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

'Learning-by-Notes' Package for Year 10 Students

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Teaching Sustainability in High Schools: Teacher Supplement

Developed by:

The Natural Edge PROJECT

Griffith UNIVERSITY

PORT of BRISBANE
Here for the future

As part of the:

sustainable Living CHALLENGE

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Acknowledgements

The development of the '*Sustainability and Really Cool Technologies: Energy, Water, Waste* has been supported by a grant from the Port of Brisbane Corporation as part of the Sustainable Living Challenge. In particular the authors would like to thank the support and mentoring provided by Ms Nikki Owen, Mr Rick Morton and Mr Brad Kitchen (The Port of Brisbane Corporation). Content was peer reviewed by Mr Cameron Mackenzie (Queensland Department of Education), and Mr Ben Roche (National Manager, Sustainable Living Challenge, University of New South Wales). The development of this publication has been supported by the contribution of non-staff related on-costs and administrative support by the Centre for Environment and Systems Research (CESR) at Griffith University; and the Fenner School of Environment and Society at the Australian National University. The material has been researched and developed by the team from The Natural Edge Project.

The Sustainable Living Challenge (www.sustainableliving.com.au)

The Sustainable Living Challenge is a leading Australian secondary schools program that encourages students and their teachers to explore sustainability issues as a part of the school experience. It aims to encourage young people to raise their awareness, engage their minds and develop their skills to be better able to respond to the challenge of sustainability in their future personal and professional lives. The annual program is available to all Australian schools (Grade 7 – 12) and is free to enter. The Queensland Node of the Sustainable Living Challenge is hosted by Griffith University.

The Port of Brisbane Corporation (www.portbris.com.au)

The Port of Brisbane Corporation is a Government Owned Corporation responsible for the operation and management of Australia's third busiest container port. Its vision is, '*To be Australia's leading port: here for the future*'. Sustainability for the Port of Brisbane Corporation means making economic progress, protecting the environment and being socially responsible. In response to the recent drought, and the wider global debate on climate change, the Port is committed to working with the port community to showcase the Port of Brisbane as a sustainable business precinct. Initiatives aimed at reducing the Port of Brisbane's ecological footprint include energy efficiency, a green corporate fleet and constructing green buildings.

The Natural Edge Project (www.naturaledgeproject.net)

The Natural Edge Project (TNEP) is an independent non-profit Sustainability Think-Tank based in Australia, administratively hosted by Griffith University and the Australian National University. TNEP operates as a partnership for education, research and policy development on innovation for sustainable development. Driven by a team of early career Australians, the Project receives mentoring and support from a range of experts and leading organisations in Australia and internationally, through a generational exchange model. TNEP's initiatives are not-for-profit. All support and revenue raised is invested directly into existing initiatives and development of future initiatives.

Introduction - How to Use This Content

This 'Sustainability and Really Cool Technologies' module 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.

This 'Teacher Supplement' provides additional information to the Subject Supplement, including an activity pack for each lesson. The content has been structured to enable a wide variety of teaching methods, from lecture-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.

The 'Subject Supplement' is divided into an Introductory Package, followed by three lessons. Depending on the students' existing knowledge base, the Introductory Package could be used as one lesson (perhaps with take-home reading), or alternatively over 2-3 lessons:

- ***Introductory Package* – Sustainable Development: The Opportunity of our Lifetime.** This lecture 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.
- ***Lesson 2* - Energy: Powerful Solutions for Getting Off Oil.** This lesson provides an overview of 'peak oil', and introduces ways of reducing our greenhouse gas emissions and reliance on fossil fuels like oil as an energy source, through: 1) using energy more efficiently in everyday places like our homes, and 2) 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 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 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. This lesson also introduces the benefits to reducing and eliminating waste, and highlights some examples of what companies and governments around the world are doing to achieve 'zero waste' goals.

Optional Supporting Text:

This module draws from the following 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.

Content Scaffold: 'Subject Supplement' Structure

Each Lesson of the 'Subject Supplement' consists of the following headings, which are intended to provide significant flexibility. It is intended that teachers will either use this structure, or be able to readily 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. The teacher may use this as an introduction to the class.
- **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. This additional information could also be used to prepare student handouts, or as additional reading for students.

