

THE POTENTIAL, PRACTICE AND CHALLENGES OF TERTIARY RENEWABLE ENERGY EDUCATION ON THE WORLD WIDE WEB IN THE ASIA-PACIFIC REGION

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ABSTRACT

The Australian Co-operative Research Center for Renewable Energy (ACRE) through its tertiary training projects seeks to help meet the increasing need in the Asia-Pacific region for more tertiary trained scientists, engineers and policy makers with the knowledge and skills to develop and implement renewable and energy efficient systems and policies. As part of this objective it is developing a range of undergraduate and postgraduate university courses in renewable energy technology and systems, energy policy, energy efficiency and greenhouse issues which will be available internationally via the World Wide Web. This paper will present the approach and objectives of ACRE in developing its internationally focussed, web based, renewable energy courses. This includes a description of the course structure and examples of the web based courses developed so far. A discussion of the potential, the practice and the challenges of offering tertiary renewable energy education on the web in the Asia-Pacific region is given.

INTRODUCTION

The Australian Cooperative Research Centre for Renewable Energy (ACRE) seeks to meet the increasing need for more tertiary trained scientists, engineers and policy makers with the knowledge and skills needed to develop and implement renewable and efficient energy systems and policies [Jennings, 1996]. It is doing this by developing, in conjunction with Murdoch University, a range of internationally focussed, online (internet-based) university courses in renewable energy technology, energy policy, energy efficiency and greenhouse issues. This includes a number of units (courses) in several disciplines at the university undergraduate and postgraduate level that will be available for both internal (on campus) and external (distance education) study. The target market is Australian undergraduate Higher Education Contribution Scheme (HECS) based students and full-fee paying postgraduate students, from both within Australia and internationally.

The structure of the courses and qualifications has been discussed in detail elsewhere [Lund and Jennings, 1997]. There are currently five coursework units and one project unit that form the basis of the undergraduate program and the first year of the postgraduate program in Energy Studies. There are four coursework units and one research unit that form the basis of the second year of the postgraduate program. Beginning in 1997, ACRE, in conjunction with Murdoch University began to develop these units into online (internet based) units. Three of these were developed and trialed in 1997 and run again as online units in 1998 while the remaining three units required for the first year of the postgraduate program were developed and run as online units in 1998. Online versions of the units required for the second year of the postgraduate program are planned for development and offering in 1999 to 2000.

This paper discusses the strategies used to present these units and reports on student's experiences of studying renewable energy via the web. Based on evaluations of the outcomes from the Energy Studies online units offered so far, and other research related to online units in other disciplines, the potential, the practice and the challenges of tertiary renewable energy education via the web are also discussed. Some of the challenges more specific to offering renewable energy education via the internet in the Asia-Pacific region will be discussed.

THE POTENTIAL - WHY ONLINE?

The Energy Studies units offered by ACRE and Murdoch have a diverse target student market. Students can come from a wide range of backgrounds and requirements. They are widely spread geographically, with some studying on campus, while others are interstate and overseas and can only study via distance education. The Energy Studies offering was therefore developed in such a way that it can be used by all of the different types of students in a similar way. In order to make the units relevant to the widest possible

audience, flexible programs were developed based on a range of internationally focussed units available online.

The advantages of offering the units online have been discussed elsewhere [Lund and Jennings, 1997; Lund et al. 1997] and include:

- *Greater access* - the potential to reach a greater number of students because the units can be completed via the internet, from CDROM, or a mixture of both, without the students having to come onto campus.
- *Greater choice of instructional methods* - the ability to introduce interactive multimedia and simulations into the units via the internet, or CDROM, means a greater range of teaching options are available. The learning experience of the students can be enriched beyond that normally available from print based material, especially for distance education students.
- *Greater flexibility* - the convenience of studying in the comfort of student's own surroundings, at a time and pace that suits them, means that online presentation is very suited to professional development and part-time studies.
- *Greater relevance* - the ability to use World Wide Web sites that are continually updated means that it is easier to keep information in the units up to date and relevant, as well as introduce materials from a wider range of sources, especially in an international framework.
- *Greater opportunity for course sharing* - because the unit content is available via the web it is easier to share units between campuses or even educational institutions. The same content can be accessed from the web, with local tutorials and laboratories.
- *Better communication* - Email and online discussion groups enable significantly faster and more convenient student-student and student-teacher interaction, electronic submission and marking of assignments, and help with problems, especially for geographically isolated external students. As electronic communication has no geographical constraints there is the potential for increased interaction between students from a wide range of countries and backgrounds who can share different perspectives on the material.
- *Easier course maintenance and administration* - the units are generally easier for the academic and the educational institution to maintain and administer as changes can be made to the material on the website and this will instantly be available to all the students.

