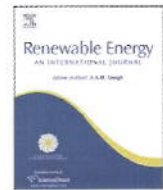


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New directions in renewable energy education

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ABSTRACT

The renewable energy industry is growing rapidly amidst rising concerns about oil depletion and climate change. Renewable energy is seen by many as part of the appropriate response to these concerns and some national Governments have put programs in place to support the wider use of sustainable energy systems. This has led to a rapid increase in demand for renewable energy specialists who are able to design, install and maintain such systems. Most engineers are not trained to use these renewable energy technologies and most are not aware of the principles of sustainability. There is therefore an urgent need to develop and implement new courses that prepare engineers, scientists and energy planners to work with renewables to produce sustainable energy generation systems.

Renewable energy education is a relatively new field and previously it formed a minor part of traditional engineering courses. These days it has an identity of its own, with special techniques, standards and requirements which are not normally encountered in other disciplines. Attempts to add one or two units of study on renewables into traditional science and engineering degrees are unlikely to produce graduates with sufficient knowledge or understanding to use renewables effectively. Modern renewable energy education includes a study of the technology, resources, systems design, economics, industry structure and policies in an integrated package. This prepares the graduates to design sound systems from amongst the range of options available. There are more pitfalls in the use of renewables than there are in using the more mature conventional technologies and systems. Designers, installers and service personnel need to be particularly aware of the industry and the characteristics of the various firms and their technologies.

Over the past decade several new approaches have emerged to renewable energy education that seek to address the needs of the 21st century for sustainable energy supply systems.

This paper will describe the aims, philosophy, structure and outcomes of several of these initiatives. It includes courses in renewable energy science, renewable energy engineering, renewable energy policy and planning and renewable energy technician training. The paper will also describe some aspects of the training of researchers in cooperation with the renewable energy industry.

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1. Introduction

Energy is an essential commodity in modern industrial society. It powers our homes, workplaces, transport and communications systems. It is an issue that affects everyone, yet one which is often poorly understood, until an energy crisis arrives.

We are clearly living in the midst of an energy crisis that seems unlikely to go away. There is unprecedented concern about fuel prices and oil depletion. There is also a high level of concern about global warming and how best to respond to it.

Many people are concerned about these problems and wish to address the symptoms as a matter of urgency, but few understand the basic causes of the problems and consequently fail to realise that fundamental social and technological changes are required to overcome them. Our education system has failed to give us a basic

understanding of energy supply options and their impact on society and the environment.

Many excellent courses have been developed to train engineers and technicians to design, install and maintain conventional energy systems. However, these systems are now the subject of controversy over issues such as global warming, energy security, public health, air pollution, waste disposal and ecological damage.

As a result of these concerns many nations are attempting to replace conventional power stations with renewable energy systems. The international community has taken the first steps towards cutting greenhouse gas emissions and the UN Commission on Environment and Development has urged all nations to adopt processes of ecologically sustainable development [20] (UNCED, 1992).

Some areas of renewable energy are experiencing rapid growth in demand as a result of supportive policies by governments (e.g. Germany, Japan, Netherlands, Denmark, Spain) and this is leading to larger scale production and falling prices for new renewable

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energy systems. Simultaneously the prices of some fossil fuels are rising and this is creating a more attractive market for renewables. In the last five years there has been a worldwide boom in the wind industry and solar PV power is thriving also in Western Europe.

However, this rapid growth has exacerbated the problem of a serious shortage of skilled professionals, with experience in renewables. The type of person in demand includes designers, installers, service and sales representatives, policy analysts, scientists, engineers, teachers and researchers. Without them the quality of systems may be compromised and the demand for renewables may be adversely affected as a result [6].

A recent survey of users of hybrid remote area power supply systems (RAPS) found that only two thirds of them were in working order at the time of the visit. Many users expressed disappointment with the product and many said that better education and training of the users and installers was essential [8]. Poor quality systems and unrealistic expectations of users can give renewable energy systems a bad reputation and lead to market rejection of the product. This is an issue that education and standards can effectively help to address.

However, the surge of demand for renewable energy systems over the past five years has caught us unprepared. Few expected such a rapid increase in demand and few had been planning to develop the capacity to train the professional people needed to launch the industry into this new phase. As a result many firms are unable to recruit people with the full range of skills required to design and implement sustainable RE-based power generation systems.