  Note that the Brief Background Information should not be considered the core source of in-depth information. The teacher should refer to additional references such as The Natural Advantage of Nations for detailed information to support lesson delivery.
- **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 Useful Resources

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 further teaching material and 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, curriculum developers, education policy makers and authors of educational materials.

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 skills, knowledge, values and behaviours that support a sustainable environment.
- 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 sustainable development in engineering and the built environment: 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).

TEACHING SUPPLEMENT : LESSON 1

Sustainable Development:
the Opportunity of Our Lifetime

The following interesting and topical facts support the Subject Supplement - Lesson 1:

- According to the Global Footprint Network's[1] calculations, humanity's current ecological footprint is over 23 percent larger than what the planet can regenerate. In other words, it now takes more than one year and two months for the Earth to regenerate what we use in a single year.
- Over the next 50 years, one of the major development issues will be fast growing urban centres or mega-cities. By 2015, Dhaka, Mumbai and Delhi will join Tokyo among the world's largest cities, and Asia as a whole will account for 12 of the world's largest 21 mega-cities.[2]
- Approximately half the world's population now live in cities and towns. In 2005, one out of three urban dwellers (approximately 1 billion people) was living in slum conditions.[3]
- Today, more than 30 tons of non-renewable natural resources are required to deliver 1 ton of goods. The Rocky Mountain Institute[4] has estimated that only 1 percent of material goods are still in use in society just six months after production, and the rest is wasted.
- Among the most riveting mysteries of human history are those posed by vanished civilizations. Those who have seen the abandoned buildings of the Khmer, the Maya, or the Anasazi, or the monuments on Easter Island, are immediately moved to ask the question: why did the societies that erected those structures disappear?
- Globally, markets in environmentally sustainable solutions are now the fastest growing markets in the world. These are markets in everything from eco-tourism, hybrid cars, green buildings, five-star homes, recycling and benign chemicals, energy efficiency, and even financial markets in, for instance, carbon emissions trading.
- Organisations all over the world, from business to government to schools, are reducing risks, saving financially and creating jobs by getting serious about energy and resource efficiency. People are finding they can make their homes, their office buildings, and many industries, 50 percent more efficient and some as much as 90 percent efficient – a Factor of 10.
- Environmental sustainability is the cause of choice for Hollywood's stars. Leonardo DiCaprio has produced a full length feature documentary on the environment called *The 11th Hour*,[5] and Vanity Fair featured Hollywood star heavyweights Julia Roberts and George Clooney with Al Gore and Robert Kennedy Junior on its cover. See Vanity Fair – *The Green Team* at http://www.vanityfair.com/politics/features/2006/05/onthecover200605

[1] See Global Footprint Network website at http://www.footprintnetwork.org/. Accessed 9 August 2007.
[2] Anitei, S (2007) Top 10 Super Cities of the Future - The world's largest cities by 2015. 3 July 2007. Available at: http://news.softpedia.com/news/Top-10-Super-Cities-of-the-Future-58934.shtml. Accessed 15 May 2008.
[3] United Nations (2007) The Millennium Development Goals Report. Available at: www.un.org/millenniumgoals/pdf/mdg2007.pdf . Additional referenced statistics on developing countries at: http://www.globalissues.org/TradeRelated/Facts.asp#src23. Accessed 15 May 2008.
[4] See the Rocky Mountain Institute website at http://www.rmi.org/. Accessed 9 August 2007.
[5] See Leonardo DiCaprio's website at http://www.leonardodicaprio.org/. Accessed 9 August 2007.

Additional Reading: Where has Sustainability Come From?

