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Lund, Chris, Jennings, Philip, Pryor, Trevor, Blackmore, Kim, Corkish, Richard, Saman, Wasim, [Miller, Wendy](#), Woods-McConney, Amanda, & Watanabe, Emiko (2014) *Renewing the Sustainable Energy Curriculum – Providing Internationally Relevant Skills for a Carbon Constrained Economy : Final Report 2014*. Australian Government Office for Learning and Teaching, Sydney, Australia.

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# Renewing the Sustainable Energy Curriculum – Providing Internationally Relevant Skills for a Carbon Constrained Economy

Final Report 2014

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Murdoch University

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University of South Australia

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<<http://www.murdoch.edu.au/projects/secfp/>>

Support for this project has been provided by the Australian Government Office for Learning and Teaching. The views expressed in this report do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.



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2014

ISBN 978-1-74361-891-2 [PRINT]  
ISBN 978-1-74361-892-9 [PDF]  
ISBN 978-1-74361-893-6 [DOCX]

# Acknowledgements

We wish to acknowledge and thank the project team for their hard work, enthusiasm and support. Our thanks also go to the three research assistants who worked on the project Angela Taylor, MD Anisuzzman and Emiko Watanabe. A special thank you goes to Emiko Watanabe whose unique background of having both a relevant science and humanities double degree and industry experience greatly enhanced the project outcomes. Thank you also goes to the external reference group members and our external evaluator, Rob Phillips.

We wish to thank the graduates from the five member universities and sustainable energy industry representatives who took the time to complete a survey and or interview. We also wish to thank the industry associations who readily agreed to promote the project and encouraged their members to complete the survey. We wish to thank the international course coordinators who responded to the survey questionnaires sent to them.

## List of acronyms used

ALTC	Australian Learning and Teaching Council Ltd.
OLT	Australian Government Office for Learning and Teaching
AQF	Australian Qualifications Framework

## Executive summary

This report documents the implementation and outcomes of the “Renewing the sustainable energy curriculum – providing internationally relevant skills for a carbon constrained economy” project, which was conducted over a two-and-a-quarter year period.

The project was led by Murdoch University and brought together a team of academics from four other Australian Universities that have recognised programs or courses in sustainable energy to develop a set of curriculum frameworks for tertiary level sustainable energy programs. The project also sought to provide guidance in regard to a number of key questions relating to program design and the delivery of the resulting programs and courses. The collaborators included Queensland University of Technology, The Australian National University, The University of New South Wales and the University of South Australia.

The aim of the project was to scope and develop sustainable energy curriculum frameworks for Australian higher education institutions that could meet the needs of Australian and international student graduates and employers, both now and into the near future. Activities undertaken in this project included:

- Developing a list of sustainable energy skills, knowledge and generic graduate attributes required by employers, which were then formulated into curriculum frameworks;
- Gaining an understanding of five key questions relating to the delivery of the skills and knowledge, including:
  - inter/multi-disciplinary training versus specialist courses (e.g. engineering, policy etc.);
  - specialist courses and programs versus embedding skills and knowledge into existing discipline training;
  - face-to-face versus online and flexible delivery;
  - the need for, and extent of, work integrated learning based education that is optimal, or acceptable;
  - internationalisation of the curriculum so that it meets the needs of international students studying in Australia and Australian graduates seeking to work overseas.

The focus was on student-centred learning and outcomes and to support graduates with the knowledge, skills and generic attributes required to work in the rapidly expanding sustainable energy industry in Australia and globally. Therefore one of the key approaches was to ensure input from graduates in the workforce and industry representatives. The outcomes of the project are designed to be relevant to specialist Sustainable Engineering and Energy Studies programs, as well as conventional engineering, science and humanities and social science programs that have a sustainable energy focus or major.

## The outcomes of the project

The project has achieved, for the first time internationally (to the knowledge of the project team) a list of industry-informed skills, knowledge and graduate attributes for graduates of University sustainable energy programs and courses, expressed in a set of curriculum frameworks. It has also been able to determine and present an understanding of five key questions related to delivery of the skills and knowledge. The curriculum frameworks developed have been successfully tested against the existing programs at the participating Universities.

As well as developing curriculum frameworks for sustainable energy projects, the approach and methodology used for this project has wider applicability and is easily adaptable to other similar, multidisciplinary subject areas.

The deliverables from the project include:

- A Curriculum Framework Guide presenting the set of curriculum frameworks together with guidance for their use. This includes a list of the skills, knowledge and generic graduate attributes required by graduates seeking to work as sustainable energy professionals. The document also includes guidance on five key questions relating to delivering the skills and knowledge in this area;
- This final report on the project including the approach, as well as the outcomes and deliverables;
- Conference and workshop presentations reporting the project findings; and
- A website providing the project deliverables and publications and a listing of all of the current sustainable energy programs offered by Australian Universities. The website also links to a dedicated blog designed to facilitate ongoing interaction between stakeholders and others to foster further adoption and development of the frameworks.

The deliverables from the project can be accessed on the project website <http://www.murdoch.edu.au/projects/secfp/>.

## Recommendations

It is clear from interaction with team members and members of their faculties, academics from other similar disciplines and program coordinators from international institutions offering sustainable energy programs that the curriculum frameworks and the approach and methodology to develop them are valuable to educators. Based on the outcomes of the project the project team has the following recommendations.

As most Australian sustainable energy programs are currently under review there is a need for rapid dissemination of the outcomes of this project to institutions and programs outside of the team member's institutions. It is recommended that the project outcomes be rapidly disseminated to institutions outside of the project team who offer sustainable energy courses to provide support to them as they review and revise their curriculums in light of the introduction of the Australian Qualifications Framework (AQF) and course rationalisation within the University sector.

There has been great interest shown by a number of international Universities in the outcomes of the project and the curriculum frameworks. It is expected that the curriculum frameworks and the underlying capability cloths and learning outcome statements, as well as the approach to developing the frameworks, will be adopted and used internationally. It is recommended that there be an ongoing collaboration with international institutions in order to adapt the frameworks and approach to a more international audience. This process will also assist to increase the international relevance of the framework for Australian Universities whose students are either international students or graduates seeking work internationally.



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# Chapter 1: Introduction and Rationale

In order to reduce greenhouse gas emissions and avoid significant climate change Australia and the international community are increasingly moving towards a low carbon economy. This transition to a low carbon economy requires new skills and knowledge particularly in the area of sustainable energy. In summary:

*“Responding to climate change will require a fundamental shift in Australia’s approach to management and workforce skills.”*

Heather Ridout, Chief Executive of the Australian Industry Group,  
The Australian October 08, 2008

During the 1990’s and early 2000’s a number of Australia’s Universities developed and now run specialist sustainable energy courses at both undergraduate and postgraduate level. Other Universities have developed sustainable energy majors or minors in existing conventional degrees such as Engineering. These programs/courses were developed individually based on the then existing technology and policy environment and an understanding (based on an interaction with industry) of the skills required at the time. After 15 or more years of these offering there was a need to now assess these courses and qualifications to ensure they are providing the skills and knowledge required by employers in a time of different technology and a changed (and rapidly changing) policy environment.

A number of studies related to sustainable energy training and skills development have been undertaken in order to determine the current and future skills needs in the areas of renewable energy (e.g. Clean Energy Council, 2009a) and energy efficiency (e.g. GHD, 2010). They have identified a number of skills and knowledge gaps that need to be addressed in the training of Australian sustainable energy graduates, as well as methods of delivery. These skills need to be incorporated into existing and new sustainable energy curricula at tertiary level. Other reports (e.g. Clean Energy Council, 2009b; Hatfield-Dodds et. al., 2008) have highlighted a rapidly emerging need for graduates with sustainable energy skills and the need for training institutions to be ready to provide appropriate, relevant training. This includes more flexible delivery and more work integrated learning approaches.

