

Tertiary Education in the Australian CRC for Renewable Energy - Renewable Energy Studies “on the ground” and “online”

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Abstract

The Australian Co-operative Research Centre for Renewable Energy (ACRE) through its postgraduate training and undergraduate studies projects is seeking to meet the increasing local and worldwide need for more tertiary trained scientists, engineers and policy makers with the knowledge and skills to develop and implement renewable and efficient energy systems and policies. It is doing this by developing a range of University courses in renewable energy technology, energy policy, energy efficiency and greenhouse issues. This includes coursework in several disciplines at the University undergraduate and postgraduate level as well as postgraduate research training with industry placements within ACRE. This paper will focus specifically on the approach and objectives of ACRE in relation to postgraduate training and undergraduate studies. It includes a description of the courses and research opportunities to be made available and the way these courses are to be offered. Examples are provided of the internationally focused, online (internet/CD ROM) based units Energy in Society, Energy Policy and Energy Systems which were developed and trialed this year.

1 INTRODUCTION

As renewable energy technology matures its use is growing rapidly. This growth is expected to escalate as a result of international efforts to reduce greenhouse gas emissions and to restructure the electricity industry. The ability of the renewable energy industry to participate in these developments is dependent on having engineers, technicians and policy analysts with appropriate training in renewable energy technology.

There is a pressing need for more scientists and engineers to develop renewable energy systems and to take advantage of new developments in the technology. Berkovski and Gottschalk have recently stated that “The student who enters a university programme today will probably do his or her most effective work between 2000 and 2010 when, by any estimate, new technologies will be more important everywhere than they are now.” [Berkovski and Gottschalk, 1996]. Developing countries are turning to renewable energy as a clean, reliable option for their rural electrification programs but they are limited by a shortage of appropriately trained engineers, technicians policy analysts and educators. Government policymakers and planners, field workers, personnel in industry and commerce all require appropriate training so they can make professional decisions about renewable energy options.

It is clear however that attention cannot be focused exclusively on the present and future student population. New renewable energy devices and technologies have already been introduced or are ready for introduction now. The sudden growth which has occurred in the industry over the last few years means utilities and industries are finding it difficult to recruit staff who are qualified to design and maintain renewable energy systems or to implement energy efficiency programs. Industry and local government increasingly need staff with experience in energy management. There is therefore a significant need for highly trained staff to meet the needs of the renewable energy industry now. Renewable energy education at the tertiary level can therefore be seen as having both long-term and short-term goals, both of which are important. In the long term, the goal is to develop a workforce of educated and skilled professionals, including specialists in all fields of science, engineering and the social sciences whose education includes an

appreciation of how renewable energy technologies will contribute in the fields they practice in. Professional trainers and educators, including university staff, will need training appropriate to their disciplines so that all educational institutions can contribute to the training of students in areas relevant to national and global problems. In the short term the goal is to reeducate specialists already in the workforce to provide professional personnel to meet the current shortfall in those with the training and skills to develop, implement, maintain and promote renewable energy technologies and energy management practises.

The education program within the Australian Co-operative Research Centre for Renewable Energy (ACRE) aims to address the need for renewable energy education at all levels from primary school to continuing professional education [Jennings, 1996]. The postgraduate training and undergraduate studies projects have the more specific aims of offering postgraduate research training with industry placement and university courses in renewable energy technology, energy policy and energy management. They seek to meet the increasing local and international need for more tertiary trained scientists, engineers, policy makers and educators, to give them the knowledge and skills to develop and implement renewable and energy efficient systems and the policies to encourage and support them. The project includes coursework in several disciplines at the University undergraduate and postgraduate level, as well as postgraduate research training with industry placements within ACRE's participating organisations. This paper focuses on the approach and objectives of ACRE in relation to postgraduate training and undergraduate studies.

2 POSTGRADUATE TRAINING

Postgraduate training includes research training with placement in industry with students working on research projects within ACRE's technical programs. These technical programs include: Power Generation; Energy Efficiency; Energy Storage; Power Conditioning; Systems Integration; Planning and Market Assessment; and Demonstration. This is a key feature of the collaborative relationship between the public and private sectors which characterises CRC's.