It is clear that the advantages of offering renewable energy studies via the internet are significant. It has the potential to significantly increase the number of people who can receive training in renewable energy and to enhance the learning experience of the students, especially those studying via distance education. This has been clearly seen in our experience of offering Energy Studies units online.

THE PRACTICE -WHAT WAS IT LIKE?

The online units were designed to enable the unit material to be offered in the same way to as wide a range of students as possible. This meant taking into account students having different amounts of internet access, from fast, unlimited access (via the University or the workplace), to slow, or limited access via a modem and Internet Service Provider (ISP), to email only or no access. This was best achieved through the units having a common interface and format that could be used effectively by both internal (on campus) and external (distance education students). In light of this the approach taken was to design the unit material so that it was accessed via a World Wide Web browser interface. This meant it could be served from an internet server or from CDROM in the same way.

Following advertising of the Energy Studies program and the opportunity to complete it externally via the internet in 1997 there was a significant increase in the number of students studying Energy Studies courses. The profile of the applicants and their reasons for choosing the Energy Studies courses is described elsewhere [Jennings and Lund, 1998]. In 1998 the Energy Studies postgraduate program had twenty-five students completing one of the postgraduate Energy Studies qualifications either full-time or part-time. Of these the majority were studying externally (23/25) and part-time (21/25). All the students were Australian nationals and had a wide geographic distribution. Ten of the 25 students were from the Perth metropolitan area, 4 were from regional Western Australia, 10 were from other states in Australia and 2 were overseas (France). Twenty-one of the 25 students had at least access to email, with only four students who could only complete the courses via conventional print based distance education due to no internet or email access. Two of the 21 students were completing the units using email only distance education. This meant that the majority of students accessed the unit materials via the internet, using a modem and ISP, or a work or university based system connected directly to the internet. Five students graduated from the postgraduate program in 1999, with three of these students completing their units externally via the internet.

The diversity in the student's modes of study meant that the units were delivered using a number of teaching methods. External students were encouraged, but not required, to access the unit material using predominantly the online mode. The external students who could not get any access to email or the internet completed the units as conventional distance education students. These students received all the unit materials in print based form and submitted and received all assessable work in hardcopy written form. Correspondence with the university staff and tutors was conducted either in written form or via telephone. The students, who had email access but no internet access received all of their unit materials in print based form but submitted and received all their assessable work, with the exception of the final exam, via email. All correspondence with the tutors was conducted via email. This ability to communicate via email was seen by these geographically isolated students as a significant advantage compared to print or telephone based communication. The email communication enabled fast responses to any questions the students had, and enabled much shorter times for feedback on assignments. The remainder of the external students used the fully online mode of study.

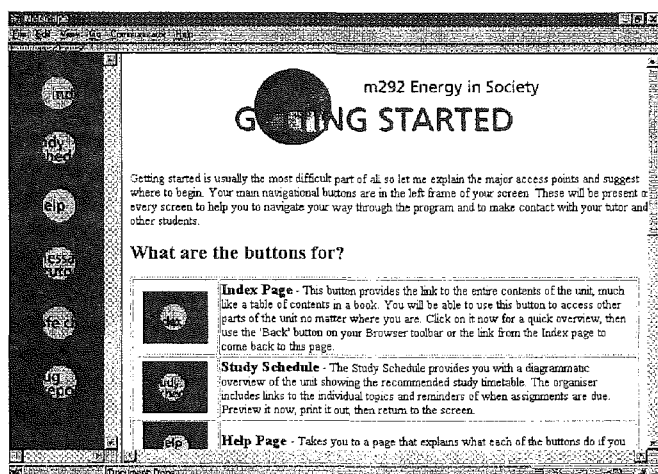


Figure 1: The first page of the online unit *Energy in Society* as seen using the Netscape Browser.

All internal (on campus) students in the Energy Studies units had priority access to a computer laboratory set up for using the internet, email and wordprocessing and they were required to access the unit material using the online mode. On campus students also had, as needed, supplementary face-to-face teaching, including lectures, tutorials, practical sessions and site visits. All students, whether studying in conventional mode, email only or online had to sit a supervised written examination. All internal and external students who used the internet mode of study accessed the unit material in the same way. For these students the unit material usually consists of a range of media. This includes published textbooks or technical brochures, printed course

readers containing compiled supplementary material, online and multimedia material provided via the host material, either from a server or CDROM, and links to other non host sites on the internet.