Prior to this project there had never been a coordinated study of the knowledge, skills and generic graduate attributes needed by the various tertiary trained sustainable energy professionals in Australia, nor the integration of these requirements into curriculum frameworks that are internationally relevant. There had also never been any published educational research into the following five key questions of how best to provide the required knowledge skills and attributes required by sustainable energy graduates:

- The mixture of inter/multi-disciplinary content vs specialised content that should be included in sustainable energy programs. For example how much and what type of policy and enablers content should be included as core content in Sustainable Engineering degrees and alternatively what type of technical knowledge should be included as core content in humanities courses on policy and enablers;

- Whether Universities should develop and offer specialist courses and programs (e.g. BEng in Sustainable Energy) at undergraduate level versus embedding the relevant skills and knowledge into existing discipline training (e.g. an existing Electrical or Power Engineering degree);
- The feasibility and desirability of providing sustainable energy teaching by face-to-face mode only versus online and flexible delivery;
- The need for and amount of work integrated learning that is optimal, or acceptable during sustainable energy degrees and what type and level of involvement industry practitioners should have in the delivery of the courses; and
- The need for, and how to, enable sufficient internationalisation of the curriculum and course content so that it meets the needs of both international students studying in Australia or at affiliated international institutions and Australian graduates seeking to work overseas.

*“Achieving the transition to a low carbon sustainable economy will require a massive mobilisation of skills and training – both to equip new workers and to enable appropriate changes in practices by the three million workers already employed in these key sectors influencing our environmental footprint. Current approaches do not appear sufficient for meeting these challenges.”*

Growing the Green Collar Economy: Skills and labour challenges in reducing our greenhouse emissions and national environmental footprint – Report to the Dusseldorp Skills Forum {Hatfield-Dodds, S., G. Turner, H. Schandl and T. Doss, 2008}

The rapidly moving national policy environment, the global transformation to a low carbon economy and rapidly changing technology options means that existing programs and courses in this area are becoming inadequate to meet current and future needs. The introduction of the Australian Quality Framework (AQF) {Australian Qualifications Framework Council, 2013} has driven changes in what University programs and courses are offered and how they are offered, with many current programs and courses needing to be revised in order to comply with the AQF. In an environment of course rationalisation individual tertiary institutions are struggling to determine how to develop and then implement the curriculum and course content revisions required. As the requirement for appropriately tertiary trained sustainable energy graduates is rapidly increasing new national curricula need to be developed and then regularly revised so that they meet the needs of employers and the industry.

It is important to tertiary education institutions to have internationally relevant curriculum frameworks that have been developed in conjunction with and supported by, employers and employer peak bodies. It is also important to have answers to the five key questions identified in this project regarding how the curricula are organised in programs/degrees and delivered so that the right curriculum can be taught in the most effective, flexible and student centred manner. This project aimed to address these two needs.

## Chapter 2: Project Aims

The aim of the project were to scope and develop sustainable energy curriculum frameworks for Australian higher education Institutions that meet the needs of Australian and international student graduates and employers both now and into the near future. This includes:

- Developing a list of sustainable energy skills, knowledge and generic graduate attributes required by employers, which will then be formulated into curriculum frameworks; and
- Gaining an understanding of five key questions about how best to design the programs and provide the skills and knowledge including:
  - The mixture of inter/multi-disciplinary content vs specialised content that should be included in sustainable energy programs. For example how much and what type of policy and enablers content should be included as core content in Sustainable Engineering degrees and alternatively what type of technical knowledge should be included as core content in humanities and social science courses on policy and enablers;
  - Whether Universities should develop and offer specialist courses and programs (e.g. BEng in Sustainable Energy) at undergraduate level versus embedding the relevant skills and knowledge into existing discipline training (e.g. an existing Electrical or Power Engineering degree);
  - The feasibility and desirability of providing sustainable energy teaching (especially engineering courses) by face-to-face mode only versus online and flexible delivery;
  - The need for and amount of work integrated learning that is optimal, or acceptable during sustainable energy degrees and what type and level of involvement industry practitioners should have in the delivery of the courses; and
  - The need for and how to enable sufficient internationalisation of the curriculum and course content so that it meets the needs of international students studying in Australia or at affiliated international institutions and Australian graduates seeking to work overseas.

The curriculum frameworks will be useful in assessing the suitability of existing curricula and courses and providing a guide for both the redevelopment of the existing courses and the development of new offerings.

The focus is on student centred learning and outcomes and providing graduates with the knowledge, skills and generic attributes required to work in the rapidly expanding sustainable energy industry in Australia and globally. It applies to specialist Sustainable Engineering and multidisciplinary Sustainable Energy programs, as well as conventional engineering and science programs which have a sustainable energy focus or major.

# Chapter 3: Methodology and Approach

*“Following a quality assurance model, curriculum design and change should be a combined effort of teaching staff, administrators, researchers, students and potential employers. Involvement of all stakeholders in the renewal process can produce an end result that is vital, practical and prepares graduates for immediate entry into a competitive workforce”*

*ALTC Good Practice Report: Curriculum Renewal {Narayan and Edwards, 2011}*

In order to develop the final curriculum frameworks the project adapted and extended the approach of Dowling and Hadgraft [March 2013] developed for Environmental Engineering curriculums and established curriculum mapping approaches (such as that promoted by the University of West Florida - see [http://uwf.edu/cutla/curriculum\\_map\\_graduate\\_ALP.cfm](http://uwf.edu/cutla/curriculum_map_graduate_ALP.cfm)). The key elements of the approach to developing the final sustainable energy curriculum frameworks are summarised in the following figure.

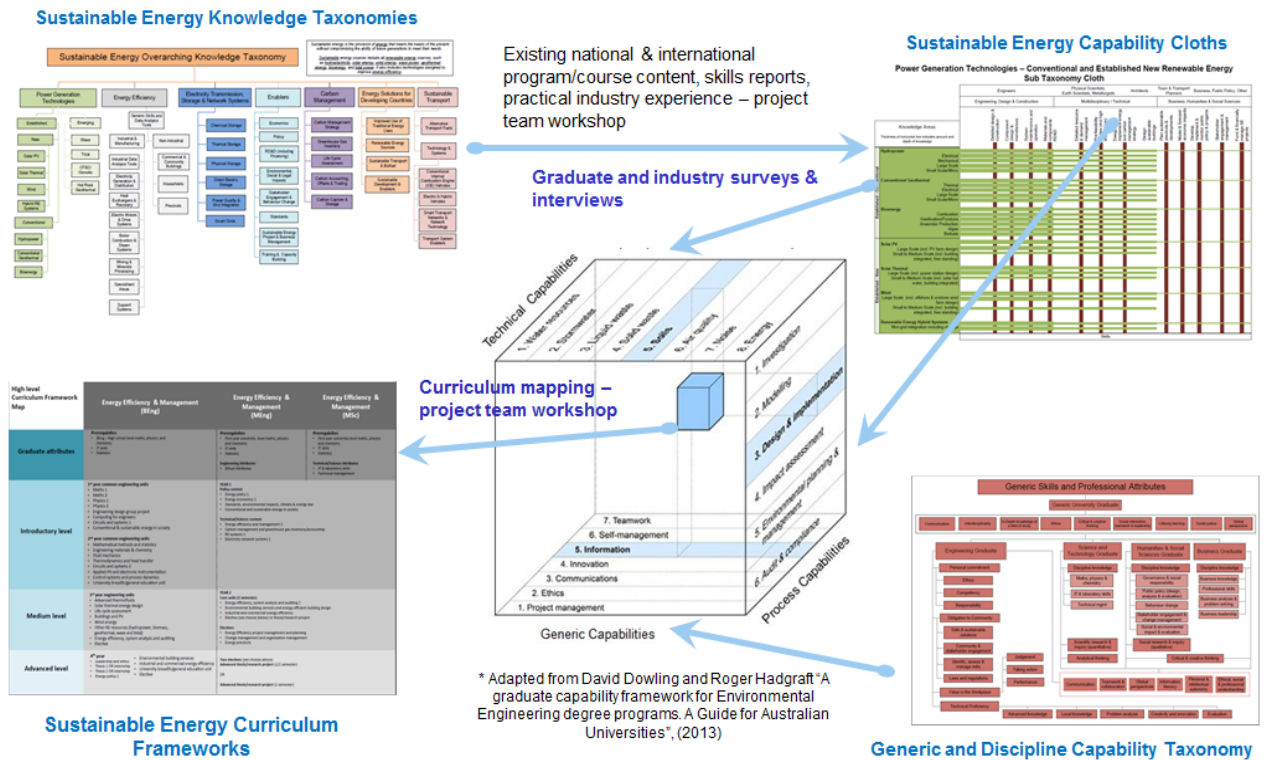


Figure 1: Approach and methodology for developing the final curriculum frameworks.

