ABSTRACT

Rising international concern about global warming and the rapid development of the renewable energy industry over recent years has led to a need for multidisciplinary programs in energy studies. We have developed a postgraduate program in energy studies, which is based on the principles of ecologically sustainable development. This program combines work in energy technology with energy policy, energy economics and environmental and social issues. The program is offered on campus at Murdoch University and by external study, via the internet, throughout Australia and overseas. It has attracted considerable interest from students seeking to find new opportunities within the renewable energy industry. This paper outlines the philosophy of the energy studies program, its implementation and outcomes.

INTRODUCTION

There is an increasing recognition that humans have mismanaged their use of energy. This has led to many undesirable impacts on our quality of life and is now beginning to threaten the basic ecological systems which sustain life on earth. (Miller, 1980)

Energy is essential for all forms of life. Most obtain it through natural processes associated with ecological cycles such as the hydrological and carbon cycles. These natural cycles are characterised by the recycling of natural resources and by the absence of waste products. (Miller, 1980)

Over the centuries humans have recognised that they could improve their quality of life by exploiting natural resources such as plants, animals, minerals and fossil fuels. By utilising their scientific and technological knowledge, they have developed large industries devoted to agriculture, mining and power supply. However, because these industries are economically-driven they have tended to ignore ecological principles which underlie the natural cycles of the biosphere and as a result serious problems have emerged (Ramage, 1997).

In our quest to increase power supply to meet the needs of development and the burgeoning human population we have begun to cause irreversible damage to the biosphere, which supports all forms of life. Serious air pollution problems have been caused by burning fossil fuels in motor vehicles, homes, factories and power stations. Global warming now appears to be underway as a result of the enhanced greenhouse effect, which is partly caused by our extensive use of hydrocarbon fuels (IGCC, 1995)

Concern about these problems has risen rapidly over the past decade and international action is now underway to address the causes. (UNCED, 1992) This is taking the form of international treaties with mandatory restrictions on the use of fossil fuels by industrialised nations. These may be achieved via fuel substitution, energy management, improved energy efficiency, the use of renewable energy systems and restrictions on land clearing.(DFAT, 1997)

Some of the solutions are technical but there are also other important ways of tackling these problems. They involve policies, legislation, economic incentives and education. All of these initiatives have an important role to play in modifying human behaviour and moving society towards a sustainable future.

Sustainability involves modifying traditional economic thinking to include social and ecological factors to ensure that development does not have adverse effects on society or the environment (IUCN, 1991). Such thinking is becoming increasingly important in many aspects of education and it is therefore important to
ensure that students are exposed to a range of relevant disciplines to prepare them for future careers in a world where sustainability is imperative for survival.

Conventional energy education has generally failed to adequately address the need for ecologically sustainable development. Most energy professionals have been trained in either the technical or economic aspects of conventional energy conversion and until recently energy management and renewable energy technology have been largely neglected. Very few energy technologists have had any formal training in energy policy, energy economics or the social and ecological aspects of energy production or use.

The Australian Cooperative Research Centre for Renewable Energy is dedicated to the development of effective renewable energy solutions to power supply problems. Its education program was designed to provide a sound technical base in renewable energy technology (Jennings, 1996). However it also addresses the need for ecologically sustainable development by covering the social and environmental aspects of energy use as well as the economic and policy issues. The entire program is taught in the context of ecologically sustainable development (ESD) - that is, solutions should be economically, environmentally and socially acceptable in terms of the accepted international criteria for ESD. In this way students receive an education that equips them to work on new energy systems which can be used to build a sustainable energy industry for the future.

