057
Phone Number: 03 9389 0144 / 03 9389 0100
Fax Number: 03 9389 0101
Email: education@ceres.org.au
Website: http://www.ceres.org.au/excursions
Melways Reference: 30 B7
Cost: $12.00 per student, minimum cost $240 per class (20 students minimum)
Resources provided: Half-day program including two fifty minute sessions, one "Renewable Energy" and the other "Australia Trail 2030"

1. *How does this excursion support students' learning in your unit?*

This excursion will allow students to physically interact with working models of renewable energy sources. This will help to cement the learning experiences they have had in the unit to date, and the hands-on aspect will ensure that students with different learning styles have a chance to interact with and understand the resources to their advantage. Students will also be utilising their critical thinking skills and seeing the results of their decisions in the Australia 2030 Trail. This will be a valuable activity as it will help to cement ideas of consequences and accountability with relation to economic, social and environmental factors.

2. *Which part(s) of VELS is this excursion is linked to?*

The Humanities - Economics: They plan and conduct investigations in order to research an economic problem.
The Humanities - Geography: Students investigate the interaction of human activities with the natural environment through a study of issues such as global warming and climate change.
The Humanities - Geography: They reflect on plans of action... considering the value positions underlying them, including a commitment to the principles of sustainability.

3. *What is your expectation of this excursion?*

Students should come out of the excursion feeling like it has helped them understand the work they have done in the unit so far, as well as having a better understanding of the future implications of the issues around sustainable and renewable energy. They should also have fun while they are doing it.

4. *What activities will the students do <u>during</u> the excursion?*

Students will have an opportunity to handle working facilities and models of various renewable energy sources. They will observe the working solar electricity system that CERES has in place to power the facility and consider the challenges of implementing renewable energy technology.
Students will participate in the Australia 2030 Trail in which they will make decisions about factors such as renewable energy, and social and economic issues. The model will then allow them to see the consequences of those decisions on society and the environment

5. *Describe any specific pre and post activities related to this excursion?*

All activities in the unit so far have been a precursor to this excursion, allowing students to take their understanding and apply it to physical models and problem solving / decision making exercises.
Following the excursion students will be moving towards the end of the unit, and will be undertaking a group project about raising awareness of and promoting sustainable and renewable energy in the community. The excursion should give them a good starting point.

6. *Other comments*

This should be a very engaging, useful excursion that will set the students in good stead for the final piece of assessment for the unit.

Assessment

Ongoing informal assessment

Much of this unit is based around inquiry based learning using informal, verbal assessment strategies. Feedback will be given in a number of ways.

1) Solicited by students - where a student asks explicitly for feedback on or assistance with their work in progress the teacher can provide targeted feedback particular to the work.
2) Unsolicited by students - while circulating around the room teachers can touch base with students and provide constructive guidance and feedback on both positive contributions and areas for improvement.
3) Self-directed feedback - the inquiry based nature of many of the activities means that the teacher will often facilitate debrief sessions where students come together and discuss their learning. This is an ideal scenario to spark discussion amongst the students and to get them thinking about their own learning progress and understanding.
4) Class approval - the structure of the final activity means that the students work will be assessed by the teacher but also judged by their classmates. This is an opportunity to teach techniques for constructive and positive criticism so that students can become confident critics of their own work and each other's.

Rubric for Activity 4

Criteria	**Toward the level**	**At the level**	**Beyond the level**
Research the economic, social, and environmental impacts and benefits of the assigned energy production technique.	Demonstrates some effort at finding and presenting information on economic, social and environmental factors, or demonstrate effort at finding and presenting detailed information on only one or two.	Demonstrates reasonable research and presents clear findings on the economic, environmental, and social impacts of the assigned energy production technique.	Demonstrates excellent research and presents articulate findings on the economic, environmental, and social impacts of the assigned energy production technique, drawing on community opinions and demonstrating knowledge of wider social and environmental issues and how they interrelate.
Identify the factors that contribute to costs and benefits, stakeholders and how they are affected, production output levels and the current proportion of total energy consumption in Australia.	Identifies and presents some examples of factors that contribute to costs/ benefits, stakeholders or production output levels.	Identifies and presents with reasonable clarity some factors that contribute to costs/ benefits, stakeholders and production output levels, using some relevant economic concepts.	Identifies and clearly presents a range of factors that contribute to costs/benefits, stakeholders and production output levels, using relevant economic concepts and illustrating the relationship between economic and environmental approaches.
Research and referencing methods are appropriate and effective, appropriate ICT tools are utilised in the presentation of the poster/booklet.	Demonstrates limited research and ineffective referencing techniques, ICT not adequately used in presentation.	Demonstrates some use of appropriate research, reasonable referencing, and use of appropriate ICT tools.	Demonstrates proficient research methods and effective referencing techniques, ICT tools selected to maximise the accuracy, clarity and completeness of the information presented.