This following section describes in detail the research based approach and techniques that were used to achieve the project outcomes.

## Determining what knowledge and skills are required

The first step in developing the curriculum frameworks was to develop an understanding of the *knowledge* (called technical capabilities by Dowling and Hadgraft {2013}), *skills* (called process capabilities by Dowling and Hadgraft {2003}) and the *generic and discipline specific capabilities*

required by sustainable energy graduates working in the range of roles required by industry and to then be able to present these in a manner that can be understood and responded to by industry. Research was undertaken to derive a catalogue of knowledge and skills taught in existing Australian and international sustainable energy programs and courses as well as relevant sustainable energy skills reports. This included an extensive list of learning outcomes and objectives covering a wide range of knowledge and skills. Based on this research, the industry experience of the senior researcher, and a workshop involving the project team members a set of sustainable energy knowledge taxonomies were developed. These taxonomies visually present the range of knowledge areas considered to constitute “sustainable energy” and their relationship to each other in a diagrammatic form. An overarching taxonomy diagram shows seven main areas of sustainable energy knowledge with each of these areas having a set of sub taxonomy diagrams presenting the knowledge required in more detail. The full sets of knowledge taxonomies with accompanying narrative are available from the project website <<http://www.murdoch.edu.au/projects/secfp/>>.

Extending the framework and approach of Dowling and Hadgraft {2013} a set of draft *skills and knowledge* (or capability) “cloths” were developed. These cloths correspond to the *process capabilities* and *technical capabilities* sides of the Dowling and Hadgraft {2013} capability cube. The cloths present in a visual manner the type (core or elective) and level (introductory, medium or advanced) of knowledge required as horizontal bars and the types of skills required as vertical bars. The skills are grouped in three conventional discipline areas (engineering; business humanities and social sciences; and multidisciplinary/technical) corresponding to the types or roles graduates are known to undertake. The colour shading (dark or light) of the horizontal knowledge bars shows whether the knowledge area is considered core (essential) or elective (required) and the thickness of the horizontal bars (thin, medium or thick) indicates the level of that knowledge. There are seven sets of capability cloths, corresponding to the seven main sustainable energy knowledge areas in the taxonomy. These cloths are the core of the curriculum development approach and enabled a framework for engaging with both graduates and industry about the type and depth of capabilities required by graduates. The full set of “skills and knowledge cloths” with accompanying narrative are available from the project website <<http://www.murdoch.edu.au/projects/secfp/>>.

In order to develop curriculum frameworks for the range of multidisciplinary areas in which sustainable energy graduates work the approach of Dowling and Hadgraft {2013} was modified to develop and differentiate a set of “generic” and “discipline” capabilities required by graduates. These generic (also known as generic attributes) and discipline specific capabilities were organised and presented in a taxonomy diagram similar to the knowledge taxonomies. In order to cover the range of roles potentially undertaken by sustainable energy graduates, as well as the generic capabilities (or attributes) required by all University graduates three sets of discipline specific capabilities were identified, corresponding to the three conventional discipline areas in the capability cloths – engineering; multidisciplinary/technical; and business, humanities and social sciences. The capabilities were derived from existing generic and discipline capability/attributes lists published by Universities and industry experience. The generic and discipline specific capability taxonomy diagram with accompanying narrative is available from the project website <<http://www.murdoch.edu.au/projects/secfp/>>.

## Ensuring the outcomes are relevant to industry

In order to ensure the curriculum frameworks lead to programs and courses that train graduates with the knowledge and skills relevant to industry it was considered essential to have significant graduate and industry representative input. An online survey instrument (with some responder initiated follow up interviews) was used to validate and calibrate the draft capability cloths. The surveys developed by the project team were coded and administered online using Murdoch University's well developed online survey system. Separate surveys were used to acquire the response of graduates and those of the employers/industry representatives. Graduates were recruited by email by project team members at each member university based on contact details from alumni and graduate lists. Industry representative recruitment was done through key Industry associations who promoted the project and the survey to their members by email and newsletter.

The online surveys also sought background information regarding the area of the industry in which respondents worked, the type of role they had and their responses regarding the five key questions about delivering the knowledge and skills. In light of the analysis of the detailed responses to the surveys the capability cloths were revised (or calibrated).

## Mapping the curriculum frameworks

The sustainable energy knowledge and skills along with the generic and discipline specific capabilities were mapped into a set of draft curriculum frameworks for the relevant types and level of qualifications in the AQF that are typically offered by Universities {Australian Qualifications Framework, Second Edition January 2004}. After identifying the types and levels of degree/qualification that correspond to the three discipline areas in the capability cloths, and feedback from graduates, a curriculum mapping approach similar that used by the University of West Florida and other Universities was used (see for example <[http://uwf.edu/cutla/curriculum\\_map\\_graduate\\_ALP.cfm](http://uwf.edu/cutla/curriculum_map_graduate_ALP.cfm)>).

Five sets of curriculum frameworks have been developed for sustainable energy programs/qualifications namely:

- Undergraduate sustainable energy engineering courses with specialisations in renewable energy systems or energy efficiency;
- Postgraduate engineering coursework programs focussing on sustainable energy with specialisations in renewable energy systems or energy efficiency;
- Postgraduate science/technical coursework programs with specialisations in renewable energy systems, energy efficiency and carbon management;
- Postgraduate humanities and social science coursework programs with a specialisation in policy and enablers; and
- A sustainable energy focus or major within conventional engineering; science; and humanities and social science programs.

Feedback derived from the graduate and industry surveys in regard to the five key questions regarding program design and course delivery was considered when designing the curriculum frameworks. In particular this included:

- The balance of inter/multi-disciplinary knowledge vs specialist knowledge (e.g. engineering technical knowledge vs policy enablers knowledge etc.);

- The use of specialist undergraduate courses and programs versus embedding skills and knowledge into existing discipline training (e.g. a specialised undergraduate course versus embedding in an existing engineering degree); and
- Whether specialist programs should be offered at undergraduate or postgraduate level.

A number of well-known and respected sustainable energy programs are offered by international Universities. In order to ensure that any best practice or lessons learned from the development and offering of these programs was incorporated into the outcomes of this project a questionnaire survey was used. Email questionnaires and some follow up interviews (responder requested) were undertaken with key staff from a range of international institutions that have recognised sustainable energy programs. The survey sought information about their programs, their curriculum development and teaching/delivery approach as well as how they address the five key questions regarding program design and course delivery. A list of the international Universities from which responses were received is presented in Appendix A.

The draft curriculum frameworks were refined then trialled using the existing programs at the member Universities at a workshop involving the project team members. The curriculum frameworks and associated cloths and knowledge taxonomies were then circulated to key stakeholders including the external reference group for review and comment. The five final sets of curriculum frameworks developed are presented in a Curriculum Framework Guide which is available from the project website <[http://uwf.edu/cutla/curriculum\\_map\\_graduate\\_ALP.cfm](http://uwf.edu/cutla/curriculum_map_graduate_ALP.cfm)>.