Now that it is clear that a fundamental shift in energy markets is under way, a major effort is developing to train the new professionals needed to introduce the new technologies. These people are not the electrical engineers of yesterday, with a slightly different training. They are a new breed who understands the new technologies and the appropriate roles for them in the society of the future. They require a broader training in social, economic and environmental issues than the current professionals who design and operate today's conventional power supply systems [4].

2. The role of education in the renewable energy industry

Education has a vital role to play in the development of a sustainable society. It is a powerful agent of social change, it raises awareness of new developments, it provides training for the professionals and it trains researchers who will develop the next generation of systems and devices.

In addition community education creates confidence in the new products and trains the public to use them effectively. The need for education of the community and the vital role it plays in market development and in building confidence in renewable energy has often been neglected by the renewable energy industry. Education, however, plays a central role in the development of new high technology industries as the examples of the computer industry and the aircraft industry clearly illustrate.

Education also has a crucial role in the development of the renewable energy industry [4]. It is not the only ingredient needed for success, but it performs several vital functions including:

- promotion of greater public awareness of the technology;
- development of consumer confidence in the technology;
- training of technical support staff, who are essential for designing, installing and maintaining high quality renewable energy systems;
- initial training of engineers, scientists and researchers who will develop new systems, devices and technologies for the industry;
- training of policy analysts who are knowledgeable about the industry and are able to produce effective policies for industry development; and

- training of people who will provide advice and assistance to future customers of the industry.

Experience shows that those firms that have given adequate attention to these issues have thrived in the highly competitive, high technology market place, while many of those that have ignored the need to invest in information and education have failed in spite of having good products for sale.

3. The educational needs of the RE industry and society

As a result of our surveys and enquiries, we have identified the following needs for renewable energy education [7]:

- retraining of professionals who wish to move into the renewable energy industry;
- retraining of technicians and tradespeople who wish to work in this field;
- initial training of scientists and engineers to design and develop new RE systems;
- training in renewable energy technology and policy for financiers, investors and policy analysts;
- short, in-service, professional development courses on aspects of renewable energy technology and policy;
- lessons and resources for schools on energy issues; and
- contemporary information about renewable energy technology for the general public.

Such information and training should not be confined to technology or policy issues. Because of the context in which renewable energy is developing, it is essential that training should address economic, social and environmental issues arising from the technology as well. Renewable energy systems are expected to provide sustainable solutions to energy supply requirements. Therefore it is essential that designers of such systems are fully aware of the philosophy and practice of ecologically sustainable development [6,2,16].

4. New approaches to renewable energy education

Over the past decade there have been several innovative developments in renewable energy education that attempt to address the needs of industry and the public aspirations for sustainability and greenhouse gas abatement. There have been a number of important renewable energy education initiatives in Australia in recent years some of which are internationally significant. I will not attempt to review this entire field but I will focus on several key examples of new approaches to renewable energy education.

4.1. Technical education

The Brisbane and North Point Institute of TAFE has offered a Certificate IV¹ in Renewable Energy for more than a decade. **Q2**

¹ Comment by Trevor Berrill not Paul Monsour: the original form of the Cert IV course was developed in 1986–1988 before SEIA resurface as the industry association. The Cert IV course was written in consultation with the RE industry, ANZSES members and other RE experts around Australia at the time and reviewed into competency format with SEIA input in 1994. SEIA introduced their five-day RAPS installers course in the early 1990s in response to rebate schemes and a recognition of the need to lift the standard of design and installation. It was meant to upgrade skills of existing industry people quickly, many of whom were self taught. SEIA supports the Cert IV course as still the best pathway to meet industry accreditation. They also support the new National Training Package qualifications but have emphasised the need to continue the existing Cert IV course since it is unique in providing a pathway to accreditation in extra-low voltage work and system design for SEIA members who do not have low voltage (240Vac) qualifications.

Trevor Berrill and colleagues at BNPIT have produced learning packages to support this course. The Business Council for Sustainable Energy (BCSE) supports this course as the preferred pathway to accredit industry system designers and installers. These materials are used in a number of TAFE colleges across Australia. They have also converted their learning package to a flexible learning format to accommodate short courses and distance education. The BNPIT package has been adopted nationally by the National Training Authority and this has greatly assisted the renewable energy industry by providing a thorough, high-quality and nationally-accredited package for training the additional technicians and tradespeople needed to support the growth of the industry.

