

**ASSESSMENT OF STATUS OF DEVELOPMENT OF  
STANDARDS AND TRAINING  
FOR RENEWABLE ENERGY IN AUSTRALIA**

**A Consultancy Report by ACRE  
June 2001**

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# ASSESSMENT OF STATUS OF DEVELOPMENT OF STANDARDS AND TRAINING FOR RENEWABLE ENERGY IN AUSTRALIA

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## Executive Summary

### Standards

Standards in Australia are the responsibility of an independent Sydney based company Standards Australia International Limited. Standards Australia was originally formed in 1922 and now has annual revenue of A\$74 million. It currently maintains over 6,000 Standards using around 9,000 voluntary experts serving on around 1,700 technical committees and supported by a full-time staff of 280. Standards Australia represents Australia on the two major international standardizing bodies, the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC). Standards for renewable energy systems are a small part of its total business.

The number and extent of Australian Standards for renewable energy systems, which currently exist, reflect the maturity of the target sector and the maturity of the specific industry. Table 1 lists all standards relating to renewable energy that were identified for this report.

### Solar hot water systems

For solar hot water systems (SHW), where there is a mature Australian industry, the standards in place cover the industry and protect the consumer relatively well, although there is a need for standardising consumer information labelling of all water heaters. A total of eleven Australian standards<sup>1</sup> are in place relating to domestic solar hot water systems and to solar pool water heating systems. International standardisation is underway with Australia playing a leading role in the development of those standards in order to minimise the non-tariff barriers to Australian exports, additional support for these activities will expedite developments and assist Australian export businesses. Existing industry is relatively happy with the national standards situation as it relates to them. The exception being some new industry players that are developing novel plastic collector and storage systems, as the existing standards do not apply easily to them. One aspect that is of some concern with regards to SHW standards is that existing testing facilities are not adequately funded to test to the necessarily stringent demands required by the standards.

### Electricity Production

For the RE sectors relating to electricity production utilising photovoltaic (PV), micro-hydro and wind generators there are fewer Australian Standards. Only one standard is in place relating to PV panels and this may be out of date. Two Australian standards exist for storage batteries but these do not relate to the design of the storage component of systems. Three Australian standards (one in draft form) exist for stand-alone power systems but these don't cover the full range of hybrid systems that are being developed. The reliability issues associated with RAPS systems suggest that

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<sup>1</sup> Here we are counting Standards as including Parts of Standards as separate Standards: this is how they are issued by Standards Australia.

standards in this area are urgently required. No Australian standards exist for small wind turbine systems although four exist for the towers and associated structures. A number of international standards and certification arrangements exist for large (> 100kW) wind turbines reflecting the state of play in this sector of the industry.

No Australian standards exist for water pumping systems, control systems, charge controllers, maximum power point trackers, PV arrays – DC side, RAPS or grid linked inverters, solar home systems (SHS), micro-hydro systems, demand side systems including DC supplied fluorescent lamps, or industry contracting. An Australian Guideline, however, exists for grid-linked inverters. A single Australian standard exists for the installation of small stand-alone generating sets.

## **International**

Internationally there is considerable interest in developing standards for electricity generating RE systems and here the situation is a bit further advanced. The International Electro-technical Commission (IEC) has a number of existing standards some of which are pertinent to this report. There is an IEC standard for small wind turbines but opinion is that this standard is currently inadequate. The IEC also has various Technical Committees writing standards for components including TC82 PV panels and balance of systems, TC 21:- storage batteries, TC 88:- wind energy systems and a new TC, TC105 for fuel cells.

For RAPS systems the first meeting of the IEC Joint Coordination Group (JCG) TC82/TC21/TC88, *Decentralized Renewable Energy Systems* was held early this year. In attendance were delegates from USA, UK, Australia, Canada, France, Germany, Japan and Denmark. This group will oversee development of a French document that covers an extensive range of RAPS, into a series of IEC standards. Other initiatives are underway including: various International Energy Agency (IEA) task forces on RE, a joint laboratory initiative under the European Commission under their Fifth Framework Convention, and the PV-GAP initiative.

## **Wood-heaters**

While wood-heaters<sup>2</sup> are certainly a mature industry in general terms Australian standards relating to them have only been developed relatively recently: as the safety problems developing from installing them in relatively large numbers in modern houses became apparent. A total of nine Australian Standards have been prepared over the past 15 years dealing with safe installation of solid-fuel burning appliances, appliance quality, appliance performance (efficiency, heat output rate), and emission of particulates.