## Guidance for program design and course delivery

In association with the development of the curriculum frameworks the project sought to determine the best approach to, and provide advice on, five key questions related to designing sustainable energy programs and delivering the skills and knowledge. These five key questions are:

- The mixture of inter/multi-disciplinary content vs specialised content that should be included in sustainable energy programs. For example how much and what type of policy and enablers content should be included as core content in Sustainable Engineering degrees and alternatively what type of technical knowledge should be included as core content in humanities and social science courses that are focussed on policy and enablers?;
- Whether Universities should develop and offer specialist courses and programs (e.g. BEng in Sustainable Energy) at undergraduate level versus embedding the relevant skills and knowledge into existing discipline training (an existing Electrical or Power Engineering degree);
- The feasibility and desirability of providing sustainable energy teaching by face-to-face mode only versus online and flexible delivery;
- The need for and amount of work integrated learning that is optimal, or acceptable during sustainable energy degrees and what type and level of involvement industry practitioners should have in the delivery of the courses; and
- The need for, and how to, ensure sufficient internationalisation of the curriculum and course content so that it meets the needs of international students studying in Australia or at affiliated international institutions and Australian graduates seeking to work overseas.



In order to gain an understanding of, and provide guidance on these questions the project took a three pronged approach:

- A review of best practice guides and other related publications from previous Office for Learning and Teaching (OLT) projects;
- Responses to questions related to these questions in the graduate and industry representative surveys; and
- A survey of staff in selected international Universities offering well recognised or best practice sustainable energy programs to see how they approached the five questions about program design and course delivery in the offering of their courses.

Based on the outcomes of the research guidance on these five questions has been included along with the curriculum frameworks in the Curriculum Frameworks Guide document which is available on the project website <<http://www.murdoch.edu.au/projects/secfp/>>.

## Chapter 4: Project Outcomes

The project successfully produced the desired deliverables but due to the timeframe was not able to fully achieve all of its desired outcomes. It has for the first time internationally (to the knowledge of the project team) produced a published list of industry informed skills, knowledge and graduate attributes for graduates of University sustainable energy programs and courses, expressed in a set of curriculum frameworks. The project has also been able to determine and present an understanding of five key questions related to the design of the frameworks and delivery of the course content. The curriculum frameworks developed have been successfully tested against the existing programs at the member Universities.

The deliverables from the project include:

- A Curriculum Frameworks Guide document presenting the set of curriculum frameworks with explanatory narration and guidance for use and providing a list of the skills, knowledge and generic graduate attributes required by graduates seeking to work as sustainable energy professionals. The document also includes guidance on the five key questions relating to program design and content delivery;
- A website providing information on the project, the project deliverables and publications as well as a blog for discussion related to the project and frameworks developed. The website also lists all of the current sustainable energy programs offered by Australian Universities; and
- Conference and workshop presentations reporting the project findings.

The deliverables from the project can be accessed on the project website <http://www.murdoch.edu.au/projects/secfp/>.

The project achieved most, but not all of its desired outcomes. It also achieved some outcomes that were not expected. The proposed outcomes that were achieved included:

- A better understanding of the skills, knowledge and generic attributes required by sustainable energy graduates. For the first time internationally a comprehensive set of the skills, knowledge and generic attributes required by sustainable energy graduates has been developed. These have been formed into a clear, accessible set of knowledge taxonomies and capability cloths that enabled detailed feedback from industry;
- A better understanding of how to best deliver sustainable energy education at tertiary level. Through research of the literature, surveys of graduates and industry representatives, and surveys of international institutions the project has developed an understanding of five key questions related to the design and delivery of sustainable energy programs. Based on this the Curriculum Frameworks Guide developed as part of the project provides guidance about these questions enabling a better understanding of how best to delivery sustainable energy programs;
- A consistent, nationally applicable, internationally relevant set of curriculum frameworks for training sustainable energy graduates in Australian tertiary education institutions has been developed and peer reviewed within the project team and externally. There is still a need to have these further disseminated and reviewed by industry and academics to get widespread agreement about them;

- Better engagement between employers and tertiary institutions regarding the most appropriate skills and knowledge training for the sustainable energy industry. Industry has already been involved in the survey and discussion about the project and one member of the external reference group is the CEO of an industry association (the Australian Sustainable Energy Association). A presentation and associated session was held as part of the Australian Solar Council 2014 Scientific Conference allowing further engagement with employers and other non-project member tertiary institutions to enable further feedback regarding the project outcomes.

The deliverables become available too close to the end of the project timeline to see them fully disseminated and then implemented across a wide range of institutions. Therefore it was not possible to achieve the desired outcome of more relevant sustainable energy courses and programs being delivered at Australian tertiary institutions as a result of comparing existing courses and programs against the curriculum frameworks and delivery guidelines. Due to the slow process of curriculum renewal and change within Universities this last outcome is expected to be achieved over the next two or three years.

Members of the project team who are key stakeholders as coordinators of sustainable energy programs in their universities have already begun using the project deliverables to review and revise their own curriculums. They are also disseminating the outcomes of the project more widely within their Schools and faculties. They have provided feedback (see Chapter 5) that the project deliverables will provide valuable assistance in assessing the suitability of their existing course offerings and guide the development of new offerings at both undergraduate and post graduate levels. As the deliverables are disseminated more widely and implemented by other institutions it is expected that they will lead to more relevant sustainable energy courses and programs being delivered at Australian tertiary institutions as a result of the process of comparing existing courses and programs against the curriculum frameworks and delivery guidelines.

There were two unintended outcomes from the project:

- The approach and methodology developed for this project should be easily adaptable to other similar, multidisciplinary subject areas, such as Sustainability Engineering; and
- The approach and methodology has international relevance and applicability. Contact made with international institutions during consultation about the project has identified significant interest from several international program coordinators.

One comment regarding the value of the project and its outcomes provided by Dr Richard Corkish, Chief Operating Officer of the Australian Centre for Advanced Photovoltaics UNSW is that:

“It [the project outcomes] cements Australia’s place among the global leaders in renewable energy education and will drive improvement that will keep us there in this “sunrise” activity.”

## Chapter 5: Dissemination and Linkages

Dissemination of information about the project and its outcomes has been undertaken, and continues, in a number of ways. These include:

- A project website containing information about the project, the project deliverables and related documentation as well as a list of Sustainable Energy programs currently offered by Australian Universities. The website also has a link to a blog for ongoing discussions regarding the project and the sustainable energy curriculum frameworks;
- Presentation of the findings and at key national and international conferences and workshops/symposiums with subsequent input from, and engagement with, relevant stakeholders either through structured workshops or surveys/interviews.
- Dissemination of information about the project and its aims to sustainability industry members (through industry association mailing lists and newsletters) and to graduates through university alumni lists at the time of conducting the surveys;
- Direct email messaging of the identified program coordinators of the key Australian sustainable energy related programs;
- Publication of the final curriculum frameworks document and associated project findings on the project website and dissemination to all relevant stakeholders; and
- Publication of the project outcomes and findings in relevant journals and publications.

Key dissemination events are summarised in the following table.

Date	Event/Activity	Attendee	Type of Dissemination
30 <sup>th</sup> Nov - 2 <sup>nd</sup> Dec 2011	<i>Australian Solar Energy Society Solar 2011 Conference</i>	Chris Lund	Networking and verbal dissemination of the project aims to industry representatives and academic colleagues.
6 <sup>th</sup> – 7 <sup>th</sup> Dec 2012	<i>Australian Solar Energy Society Solar 2012 Conference</i>	Trevor Pryor	Poster presentation disseminating information about the project and progress to date to academic colleagues and industry representatives.
22 <sup>nd</sup> May 2013	<i>Email mailout to identified program coordinators/contact persons for all known Australian tertiary sustainable energy programs.</i>	Chris Lund	An email providing information about the project and the website details to enable ongoing dissemination and updates. Also requested feedback and correction of any errors in the program listings on the website.
25-26 <sup>th</sup> Jun 2013	<i>Sustainability Engineering Network Symposium “Developing an Engineering Education for the Engineer of 2030”.</i>	Chris Lund	Presentation on project and outcomes at that stage. Participation in related workshop activities, including input on the approach to curriculum design for Sustainable Engineering.