Generally research students work in industrial laboratories for part of their studies and have both academic and industrial supervisors. This will benefit both industry and the students by ensuring that their work is relevant to the needs of industry and the university. This is the practical, "on the ground" part of the project. To encourage students to undertake research in renewable energy, ACRE offers a number of research scholarships for projects within its technical programs.

As well as postgraduate research opportunities ACRE, in conjunction with several Australian universities, is also developing a number of postgraduate coursework programmes. These will be available for internal (on campus) and external (CDROM/internet) study and the major market is full-fee paying energy professionals who require further training in renewable energy. There are currently two postgraduate certificates, one in energy policy and one in energy systems, a Postgraduate Diploma in Energy Studies and a Master of Science in Renewable Energy Technology. These programmes are being offered in conjunction with Murdoch University and other education providers such as Engineering Education Australia.

2.1 Postgraduate Certificates in Energy Policy and Energy Systems.

The postgraduate Certificate in Energy Policy is designed to cater for those who wish to acquire knowledge and skills in energy policy, economics and planning. It includes the units, Energy in Society, Energy Policy and Energy Economics.

The Postgraduate Certificate in Energy Systems is designed to cater for those who wish to acquire knowledge and skills in energy management and the design of small to medium sized energy systems, especially renewable energy systems. It includes the units, Energy in Society, Energy Management, and Energy Systems.

The certificates, available on a full-fee paying basis only, are equivalent to one semester of full time study, and are designed to be studied internally or externally over one year, although students can take longer if they wish.

2.2 Postgraduate Diploma in Energy Studies

The Postgraduate Diploma in Energy Studies (PgDipEnSt) is designed for those who have already completed a degree in any discipline who wish to acquire skills in all the core areas of energy studies. These include the role and use of energy in society, energy management, energy policy and planning, energy economics and the design of small to medium sized energy systems, especially renewable energy systems.

The diploma, which is available on a full-fee paying basis only, is equivalent to one year of full time study and is designed to be studied internally or externally over one or more years. Students who have previously completed one of the postgraduate certificates are able to gain credit for the units already completed thereby articulating into the postgraduate diploma.

The Postgraduate Diploma in Energy Studies includes the units, Energy in Society, Energy Management, Energy Systems, Energy Policy, Energy Economics and Energy Studies Project. Energy Studies Project consists of a practical project, a review of the literature or an assessment of technology or policy.

2.3 Masters in Science (Renewable Energy Technology)

The Master of Science (MSc) in Renewable Energy Technology is designed for those who have already completed a degree in any discipline and provides specific training in advanced areas of energy technology. The emphasis of the studies is on the design, analysis and implementation of energy systems, with a particular focus on renewable energy systems.

The first year of the MSc programme consists of the Postgraduate Diploma in Energy Studies. The MSc then requires the equivalent of one further (full-time equivalent) years study, which includes coursework and a dissertation. The MSc, which is available on a full-fee paying basis only, is equivalent to two years of full time study and is designed to be studied internally or externally (from 1999) over two or more years.

The MSc includes the units, Renewable Energy Resources, Renewable Energy Conversion Devices, Renewable Energy Systems Design, Case Studies of Renewable Energy Systems and Renewable Energy Technology Dissertation. Renewable Energy Technology Dissertation is a project report of about 10,000 words which details a piece of research related to renewable energy technology. The dissertation may consist of a literature review and technology assessment or a practical investigation of some aspect of a renewable energy system or device.

3 UNDERGRADUATE STUDIES

This project involves the development and use of courseware for undergraduate education in science, engineering and social studies. The courseware is being developed by several of the participating Universities and will be tested by them before it is offered to other ACRE participants. Eventually it will be sold to other universities and education providers in Australia and overseas. This project will address the market need for trained professionals to design, build and operate renewable energy systems and to formulate policy that encourages their development.