ENERGY AND ESD
Ecologically sustainable development has been defined in various ways including:

"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987)

and,

"Improving the quality of life while living within the carrying capacity of supporting ecosystems" (IUCN 1991)

According to the IUCN (1991), ecologically sustainable development is based on the following principles:

- respect and care for the community of life
- improving the quality of human life
- conserving the earth's vitality and diversity
- minimizing the depletion of non-renewable resources
- keeping within the earth's carrying capacity
- changing personal attitudes and perspectives
- enabling communities to care for their own environments
- providing a national framework for integrating development and conservation
- creating a global balance

This is an ambitious agenda which has been discussed and analysed in detail by many nations and by the international community at the Earth Summit in Rio de Janeiro in June 1992 and the Earth Summit +5 in New York in 1997. A program of action called Agenda 21 was developed at Rio and this is gradually being implemented by the signatories. (UNCED, 1992; Keating, 1993)

For the energy industry the IUCN (1991) has developed a general strategy for ESD, containing the following elements:

- develop national energy strategies
- reduce the use of fossil fuels
- reduce the wastage of energy
- reduce pollution from power generation
- develop renewable energy sources
- develop energy-efficient appliances
- promote energy conservation
The WCED (1987) emphasized the importance of teachers and education for ESD by saying:

"The world's teachers... have a crucial role to play (in helping to bring about) the extensive social changes (needed for ESD)" (WCED, 1987 pxiv)

The IUCN (1991) underlined the importance of changing attitudes through education:

"Sustainable living must be the new pattern for all levels, individuals, communities, nations and the world. To adopt the new pattern will require a significant change in the attitudes and practices of many people. We will need to ensure that education programs reflect the importance of an ethic for living sustainably." (IUCN, 1991 p5)

Agenda 21 defined more precisely the role of education in developing sustainability and set out a challenge for educators in the following terms:

"Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues. It is critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective public participation in decision-making." (UNCED, 1992, Ch36 p2)

Agenda 21 calls on all nations to develop and implement national strategies for ESD and notes that scientific and technological education in the past has often been too narrowly-focussed. It advocates a change of approach to meet the needs of ESD and suggests that all students and their teachers should be exposed to the concepts and methods of ESD as part of their formal education. (Keating, 1993; UNCED, 1992)

According to Agenda 21 the role for education in achieving a sustainable society is to:

• promote environmental and ethical awareness, values, attitudes, skills and behaviour needed for sustainable development
• build capacity for nations to develop Agenda 21 action programs
• train more scientists and engineers with an understanding of ESD and the technology for sustainable development
• re-orient all levels of education towards ESD. (UNCED, 1992 p112)

Education and training therefore have a vital role to play in ESD. They can create awareness of the issues and equip people with the technical, ecological and economic knowledge required to implement ESD. Education can provide examples of ESD in practise and through presentation of these examples create consumer confidence in renewable energy and energy management. Education is an essential foundation for market development of the renewable energy industry (Jennings, 1997)

Clearly this presents a major challenge to energy educators and we have responded by addressing these criteria with a multidisciplinary approach to energy studies.

**PROGRAM DESIGN**

In designing the ACRE University Education program it was decided to specifically address the criteria for ESD and this led to an entirely new curriculum in energy studies. Our program also includes the following additional educational objectives:

• caters for graduates of any discipline
• provides a multidisciplinary approach
• is widely accessible via external studies and on-line presentation
• suitable for part-time and distance education and continuing professional education.

Using the ESD criteria and these additional educational objectives we have developed a coherent stream of units covering all aspects of energy and ESD. It requires two years of full time study. In the first year the following units are offered:
Energy in Society: a study of the technology, applications and uses of energy in society and the consequences of energy use including social and environmental impacts.

Energy Management: a study of the efficient use of energy in buildings, factories and transport systems. This includes an energy audit of a building and a report on the project.

Energy Economics: an introduction to economic theory relevant to the operation of energy supply systems.

Energy Systems: an introduction to the design and operation of energy conversion and supply systems, including RAPS systems, hybrid systems and co-generation.

Energy Policy: a study of the institutions, policies and legislation relating to energy production and use in Australia and several other countries.

Energy Studies Project: this is designed to provide students with an opportunity to apply and extend their knowledge of energy technology or policy in an area which interests them.