15 <sup>th</sup> – 17 <sup>th</sup> Jul 2013	World Renewable Energy Congress – Australia 2013 – International Conference on Renewable Energy for Sustainable Development and	Chris Lund	Invited plenary presentation entitled “Renewing the Sustainable Energy Curriculum - Providing Internationally Relevant Skills for a Carbon Constrained Economy” presenting on the project and outcomes at that stage to audience of local national and international academics and researchers, as well as industry representatives.
30-31 <sup>st</sup> Jan 2014	<i>Teaching and Learning Forum 2014: Transformative, Innovative and</i>	Chris Lund	Workshop presentation entitled “Renewing the Sustainable Energy Curriculum – Combining Theory and Industry Input to Develop Multidisciplinary Tertiary Curriculum Frameworks”.
8 <sup>th</sup> - 9 <sup>th</sup> May 2014	<i>Australian Solar Council 2014 Scientific Conference</i>	Chris Lund	Extended lead in talk entitled “Renewing the Sustainable Energy Curriculum – Ensuring the Teaching of Internationally Relevant Skills in Australian Universities Through Industry Input”. Subsequent discussion and feedback session involving industry and academic participants.

The list of industry associations that disseminated information about the project and whose members were involved in the surveys included:

- The Australian Solar Council;
- The Clean Energy Council;
- The Sustainable Energy Association;
- The Australian Photovoltaics Association; and
- Bioenergy Australia.

Early in 2013 emails were sent to 25 program coordinators or contacts for identified sustainable energy programs offered at Australian universities (listed on the project website) notifying them of the project and its aims, providing details of the project website for more information and seeking corrections or comments to their listings on the website. At the conclusion of the project the finalised Curriculum Frameworks Guide was sent to these program coordinators/contacts. The list of sustainable energy programs and the relevant contacts is provided in Appendix B.

The list of international Universities with well recognised or best practice sustainable energy programs contacted to disseminate information about the project and who then subsequently responded is provided in Appendix A. A wider list of universities was contacted and informed of the project and its aims.

The project team members acted as an internal reference group providing peer review and guidance to the project. An external reference group was created to provide peer review of the project and its deliverables. The members of the external reference group included:

- Associate Professor Bob Lloyd, Energy Efficiency Program Coordinator at the University of Otago, New Zealand;
- Kirsten Rose, CEO of the Sustainable Energy Association – Industry

- representative organisation; and
- Professor Dr August Schlaepfer, until recently Director of SESAM and Program Coordinator for the Master of Engineering in Energy and Environmental Management at the Universität Flensburg, Germany.

As discussed in Chapter 4 members of the project have already begun actively using the curriculum frameworks and other outcomes from the project to review and revise their programs and courses. Some of the comments from project team members who are key stakeholders in sustainable energy programs in their member Universities included:

“The project’s curriculum maps will provide valuable assistance in assessing the suitability of our existing course offerings and guide the development of new offerings at both undergraduate and post graduate levels. The mapping of graduate attributes and the introductory, intermediate and advanced level learning outcomes will provide invaluable assistance in being able to quickly identify which pathways our university will pursue (e.g. generic or specialised courses) and to develop the appropriate unit outlines.” *Dr Wendy Miller, Co-ordinator M.Eng (Sustainable Energy), QUT.*

“The curriculum documents produced by the project will be extremely helpful input for the ANU’s annual curriculum review process. Education review workshops are held by the Research School of Engineering each year, and these regularly result in changes to the undergraduate degree and the Master’s degree. The renewable energy staff will use the information in these documents as a rich source of data for evidence-based planning.” *Dr Kim Blackmore, ANU.*

“The challenge for us at Murdoch at present is to reformulate our postgraduate multidisciplinary Energy Studies courses in order to comply with the AQF and to implement an internal Murdoch change from four point to three point units. The availability of these frameworks will be very valuable guides to assist us in this project.” *Dr Trevor Pryor, Energy Studies Program Chair, Murdoch University.*

The curriculum frameworks and associated narrative documentation can be obtained from the project website < <http://www.murdoch.edu.au/projects/secfp/>>.

## Chapter 6: Evaluation

To what extent did the Renewing the Sustainable Energy Curriculum Project meet its outcomes?

The Project Report states that the project has “successfully produced the desired deliverables but has not fully achieved all of its desired outcomes”.

The external evaluation confirmed this. A comprehensive set of curriculum framework documents has been developed with a Guide to their use. However, the complexity of this task resulted in substantially reduced dissemination of the outcomes to universities teaching aspects of the sustainable energy curriculum. Despite this, the project has remained within budget and with a slightly extended timeline.

A full evaluation report is provided in Appendix C.

## Chapter 7: Recommendations and Future Plans

### Recommendations

It is clear from interaction with team members and members of their faculties, academics from other similar disciplines and program coordinators from international institutions offering sustainable energy programs that the curriculum frameworks and the approach and methodology to develop them are valuable to educators. Based on the outcomes of the project the project team has the following recommendations.

#### Rapid Dissemination of the project outcomes to National and International Institutions

In light of the introduction of the AQF and course rationalisation within the University sector most Australian sustainable energy programs are currently under review and faculties are revising their programs and curriculums. The completion of this project is timely and now that the deliverables are available there is a need for rapid dissemination to institutions and programs outside of the team member's institutions. The frameworks will also be further enhanced by further trialling through application to other programs.

It is recommended that the project outcomes be rapidly disseminated to institutions outside of the project team who offer sustainable energy courses so as to provide support to them as they review and revise their curriculums.

#### Collaboration with international institutions to increase the international relevance of the frameworks and guidance.

During the project the details of the project were disseminated to a range of leading international University programs in sustainable energy and the coordinators were invited to participate in a short email survey. During this process there has been a great amount of interest shown by a number of international Universities in the outcomes of the project and the curriculum frameworks. It is expected that the curriculum frameworks and underlying capability cloths and learning outcome statements, as well as the approach to developing the frameworks will be adopted and used by as number of institutions internationally.

It is recommended that there be an ongoing collaboration with international institutions in order to adapt the frameworks and approach to a more international audience. This process will also assist to increase the international relevance of the framework for Australian Universities whose students are international students and whose graduates often find work internationally.



## Future plans

Given the significant interest in the project outcomes future plans include:

- Continuation of the project website and blog, in order to facilitate ongoing interaction between stakeholders and encourage the ongoing revision and development of the curriculum frameworks;
- Further dissemination of the Curriculum Frameworks Guide and other documentation to institutions outside of the project members, both nationally and internationally;
- Dissemination of the project outcomes and methodologies through the preparation and publication of refereed publications and conference papers;
- Ongoing collaboration with interested international Universities to adapt the curriculum frameworks and approach to their programs; and
- To develop and disseminate a guide to the approach and methodology developed, which is applicable to other multidisciplinary areas (e.g. Sustainability Engineering).

## Chapter 8: References and Bibliography

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Clean Energy Council (2009a), “Australian Renewable Energy Training and Workforce Strategy for 2020 - Renewable Energy Training in Australia 2009”.

Clean Energy Council (2009b), “Australian Renewable Energy Training and Workforce Strategy for 2020 - Renewable Energy Jobs in 2009 and Forecasts to 2020”.

David Dowling and Roger Hadgraft (2013) “A Graduate Capability Framework for Environmental Engineering Degree Programs. A Guide for Australian Universities”, Office for Teaching and Learning. ISBN 978-1922125-92-7.