## **Testing Facilities**

In addition to the writing of standards it is considered essential for Australia to develop the capacity to test to any standards developed. The testing has to be available to industry at a cost commensurate with the cost and volume of the product line being tested for. If this is not done it will only frustrate industry and make the standards development work irrelevant to that industry. Australia had been very tardy compared to many comparable countries internationally, which mostly have their own national renewable energy laboratories. In Australia the testing facility

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<sup>2</sup> The brief for the study refers to 'wood stoves'. This is a term used in North America, but in Australia and Europe the term for controlled-combustion wood-burning heaters is 'wood-heater'. Wood-stove is used in relation to cooking stoves.

situation has been very fragmented. There is already a problem with testing of SHW systems in that the facilities at the only QAS registered test laboratory at the UNSW needs an urgent injection of funding to enable it to continue offering services. Testing of wood-heaters has fared somewhat better due to a transfer of the testing from the University of Tasmania (which offered the original test service) to two private test companies. For electricity producing RE systems the situation will improve as the new ACRELab facility comes on line. It is anticipated that this facility, which is presently operational, will be accredited by the National Association of Testing Authorities (NATA) by the end of 2001.

### **Short term goals**

The report identifies a list of short and long-term goals for standards development. The short-term goals include:

- Converting the present grid linked inverter guideline into an Australian standard
- Converting the existing IEC international standard for small wind turbines into an Australian standard.
- Developing a standard for DC PV arrays
- Developing a standard for RAPS inverters
- Developing a standard for industry contracts for RAPS supply
- Developing a standard for micro-hydro systems

It is thought that all these short-term goals are achievable provided sufficient resources are available to allow technical drafting and survey work to be carried out.

### **Long term goals**

In addition more extensive list of longer-term goals is given to cover the remaining gaps. These goals include developing Australian standards, or adopting international standards, for the following:

- RAPS systems
- Charge controllers
- Systems controllers
- Rating scheme for PV modules
- DC loads including fluorescent lamps
- RAPS batteries (classification/testing procedures)
- RAPS batteries (installation, voltages > 115 Vdc)
- Solar home systems (SHS)
- Maximum power point trackers (MPPT)
- Water pumping systems
- Redox / flow batteries
- Metering of grid connect and RAPS systems
- Fuel cell generators (further down the track as these systems are still at the research stage)

In many cases it may be best for Australia to keep a close watch on international developments and participate in international programs before entering specific standard development. In all cases substantial laboratory and industry liaison is needed before embarking upon the actual writing stage.

**Table 1: summary table of Australian Standards relating to RE systems**

<b>Sector</b>	<b>Standard #</b>	<b>Short Title</b>
SHW	AS 3500.4.2-1997	<i>National Plumbing and Drainage Part 4.2: Hot water supply systems – Acceptable Solutions</i>
SHW	AS 2535-1986	<i>Solar Collectors with Liquid as the Heat-Transfer Fluid</i>
SHW	AS 2535.1:1999	<i>Thermal performance of glazed liquid heating collectors including pressure drop</i>
SHW	AS 2813-1985	<i>Method of Test for Thermal Performance – Simulator Method</i>
SHW	AS 2984-1987	<i>Method of Test for Thermal Performance – Outdoor Test Method</i>
SHW	AS/NZS 4445.1:1997	<i>Domestic water heating systems- performance rating procedure using indoor test methods.</i>
SHW	AS 4234-1994	<i>Domestic and heat pump water heaters – Calculation of energy consumption</i>
SHW	AS 2712-1993	<i>Solar Water Heaters Design and Construction</i>
SHW	AS 3634-1989	<i>Solar heating systems for swimming pools</i>
SHW	AS 2369.1-1990	<i>Materials for solar collectors for swimming pool heating - Rubber materials</i>
SHW	AS 2369.2-1993	<i>Materials for solar collectors for swimming pool heating - Flexible or plasticized polyvinyl chloride</i>
PV	AS 2915-1987:	<i>Solar photovoltaic modules - Performance requirements</i>

