Presenting a course in renewable energy for engineering students

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Abstract: *The electrical engineering courses at Curtin University were re-structured in 1997 in line with IEAust recommendations to include social, economic and environmental aspects of engineering. The new courses include elective units, one of which, "Renewable Energy Principles", is an example of a unit which combines technical and non-technical aspects of engineering. Subsequently there has been a consolidation process across the university standardising the number of units per semester (to 4) as well as a move to 12 week teaching semesters. Renewable Energy Principles has been revised to fit the new format and remains a popular final year elective unit. The paper gives background information and philosophy on the unit development, details of the unit and feedback from students who have taken the course.*

Keywords: *renewable energy education*

Background

The Department of Electrical and Computer Engineering at Curtin University of Technology has an enrolment of around 450 undergraduate students and offers degree courses in Electrical Power, Communications and Computer Engineering. The School restructured its undergraduate courses in 1997 in line with the review and recommendations for engineering education made by IEAust. This review was appropriately titled "Changing the Culture: Engineering Education into the Future" [1], it proposed cultural changes in the structure of engineering degree courses in Australian universities. Comments from the report such as, "Courses should promote environmental, economic and global awareness and become more attuned to the real concerns of communities", were taken into account when formulating the new electrical engineering courses at Curtin.

Following completion of the common core units in semesters 1-5, students specialise in Electrical, Communications or Computer Engineering in the final three semesters (fig 1). Within these final semesters there is some flexibility via electives. Each of the three departments is expected to provide elective units that are available to all students within the School. There were a number of reasons why the electrical department was keen to offer both an introductory unit and an advanced unit in the field of renewable energy (RE).

Semester 1

Common electrical engineering core units (3) **+ Engineering and society**

Semester 2

Common electrical engineering core units (3.5) **+ Liberal elective**

Semesters 3,4,5

Common electrical engineering core units

Semesters 6,7,8

Specialised electrical engineering units (3/sem) **+Engineering management and 2 elective units**

Figure 1: Outline of current course structure

Engineering courses have been criticised in the past for being narrow with an undue bias towards the purely technical aspects of engineering [2]. The proposed unit in RE would address this problem by exposing students to social and economic issues as well as the engineering aspects of renewable energy systems.

Renewable Energy is one of the major research areas within the electrical engineering department at Curtin (covering photo-voltaic applications, wind energy and remote area power supplies) and many students, especially those from overseas, carry out projects related to these topics at the Centre for Renewable Energy Systems Technology (CRESTA). A unit covering the principles of renewable energy would obviously fit well with this focus and expose undergraduates to some of the interesting developments in the RE field which would lead to enthusiasm for final year projects in RE. Subsequently some of these students may choose to pursue post-graduate research in the field of renewable energy.

A further reason for introducing the new unit has been the popularity of the coursework Masters' program in Renewable Energy (RE). In the past, post-graduates came solely to do research, but increasingly we are attracting PG students who come for one year of coursework. The Master's course in RE is taken mostly by overseas students who are keen to apply RE technology in their home country.

Why are students interested in RE? There is general concern over the production of energy from fossil fuels, this arises from the issue of sustainabity as well as the environmental impact of burning fossil fuels. The Prime Minister has stated that by the year 2010, an additional 2% of Australia's electrical energy will come from renewable sources [3]. Although the implications of this statement are unclear, it has signalled an increased level of support for the production of energy from renewable sources, and led to the establishment of the Austraian Greenhouse Office. In this favourable economic environment several utilities

are proceeding with renewable energy projects eg the wind farms at Albany, WA [4] and Woolnorth, Tasmania [5].