GHD (2010). “Report for Long Term Strategy for the Development of Energy Efficiency Assessment Skills – Training Needs Analysis Report”, report prepared for the Department of Resources, Energy and Tourism, January 2010.

Hatfield-Dodds, S., G. Turner, H. Schandl and T. Doss (2008), “Growing the green collar economy: Skills and labour challenges in reducing our greenhouse emissions and national environmental footprint”. Report to the Dusseldorp Skills Forum, June 2008. CSIRO Sustainable Ecosystems, Canberra.

Janice Orrell (2011), “Good Practice Report: Work-integrated learning” Australian Learning and Teaching Council. ISBN 978-1-921856-82-2.

Volker Schneider (2013), “European Postgraduate Programs in Sustainable Energy” report. ECI publication no Cu0195 – available from <[www.leonardo-energy.org](http://www.leonardo-energy.org)>.

## Appendix A – International institutions responding to the survey

The following table lists the international institutions and the sustainable energy programs that they offer for those that responded to the survey about their programs.

Institution	SE Degrees Offered
Lucerne University of Applied Sciences and Arts (Switzerland)	Bachelor in Business Engineering Sustainable Energy Systems <a href="http://www.hslu.ch/technik-architektur/t-ausbildung/t-ausbildung_bachelor/t-bachelor_in_business_engineering_sustainable_energy_systems">http://www.hslu.ch/technik-architektur/t-ausbildung/t-ausbildung_bachelor/t-bachelor_in_business_engineering_sustainable_energy_systems</a>
Oldenburg University (Germany)	Postgraduate Programme Renewable Energy (MSc) <a href="http://www.ppre.de/">http://www.ppre.de/</a>
Aalborg University (Denmark)	BSc in Energy Engineering Specialisations: <ul style="list-style-type: none"> <li>• Electrical Energy Engineering</li> <li>• Thermal Energy Engineering</li> <li>• Mechatronic Control Engineering</li> </ul> MSc in Energy Engineering: Specialisations: <ul style="list-style-type: none"> <li>• Power Electronics and Drives</li> <li>• Electrical Power Systems and High Voltage Engineering</li> <li>• Wind Power Systems</li> <li>• Thermal Energy and Process Engineering (Aalborg)</li> <li>• Fuel Cells and Hydrogen Technology (Aalborg)</li> <li>• Combustion Technology (Esbjerg)</li> </ul> <a href="http://www.studyguide.aau.dk/programmes/guest-exchange/57297/">http://www.studyguide.aau.dk/programmes/guest-exchange/57297/</a>  M.Sc. in Fuel Cells and Hydrogen Technology <a href="http://www.studyguide.aau.dk/programmes/postgraduate/55801/">http://www.studyguide.aau.dk/programmes/postgraduate/55801/</a>  MSc in Offshore Energy Systems (OES) <a href="http://www.studyguide.aau.dk/programmes/postgraduate/55808/">http://www.studyguide.aau.dk/programmes/postgraduate/55808/</a>  M.Sc. in Wind Power Systems (Aalborg)

	<a href="http://www.studyguide.aau.dk/programmes/postgraduate/55806/">http://www.studyguide.aau.dk/programmes/postgraduate/55806/</a>
Royal Institute of Technology (Sweden)	<p>Master of Science in Innovative Sustainable Energy Engineering <a href="http://www.kth.se/en/studies/2.8797">http://www.kth.se/en/studies/2.8797</a></p> <p>Master of Science in Sustainable Energy Engineering <a href="http://www.kth.se/en/studies/master/kth/sustainable-energy-engineering">http://www.kth.se/en/studies/master/kth/sustainable-energy-engineering</a></p> <p>Master of Science in Sustainable Technology <a href="http://www.kth.se/en/studies/master/kth/sustainable-technology">http://www.kth.se/en/studies/master/kth/sustainable-technology</a></p>
Centre for Renewable and Sustainable Energy Studies Stellenbosch University (South Africa)	<p>Masters in Renewable and Sustainable Energy Postgraduate Diploma in Engineering (Mechanical Engineering) in Renewable and Sustainable Energy Studies <a href="http://www.crses.sun.ac.za/studies-postgraduate-programmes-coursework.php">http://www.crses.sun.ac.za/studies-postgraduate-programmes-coursework.php</a></p>
University of Flensburg	<p>SESAM - Master of Engineering in Energy and Environmental Management <a href="http://www.iim.uni-flensburg.de/sesam/front_content.php?idart=4663">http://www.iim.uni-flensburg.de/sesam/front_content.php?idart=4663</a></p>
European Renewable Energy Centres (EUREC)	<p>European Masters in Renewable Energy <a href="http://www.master.eurec.be/en/">http://www.master.eurec.be/en/</a></p>

## Appendix B – Australian institutions with sustainable energy programs contacted by email to disseminate information about the project

Name	Institution	Role	Relevant Degree/s
Professor Michael Negnevitsky	University of Tasmania	Director of Centre for Renewable Energy and Power Systems	Graduate Certificate in Renewable Energy and Power Systems
Prof JC Olivier	University of Tasmania	Head of School Electronics & Communications Engineering	Bachelor of Engineering (Electrical Power)
Professor Daryoush Habibi	Edith Cowan University	Head of School - Engineering	Bachelor of Engineering (Electrical Power) Bachelor of Engineering (Electronics and Communications)) Bachelor of Engineering (Mechatronics)
W/Prof John Dell	UWA	Dean Faculty of Engineering, Computing and Mathematics	Bachelor of Science (Engineering Science) Bachelor of Science (Engineering Science/Electrical specialisation) Bachelor of Science (Engineering Science/Chemical specialisation)
John Chandler	UWA	Associate Director, Centre for Mining Energy and Natural Resources Law	Graduate Diploma in Energy Law
Professor Sven Nordholm  Professor Mohammad A.S Masoum	Curtin University	Head of Department- Electrical and Computer Engineering  Head of Discipline - Electrical Engineering	Bachelor of Engineering (Electrical Power Engineering)
Associate Professor Cheng-Chew Lim	University of Adelaide	Head of School Electrical & Electronic Engineering	Bachelor of Engineering (Electrical and Sustainable Energy)
Professor Mark Biggs	University of Adelaide	Head of School Chemical Engineering	Bachelor of Engineering (Chemical – Sustainable Energy)
Professor Bassam Dally	University of Adelaide	Head of School Mechanical Engineering	Bachelor of Engineering (Mechanical and Sustainable Energy)

Professor Jianguo Zhu	UTS	Head of School, Elec, Mech & Mechatronic Systems	Bachelor of Engineering (Electrical Engineering) Graduate Certificate in Engineering (Energy Planning and Policy) Master of Engineering (Energy Planning and Policy)
Professor Jamie Evans	Monash University	Head of Department, Electrical and Computer Systems Eng	Bachelor of Engineering (Electrical and Computer Systems Engineering)
Associate Professor Karen Hapgood	Monash University	Head of Department, Chem Eng	Bachelor of Engineering (Chemical Engineering – Sustainable Processing)
Professor George Simon	Monash University	Professor and Head of Department, Mechanical Eng	Bachelor of Engineering (Materials Engineering)
Professor Geoff Tansley	Griffith University	Head of Griffith School of Engineering	Bachelor of Engineering (Sustainable Energy Systems) Master of Engineering (Energy Systems)
Professor Behdad Moghtaderi	University of Newcastle	Head of Discipline, Chemical Engineering	Bachelor of Engineering (Chemical)
Professor Aleksandar Subic  Professor Reza Nakahie Jazar	RMIT	Dean of Engineering – Aerospace Mech & Manuf Eng  Discipline Head – Aerospace, Mechanical & Manufacturing Engineering	Bachelor of Engineering (Sustainable Systems Engineering – Sustainable Energy Systems) Bachelor of Engineering (Sustainable Systems Engineering – Sustainable Transport Systems) Bachelor of Engineering (Sustainable Systems Engineering – Sustainable Logistics Systems) Master of Engineering (Sustainable Energy) Graduate Cert/Diploma in Sustainable Energy
Prof Alex Stojcevski	Deakin University	Associate Head of School Engineering and Head of Electrical Engineering	Master of Engineering (Electrical and Renewable Energy Engineering)
Prof Hisham Elkadi	Deakin University	Head of School of Architecture and Built Environment	Master of Facilities Management
Associate Professor Michael Brear	University of Melbourne	Academic Program Coordinator of the Master of Energy Systems	Master of Energy Systems
Professor Michael	University of	Director of Studies	Grad Dip/Master of Energy and