An Evolutionary Perspective

John Seed and Joanna Macy in their ground breaking book titled, *Thinking Like a Mountain: Towards a Council of All Beings*[6] created one of the earliest modern methods of attempting to change the way we look at the world and humanity's place in it. This book's title is taken from the 1949 *Sand County Almanac*,[7] in which Aldo Leopold warned that unless we attempt to connect with our ecosystem by thinking like a mountain, disaster is inevitable. The workshops that Seed and Macy began in the 1980s called '*Towards a Council of all Beings*', included a meditation around 'Evolutionary Remembering'. An example of such a meditation is provided here:

The following text excerpts are drawn with permission, from a presentation delivered by Molly Harris-Olsen: [8]

> *Today I want to challenge you to 'Think like a Mountain', to look back over the last 4.5 billion years, and forward to the next 1000 years of planet Earth. I want to challenge you to step out of your comfort zone, to contemplate the evolution of the planet that brought you here and grapple with the enormous challenges we face today. I want to challenge you to imagine what a sustainable civilisation will look like in the year three thousand (3000). Humanity in all its wonderful diversity, living on an ecologically rich, climate stable, healthy, peaceful planet Earth.*
>
> *Let us go back, way back before the birth of our planet Earth, back to the mystery of the universe coming into being. We go back to a time of primordial silence… of emptiness… before the beginning of time… the very ground of all being. From this state of immense potential, an unimaginably powerful explosion takes place… energy travelling at the speed of light hurtles in all directions, creating direction, creating the universe. It is so hot in these first moments that no matter can exist; only pure energy in the form of light… thus time and space are born. Using a compressed time scale (one day = 750, 000, 000 years), the Earth is formed out of the solar nebula Sunday at midnight, the beginning of the 1st day. All day Monday is spent getting geologically organized. There is no life until Tuesday noon. Amazingly, life, beginning with that first prokaryote cell in the primordial oceans, lifts itself by its own bootstraps, and survives!*
>
> *About Wednesday at midnight, photosynthesis gets going into high gear. Early Thursday morning in the wee hours, the eukaryote cells appear. Life begins then to really flourish and evolve into more complex forms. By Saturday morning (the sixth day, the last day of creation) there's finally enough oxygen that the amphibians come onto the land, and there's been enough chlorophyll manufactured for the fossil fuels to begin to form. Around four o'clock Saturday afternoon, the giant reptiles begin to appear. They hang around for quite a long time as species go, until 9:55pm, nearly six hours. Humanity should be so lucky.*
>
> *About 20 minutes after they are gone, at 10:15 pm Saturday night, the primates appear. The Grand Canyon begins to take shape 16 minutes before midnight. Australapithecus,*

[6] Seed, J., Macy, J., Fleming, P. and Naess, A. (1988) *Thinking Like A Mountain - Towards a Council of All Beings*, New Society Publishers, Philadelphia, USA.
[7] Leopold, A. (1949) *A Sand County Almanac – and sketches here and there*, Oxford University Press.
[8] Olsen, M. (2005) Keynote Presentation to the 2005 Outdoor Education Conference, Tallebudgera, Australia, July 2005. Text drawn from Seed, J. and Macy, J. (1998) *Thinking Like a Mountain,* New Society Publishers, Philadelphia.

the first species on our branch off the main primate tree, shows up at 11:53 pm, seven minutes ago. Homo Sapien Sapien arrives at 11:59:54 pm – that is us!

Arriving on the scene just six seconds ago! 'Let the party begin!' with just a little over one second to go, 1.2 seconds in geologic time, we (i.e. our forbearers) throw off the habits of hunting and gathering to become farmers, and begin to change and sacrifice the environment to suit, and feed our appetites... one fortieth of a second ago, the industrial revolution ushers in the age of technology; an eightieth of a second ago, we discover oil (the party picks up steam); one/two-hundredth of a second ago, we learn how to split the atom. The party gets very dangerous indeed. And now it's midnight, the beginning of the seventh day.

The Union of Concerned Scientists, numbering some 2000 (including more than 100 Nobel Laureates), say we have 'one to a few' decades to reverse course. In other words, the next 200th of a second will be decisive; the time since we learned to split the atom, that short span of time projected not backward, but into the future, will decide our fate.