Rubric for Activity 8

Criteria	**Toward the level**	**At the level**	**Beyond the level**
Research and propose strategies to raise community awareness of sustainable and renewable energy, consider economic, social, environmental factors.	Demonstrates limited knowledge of economic, social or environmental issues around sustainable energy; demonstrates low-level thinking and planning in strategies suggested to raise community awareness.	Demonstrates knowledge of economic, social or environmental issues around sustainable energy; demonstrates moderate-level thinking and planning in strategies suggested to raise community awareness.	Demonstrates knowledge of economic, social and environmental issues around sustainable energy; demonstrates high-level thinking and planning in strategies suggested to raise community awareness.
Use appropriate ICT tools for research and presentation; create a suitable information product for presentation in an appropriate format.	Demonstrates some effectiveness in the choice of appropriate ICT tools for research and presentation, creates an information product that partially suits the purpose.	Demonstrates reasonable effectiveness in the choice of appropriate ICT tools for research and presentation, creates a reasonable information product that suits the purpose.	Demonstrates competence and efficiency in the choice of appropriate ICT tools for research and presentation, creates a quality information product that suits the purpose.
Presentation demonstrates justification for the proposed action, utilises appropriate persuasive techniques and supporting evidence.	Demonstrates very little or inappropriate justification for the proposal.	Demonstrates reasonable justification for the proposal, some attempt at persuasive techniques and supporting evidence.	Demonstrates clear, well stated justification for the proposal, includes a variety of persuasive techniques and convincing supporting evidence.

Resources

Student

Prezi on Environmental Economics (many interesting embedded youtube clips that provide an overall picture of the economic implications of environmental factors
http://www.tutor2u.net/blog/index.php/economics/comments/unit-3-micro-prezi-on-environmental-economics#extended

Australia's renewable energy future report
http://www.science.org.au/reports/documents/AusRenewableEnergyFuture.pdf

Sustainability Victoria
http://www.sustainability.vic.gov.au/www/html/1517-home-page.asp

Clean Energy Council
http://www.cleanenergycouncil.org.au/

Securing a clean energy future - The Australian Government's Climate Change Plan
http://www.cleanenergyfuture.gov.au/wp-content/uploads/2011/07/Consolidated-Final.pdf

Securing a clean energy future: some economic aspects
http://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp1112/12rp05

Teacher

VELS
http://vels.vcaa.vic.edu.au/

Environmental Economics by the Environmental Literacy Council
http://www.enviroliteracy.org/pdf/EnviroEcon-vol1.pdf

Materano, L & Atkinson, G 2001, *Economics For Business*, Eastern House, Croydon

McTaggart, D, Findlay, C & Parkin, M 2006, *Economics* 4th Edition, Pearson Education Australia, Frenchs Forest

Appendix One

Economics of the Environment

Environmental problems aren't new, and they aren't restricted to rich industrial countries. Pre-industrial towns and cities in Europe had severe sewage disposal problems that created cholera epidemics and plagues that killed tens of millions of people. Nor is the desire to find solutions to environmental problems new. The development in the 14th century of pure water supplies and garbage disposal and sewage disposal are examples of early contributions to improving the quality of the environment.
Popular discussion of the environment usually pay little attention to economics. They focus on physical aspects of the environment, not costs and benefits. A common assumption is that if people's actions cause *any* environmental degradation, those actions must cease. In contrast, an economic study of the environment emphasises costs and benefits. An economist talks about the efficient amount of pollution or environmental damage. Economics provides a set of tools and principles that clarify the issues. It doesn't provide an agreed list of solutions. The starting point for an economic analysis of the environment is the demand for a healthy environment.