In order to rationalise courses across the university a Consolidated Teaching Policy was introduced at Curtin University in 2001, this policy mandated that all courses would consist of 4 units worth 25 credit points, each semester. (One unit can be replaced by 2 'half units'). This year (2003) has seen the introduction of 12 week semesters. In this changing environment it has been "challenging" to include two final year units in the field of renewable energy, Renewable Energy Principles is an introductory unit suitable for all engineering students and Renewable Energy Systems a more advanced unit which looks at the power electronic systems needed to interface with renewable sources of energy. The course structure for REP is shown in the appendix. This is a unit which fits well with the IEAust guidelines and emphasises the need for both technical and social factors to be considered when designing systems based on renewable energy, ie the concept of "appropriate technology".

Course Objectives and Outline

The course objectives for the REP unit were written as a set of enabling skills, which students would acquire by participating in the lecture/lab program.

We placed particular importance on the lab program, which consists of a series of exercises in simulation as well as hands on PV experiments and a field trip.

On successful completion of the course students should be able to:

- describe the fundamental principles of renewable energy systems (wind, solar and hybrid)
- select an optimum system configuration for a given application
- apply best practice design principles to the sizing and operation of renewable energy systems
- be aware of both technical and non-technical issues in the planning stage of renewable energy projects
- perform economic feasibility studies of renewable energy systems
- have an awareness of the potential market of renewable energy technology

All units in the School have a similar structure, two hours lecture combined with two hours laboratory/tutorial per week (ie four hours contact which is worth 25 credit points). The weekly outline of the course is shown in the Appendix. Assessment is normally based on a 2 hour final examination worth 60%, plus assignments 20% and practical work worth 20%. The assessment is linked to the specified course outcomes eg. in the written exam, students are required to size a RE system considering local conditions and constraints. Since the unit is also offered to postgraduates as part of their coursework program, the assignments are modified for these students, but all students take the same written exam.

Running the unit

The current version of the course has been offered since 2002. In 2002 there were 25 students (17 undergrads from electrical engineering and 8 postgraduates), while in 2003 there were 49 students (22 undergrads from electrical engineering, 18 undergrads from other schools and 9 postgraduates). Attracting students from other areas can be a challenge as they

bring a different set of pre-conceptions to the course. Exchange students from countries such as Norway, Germany and the US have also taken the course, these students also bring different inputs to the course and demonstrate that renewable energy and sustainable development are topics of global importance.

The course is managed (but not delivered) via WebCT – this facilitates communication with the group - as well as within the group. At the end of each week a summary of the lecture outcomes is posted, along with links to relevant web-sites (especially for wind energy, as the text book [6] only covers solar energy). An advantage of using the electronic bulletin board is that student feedback is much more timely than the usual end of semester surveys. For example some students complained about the conditions in the lecture venue, quickly raised support and this led to a new venue being arranged.

Assignments are also posted on WebCT. I have attempted to give the assignments an individual flavour by specifying a broad problem and then asking students to tailor the problem to a situation of their own choice. Eg one assignment involves the design of a solar home system. Working in pairs, students are able to choose a location of interest (and where they can get weather data) and specify their own load profile.

The reaction of students to the unit has been overwhelmingly positive (as shown by the student unit evaluation) and students seem to take a genuine interest in the topic. There were often points raised in the lectures which led to informative discussions. Eg, a student asked if a voltmeter placed across a PV cell (diode) would measure the barrier potential. My response was to encourage him to take a measurement in the lab and then to refer him to a suitable reference for an explanation.

The presence of the postgraduate students in the group is an added bonus as often these are mature students, sometimes with experience in the renewable energy field, which is helpful, but more importantly they have experience in implementing engineering projects in a variety of environments.

Apart from enjoying the course, most students felt they had gained valuable insights into renewable energy technology and its applications, especially in developing countries. They had a heightened awareness of the social and economic factors associated with introducing a new technology. An example of this topic is grid connected PV systems - why are they popular in Germany but not in Australia?