BAT	AS 4086.1-1993	<i>Secondary batteries for use with stand-alone power systems - General requirements</i>
BAT	AS 4086.2-1997	<i>Secondary batteries for use with stand-alone power systems - Installation and maintenance</i>
<b>Sector</b>	<b>Standard #</b>	<b>Short Title</b>
SYS	AS 4509.1-1999	<i>Stand-alone power systems - Safety requirements</i>
SYS	AS 4509.2- 2001?	<i>Draft Stand-alone power systems - Part 2 System Design Guidelines</i>
SYS	AS 4509.3-1999	<i>Stand-alone power systems - Installation and maintenance</i>
WIND	AS 1170.1-1989	<i>Minimum design loads on structures (known as the SAA Loading Code) - Dead and live loads and load combinations</i>
WIND	AS 1170.2-1989:	<i>Minimum design loads on structures (known as the SAA Loading Code). Part 2: Wind loads</i>
WIND	AS 1170.3-1990	<i>Minimum design loads on structures (known as the SAA Loading Code) - Snow loads</i>
WIND	AS 3995-1994:	<i>Design of steel lattice towers and masts</i>
GEN	AS 3010.1-1987	<i>Electrical installations - Supply by generating set - Internal combustion engine driven sets</i>
WOOD	AS 2918-1990	<i>Domestic solid fuel burning appliances – Installation</i>
WOOD	AS/NZS 3869:1999	<i>Domestic solid fuel burning appliances – Design and construction</i>
WOOD	AS/NZS 4012:1999	<i>Domestic solid fuel burning appliances – Method for determination of power output and efficiency.</i>

WOOD	AS/NZS 4013:1999	<i>Domestic solid fuel burning appliances – Method for determination of flue gas emission</i>
WOOD	AS/NZS 4014:1999	<i>Domestic solid fuel burning appliances – Test Fuels Parts 1 to 5 for different fuels</i>

**Abbreviations:** SHW- solar hot water systems, PV- Photovoltaic Panels, BAT – storage batteries, SYS- Renewable Energy Systems, WIND- Wind Energy Systems, WOOD – Wood-heaters

## Training

Australia is a recognised world leader in renewable energy education with well-developed courses available at all levels including university research training, undergraduate and postgraduate coursework, TAFE and short courses for industry and Government. The report is the result of an extensive national survey of RE courses but it does not claim to be all-inclusive. In particular the report does not include once-off courses, courses run at secondary level including secondary level vocational courses and specialist courses run by Government departments or Government agencies.

## University

Ten universities (see table3) were identified as offering research training in various aspects of renewable energy installation and design. In general there is good coverage of photovoltaics and renewable energy systems but several other areas, including micro-hydro, wind and biomass are poorly represented. Coursework Masters level courses with a major emphasis on Renewable Energy are available at four institutions at present (see Table 2) although several others are considering entering this field. Units or courses in renewable energy are available at undergraduate and postgraduate level at most Universities but only two currently offer full undergraduate degree programs in this area. Formal research into renewable energy topics was identified at 10 universities but could obviously be carried out (with regard to some aspect) at many more.

## TAFE

There are 8 TAFE colleges (see table 4), which offer the Certificate IV in Renewable Energy. Four of these are in Victoria and two in Queensland. TAFE colleges in WA and NT also offer this qualification but no offerings are available in NSW, SA, Tasmania or the ACT. This is a serious issue, which affects the ability of the industry to recruit well-trained trades people for the design, installation and maintenance of renewable energy systems. The Australian National Training Authority (ANTA) is now addressing this issue with a view to developing a national curriculum that will be available in all States. There are also some gaps in the offerings. Although PV, wind and diesel hybrid power supply systems are adequately covered in the existing TAFE syllabus, there is a lack of training packages available on wood heaters and microhydro systems.

## Industry

More than 50 companies and agencies run short training courses on various aspects of renewable energy systems. These are mostly offered on an occasional basis in response to demand or the opportunity to piggyback on a conference. Most of these courses are not offered by Recognised

Training Organisations (RTOs) or accredited. There is no coordination in these offerings and some are not available to the public.

There is a shortage of supply of trained personnel for the renewable energy industry at present. This is a result of the rapid growth of demand for systems and personnel in response to Government policy initiatives. Current training programs have largely been driven by company needs and Government policy initiatives (such as ACRE, SEIA and the Key Centre for Photovoltaic Engineering).