This package is not a conventional engineering technology or electrical trade course with a few add-ons relating to renewables but a completely new approach that addresses renewable energy systems and their design, installation and maintenance. It was developed in consultation with the renewable energy industry around Australia. Course modules were written by renewable energy experts with industry development committees overseeing the final syllabus. Such courses are essential to ensure that we have an adequate supply of well-trained tradespeople who can design, produce and maintain reliable and cost effective systems. High quality educational packages of this type are as important as the technology itself for ensuring quality of the product and success of the industry. Further information about this course is available at <http://>.

4.2. Energy studies

Murdoch University began offering a postgraduate diploma in energy studies in 1992. This was aimed at graduates who wished to shift their career path into renewable energy technology, energy efficiency or policy. The postgraduate diploma in energy studies was developed for both on-campus and external study to cater for the needs of busy professionals who could not attend classes during work hours.

Energy studies is a new interdisciplinary area which aims to train professionals to work in technology or policy areas. It equips them with skills in technology, engineering, economics, management and environmental science to enable them to plan, design, evaluate or research energy supply and use issues in the context of ecologically sustainable development. Further details of the course structure and outcomes are provided elsewhere [3,5]; <http://energy.murdoch.edu.au/>.

In the late nineties the Postgraduate Diploma in Energy Studies and Master of Science in Renewable Energy were made fully available on-line and no on-campus attendance was required. These courses now attract significant numbers of external students from throughout Australia and overseas. The on-line option is extremely popular with both external and on-campus students and regular surveys of the students have shown high levels of satisfaction with the online delivery. Many of the graduates of these courses have been successful in changing their career paths and have obtained interesting new jobs in the renewable energy industry or in public service agencies concerned with energy or greenhouse policy [5].

The success of these courses has led to international demand for them and arrangements are now in place to offer them via licence agreements in Singapore and New Zealand. Massey University in New Zealand offers the Murdoch Masters units and contributes two units of its own to Murdoch students for online study.

In 2002 a new undergraduate course in Energy Studies was introduced at Murdoch University and this has also proven popular, particularly in combination with courses in physics, renewable energy engineering and sustainable development. In 2006 the name of the undergraduate course was changed from Energy

Studies to Sustainable Energy Management to better reflect its content.

4.3. Photovoltaic engineering

The Key Centre for Photovoltaic Engineering at the University of New South Wales, led by Professor Stuart Wenham, opened for business in 1999. One of its key objectives is to offer a new type of engineering degree devoted to solar energy and photovoltaic engineering. The first intake of students into this course occurred in 2000. This campus-based course contains a blend of traditional engineering subjects together with new units in areas such as PV design and manufacturing, grid connected and building integrated systems, wind power systems, biomass conversion, solar thermal and applications of these technologies. Students also have some freedom of choice to select areas of specialisation and to enrol in double degrees to enhance their employment opportunities. This course aims to address the industry needs for engineers to research, design and install major new renewable energy systems, particularly those based on photovoltaics [18].

4.4. Renewable energy engineering

Murdoch University's School of Engineering offers a campus-based course in renewable energy engineering which commenced in 2001. It covers traditional engineering subjects plus major renewable energy technologies such as wind, biomass, solar thermal and photovoltaics, and their applications. This course was initiated at the request of Western Power Corporation, who perceived a need for renewable energy engineers to support its program of development of renewable energy technology for green power and the 2% mandatory renewable energy target. The course was designed by staff from Murdoch University, Western Power Corporation and the University of NSW. It complements the course in Sustainable Energy Management, also offered by Murdoch University, and the two form a popular double degree covering many aspects of sustainable energy [18].

4.5. Environmental architecture

In response to requests from graduate architects for an advanced course covering the principles of energy efficient buildings and passive solar design, Murdoch University introduced a Masters by coursework in Environmental Architecture in 2006. This course is closely related to other courses in renewable energy and sustainable development, also offered by Murdoch University. It will be offered initially for on-campus study only, but once it is fully developed it will be offered on-line to the international market. Further details are available in the paper by Baverstock and Parker [1] and from <http://energy.murdoch.edu.au>.