Crommelin AO	Melbourne		Resources Law
Professor Graham Schaffer	University of Queensland	Executive Dean, Faculty of Engineering, Architecture and Information Technology	Graduate Certificate/Dip in Energy Studies Master of Energy Studies
Prof George Earl	Bond University	Dean Institute of Sustainable Development and Architecture	Master/Grad Dip/Cert of Energy Management
PROF TONY OWEN	University College London Australia	UCL Australia Professor in Energy Economics	Graduate Certificate in Energy and Resources: Policy and Practice Master of Science in Energy and Resources Management

## Appendix C – External Evaluator’s Report



# Renewing the Sustainable Energy Curriculum Project

## Final Evaluation Report

Renewing the Sustainable Energy Curriculum – Providing Internationally Relevant Skills for a Carbon Constrained Economy (**ALTC Ref: ID11-2080**)

**Project Evaluator:** Adjunct Associate Professor Rob Phillips, School of Education, Murdoch University

**Date:** 5 February 2014

### Purpose of the Report

This is the final evaluation report for the Renewing the Sustainable Energy Curriculum Project as required by the project reporting requirements of the Office for Learning and Teaching.

The evaluation addresses the broad evaluation question:  
“To what extent did the Renewing the Sustainable Energy Curriculum Project meet its outcomes?”

### Project Background

The project was led by Murdoch University through a management group of three. This **‘core project team’** consisted of:

- Adjunct Associate Professor **Chris Lund**, who was the Project Manager and *de-facto* **Project Leader**, responsible for day-to-day oversight of the project. As well as his adjunct role with Murdoch University, Chris works as a consultant to industry, with strong industry connections. This was advantageous in ensuring that the outcomes were relevant to industry.
- Dr **Trevor Pryor**, who was the permanent Murdoch University staff member responsible for financial and staffing decisions. He is also responsible for renewal of the School’s sustainable energy curriculum.
- Emeritus Professor **Philip Jennings**, who acted as a mentor to the management group, drawing on his long experience with funded projects and the sustainable energy curriculum.

The project had four partners from four other Australian universities.

- Kim Blackmore (The Australian National University)
- Dr Richard Corkish (The University of New South Wales)
- Professor Wasim Saman (University of South Australia)
- Dr Wendy Miller (Queensland University of Technology)

Given the way the project evolved, the project partners acted as a project **‘advisory group’**, with functions similar to a reference group.

Dr Amanda Woods-McConney from the School of Education at Murdoch University was also listed on the project team. Her role also became part of the project 'advisory group', providing pedagogical advice about curriculum and providing independent peer review of project documents for general readability and usability.

Three research assistants were employed at various stages of the project to provide logistical support, collate data and generally support the project team.

The project ran from October 2011 to February 2014.

## Aims, Outcomes and Deliverables

The initial aims of the project were to “scope and develop sustainable energy curriculum frameworks for Australian higher education Institutions that meet the needs of Australian and international student graduates and employers, both now and into the near future”. At its core, this involved “Developing a list of sustainable energy skills, knowledge and generic graduate attributes required by employers, which will then be formulated into curriculum frameworks”.

## Project Outcomes and Deliverables

The initial proposal specified that the **outcomes** of the project were:

- A better understanding of the skills, knowledge and generic attributes required by sustainable energy graduates;
- A better understanding of how to best deliver sustainable energy education at tertiary level;
- A consistent, agreed, nationally applicable, internationally relevant set of curriculum frameworks for training sustainable energy graduates in Australian tertiary education institutions;
- Better engagement between employers and tertiary institutions regarding the most appropriate skills and knowledge training for the sustainable energy industry; and
- Improved, more relevant sustainable energy courses and programs being delivered at Australian tertiary institutions as a result of comparison of existing courses and programs against the curriculum frameworks and delivery guidelines.

Some longer term outcomes were specified, but they are beyond the scope of this project.

The specified deliverables were:

- A set of curriculum framework documents providing a list of the skills, knowledge and generic graduate attributes required by graduates seeking to work as sustainable energy professionals;
- A guidance document on preferred content/curriculum delivery methods.
- A report on the project including the approach, as well as key findings, and the curriculum frameworks.
- Conference presentations and journal articles reporting the project findings.

## Evaluation approach

The initial proposal required the evaluator to address four key evaluation questions about the Renewing the Sustainable Energy Curriculum project:

**Process evaluation.** To what extent was the project implemented as planned and funded?

**Outcome evaluation.** To what extent did the project accomplish its goals and objectives?

**Sustainability evaluation.** To what degree can the work and achievements of the project be considered scalable and sustainable?

**Product evaluation** To what extent do the curriculum frameworks, delivery guidelines and final report assist academics in engaging and fostering enhanced learning and improved graduate outcomes?

The evaluation investigated the first three of these questions. The sustainability evaluation also addresses the potential to meet the OLT's performance indicator "to change curriculum development, learning and teaching practices and/or teaching management processes in one or more institutions outside the project team". Product evaluation was deemed to be out of scope.

## Evidence against the evaluation questions

**Process evaluation.** To what extent was the project implemented as planned and funded?

The Core Project Team worked closely with the Research Assistant (when available) to manage the project. They met approximately monthly during the project, with some longer gaps. Evidence is available through meeting minutes of two meetings in 2011, nine in 2012, and four meetings in 2013.

The Core Project Team worked together on initial strategising, data analysis and the development of the curriculum frameworks. A Risk Assessment Plan was developed in 2012 and monitored throughout the project. An appropriate list of potential issues was recognised, reported in the year one report and attempts were made to manage them. However, as discussed below, in some case, project resources did not enable risks to be mitigated, with associated impacts on project outcomes.

Progress reports to the OLT identified numerous changes to the project timeline, and subsequent reports made it clear that revised milestones had not been met. However, the unmet milestones were mostly related to dissemination activities, rather than the development of the project deliverables.

Interviews with project participants and project documentation indicates that the project was more complex than anticipated. This is borne out by the content of the Curriculum Framework Guide and associated documentation. It was appropriate to focus on the deliverables, rather than disseminate about part-finished work.

The Project Leader's role as an adjunct academic was problematic in terms of achieving timely outcomes. A fixed budget was allocated for this role, and it proved inadequate to the volume of work required. The Project Leader's role as a sustainable energy consultant in private industry did not permit him to allocate more time to the project each week during busy times. There was also insufficient slack in the budget to allocate more funds to the Project Leader. Where projects are run by university employees, there is more scope to absorb extra project activities into the academic workload. This was not possible in this case. Further, the workload and roles of the core project team prevented them from playing a more active role in the project.

Despite this, the Project Leader has contributed significant amounts of unpaid time to the successful conclusion of the project, working unpaid since October 2013 to finalise project activities.

A second factor which delayed timelines was the availability and retention of research assistants. Three research assistants were employed during the course of the project, but delayed the project by taking up more secure employment.

The budget acquittal indicates that funds were largely spent as planned. Some small amendments were made, with the major surplus being in the dissemination line item. However, this surplus has been pre-committed to upcoming dissemination activities, namely airfares.

### **Stakeholder communication**

As noted above, the broader project team focused largely as an advisory group (see Reference Group below), but with no regular, ongoing contact with representatives from other universities. According to the Project Leader, there was good buy-in from this group, and they contributed when it counted. This included contacting their alumni about the survey.