Molly Harris-Olsen, 2005

Looking Back at Sustainability Discussions

When was the first articulation of designing and engineering for sustainable development? Most would expect this occurred sometime during the 1960s or 1970s. In fact, the first documented articulation about the need for design professionals to design sustainably and with awareness of the needs of future generations (intergenerational equity), comes from Professor Svante August Arrhenius (1859–1927) in his work, *Chemistry in Modern Life* (1925).[9] Arrhenius was the Director of the Nobel Institute in Sweden at the time that he wrote,

> *Engineers must design more efficient internal combustion engines capable of running on alternative fuels such as alcohol, and new research into battery power should be undertaken… Wind motors and solar engines hold great promise and would reduce the level of CO_2 emissions. Forests must be planted… To conserve coal, half a tonne of which is burned in transporting the other half tonne to market… so the building of power plants should be in close proximity to the mines… All lighting with petroleum products should be replaced with more efficient electric lamps.*

Professor Svante August Arrhenius, 1925

Arrhenius called for the amount of waste from industry to be reduced, to ensure that future generations could also meet their needs for living. He argued that the industrial world had given rise to a new kind of international warrior, who he called the 'conquistador of waste'. Arrhenius wrote,

> *Like insane wastrels, we spend that which we received in legacy from our fathers. Our descendants surely will sensor us for having squandered their just birthright… Statesman can plead no excuse for letting development go on to the point where mankind will run the danger of the end of natural resources in a few hundred years.*

Arrhenius invoked the chemist's commandment '*Though Shall Not Waste*' to argue that legislation be enacted aimed at both reducing consumption and promoting conservation. Arrhenius above all believed in humanity's capacity for innovation and foresight to solve these problems:

[9] Arrhenius, S. (1925) *Chemistry in Modern Life*, Library of Modern Sciences, D. Van Nostrand Company, New Jersey.

> *Doubtless humanity will succeed eventually in solving this problem… Herein lies our hope for the future. Priceless is that forethought which has lifted mankind from the wild beast to the high standpoint of civilized humanity.*

He also saw the danger of resource wars, fearing a return to 'dark times' after the end of World War One:

> *Concern about our raw materials casts its dark shadow over mankind. Those states which lack* [them] *throw lustful glances at neighbours, which happen to have more than they use. Still more tempting is the desire for gain from lands on the other side of the seas, inhabited by uncivilized natives, with interest unawakened in guardianship.*

Recognition of Ecological Limits

We can learn a lot from the innovations of previous civilisations. There have been many interesting findings about the way forests and trees were managed by villages in India in ancient times, and their careful methods of harvesting medicines, firewood, and building material in accordance with natural renewal rates. The Indian (Indus-Sarasvati) Civilisation was the world's first to build planned towns, with underground drainage, civil sanitation, hydraulic engineering, and air-cooling architecture. Oven baked bricks were invented in India in approximately 4,000 BC. From complex Harappan towns to Delhi's Qutub Minar and other large projects, India's indigenous technologies were very sophisticated in design, planning, water supply, traffic flow, natural air-conditioning, complex stone work, and construction engineering.

Comparatively, it was a fuel crisis which led Ancient Greeks to use passive solar energy by orienting toward the sun. Greeks planned whole cities (Priene for instance) so all homes had access to sunlight during winter. John Perlin and co-author Ken Butti have written a history of passive solar design in *A Golden Thread - 2500 Years of Solar Architecture and Technology*;[10] an approach to heating and cooling homes through simple devices and architectural design rather than mechanically operated systems.

Note: Students may be interested in exploring the successes and failures of past civilisations in Jared Diamond's book 'Collapse: How Societies Choose to Fail or Succeed'.[11] *The chapter on Australia's journey and the final chapters provide a good snapshot of his argument - that there is nothing inevitable about the survival of a civilisation, and that population and material consumption are currently outrunning the planet's capacity. Diamond's hypothesis is that a common factor in civilisation decline is environmental decline which has been ignored by the population and its leaders at their peril.*

Sources of Energy – An historical Context

Before the industrial revolution, many societies used renewable energy from the sun and wind as the cheap energy source. For instance, wind-driven mills were used as early as 700 AD in Persia for irrigation and milling grain. Solar power was used in everything from sailing boats and ships, to passive solar designed homes/buildings, to the drying of bricks for buildings, to the burning of biomass, including wood, for the refining of metal and the making of swords.