4.6. Short courses

The rapid development of renewable energy technology and the changing market conditions have produced a demand for specialist short courses on topics such as renewable energy technologies, system design, maintenance, installation, power quality, applications and energy policy and economics. Industry bodies such as the Business Council for Sustainable Energy (BCSE) and the Electricity Supply Association of Australia (ESAA) have provided such courses, as well as private conference organizers. However, as the demand has grown several Universities have also entered this field. The University of Melbourne offers short courses in renewable energy for development. The University of NSW and Murdoch University have offered short courses in PV applications and RAPS system simulation. Curtin University of Technology has offered short

374 courses on power quality, solar water pumping and passive solar
375 design.

376 Murdoch University's Research Institute for Sustainable Energy
377 (RISE) also offers short courses and has an extensive web site with
378 many educational materials that students and teachers can access
379 and use, free of charge at <http://www.rise.org.au/info/education/>.

380 These activities are all regarded as an important part of market
381 development for the renewable energy industry and they are
382 generally well supported by the public [3].
383

384 5. New techniques for renewable energy education

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386 Because of the urgent need for on-the-job training as well as the
387 conventional face-to-face training in renewable energy we have
388 utilised modern educational technology to reach a wider audience.

389 The World Wide Web provides an excellent vehicle for teaching
390 students off campus. It is well suited to the needs of professionals,
391 who cannot attend classes on campus as well as schoolteachers,
392 students and consumers who wish to access information from their
393 homes and workplaces. We have been able to provide high quality
394 materials to schools via Internet sites and CDROMs. These materials
395 include lesson plans, information files, demonstrations and links to
396 other relevant Internet sites. Because students and teachers are
397 generally familiar with the World Wide Web they can readily access
398 these materials without the need for assistance from our small staff.
399 This ensures efficient dissemination of information about renew-
400 ables to a global audience [17].

401 We have also used the World Wide Web for delivering Univer-
402 sity courses in energy studies and renewable energy to a national
403 and international market. The team at BNPIIT has also developed
404 their TAFE courses for on-line international delivery. Our experi-
405 ence has demonstrated that the Internet is a powerful and effective
406 tool for distance learning [9,10,11,14]. It provides a wealth of re-
407 sources for isolated students and most of this information is very
408 up-to-date. The Internet courses can be studied wherever the stu-
409 dents are and at a time and pace that suits them. Email also enables
410 students to submit queries and assignments from anywhere in the
411 world and receive rapid feedback from their instructors.

412 We have also developed "picture book" laboratory sessions for
413 isolated students who cannot attend on campus. These enable
414 them to learn the techniques of data analysis and experimental
415 design, although they miss out inevitably on some of the manual
416 skills involved in collecting their own data. However, for post-
417 graduate students this is less of a problem than it would be for
418 undergraduates because most of them already have extensive
419 practical experience in their own fields [14].

420 For those students who do not have Internet access, or for whom
421 it is costly or unreliable, we have provided courses on CDROM. The
422 University of NSW is also using this medium effectively in their
423 university level and short course training.

424 There are some disadvantages of the Internet compared to
425 face-to-face teaching [15,12]. For example students do not have
426 direct access to their lecturer and cannot enjoy the interaction
427 that occurs in a conventional tutorial. However, many part time
428 and external students have never had these privileges and the
429 Internet now provides them with a wealth of resources and quick
430 feedback from experienced staff when they encounter difficulties.
431 Also WebCT offers the students the opportunity to interact with
432 other on-line students via discussion groups and these are very
433 useful for facilitating learning. So popular is this mode of study
434 amongst professionals that over 80% of the students enrolled in
435 our postgraduate diploma and M.Sc. have chosen to study in this
436 mode. Most undergraduates prefer conventional classroom
437 teaching in their first year of study, but they also soon realise that
438 the Internet provides them with access to a wealth of information
439 and a convenient way to submit assignments to their instructors.