Education providers are aware of the need for greater training capacity and steps are being taken to increase the range of courses available. However there are still serious deficiencies in coverage in all sectors. Additional ongoing Government support is particularly needed to increase research training capacity. TAFE coverage is lacking in several States and some areas such as wood-heaters and micro-hydro are not covered at all. Training for indigenous communities is lacking at present. The area of short courses for in-service training is growing rapidly but needs better coordination and there is a need to look more closely at training standards and accreditation in this area. There is an important role here for Governments and professional bodies.

Standards and accreditation need to be more closely linked to education and training to ensure that trades people are fully aware of the standards for renewable energy systems. There is an important role here for Governments to facilitate this process.

**Table 2: University Level Courses in Renewable Energy**

<b>Institution</b>	<b>Award Level</b>
Curtin University of Technology	Master of Engineering Science in Renewable Energy Engineering - higher degree by coursework
University of Melbourne	Graduate Certificate of Engineering (Energy Studies) - higher degree by coursework
University of Melbourne	Graduate Diploma of Engineering (Energy Studies) - higher degree by coursework
University of Melbourne	Master of Energy Studies - higher degree by coursework
University of Melbourne	Master of Engineering (Energy Studies) - higher degree by coursework
Murdoch University	Postgraduate Certificate in Energy Studies - higher degree by coursework
Murdoch University	Postgraduate Diploma in Energy Studies and Bachelor of Applied Science (Energy Studies)- higher degree by coursework
Murdoch University	Master of Science in Renewable Energy - higher degree by coursework
Murdoch University	Bachelor of Engineering (Renewable Energy Engineering) – undergraduate degree
Murdoch University	Bachelor of Science (Energy Studies) – undergraduate degree

University of New South Wales	Bachelor of Engineering (Photovoltaics and Solar Energy) – undergraduate degree
University of New South Wales	Graduate Diploma in Electrical Engineering (major in Photovoltaics) – higher degree by coursework
University of New South Wales	Master of Engineering Science in Electrical Engineering (major in Photovoltaics) – higher degree by coursework

**TABLE 3: University Research Training in Renewable Energy**

University	Research Awards Offered	Major Areas Available
Curtin University of Technology	MPhil, PhD	Power conditioning, hybrid systems
Royal Melbourne Institute of Technology	MEng, PhD	Solar Thermal, Cogeneration
University of Melbourne	MPhil, PhD	Solar thermal, biomass
Murdoch University	MPhil, PhD	Hybrid systems, photovoltaics, energy storage
University of NSW	MPhil, PhD	Photovoltaics, hybrid systems, grid-connected systems, solar thermal, energy storage
Australian National University	MPhil, PhD	Photovoltaics, solar thermal
Northern Territory University	MEng, PhD	Hybrid systems
University of Newcastle	MPhil, PhD	Wind and hybrid systems
University of Tasmania	MPhil, PhD	Solar cooking, Wood heaters
University of Sydney	MPhil, PhD	Solar thermal power systems

**Table 4: TAFE Courses in Renewable Energy**

Institution	Award Level
Brisbane Institute of TAFE, ITHACA Campus	Certificate IV in Ren. Energy Tech, Short Courses in Specific Tech Areas, Starting Certificate II in Electrotechnology Servicing (Renewable Energy Specialisation) - July 2002
Central TAFE, Perth	Certificate IV in Ren. Energy Tech, Short Courses and SEIA accreditation
NTU/TAFE	Certificate IV in Renewable Energy Technology
Swinburne Uni/TAFE	Certificate IV in Renewable Energy Technology
NMIT Victoria	Certificate IV in Renewable Energy Technology
Gordon TAFE, Victoria	Certificate IV in Renewable Energy Technology
CSIT TAFE Queensland	Certificate IV in Renewable Energy Technology

Queensland	
Chisholm TAFE Victoria	Certificate IV in Renewable Energy Technology

### Authors of the report

The report, compiled by ACRE, has had a number of contributors, each expert in his or her respective field. Some are ACRE staff and others worked as consultants, accessed via ACRE's extensive matrix network. ACRE staff have been involved in Australian and international standards committees since 1997. Important IEA survey documents on renewable energy systems have also been reviewed.