The demand for environmental quality

The demand for a clean and healthy environment is greater today than it has ever been. We express our demand for a better environment in several ways. We join organisations that lobby for environmental regulations and policies. We vote for politicians who support the environmental policies that we want to see implemented. We buy 'green' products and avoid hazardous products, even if we pay a bit more to do so. And we pay higher housing costs and commuting costs in order to live in pleasant neighbourhoods.
The demand for a cleaner and healthier environment has grown for two main reasons. First, as our incomes increase, we demand a larger range of goods and services, and one of these 'goods' is a high-quality environment. We value clean air, unspoiled natural scenery, and wildlife.
Second, as our knowledge of the effects of our actions on the environment grows, so are we able to take measures that improve the environment. For example, now that we know how sulphur dioxide causes acid rain and how clearing the rain forests destroys natural stores of carbon dioxide, we are able, in principle, to design measures that limit these problems.

THE SOURCES OF ENVIRONMENTAL PROBLEMS

Air pollution: Major air pollution problems are both local - for example, urban smog and the concentration of toxic materials in the air - and global - such as global warming and ozone layer destruction.
Important sources of urban smog are dust, oxides of nitrogen, and volatile organic compounds. Dust (sometimes called suspended particles) comes from natural sources, but also from motor vehicles, wood fires, and industrial activity. Motor vehicles are the principal sources of oxides of nitrogen. These pollutants cause health problems, and contribute to the brown winter haze and white summer haze (or photochemical smog). Volatile organic compounds are emitted by motor vehicles, and also have industrial and domestic sources - for example, unburnt fuel and solvents from paints. These compounds react with sunlight to form ozone, a component of smog and a health hazard in its own right.

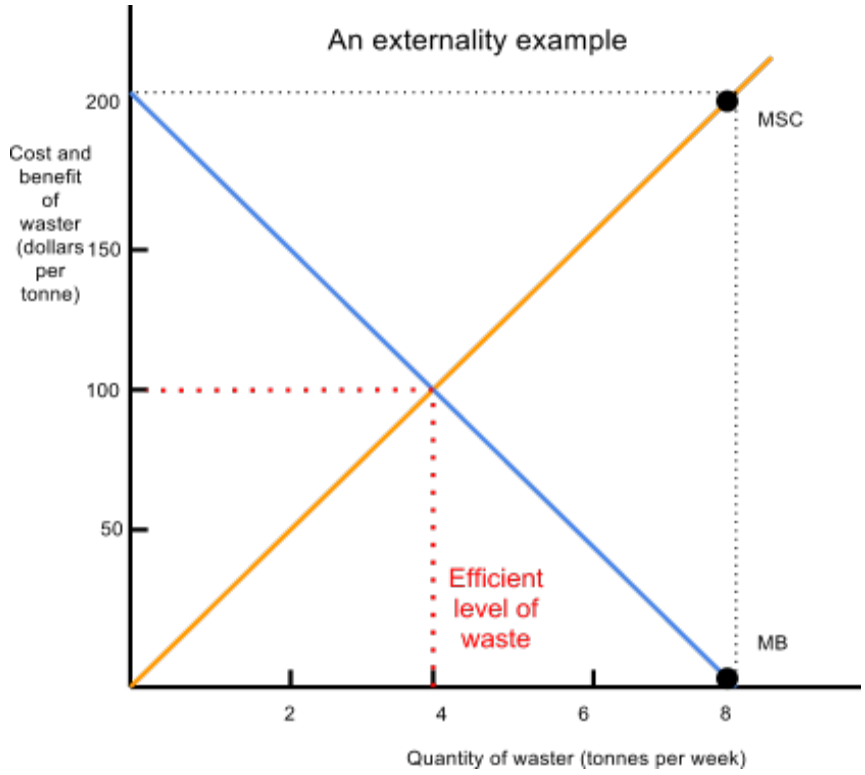
Water pollution: Sources of water pollution include the output of sewage treatment plants, the use of herbicides, pesticides, and fertilisers in intensive agriculture, the effects of the release of toxic materials from industrial processes, accidental spills of oil or fuel from ships into the ocean, and the effect of rubbish and litter on water catchments.