Conclusion

The paper by Carrie Sonneborn [6] reports that, …"engineers mostly work in controlled environments (large bureaucracies) which restricts their opportunities for making change, (engineers are unlikely to become revolutionaries!) plus engineers are generally less likely to be interested in social issues". Further she goes on to say that …"engineers have an important role to play in creating a sustainable future and in the process the profession could reclaim its positive image". The popularity of the Renewable Energy Principles course is encouraging and augers well for the implementation and acceptance of renewable energy systems in the future. A further aim of the new unit was to demonstrate to students that engineering is more than a narrow technological field of study. To quote from Sharon Beder [2]
"Given the ignorance amongst students and in the community about what engineering is all about, the content of engineering education has provided a window into the profession and

shaped perceptions of it. As a result of the largely mathematical and technical content of the curriculum, engineering is seen as a technical career that combines maths and science rather than one that is involved with people and issues". By introducing the new course, we have attempted to address this bias in the engineering curricula and produce engineering graduates, who, as well as being technically competent, have an awareness of the wider social, economic and environmental issues. A unit such as this, which combines technical, economic and social considerations, is closer to the reality that graduates will be confronted with when they start their careers as professional engineers.

One cannot expect the introduction of one innovative unit, in isolation, to bring about a cultural change in our graduates. However, the unit, Renewable Energy Principles, is presented as an example of the new ethos in the Faculty of Engineering at Curtin University [7]. Examples of other changes in the Faculty which have taken place are:

- the encouragement of women to enrol (and succeed via a support network) in engineering courses.
- the introduction of a Teaching Quality Index in the Faculty to promote good teaching practices etc.
- course feedback sessions where staff meet students to hear their concerns.

The experience of todays engineering students is vastly different from the past and hopefully the university experience equips them with attributes which facilitate their development into professional engineers who are more than just "technically competent".

References

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Appendix

LECTURE PROGRAM for REP 403/603

Week #	Week starting	2 Hour Lecture Topics	Ref Ch #	Lecture #	Tut #	Lab #	Remarks
1	03-Mar-03	Introduction to renewable energy: Sources and applications; Australia's energy balance; Market potential for renewable energy	1	1	1		Introduction to simulation
2	10-Mar-03	PV energy conversion: Char. of sunlight; the PV effect; PV technologies; PV cell models	2,3	2	2	1	Simulation task 1
3	17-Mar-03	PV cells, modules and arrays: module char; practical aspects of module siting; max power point tracking	4	3	3	2	Simulation task 2
4	24-Mar-03	Introduction to wind energy: Fundamentals of WE generators; wind resource assessment AC Circuits 1	web	4	4	3	Simulation task 2
5	31-Mar-03	Utility scale WE conversion (Utility perspective)	web	5	5	4	Experiment 1 (PV)
6	07-Apr-03	Energy storage in RE systems: Batteries and fuel cells	4,7	6	6	5	Experiment 2 (MPPT) Assignment 1 (out)
7	14-Apr-03	**Tuition Free Week**					
8	21-Apr-03	**Easter Break**					
9	28-Apr-03	Energy services for remote communities: RAPS installations, Solar home systems	4	7	7	6	Simulation task 3 (RAPSIM) Assignment 1 (due)
10	05-May-03	Hybrid energy systems: operation and performance	4	8	8	7	Simulation task 3 (RAPSIM)
11	12-May-03	Hybrid energy systems: performance and design	5	9	9	8	RE Systems 1 (CRESTA)
12	19-May-03	Grid interactive systems: rooftop PV systems; utility scale systems	7	10	10	9	RE Systems 2 (CRESTA) Assignment 2 (out)
13	26-May-03	Economics of RE systems: lifecycle cost analysis; external costs of generation; rebate schemes		11	11	10	RE Systems 3 (CRESTA)
14	02-Jun-03	Future prospects for RE: fossil resources; greenhouse effect; energy efficiency; DSM		12	12		Assignment 2 (in)
15	09-Jun-03	**Study Week**					
16	16-Jun-03	**Examinations**					
17	23-Jun-03	**Examinations**					

- A field trip will be held at a mutually convenient time in week 14.