In the early 1600s the rising cost and scarcity of wood (making it essentially a 'non-renewable' resource) led to authorities in England looking for alternative energy forms as well as a cheaper

[10] Perlin, J. and Butti, K. (1980) *A Golden Thread - 2500 Years of Solar Architecture and Technology*, Cheshire Books, Palo Alto. Perlin and Butti provide a short summary of the evolution of passive solar design online at www.californiasolarcenter.org/history_passive.html. Accessed 26 November 2007.

[11] Diamond, J. (2005) *Collapse: How Societies Choose to Fail or Succeed*, Penguin Books, New York.

and more efficient means of transporting them to the capital. Politicians, engineers, and the general public became aware that the amount of forests being cut down for building materials, furniture, heating fuel, and for the needs of industry and the military was unsustainable. In 1603 James the First of England ordered that clean-burning anthracite coal be burned in the fireplaces of his household. With the King of England setting the example, by 1700 London had made the transition from a wood burning city to one that relied mainly on imported coal. In 1784 when Benjamin Franklin visited Europe, he noted that the switch from wood to coal had saved what remained of England's forests and he urged France and Germany to do the same. Scientists and engineers at the time were not aware of the scale of impact that the burning of coal could contribute to climate change.

Early Alarms over Burning Fossil Fuels

Guy Challender, a coal engineer, was one of the first to sound the alarm over increasing Carbon Dioxide (CO_2) levels in the Earth's atmosphere. Challender measured CO_2 levels in his spare time during the 1930s-1940s as well as researching historic CO_2 levels. When he realised they were increasing in the Earth's atmosphere he warned that burning fossil fuels would contribute to global warming. In the 1950s scientists explored the science behind why CO_2 was not being significantly absorbed by the oceans and with Challenger's empirical results, began recent efforts to understand and address climate change.

But it was not until 1987 that a critical mass of people round the globe realised how far greenhouse gas emissions were overshooting the planet's ecological limits. In 1987 Antarctic results showed that the Earth's atmospheric concentrations of CO_2 and another greenhouse gas, methane (CH_4), were well above the historic levels of the last 160,000 years. It was concluded that significant 'Factor 10'[12] type reductions in these emissions would be needed to bring the planet back within its ecological limits.

[12] The term 'Factor 10' reduction in emissions means reducing emissions by 90 percent.

Additional Reading: Why Do We Need to Think 'Sustainably'?

A key aspect to understanding why sustainable development is so important is understanding ecological systems limitations and thresholds, so that we can design within these systems. Although the planet is a complex system, our understanding has improved by orders of magnitude in the last two centuries. Raymond Cole from the University of British Columbia cautions that, *'irrespective of the social and economic context, the health of the biosphere is the limiting factor for sustainability'*.[13]

Valuing the Earth's Ecosystem Services – UN Millennium Assessment

Today, advancements in ecological monitoring and computer modelling allows humans to assess and better manage the health of the Earth's ecosystems. The Millennium Ecosystem Assessment (MEA)[14] is the largest study to ever do so.

The MEA is an international work program designed to meet the needs of decision makers and the public for scientific information concerning the consequences of ecosystem change for human well-being and options for responding to those changes. The MEA was launched by former UN Secretary Kofe Annan in June 2001 and was completed in March 2005, meeting assessment needs of the Convention on Biological Diversity,[15] Convention to Combat Desertification,[16] the Ramsar Convention on Wetlands,[17] and the Convention on Migratory Species,[18] as well as the needs of other users in the private sector and civil society. If the MEA proves useful to its stakeholders, it is anticipated that such integrated assessments will be repeated every five to ten years and that ecosystem assessments will be regularly conducted at national or sub-national scales.

The MEA focuses on ecosystem services (the benefits people obtain from ecosystems); how changes in ecosystem services have affected human well-being, how ecosystem changes may affect people in future decades, and response options that might be adopted at local, national, or global scales to improve ecosystem management and thereby contribute to human well-being and poverty alleviation.

The MEA study concluded the following:

- Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history - largely to meet rapidly growing demands for food, fresh water, timber, fibre and fuel.
- The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of many ecosystem services, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people.