Some of the undergraduate units are intended for inclusion in University courses to ensure that graduates from a wide range of disciplines are familiar with renewable energy systems, energy efficiency and greenhouse issues. As stated by Berkovski and Gottschalk [1996], "The basic sciences, engineering, agronomy, architecture, economics, political science and other disciplines leading to research or practical careers in which technology issues will be paramount must, therefore, incorporate new technology considerations into their curricula". This is certainly true of renewable energy technology.

Units about renewable energy and energy efficiency are offered at undergraduate level at a number of Universities around Australia. Murdoch University, for example, offers energy studies units at undergraduate level in two ways, as a major stream in the Applied Computational Physics degree (5 energy studies units) and as a minor in a number of other degrees including Engineering and Social Ecology (3 energy studies units). The units available to choose from at undergraduate level at Murdoch university include, Energy in Society, Energy Management, Energy Policy, Energy Economics, Energy Systems and Environmental Technology for Sustainable Development.

In this way undergraduate students in a number of disciplines such as the physical sciences, engineering, social ecology and environmental science can gain knowledge about renewables which they can then use in their particular discipline. Examples of energy studies, renewable energy systems and energy management related topics taught in undergraduate units offered by other university members of ACRE include; energy, environment and society, energy conversion and energy systems (Australian National University); energy studies, thermal performance and energy consumption in buildings, photovoltaic devices and applications (University of New South Wales); energy management and systems (University of Tasmania); and energy generation, power apparatus and systems, appropriate technology (University of Technology Sydney). There are also units in energy studies, renewable energy systems and energy management related topics taught in undergraduate units offered by other universities in Australia and New Zealand.

4 ONLINE COURSES

One of the ways in which the Education Program seeks to meet its aims, especially those addressing the need for renewable energy education at the continuing professional development level and reaching the widest possible audience, is by making a range of energy studies units and programmes available through the internet (online) and by agreements with a number of education and training agencies. Despite some reservations as to whether online presentation will be able to replace conventional teaching methods [Godfrey, 1996] there are a number of reasons for offering the units in online mode:

- 1) The potential to reach a greater number of students. Because the units can be completed via the internet, from CDROM, or both, without ever having to come onto the campus it is irrelevant where in the world the student is. This has particular advantages for students in developing countries who can complete the programme in their own country without the significant expense of moving to and living in another country.
- 2) The convenience for students of being able to study at their own time in the comfort of their own surroundings. Online presentation is particularly suited to professional development as those taking the courses can study at their own desk at work or at home, at a time that suits them.
- 3) The ability to link to and use world wide web sites that are continually updated. This means that it is easier to keep information in the units up to date and relevant as well as introduce source material from a wider group of sources, especially in an international framework.
- 4) The ability to introduce interactive multimedia and simulation into the units via CDROM or the internet. This means that a greater range of teaching options are available and the learning experience of the student, especially external students, can be enriched beyond that normally available from conventional print based material.
- 5) Email and online discussion groups enable significantly faster and convenient student-student and student-teacher interaction. This is especially important for external students who are usually widely spread geographically. Online discussion facilities or email list servers enable external students to interact with each other and the tutor in a manner similar to internal tutorials. Email submission of assignments and requests for help with problems in the unit mean greatly reduced turn around times compared to the normal mail service, especially for students in remote areas or different states or countries to that of the tutor. Email can also save expensive STD or ISD charges or periods of repeated, frustrating attempts to contact the tutor to have problems solved over the phone.
- 6) The units are generally easier for the academic in charge of the unit and the educational institution to maintain and administer. If the unit is offered in online mode, information can be added or changed easily in one place and is then disseminated to all the students without needing to send it individually to each student. The tutor or lecturer can easily add new relevant material or post solutions to common problems on the online discussion group or email listserver and it will be automatically available to all the students.