Solar hot water systems have been covered by a number of people including Graham Morrison (UNSW), Ken Guthrie (SEA-Victoria) , Bob Lloyd (ACRE) and Trevor Pryor (ACRE). The electricity producing RE section was largely written by Ted Spooner (ACRE) with contributions on wind from David Wood (University of Newcastle) and micro-hydro from John Todd (University of Tasmania). John Todd also wrote the wood-heater section. Phil Jennings contributed to and coordinated the training section with assistance from Chris Lund, John Todd and Prakash Dubey. The report has been edited and assembled by Bob Lloyd (ACRE).

**Graham Morrison** is director of the Solar Thermal Energy Laboratory at the University of NSW. He has worked on the Standards Australia CS28 Solar Thermal Committee since 1980 and has been one of the Australian representatives to ISO TC180 committee. He has been involved in drafting many of the Australian and international solar thermal standards and developed the computer software used for rating solar water heaters (AS42324 and the Solar Certification and Rating Corporation in the USA).

**Ken Guthrie** is Group Manager Government and Renewables at SEAVictoria. He has 20 years experience in energy efficiency and renewables. He has carried out consulting on solar water heating for the United Nations in India and Syria and for the Pacific Forum, as well as working on EEC funded projects in the UK. He chairs both the Australian and the International Solar water heating standards committees.

**Trevor Pryor** is the Director of the Murdoch University Energy Research Institute (MUERI) and has been involved in the testing and monitoring of RE systems for over twenty years. This work has included the testing of solar thermal collectors, the monitoring of solar thermal systems and, more recently, the testing and monitoring of diesel hybrid and standalone diesel RAPS systems.

**Ted Spooner** is chairman of EL42/3 subcommittee on Grid Connection and a member of the International Electrotechnical Commission's (IEC) technical committee TC82 that covers photovoltaics. He has been involved in testing of RAPS inverters for the NSW RAPAS scheme since the early days of its implementation. He has also been involved since 1997 in testing grid connected inverters for PV systems

**David Wood** is the only Australian member of IEC committee MT2, a committee, which is charged with revising the small wind turbine standard IEC 61400-2. He has been researching wind turbine aerodynamics for nearly 20 years and has designed blades from 600 W to 20 kW (1m to 5 m) for three Australian manufacturers.

**Bob Lloyd** is the ACRE Product Executive for RAPS and is a founding member of the IEC- JWG of TC21/TC82/TC88 for the production of RAPS standards from PAS 62111. He has worked on a survey of hot water systems in remote areas of Australia.

**John Todd** is a member of the Australian Standards Committee CS/62 that has prepared the Residential Solid Fuel Burning Appliance Standards. He was Chairman of the Committee from its inception in 1981 to 1998 and has represented Australia on the International Organization for Standardization Technical Committee ISO/TC 116 SC3.

**Philip Jennings** is the ACRE Product Executive for Education and Training and Professor of Physics at Murdoch University. He has been involved with education and training in the field of renewable energy for more than a decade.

**Chris Lund** is a Lecturer in Energy Studies at Murdoch University and the project leader of ACRE's University Education project

**Prakash Dubey** has a PhD in renewable energy and is ACRE's Education Product Development Officer.

## **Main Report**

### **Background**

In the National Greenhouse Strategy (1998) responsibility for measure 4.6 (iii) lies with all jurisdictions through ANZMEC. The Energy Management Task Force (EMTF) standing committee of ANZMEC has been allocated the task of coordinating actions for this measure.

#### **NGS Measure 4.6 - Strategic Development of Renewable Energy (iii) energy industry standards and training**

*Energy industry standards and training will be strengthened by the introduction of training and accreditation schemes for service providers in the industry and the development of standards for renewable energy equipment and systems to promote customer acceptance and export market development.*

The objective of this measure is to promote customer acceptance and export market development opportunities for renewable energy technologies by promoting reliable and consistent high standards in the manufacture installation and maintenance of equipment and systems.

As some Australian Standards work has already been completed and there has been considerable work in developing training initiatives for RE, the EMTF decided, as a first step, to commission a study to identify existing information and programs from all jurisdictions. This report is the result of the study carried out by the Australian Cooperative Research Centre for Renewable Energy (ACRE). The terms of reference for the study are given in Annex A.

## **PART 1: Standards**

### **Introduction**

The following section details the situation in Australia and overseas with regards to standards for RE systems including:

- Solar hot water systems;
- Remote area power systems and components (including: inverters, batteries, solar panels and cells, fixed array frames and trackers for solar panels, battery chargers, maximum power point trackers, wind turbines and turbine towers, micro hydro turbines);
- Solar water pumping;
- Grid connected inverters; and
- Wood-heaters<sup>3</sup>.