[13] Cole, R. (1999) 'Building environmental assessment methods: clarifying intentions', *Building Research & Information,* vol 27 (4/5), pp 230-246.
[14] See the Millennium Ecosystem Assessment website at http://www.millenniumassessment.org/en/index.aspx. Accessed 9 August 2007.
[15] See Convention on Biological Diversity website at http://www.cbd.int/default.shtml. Accessed 9 August 2007.
[16] See Convention to Combat Desertification website at http://www.unccd.int/. Accessed 9 August 2007.
[17] See the Ramsar Convention on Wetlands website at www.ramsar.org. Accessed 9 August 2007.
[18] See the Convention on Migratory Species website at http://www.cms.int/. Accessed 9 August 2007.

- The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals[19] which aim to reduce poverty and hunger worldwide.
- The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MEA has considered, but these involve significant changes in policies, institutions and practices, which are not currently underway.

The market value of ecosystem service-industries is significant and the loss of such services would be devastating to the global economy, for example:

- Food production: US$980 billion per year
- Timber industry: US$400 billion per year
- Marine fisheries: US$80 billion per year
- Marine aquaculture: US$57 billion per year
- Recreational hunting and fishing: >US$75 billion per year in the United States alone

Can We Replicate Nature's Services?[20]

Whenever the economy has faced factors limiting development in the past, industrial nations sought to optimise the productivity and increase the supply of the limiting factor. Economic development has periodically faced one or more limiting factors, including the availability of workers, energy resources and financial capital. Engineers and scientists then found new energy sources and created new enabling technologies to help make global transportation and communication possible. Financial capital became universally available through central banks, credit, stock exchanges and currency exchange mechanisms. Human ingenuity has accomplished remarkable things over the last 300 years. But can we really hope to find substitutes for all natural ecosystem services? The complexity and diversity of natural ecosystems is very hard to replace. Nobel laureate and world famous physicist, Richard Feynman once said that attempting to understand nature is like trying to learn how to play chess by watching a game while being able to see only two squares at a time. The ecosystem services listed below that nature provides for free are not cost effectively replaceable or substitutable by technological innovation, and these services complement and are depended on by life on our planet (adapted from *Natural Capitalism*):

- production of atmospheric gases
- supporting evolutionary processes, and biodiversity
- purification of soil, water and air
- storage and cycling of fresh water and nutrients
- regulation of the chemistry of the atmosphere and oceans
- maintenance of habitats for wildlife
- sequestration and treatment of waste
- pest and disease control by insects, birds and other organisms
- production of the variety of species for food, fibres, pharmaceuticals and materials
- conversion of solar energy into natural materials
- prevention of soil erosion and sediment loss
- alleviating floods and managing runoff

[19] See UN Millenium Development Goals website at http://www.un.org/millenniumgoals/. Accessed 9 August 2007.
[20] Hargroves, K. and Smith, M. (2006) *The Natural Advantage of Nations: Business Opportunities, Innovation and Governance in the 21st Century,* Earthscan, London, pp 41-42.

- protection against UV radiation
- regulation of the local and global climate
- development of topsoil and maintenance of soil fertility
- production of grasslands, fertilisers and food

TEACHING SUPPLEMENT : LESSON 2

Energy:

Powerful Solutions for Getting off Oil

The following interesting and topical facts support the information in Lesson 1:[21]