In the light of the diverse and geographically widespread target market and the inherent advantages of online offering, during 1997 and 1998 all of the units in the Postgraduate Certificates and the Postgraduate Diploma are being developed and offered as online (internet and/or CDROM) based units. Definitions of "online" vary, but the definition used here is that given in the Murdoch University draft document "Murdoch Online: Academic policy for approving online units" which defines online units in the following way, "Units classified as available online give online access to a full study guide, including the unit's teaching and learning activities, assignments, and online readings. Instructional designs may be drawn from a wide variety of models to suit the unit's curriculum, and the unit may use a range of other kinds of resources such as classroom teaching and text books, in accordance with its mode of study being "distance education" or "on campus".

Although the bulk of the unit material will be accessed through the internet (or from CDROM) other resources such as text books or readers may also be required. The energy studies units will be offered online in this way from 1998 through Murdoch University, via Murdoch Online, and other education providers and agencies such as Engineering Education Australia. It is planned to develop and offer the MSc courses in online mode from 1999. This is the "online" part of the project. Three of the Energy Studies units, Energy in Society, Energy Policy and Energy Systems were developed and trialled this year in conjunction with Murdoch University. Demonstration sites for these three units can be viewed at the ACRE web page <http://www.phys.murdoch.edu.au/acre> under the Renewable Energy Education section.

The online units are designed to enable the same unit material to be offered in the same way to as wide a range of students as possible. This meant the units had to have a common interface and format that could be used effectively by internal (on campus students) and external (correspondence) students, including both Australian and international students. The design of the interface and delivery format also had to account for students having different amounts of internet access, which could include full unlimited access, partial access or access for limited periods of time, or even email access only. In the light of these requirements the approach taken was to design the unit material so that it was accessed via a World Wide Web Browser interface. The unit material itself usually consists of a range of media, including published text books, printed course readers containing supplementary material, online and multimedia material provided by the host university, and links to other non host sites on the World Wide Web. Interaction with the online and multimedia material provided by the host university is done via a Web browser, such as Netscape Navigator.

The unit online and multimedia material can be provided in a number of ways, by a local area network (for internal students), by an active internet link to the university's World Wide Web server or from CDROM. This enables access by a wide range of students and has a number of advantages for the academic offering the unit and the students. All students need to complete the unit is to have access to a suitable computer that has a CDROM drive and is capable of running an appropriate Web browser. Although active internet access and email are preferable, they are not essential. Students who have no internet or email access are able to access all the necessary unit material to complete the unit via the CDROM and textbook or printed material, submitting their assessable work via normal mail. Questions or problems the student has are answered by phone, fax or normal mail. For students who have email access but no internet access the necessary unit material is accessed via the CDROM and textbook or printed material. Assessable material and questions or problems with understanding concepts in the material can be submitted and marked or answered via email. These students will not have access to the additional enrichment material provided by the live internet links but will still be able to complete the unit satisfactorily.

A number of students have internet access, but either the cost of accessing significant amounts of material or download times from the host university are prohibitive. These students are able to access the bulk of the material for the unit from CDROM, only accessing the internet for enrichment material provided at other World Wide Web sites, to participate in online discussion groups at the host university, to submit assessment material or to seek solutions to questions about the unit content. Internal students, via the on campus LAN, and external students with full, unlimited internet access will access all the online and multimedia material for the unit via the internet without the need for a CDROM. Internal students may also have additional conventional learning opportunities such as face-to-face tutorials, lectures providing additional enrichment material such as videos, and practical sessions or local site visits. An advantage for academic staff of using the approach of a common interface to common unit material is that the same material is prepared once, whether it is placed on the host university's World Wide Web server or burnt onto a CDROM.

Figure 1 shows a typical example of the interface to the online energy studies units prepared by Murdoch and ACRE as viewed using Netscape Navigator. The original is of course in color. In light of some of the recognised disadvantages of an online environment [Neilson et al, 1996] such as the inherent navigational problems and the often fragmentary perception of the material and concepts, the design of the unit interface and organisation of the unit content are important. The interface and unit organisation for the energy studies units has been carefully designed with these considerations in mind so as to optimise the effectiveness of the online learning.