The design of the online interface and unit structure, was based on contemporary teaching and learning theory and practice [Brown, 1997]. These design principles and features of the online units have been described in detail elsewhere [Lund and Jennings, 1997, Lund et. al. 1997]. Figure 1 shows the first page of a typical Energy Studies online unit, showing the online interface. It gives an idea of the features of the interface and the contents of the online unit. Demonstration versions of the units developed so far can be viewed at the ACRE website <http://acre.murdoch.edu.au/> under Education.

The operation and effectiveness of the online Energy Studies units was monitored during the initial trial period, and later during full implementation, by gathering extensive feedback from the students themselves. One of the authors has also been involved in a broader study looking at students studying online for the first time across a large number of online units from several disciplines within the university [Lund and Volet, 1998], including the Energy Studies units. This has led to a number of observations about offering online units generally, and some specific to renewable energy units. Most of the students who were able to use the online versions of the Energy Studies units showed high levels of satisfaction with the online mode of delivery of the units, with many encouraging and positive responses received. The Energy Studies students perceived the main benefits of the online mode of delivery to be: easy access to unit materials; more flexibility in how and when to study; and an increase in the amount of information available. These perceived benefits are in line with those seen in studies of students taking online units for the first time [Lund and Volet, 1998; Lund et. al., 1997]. Students from a wide range of disciplines perceive the major advantages of studying online to be: flexibility in learning place and time; guided access to useful resources beyond those available in the conventional mode; and the convenience of electronic contact with university staff and other students, especially for those studying via distance education.

THE CHALLENGES

The drawbacks of studying the Energy Studies units online that were reported by the students mainly related to operational difficulties. Most of these problems will be addressed in subsequent offerings of the units. Although the students, when surveyed, did not report any significant drawbacks, our experience and research have shown a number of challenges with offering renewable energy courses on the web. Some of these are general to all online units, and some are more specific to Science or Engineering units. Our studies of students studying online units in a number of disciplines, including Energy Studies [Lund and Volet, 1998], have highlighted a number of potential problems, or challenges, with teaching renewable energy on the web. These include: a perceived loss, by internal students, of face-to-face contact with university staff and other students; uncertainty about how to study using this "new" mode of learning; and a lack of adequate access to computers and the internet, on and off campus. External students generally only rated the third one of these as a problem with studying effectively online. One problem observed that is specific to the Science based renewable energy units is that of a lack of practical, hands on experience.

As well as the general challenges presented by online delivery there are some challenges that particularly relate to the Asia-Pacific region, in particular to students in developing countries. These include: a lack of adequate access to computers and the internet; and the high price of fees in developed country universities. There are a number of ways in which the challenges mentioned above can potentially be reduced.

Uncertainty about how to use this new mode of learning

Our studies [Lund and Volet, 1998] of students studying online for the first time have shown that they often lack the confidence and skills needed to study using this "new" mode of learning. Careful consideration of the instructional design of the unit, and the provision of appropriate support to assist students to learn how to study effectively using online materials can reduce these problems. An online unit must have a carefully designed interface that provides ease of navigation, a sense of human interaction, and helpfulness and responsiveness to the needs of the learners studying in an information rich, self directed medium [Brown, 1997]. This approach has been used in the Energy Studies units and our studies [Lund et. al., 1997] have shown that this can increase a student's confidence and effectiveness in learning online. Those students who have not studied using the online mode before should have access to support and training in how to use all of the components of an online unit in order to increase their confidence and effectiveness in studying online. Murdoch University has developed a computer and internet based learning skills package that includes training in learning skills for library, information technology and online skills.

A perceived loss of face-to-face contact with university staff and other students

The loss of face-to-face contact with university staff and other students is the primary concern of internal students who are taking online units for the first time. Results of our studies [Lund and Volet, 1998] show that even if it is possible to complete the unit entirely online on-campus students also want to have face-to-face contact with each other and teaching staff. Effective teacher-student and peer support networks have been shown to reduce the problems encountered by first time online users [Lund and Volet, 1998]. Online delivery enables much greater teacher-student and student-peer support for distance education students. The use of email and electronic discussion groups/bulletin boards, can greatly reduce the isolation normally felt by distance education students, and they value this kind of interaction. To quote Freeman [1997] "Considerate student communications are still critical to ensuring positive student learning conceptions. Moral support from friends, supervisors and colleagues can go a long way to maintaining enthusiasm..."