- Australian households generate almost one-fifth of Australia's greenhouse gases - more than 15 tons per household per year - through everyday activities such as transport, household energy use and the decay of household waste in landfills.
- For every kilogram of coal burned, three kilograms of greenhouse gases (mostly carbon dioxide) enters the atmosphere.
- Australians use approximately four times more energy per person than the world average.
- Ex-actor and now Governor of California, Arnold Schwarzenegger, recently announced a target for California of 80 percent greenhouse gas reductions by 2050 and stated that, *'California is going to be the leader in the fight against global warming, I say the debate is over. We know the science, we see the threat, and the time for action is now'.*[22]
- Countries like Sweden and Iceland have already committed to becoming completely independent of oil imports by 2020. The high oil price is creating new business opportunities for innovation in fuel efficiency, alternative fuels and car design. Brazil already gets over 50 percent of its fuel from biofuels made from sugar cane.
- Since 2003, Clean Energy Technologies - solar, biofuels, geothermal, tidal and hydropower – have produced more electricity globally than nuclear energy ever has.
- A recent study by the Australian Federal Government found there was at least AU$5 billion worth of energy efficiency savings possible in the Australian economy, and maybe as much as AU$15 billion.[23]
- The Lighting Council of Australia explained that, *'in 1999, Australia had spent approximately $15 billion on electricity. Of this, lighting accounted for some $5 billion. Well-designed, energy-efficient lighting and lighting controls can slash $1.25 billion a year off this bill'*.
- The largest wind turbine in the world, located in Hawaii (US), stands 20 stories tall and has blades the length of a football field. An average wind speed of 14 miles per hour is needed to convert wind energy into electricity. One wind turbine can produce enough electricity to power up to 300 homes.
- About 99 percent of Norway's energy is hydro power and only 0.4 percent is fossil fuel power!
- The greatest energy expense in the average Australian home is heating and cooling.
- Some 87 percent of Iceland is powered by geothermal energy from naturally occurring hot springs, and geysers are harnessed and used to power most of the island.

[21] In addition to TNEP references, these facts were compiled using the ACTEW AGL - *Quirky Facts* webpage at http://www.actewagl.com.au/education/QuirkyFacts/. Accessed 9 August 2007.
[22] Schwarzenegger, A. (2005) 'Leading the Fight Against Global Warming', *Radio Address*, Office of the Governor, CA. Available at http://gov.ca.gov/index.php?/radio-address/3404/. Accessed 9 August 2007.
[23] Commonwealth of Australia (2004) *Securing Australia's Energy Future,* Produced by the Energy Taskforce.

Energy References:

- Recommended 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. Many consider it one of the most important films to ever hit the big screen. To learn more about the documentary or to preview the trailer, visit www.climatecrisis.net. Accessed 9 August 2007.
- UNEP/UNFCCC (2002) *Climate Change: Information Kit,* UNEP, Geneva. The Kit can be downloaded from http://unfccc.int/files/essential_background/application/pdf/infokit_02_en.pdf. Accessed 9 August 2007.
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- The Australian Department of Environment and Heritage has a page on useful links to various websites dealing with Climate Change and energy, http://www.deh.gov.au/education/aussi/additional-resources-subject.html#climate. Accessed 9 August 2007.

TEACHING SUPPLEMENT - LESSON 3

Water:

Solutions that Protect Our Most Valuable Resource

The following interesting and topical facts support the information in Lesson 2:[24]

- Humankind is already using a staggering 55 percent of the world's renewable fresh water.
- Of all the water on the planet, less than 3 percent is freshwater. About 77 percent of this three percent freshwater is ice, stored mostly in the polar regions. Most of the rest is groundwater. That leaves an estimated 0.6 percent of the Earth's water readily available as a source of water supply to the world's population of six billion people.
- Australia is the driest inhabited continent on Earth - but per capita we are one of the world's largest consumers of water.
- Only 12 percent of the annual rainfall over Australia results in runoff into streams and rivers or it soaks into the ground and is retained. The rest is returned to the atmosphere directly by evaporation or from vegetation through the process of transpiration.
- Australians typically use enough water every year to fill Sydney Harbour almost 50 times – between 18 and 22 million megalitres of water a year. (1 megalitre = 1 million litres = the volume of an Olympic-sized swimming pool).
- Water obtained from natural sources is not pure; it usually requires some form of physical and/or chemical treatment to make it safe and pleasant to drink.
- One particular issue affecting water quality in many areas of Australia is the amount of salt dissolved in the water (salinity). Salinity is now widely recognised as one of the nation's most devastating environmental problems.
- Recently (2004-2005) the Australian Bureau of Statistics estimated the percentage of water consumed in Australia from different sectors of society: Agriculture used 65 percent; Households 11 percent; Water supply, sewerage and drainage services industry 11 percent; Electricity and gas generation industry (excluding hydroelectricity) 1 percent; Manufacturing industry 3 percent; Mining industry 2 percent; and other industries 3 percent.[25]
- Tips for conserving water in the bathroom:
  - Take shorter showers - a shower uses 10-20 litres of water every minute.
  - Save up to 11 litres of water each minute by installing a water efficient shower head.
  - Install a dual flush toilet - this can save you up to 50 percent on every flush.
  - Check for a leaking toilet cistern - put food colouring in the cistern, if the colour shows in the toilet bowl without flushing, you've got a leak.
  - Turn the taps off when you're brushing your teeth, washing your hands and shaving.
  - Install water-efficient appliances where possible.