Three productive face-to-face meetings were held with the advisory group at critical stages.

	Date, place	Activities	Attendance
1	November 2011, Australian Technology Park, Sydney	Mapping taxonomies	Project team: four Others: two
2	November 2012, Swinburne University	Reviewing taxonomies and mapping cloths	Project team: five Others: 0
3	November 2013, UNSW	Reviewing cloths and frameworks	Project team: five Others: three

### **Reference Group**

The initial proposal referred to a Reference Group consisting of “experienced academics with sustainable energy knowledge, representatives of relevant industry bodies (Engineers Australia, AuSES, Sustainable Energy Association) and an international educational institution representative”, and proposed a membership of seven.

However, despite initial interest, a number of factors led to the unavailability of many of these people. Efforts were made to engage proposed and new Reference Group members and three people became Reference Group members, towards the end of the project.

During the bulk of the project, little contact was made with the Reference Group and they only played a small role in providing feedback.

The Reference Group and one international stakeholder were asked to peer review the curriculum frameworks.

## Outcome evaluation

### **A better understanding of the skills, knowledge and generic attributes required by sustainable energy graduates**

The Sustainable Energy Knowledge Taxonomies, the Generic and Discipline Capability Taxonomies, the Sustainable Energy Capability Cloths and the Sustainable Energy Curriculum Frameworks developed through this project provide a *detailed* understanding of the requirements of sustainable energy graduates.

This project has undertaken an extremely fine-toothed analysis of a complex problem space. This is a valuable outcome for sustainable energy and the approach taken could be useful for other curriculum renewal projects.

### **A better understanding of how to best deliver sustainable energy education at tertiary level**

The Sustainable Energy Curriculum Frameworks and the Curriculum Framework Guide have clear potential to inform the delivery of sustainable energy education at tertiary level. However, knowledge of this currently resides only with the project team.

### **A consistent, agreed, nationally applicable, internationally relevant set of curriculum frameworks**

It is apparent that the project deliverables provide a consistent, nationally applicable, internationally relevant set of curriculum frameworks. The factor which prevents this outcome being achieved is that the frameworks are not yet *agreed*. Previous sections have indicated that there was insufficient time to test the curriculum frameworks with programs and courses outside those offered by the member institutions.

### **Better engagement between employers and tertiary institutions regarding the most appropriate skills and knowledge training for the sustainable energy industry**

While employers and tertiary institutions contributed to the survey about skills and knowledge required for the sustainable energy industry, they have not yet had the opportunity to validate the outcomes of this project. While contact has been established, this needs to be followed up.

### **Improved, more relevant sustainable energy courses and programs**

There is currently no evidence of improved, more relevant sustainable energy courses and programs being delivered at Australian tertiary institutions as a result of this project. It is unrealistic to expect to achieve this outcome during the conduct of the project.

## **Unintended outcomes**

The Part 1 Report identifies two unintended outcomes:

- The approach and methodology developed for this project should be easily adaptable to other similar, multidisciplinary subject areas, such as Sustainability Engineering.

- The approach and methodology has international relevance and applicability. International contacts made through consultation about the project has identified significant interest from several international program coordinators.

## Deliverables

### **A set of curriculum framework documents**

As noted above the Sustainable Energy Knowledge Taxonomies, the Generic and Discipline Capability Taxonomies, the Sustainable Energy Capability Cloths and the Sustainable Energy Curriculum Frameworks have all been developed through this project.

Validation of these documents has only been performed at the institutions of the broader project team at the third full project meeting in December 2013. Feedback from advisory group members noted in the Part I report indicates that they find the project deliverables to be valuable documents and there is a strong possibility that they will be used in internal curriculum renewal activities at their institutions.

### **A Curriculum Framework Guide**

A 67 page document entitled “Renewing the Sustainable Energy Curriculum – Curriculum Frameworks and Guidance for Course Delivery” has been produced. This substantial piece of work contains five chapters about the curriculum frameworks, a section about “Five Key Program Design and Delivery Questions” and a description of the methodology used to develop the curriculum frameworks.

This document was placed on the project website, distributed to the project advisory group and re-formed reference group and refined subsequently based on feedback received at the May 2014 presentation and session.

### **A final Project Report**

Submitted.

### **Conference presentations and journal articles**

Some conference presentations have been noted in the final report and progress reports. Despite plans in various timelines, no peer reviewed papers have yet been produced, for reasons already canvassed.

### **Impact Evaluation: How sustainable are the project outcomes and deliverables?**

This section addresses the OLT's performance indicator "to change curriculum development, learning and teaching practices and/or teaching management processes in one or more institutions outside the project team".

As described above, for the excellent resources developed through this project to be usable, individuals and institutions outside the project team need to know about them, and then decide to use them.

The April 2013 progress report advised the OLT that dissemination was unlikely to be as comprehensive as planned and disclosed that “[Dissemination] should have been more clearly built into the original project proposal”. The Evaluator agrees with these statements.

It is clear that core project team members are well connected in the Australian and International sustainable energy sectors. An appropriate range of information-provision activities were carried out within those networks, and there seems to be solid knowledge of the project by both industry and academia. Strong response rates to the project survey also indicate a solid interest in the project.

However, to date, the project has not engaged substantively with potential users of the curriculum frameworks. Dissemination has tended to be *about* the project - obtaining the views of others, and not dissemination of the outcomes *of* the project and securing buy in. There has been little evidence in the project documentation of an understanding of the OLT’s approach to dissemination and the need to plan for engagement with the sector.

Workload reasons for the delay of dissemination to date have been discussed earlier. However, other factors beyond the control of the project team impacted on planned dissemination activities. A workshop was planned for the December 2013 Australian Solar Council Academic Conference. Subsequent to the postponement of the conference, plans were made to meet with the broader project team and various stakeholders in Sydney (December 2013). As noted earlier, this was attended by the project advisory group and three other academics, who are key stakeholders in the upcoming curriculum renewal at the University of New South Wales: the head of School, Deputy Dean of Faculty and one of the key lecturers. A key industry representative had agreed to attend, but subsequently declined. This final workshop provided validation of the curriculum frameworks.

The outcomes of this project have strong potential to be of value to the sector. Sustainable energy programs across Australia are currently being reviewed in light of the need to i) meet Australian Qualifications Framework and TEQSA requirements; ii) rationalise offerings within the University sector in general; and iii) modernise the sustainable energy curriculum.

The Final Report recognises the urgency of disseminating project outcomes and deliverables across Australia and internationally, to support institutions as they review and revise their curricula. It is unclear how this will happen beyond the project end. There is no peak body (e.g. a Council of Deans) in such a multi-disciplinary field to support sector wide uptake. However, the development of a contemporary sustainable energy curriculum is likely to be in the nation’s long-term strategic interests. In the absence of further funding, claims throughout the final reports about the uptake of the curriculum frameworks may be aspirational.

A further factor mitigating against the uptake of the curriculum frameworks is the complexity. There are 28 tables at several levels, which nest into each other. While the core project team has a clear understanding of how the frameworks fit together, through two years of engagement with them, others may find navigating within the frameworks daunting. This will mitigate against successful uptake, unless mechanisms can be put in place to assist users. This may require workshops at each institution to assist curriculum planners to interpret the ‘cloths’ and curriculum frameworks. Without further funding, this may not be achievable.

## Conclusion

In conclusion, let us return to the overarching question of this evaluation: “To what extent did the Renewing the Sustainable Energy Curriculum Project meet its outcomes?” The Project Report states that the project has “successfully produced the desired deliverables but has not fully achieved all of its desired outcomes”. This evaluation confirms this. A comprehensive set of curriculum framework documents has been developed with a Guide to their use. However, the complexity of this task resulted in substantially reduced dissemination of the outcomes to universities teaching aspects of the sustainable energy curriculum. Despite this, the project has remained within budget and with a slightly extended timeline.