Slow or no Internet access

One of the important issues with offering renewable energy units online is the diversity of computing facilities and internet access available to external students. Although a large percentage of the students taking the postgraduate Energy Studies units appear to have access to the internet (21/25) there are still ~25% who have no access or "email only" access. These students can be catered for by conventional print based delivery, supplemented by email communication where available. This lack of adequate access to the internet is likely to be a problem for a decreasing number of students in developed countries such as Australia [Ivanoff and Clarke, 1996]. Adequate access to computing and internet facilities will however remain a problem for students in developing countries for some time, and this is one of the challenges to offering renewable energy education via the internet in the Asia-Pacific region.

For a significant number of external students access is through a modem and Internet Service Provider (ISP). Because modem speeds are still very slow, down-loading large amounts of online unit material can be time consuming and expensive. One approach to this problem, particularly in developing countries is to create a version of the online materials designed for access from a CDROM. With this approach no

significant extra development of the unit is needed as the material on the server can be burnt directly to the CDROM. The materials are then accessed in the same way using the web browser interface, but the bulk of the unit material now comes directly from the local CDROM rather than via modem from the host university server. The student only needs to access the internet for other non host university web sites and electronic communication and this approach can lead to a significant reduction in the time and cost required to access the unit materials.

A lack of practical hands on experience

One challenge mentioned by a number of students, particularly those with a Science or Engineering background, was that the online units do not provide enough practical hands on experience. This is a difficulty with offering distance education in any Science or Engineering based unit that has a practical component, and this is not unique to online units. Although this is a problem that cannot be overcome entirely, there are a number of ways that it can be reduced and online delivery offers a number of advantages over conventional print-based distance education in this regard. One of these advantages is the ability to incorporate multimedia, simulations and an interface to real data collection and equipment control. Examples of the features that can be incorporated into the online renewable energy courses include:

- **Multimedia.** The Center for Renewable Energy and Sustainable Technology (CREST) have developed a very good, inexpensive, interactive CD entitled "The Sun's Joules" which contains a large amount of information on various renewable energy, energy conservation and climate change topics. One of its features is the incorporation of multimedia movie clips showing various aspects of the content being discussed. An internet version of this CDROM can be found at <http://solstice.crest.org/renewables/SJ/>, but due to bandwidth considerations this site does not have the multimedia movie clips.
- **Simulations.** A number of simulations of renewable energy systems are now becoming available. These range from simple interactive demonstrations such as the SolarSim program developed by the Australian National University [Hume and Cuevas, 1997] to complex system simulation and analysis tools like RAPSIM, which has been developed by the Murdoch University Energy Research Institute (MUERI). A web based version of the SolarSim simulation, shown in Figure 2, is available at <http://online.anu.edu.au/engn/solar/Sun/>. These simulations, which are available as online simulations (SolarSim) or can be down-loaded as stand-alone programs (RAPSIM) from the internet or CDROM, can be incorporated into the online units to give more practical experience.

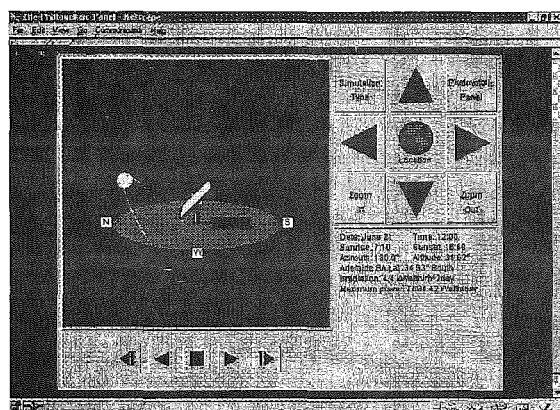


Figure 2: A typical screen from the web based solar simulation program SolarSim. This demonstrates the use in renewable energy teaching of internet or CDROM based simulation programs.