6. Future trends in renewable energy education

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441
442 As the renewable energy industry develops, as a result of
443 technological advances and market demands, there will be a sub-
444 stantial increase in demand for trained professionals. It is crucial to
445 the success of the industry that we maintain the highest standards
446 of performance and efficiency so that consumer confidence will
447 continue to grow and we can shed forever the image that renew-
448 ables are unreliable and only of limited value in real power gen-
449 eration systems. There have been too many occasions in the past
450 where renewable energy systems have failed to achieve the level of
451 performance expected by the customer. In some cases this was due
452 to misrepresentation by sales persons but in many others it was due
453 to poor quality design, installation or maintenance. Such failures
454 damage the reputation of the industry and can in serious cases lead
455 to rejection of the technology. Nuclear power is a good example of
456 how a promising new technology has failed because of unsolved
457 technical and social problems and inadequate training of operators
458 and designers.

459 Education and standards are the keys to quality renewable en-
460 ergy systems and market confidence. Education provides courses to
461 train professionals and it provides information to consumers about
462 the technology and its performance. Quality is also essential in
463 educational products and in many fields professional bodies keep
464 a watching brief on course content and the qualifications of the
465 instructors. This has not happened to any great extent so far in
466 renewable energy but it is now timely to consider appropriate
467 accreditation procedures for courses.

468 The formal education system is unlikely to be able to keep pace
469 with the needs of the renewable energy industry during the period
470 of rapid growth that lies ahead. Therefore it will be necessary to use
471 modern educational technology to provide in-service training for
472 professionals who wish to enhance their knowledge of various
473 aspects of renewable energy. They will want access to advanced
474 award courses and to short courses from time to time as lifelong
475 learning becomes an integral part of modern industry. The re-
476 newable energy field is developing so rapidly that the short training
477 course area is likely to be crucial to the needs of industry over the
478 next 20 years. Even recent graduates will need to update their
479 knowledge on the job and this will be done via continuing pro-
480 fessional education courses using flexible learning packages.

481 Many countries are now realising the need to move rapidly into
482 renewable energy and they are seeking courses that meet their
483 needs. The Internet has created a global market in courses and in-
484 stitutions are competing strongly to supply appropriate training
485 packages to meet the needs of international customers. There is
486 likely to be a large demand for specialised short courses on areas
487 like design and installation of roof top systems, RAPS system design
488 and installation, renewable energy systems maintenance, power
489 quality for renewables and energy policies. The TAFE courses for
490 designers, installers and maintenance personnel will also have wide
491 application as they address the immediate needs of nations wishing
492 to install more renewable energy systems. Renewable energy
493 education is poised to develop a significant international market
494 with a large export potential and good return on investment.

495 User education is likely to be another area where considerable
496 work is required. Renewable energy technology is novel and users
497 will need training to select and use it effectively. The computer
498 industry and the automobile industry have both recognised the
499 vital link between education and market development and have
500 addressed it effectively to ensure that consumers are given the
501 knowledge they need to make wise choices and to get the best
502 value from their investment. The renewable energy industry will
503 need to do likewise if it wishes to reap the full benefits of public
504 support and the desire of people to find safe, sustainable energy
505 systems for the future.

High quality engineering and market demand are clearly essential for the prosperity of the renewable energy industry, but they are not sufficient. Unless the systems are meeting consumer needs, there will be an adverse reaction and the demand will decline. Education and training must be provided at all levels from customers to managers to ensure that renewable energy systems meet the highest standards of reliability and efficiency. Renewable energy must shed its cinderella image and prove to society that it can achieve the standards expected of modern technology.

In order to achieve this objective government and industry will need to put more funding into RE education and research. They must combine and focus their efforts to address training needs and to ensure that courses address the needs of society and achieve the standards required. This means that industry, government and educational institutions will need to work closely together to help build this new power generation industry. It is also important for the industry and professional societies like ANZSES and BCSE to take a lead in establishing this cooperation. In the current situation universities and TAFE colleges are desperately short of funds and all new initiatives are dollar-driven. The only way that these initiatives will come about is if industry or government provides additional funding to facilitate them.

7. Conclusions

Several new approaches to renewable energy education have been introduced in the past decade. These are based on an assessment of the needs of industry and society. They are based in a different educational paradigm to conventional energy education and they make use of flexible, modern educational technology to reach a worldwide audience, including distance education students. The outcomes of these new courses will be crucial in assisting the industry and government to make a smooth transition to a greater reliance on renewable energy for power generation.

Uncited references

[13,19].

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