This report has been drafted by ACRE having the advantage of working from a matrix organisation with a large network of associated experts working in the renewable energy field. To complement

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<sup>3</sup> The brief for the study refers to 'wood stoves'. This is a term used in North America, but in Australia and Europe the term for controlled-combustion wood-burning heaters is 'wood-heater'. Wood-stove is used in relation to cooking stoves.

this experience, ACRE has also previously convened workshops on renewable energy systems to involve the renewable energy industry in consultation and interaction on important issues. Recent workshops that have included industry feedback have been:

- "Grid Connection of Energy Systems via Inverters". ACRE workshop, Sydney, 17/3/1999
- "Workshop on survey of Remote RAPS systems" Alice Springs, ACRE/CAT 19-20/6/2000
- "Workshop on Grid Connected Inverter Energy Systems in WA", Perth ACRELab 20/2/2001

Another workshop on grid-connected systems is planned for the east coast later in 2001. Further industry feedback has been via Ted Spooner who has been involved in testing of RAPS inverters for the NSW RAPAS scheme since the early days of its implementation. He has also been involved since 1997 in testing grid connected inverters for PV systems. This involvement has meant considerable interaction with at least one section of the RE manufacturing industry in Australia and overseas and has allowed industry opinion in part to be reflected in this report.

The process of standards development involves someone (institution) drafting an initial document and then the document being taken in hand by a committee of industry experts and reviewed and revised. It is then sent out through a public consultation and review process before returning to committee again for further review and then to an industry ballot before publication. Testing may also need to be carried out to validate a standard and/or to develop test methodology. The process usually takes considerable time. The initial stages involved in gathering of experience and initial drafting of a document can take many years depending on the knowledge base and the amount of change occurring in an industry.

The number and extent of existing Australian Standards for renewable energy systems depends largely on the maturity of the target sector and the maturity of the specific industry. Thus for solar hot water systems, where there is a mature Australian industry, the standards in place cover the industry and protect the consumer relatively well. Solar hot water systems existed as an industry in Australia by the mid 1900s. Australian Standards for this industry were developed in the late 1970s and early 1980s and have been refined since then. Whilst the extent of the SHW standards reflects the predominance of the particular type of product available in Australia; that is metal flat plate collector with metal storage tank there is an active program of international standards development underway. Standards Australia is committed to utilising international standards where they better meet the needs of new developments. The present report will look at the existing Australian standards and discuss the difficulties imposed by current test regimes and the lack of standards for new innovative products coming on to the market.

For the RE sectors relating to electricity production utilising: photovoltaic (PV), micro-hydro and wind generators the situation is somewhat sparser with regards to Australian Standards. While early forms of micro-hydro and wind generators have been available for most of the 1900s, PV only started to be deployed in the 1970s (predominantly in the telecommunications sector). RE systems using such sources have, however, only become popular as a consumer product in the last couple of decades. The main acceleration in the industry has in fact occurred over the last five years or so spurred on by environmental concerns related to the greenhouse effect. Thus standards for systems relating to these particular target sectors are only just now being written or developed. While solar hot water systems have mostly been sold as complete systems, electricity generating RE systems utilising solar PV, wind or micro-hydro have consistently been provided as separate entities in component form: that is the generator, control systems, power conditioning systems (inverter and

maximum power point tracker), back up diesel generators and storage systems. In addition the large number of variations of such systems available when used in hybrid combinations makes the formulations of standards for complete systems formidable. In this context the development of standardised, modular systems would be of considerable merit.

The present report looks at the development of standards in Australia for components and also looks at the struggle in the international community to come to terms with the variety of possible system combinations and sizes. In the electricity production section the action with regards to the international scene is given prior to looking at the Australian situation.

While wood-heaters are certainly a mature industry in general terms Australian standards relating to them have only been developed relatively recently, as the safety problems developing from installing them in relatively large numbers in modern houses became apparent. A suite of Australian Standards has been prepared over the past 15 years dealing with safe installation of solid-fuel burning appliances, appliance quality, appliance performance (efficiency, heat output rate), and emission of particulates. The safety, performance and emissions standards are widely used by most sectors of the industry and have shaped the on-going development of wood-heaters in Australia.