[24] In addition to TNEP references, these facts were compiled from the CRC for Water Quality and Treatment site at http://www.waterquality.crc.org.au. Accessed 9 August 2007.

[25] Australian Bureau of Statistics (2005) *Water Account, Australia, 2004-05*, ABS, Australia. A summary of the findings can be found on the National Water Commission website – *Australian Water Resources 2005* at http://www.water.gov.au/WaterUse/index.aspx?Menu=Level1_4. Accessed 9 August 2007.

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TEACHING SUPPLEMENT - LESSON 4

Waste:

Smart Solutions Towards No-Waste Lifestyles

The following interesting and topical facts support the information in Lesson 3:[26]

- Australians create about 28 million tons of garbage every year. Just over one third of this material is recovered for recycling.[27]
- Australia is also one of the highest producers of waste per head of population in the world. In 1999 Australia ranked second behind the USA in terms of domestic waste generation.[28]
- If we reduce the amount of organic waste from waste streams we could reduce Australia's greenhouse gas emissions by as much as 3 percent and significantly reduce landfill volume.
- Couples with children and households with all members aged 15 years and over have the highest levels of activity in recycling paper in Australia, recycling 91 percent and 92 percent of the paper used respectively).
- Batteries are the most common form of hazardous waste disposed of by Australian households, with 94 percent of those disposing of them via their usual rubbish collection.
- Plastics are made from fossil fuels. Making plastic from recycled materials uses only 30 percent of the energy required to make plastic products from fossil fuels.
- In 2002, Australia recycled over 31,000 tons of aluminium drink cans – that's 63 percent of the cans we used in 2001, or around 2 billion individual cans.
- Paper products make up the largest part (approximately 40 percent) of our trash. Making recycled paper instead of new paper uses 64 percent less energy and 58 percent less water.
- Currently most electronic waste in developed countries meets with these fates:[29]
  - Put into storage and awaiting disposal
  - Sent to landfill or incinerated
  - Re-used, either second-hand or refurbished
  - Recycled at recycling facilities in the country of consumption
  - Exported to developing countries
  - One of the most materials intensive components of a computer is the 2 gram microprocessor. It takes 630 times its own weight in resources to make it.[30]
- Every day household items that can be recycled include: green/garden waste, paper, glass, cardboard, aluminium, steel, rubber, plastics, liquid paper board, clothes, timber and some electronic equipment.[31]

[26] Some of the facts were taken from the ACTEW AGL - *Quirky Facts* webpage at http://www.actewagl.com.au/education/QuirkyFacts/. Accessed 9 August 2007.
[27] WCS Market Intelligence (2001) *Australian Waste Industry – Industry and Market Report*, WCS Market Intelligence.
[28] Australia State of the Environment Committee (2001) *Australia State of the Environment 2001*, Independent Report to the Commonwealth Minister for the Environment and Heritage, CSIRO Publishing.
[29] Puckett, J. *et al* (2002) *Exporting harm: the high-tech trashing of Asia*, Basel Action Network, pp 6-8. Available at http://www.ban.org/E-waste/technotrashfinalcomp.pdf. Accessed 9 August 2007.
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- The Australian Department of Environment and Heritage has a page with useful links to various websites on waste, http://www.deh.gov.au/education/aussi/additional-resources-subject.html#waste. Accessed 9 August 2007.

[31] Information on local recycling can be obtained from the Planet Ark website http://recyclingnearyou.com.au/.