These six units constitute the Postgraduate Diploma in Energy Studies which can be studied on campus or entirely externally via correspondence or the internet. The Diploma can be completed in one year of full-time study or over several years part-time.

Following the completion of the Diploma, students who wish to specialize in renewable energy technology may complete a further year of study and research to obtain a Master of Science degree.

The additional units available in the MSc program are:

Renewable Energy Resources: a study of the origin, availability and distribution of renewable energy resources such as solar radiation, wind, hydro, tidal, waves, geothermal and biomass.

Renewable Energy Conversion Devices: a study of the principles of operation, design and installation of the major renewable energy conversion devices.

Renewable Energy Systems Design: the design of renewable energy systems including the estimation of performance and the economics of such systems using simulation techniques.

Case Studies of Renewable Energy Systems: the principles of innovation, project management, demonstration and commercialisation of renewable energy systems with examples drawn from Australia and overseas.

The MSc also includes a dissertation that accounts for one third of the student's time over the year. It involves a practical investigation of a renewable energy system or device.

For further details the reader is referred to the education section of ACRE's web site http://acre.murdoch.edu.au/.

STUDENT RESPONSE

The Postgraduate Diploma has been available since 1992 and the Masters was offered for the first time in 1998. These units were offered initially to students at Murdoch University and attracted interest from students enrolled in a wide range of disciplines. Following the creation of ACRE the Diploma was offered nationally in 1998 and attracted a substantial response. Many of the interstate (and overseas) students are studying on-line using the internet version of the units. This is a special feature of the ACRE education program and it is designed to make it widely available.

On the basis of this experience we have surveyed the market for energy studies and identified the range of students who are attracted to this field. The results of our survey indicate that:

- the applicants for admission come primarily from science backgrounds with smaller numbers from engineering and commerce
• more than one third of the students come from interstate and are studying externally using on-line facilities
• most of the students are currently employed and have chosen to study part-time or externally, using on-line study materials (Lund, 1997, 1998)
• there is a strong demand for multidisciplinary energy studies from overseas but it is difficult to service the interest from developing countries because of the high cost of Australian University fees
• there is potentially a large market for energy studies in Europe and North America where Australian fees are not such an impediment
• many undergraduate students from related disciplines choose to take one or more of the energy studies units as part of their program of study
• most of the students chose this area of study because of their personal interest but they also believe that it has good career prospects
• many of the students are motivated by a desire to do something valuable for society as well as finding satisfying employment
• slightly more than half of the students are male.
• most of the students expressed their satisfaction with the balance of technology, policy and economics in the program and with the on-line mode of study

EMPLOYMENT OPTIONS
Our survey also attempted to find the employment objectives of the applicants for the program. In addition we have some information on the employment of recent graduates from the Diploma of Energy Studies. Our main findings were:

• there is a substantial demand for graduates with qualifications in multidisciplinary energy studies
• the main fields of employment are energy policy development, energy planning, energy management, energy education and information, energy research, consulting and systems design
• the main employers are utilities, government departments, small private firms, energy consultants and Universities
• student preferences are for jobs in systems design, policy analysis, building applications and research
• currently most of the students are employed in engineering, research or policy areas
• the market is expanding rapidly as nations face up to global warming. There is a substantial demand for policy analysts to assess proposed measures for greenhouse gas abatement.

CONCLUSIONS
On the basis of this work we conclude that:

• Energy Studies is rapidly emerging as a new discipline of relevance to meeting future energy needs within the context of ecologically sustainable development.
• Many energy professionals lack formal training in the skills and disciplines needed to undertake work on renewable energy systems and energy management.
• The availability of external, on-line courses is proving attractive to people interested in energy policy and energy systems. Many of these people have a background in science or engineering.
• New employment opportunities are opening up for graduates with a broad knowledge of the technical, environmental, economic and social issues connected to energy conversion and use.

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