Land pollution: Land pollution arises from dumping non-hazardous garbage and toxic waste products.

Greenhouse gas emissions: Global warming results from emission of carbon dioxide, methane, nitrous oxide, and other gases, such as perfluorocarbons. The main source of carbon dioxide is transportation and electricity generation. Methane comes from transportation, livestock, and garbage. Nitrous oxide, a contributor to urban smog, comes from energy generation and fertilisers.

Absence of property rights and environmental externalities

Externalities (the side effect on an individual or entity due to the actions of another individual or entity) arise because of an *absence* of property rights. **Property rights** are social arrangements that govern the ownership, use, and disposal of factors of production and goods and services. In modern society, a property right is a legally established title that is enforceable in the courts.
Property rights are absent when externalities arise. No one owns the air, the rivers, and the oceans. So it is no one's private business to ensure that these resources are used in an efficient way. In fact, there is an incentive to use them more than if there were property rights.
Marginal social cost is the marginal cost incurred by the producer of a good - marginal private cost - plus the marginal cost imposed on others - the external cost.



A chemical factory's marginal benefit from dumping its waste into a river is *MB*, and a fishing club's marginal cost of having waste dumped is *MSC*. With no property rights, the factory maximises total benefit by dumping 8 tonnes a week, the quantity at which the marginal benefit of dumping equals the marginal cost to the factory of zero. With this quantity of waste, the fishing club bears a marginal cost of $200 per tonne. The outcome is inefficient because the marginal social cost exceed the marginal benefit.

Property rights and the Coase theorem

Sometimes it is possible to correct an externality by establishing a property right where one doesn't currently exist. For example, suppose that the chemical factory own the river. The fishing club must pay the factory for the right to fish in the river. But the price that the club is willing to pay depends on the number and quality of fish, which in turn depends on how much waste the factory dumps into the river. The greater the amount of pollution, the smaller is the amount the fishing club is willing to pay for the right to fish. The chemical factory is now confronted with the cost of its pollution decision. It might still decide to pollute, but if it does, it faces the opportunity cost of its actions - forgone revenue from the fishing club.

Does it matter how property rights are assigned? Does it matter whether the polluter or the victim of the pollution owns the resource that might be polluted? The **Coase theorem** is the proposition that if property rights exist and transaction costs are low, private transactions are efficient. Equivalently, with property rights and low transaction costs, there are no externalities. All the costs and benefits are taken into account by the transacting parties, so it doesn't matter how the property rights are assigned.

Referring to the figure above, pollution of a river imposes a marginal social cost MSC on the victim and provides a marginal benefit MB to the polluter. Where property rights exist the efficient amount of pollution (marked in red) is the quantity that makes MB equal to MSC - in this example 4 tonnes per week. If the polluter owns the river, the victim will pay $400 per week ($100 a tonne x 4 tonnes per week) to the polluter for the assurance that pollution will not exceed 4 tonnes per week. If the victim owns the river, the polluter will pay $400 for pollution right to dump 4 tonnes per week.

Property rights work if transaction costs are low. But in many situations transaction costs are high and property rights cannot be enforced. In this type of case governments use alternative methods of coping with externalities.

Questions on Economics of the Environment

1. What is the starting point for an economic analysis of the environment?

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2. What are some examples of early contributions to improving the quality of the environment?

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3. Name some of the organisations, politicians or political parties, and 'green' products that you know people support because they demand better environmental quality.

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4. Analyse the sources of environmental problems. Did you notice any one particular factor that contributes to multiple forms of environmental issues? Can you identify any other forms of pollution or emissions not mentioned in the list?

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5. Do you think it is accurate to say that in Australia no one has property rights over the air, the rivers and the ocean? Why? Name any groups who you believe may have a legitimate interest in the natural features of this country.

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6. The Coase theorem states that externalities can be made efficient by property rights owned by either party. What is the condition that makes this true? Do you believe this is actually the case in real life situations, can you identify any factors or behaviours which might make the theorem untrue?

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