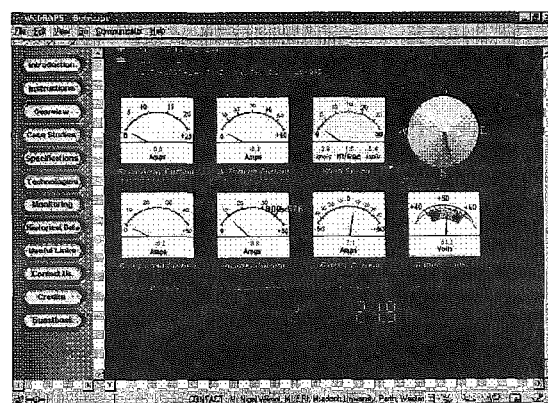


Figure 3: A typical screen from the WebRAPS website. This demonstrates the use in renewable energy teaching of a computer interface to display real-time data from a physical system.

- **Interface to real renewable energy equipment and systems.** A number of Internet sites are now being developed which incorporate a computer interface to enable the collection and display of data from a real world system. These systems, which can display data in close to real time, enable the user to see the system in operation without actually having to be at the physical site. One such site is the WebRAPS site developed by MUERI and ACRE. This website, at <http://wwwphys.murdoch.edu.au/WebRAPS/>, is designed to display both weather and system performance data in close to real-time for the physical remote area power supply (RAPS) demonstration system at MUERI. The site, shown in Figure 3, and described in more detail elsewhere [Lund et al., 1998], enables a user to see how the system operates

without actually having to visit the physical site itself, but rather by monitoring its performance over the internet.

- *The use of research projects or industry experience.* One important way in which the difficulty of obtaining hands on practical experience when studying online is tackled in the Energy Studies program is through the incorporation of research projects. These projects which constitute one quarter of the total MSc program enable the students to concentrate in more detail on an area of renewable energy that they wish to pursue in more detail. Students are encouraged to work with industry, utility or University groups to look at real practical issues or applications. This gives the student the chance to get practical experience in the area that they are interested in.

Therefore, although the problem of receiving less practical hands on experience when studying online, compared to conventional on campus study, cannot be entirely overcome, there are a number of ways in which it can be reduced.

One challenge with offering Energy Studies units online in the Asia-Pacific region is the high price of university fees in developed countries. This is a particular issue for renewable energy courses as developing countries are often those that have an emphasis on renewable energy for power generation, but have few trained professionals to install and maintain them. A different approach will be needed in these countries if an adequate number of students are to receive training in the renewable energy field in this way. One approach that has the potential for meeting this challenge is the formation of partnerships between institutions in the developing country and those in the country that has developed the online units. This would involve franchising the online units at low cost to the institution in the developing country. In this way students would be able to complete the units at an institution in their own country under a fees regime in line with what they can afford. Another advantage of this approach is the ability for students to receive teaching and tuition from local teachers in their own language in a culturally and nationally appropriate context.

CONCLUSIONS

The Australian Cooperative Research Centre for Renewable Energy (ACRE) in conjunction with Murdoch University have successfully developed and run a range of internationally focussed university courses in renewable energy technology, energy policy, energy efficiency and greenhouse issues, which are available entirely via the world wide web (online). Our experiences so far have shown that there are many potential benefits of offering renewable energy units online and these have been presented. The features of the online units and the methods used to present them, or the practise, have also been discussed. Evaluations of students' responses to their experiences of studying units online have shown high levels of satisfaction. The students perceive the major advantages of studying online to be; flexibility in learning pace and time; access to useful resources beyond those available in conventional modes of delivery; and the convenience of electronic interaction with university staff and other students, especially for distance education students.

The student responses have also highlighted some operational difficulties that will be addressed when the units are run again in the future. As well as these operational difficulties, which are easily rectified, our experience has highlighted some potential challenges with offering renewable energy courses online. These include: uncertainty about how to study using this "new" mode of learning; a perceived loss of adequate face-to-face contact with university staff and other students difficulties with adequate access to the internet; and a lack of practical hands on experience for those studying the online units via distance education. A number of strategies to overcome these challenges have been presented.

ACKNOWLEDGMENTS

The work described in this paper has been supported by the Australian CRC for Renewable Energy (ACRE). ACRE's activities are funded by the Commonwealth's Cooperative Research Centres Program. ACRE also receives investment funding from the former Energy Research & Development Corporation (ERDC) which managed the federal government's direct investment in energy innovation. The authors would like to thank Simone Volet from the School of Education for her assistance with the collection and analysis of student response data. They would also like to thank Trevor Pryor, Kenneth Cheok, Laura Stocker and Frank Harman for their input to the development of the Energy Studies units and program. Support for assistance with various aspects of online implementation and instructional design from Geoff Rehn, Roger Atkinson, Allison Brown and Romana Pospisal of the Teaching and Learning Centre at Murdoch University is gratefully acknowledged.

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