Many of the inherent navigation problems are overcome by always having the same set of icons visible in the frame at the left of the page. In this way students are always able to access major parts of the unit from anywhere in the pages, much like the index of a book. For example a student can gain instant access to the tutor via the "Message to Tutor" button, enabling them to send a message asking for resolution of a problem they are having with the concepts in the unit material, at the place in the unit content where the problem occurs. The student can always return to the start of a

given unit or lecture at any time via the "Study Schedule" button.



Figure 1 - The first page of the online unit Energy in Society as seen using the Netscape Browser.

	INDEX - This button provides the link to the entire contents of the unit, such like a table of contents in a book. You will be able to use this button to access other parts of the unit no matter where you are. Click on it now for a quick overview, then use the 'Back' button on your Browser toolbar or the link from the Index page to come back to this page.
	STUDY SCHEDULE - The Study Schedule provides you with a diagrammatic overview of the unit showing the recommended study timetable. The organizer includes links to the individual topics and reminders of when assignments are due. Preview it now, print it out, then return to the screen.
	HELP - Takes you to a page that explains what each of the buttons do if you need help anywhere in one of the other unit pages.
	Message to your Tutor - If you are having any difficulties in the unit or you want to ask any questions, you will be able to contact your tutor through this link. If you click on this button an automated email message will appear for you to type in your message and send it. Your tutor will negotiate response times with you.
	Cafechat - This button will link you to all of the other students (and the tutors/courses coordinator) in the unit through a Web based, bulletin board type discussion list. You will be prompted to 'Have your say' in suggested activities in the Study Guide.
	Disreport - If you come across any sections of this online unit that don't quite 'work' for you or you find any technical bugs, use this link to report it. Your feedback is very welcome and will be used to improve the unit.

what each of the index buttons means in order to give an idea of some of the features of the interface and the contents of the online unit.

Figure 2, from the initial Getting Started screen, shows what each of the index buttons mean and also gives an idea of some of the features of the interface and the online unit. Included in the online units are such things as the full administrative and unit organisational details similar to what is found in a normal printed unit study guide, lecture notes in HTML format, often containing multimedia features and with imbedded links to other internet sites for enrichment, or simulations and a list of useful internet sites as a bibliography for further reading. They also contain such things as an online bulletin board, called the "café chat", on which messages can be added and read by anyone, and which enables students to have a discussion with one another and the tutor in a way similar to face-to-face tutorials.

Figure 3 shows examples of some of these other features as implemented in the online energy studies units. The left most picture in Figure 3 shows an example of a topic/lecture page outlining the aim of the lecture, the reading, additional reading and internet sites and the availability of the lecture notes in HTML format. The middle picture in Figure 3 shows an example of such a set of lecture notes in HTML format, including diagrams. The right most picture in Figure 3 shows some examples of comments entered on the café chat for the unit Energy in Society.



Figure 3 - Examples of some of the pages from the online energy studies units. From left to right; an example of a topic/lecture page; an example of a set of lecture notes in HTML format; some examples of comments entered on the café chat .

The units are run in dual mode first, that is both print based and online, to gain student feedback and to remove any glitches before offering in fully online mode. Energy in Society was offered internally and externally in dual mode in first semester 1997, and was well received by those students who used the online mode. Two other units Energy Policy and Energy Systems are being run in dual mode in second semester and will be assessed at the end of 1997. All three of the developed units will be offered to both internal and external students in online mode only in 1998. The two other content based units, Energy Management and Energy Economics will be offered in dual mode in 1998.

5 SUMMARY

This paper has focussed specifically on the approach and objectives of the Australian Co-operative Research Centre for Renewable Energy in relation to postgraduate training and undergraduate studies. It included a description of the University courses and postgraduate research opportunities to be made available and the way the courses are to be offered. The advantages of offering renewable energy units in "online" mode (via the internet and/or CDROM) were discussed. Examples of the internationally focussed, online (internet/CD ROM) based units Energy in Society, Energy Policy and Energy Systems which were developed and trialed this year, in conjunction with Murdoch University, were demonstrated.

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