## **1.0 Solar Hot Water Systems**

### **General**

Solar hot water systems are an established RE technology in Australia and so the standards pertaining to the installation, construction and performance of such systems have been around for some time. The original standards were the result of work by CSIRO, University of NSW, the Victorian Solar Energy Council (now SEAV) and others over the period 1980 to 1990. The Australian manufacturing market is dominated by metal flat plate collector systems with metal storage tanks and thermo-siphon circulation. For the last decade or so manufacturers have largely produced models with the storage tanks mounted above the collector panels although some varieties with forced circulation and separate tanks located at ground level have appeared recently. There are four major manufacturers, which produce mostly all metal systems. More recently companies producing plastic solar hot water systems have entered the Australian market.

Australia is very active in the development of International Standards, with Standards Australia holding the Secretariat of the International committee ISO TC180 since the early 1980s. Since the mid 1990s CEN, the European Standards Organisation, has also become very active in developing standards to meet European needs. The Geneva Agreement between ISO and CEN commits each to use the others documents when they are available. As much of the solar water heater configuration in Europe is different to much Australian production there is concern that this situation may inadvertently disadvantage Australian exports, especially if the CEN standards are prepared without Australian input and become International Standards. It might be noted here that Australia exports approximately 50% of the production of solar water heaters with a large proportion going to Europe. Continuation of Australian representation on the ISO TC180 solar thermal committee and in the representation of ISO at CEN working meetings is essential to support and build the existing export industry.

### *1.1 Standards relating to installation of SHW systems*

#### **AS2002-1987**

##### Solar water heaters - Installation

**Updated** from: AS2002-1981 The Installation of Household Type Solar Hot Water Systems  
**Withdrawn** August 1990, **Replaced** by AS3500.4 -1990

**Description:** Produced by TC: CS/28. Sets out requirements for installation of solar water heaters (including those that combine solar with some other form of energy input). It is applicable to systems with fixed orientation and inclination, of storage capacity up to 700 L, used either singly or in multiple-unit installations. The Standard covers thermo-siphon and pumped systems, either incorporating a heat exchanger or using direct circulation of potable water. Appendices include reference irradiation data, estimation of shading of collectors and recommendations for efficient use and maintenance. (57 pages)

This standard was withdrawn after the material was incorporated into the integrated residential water heater installation standard AS3500.

#### **AS 3500.4.2-1999**

##### National Plumbing and Drainage Part 4.1: Hot water supply systems – Acceptable Solutions

**Description:** Specifies requirements for the design and construction of all forms of residential hot water services, from the water service to the points of discharge. (100 pages)

### *1.2 Standards relating to performance testing of SHW systems*

#### **AS2535-1986**

##### Solar Collectors with Liquid as the Heat-Transfer Fluid – Method of Testing Thermal Performance

First published in Australia as part of AS 2535-1982. The second edition appeared in 1986.  
 Replaced by AS2535.1:1999

**Description:** This standard sets out a method for determining the thermal performance characteristic of all classes of solar collectors operating with liquid as the heat-transfer fluid. This thermal performance characteristic may be used to estimate the performance of the collector when subjected to different ambient conditions, water temperatures and solar radiation conditions. It can also be used as a basis for rating different collectors. The test method described is intended for use on all types of collector, which transfer incident solar energy, as heat, to liquid passing through the collector.

## **AS2535.1:1999**

### Test methods for solar collectors

#### Part 1: Thermal performance of glazed liquid heating collectors including pressure drop

**This is a revised version that replaces most of AS2535-1986.** Jointly revised and designated in part as AS/NZS 2535.1:1999. Standards Australia still, however, lists the 1986 version on its web site. This double listing causes some confusion especially in later standards such as AS4234, which refers simply to AS2535 as the later version – 1999 was produced after the publication.

**Description:** Establishes methods for determining the thermal performance of glazed liquid heating solar collectors. It provides test methods and calculation procedures for determining the steady-state and quasi-steady-state thermal performance of solar collectors. This Standard is technically equivalent to and has been reproduced from ISO 9806-1:1994. The standard doesn't cover as wide a range of collectors as AS2535 1986, but it is the appropriate method for most current Australian collectors.

## **AS2813-1985**

### Solar Water Heaters – Method of Test for Thermal Performance – Simulator Method

This standard has been withdrawn and replaced by AS/NZS4445.1:1997

**Description:** This standard sets out a method of determining the performance of a solar water heating system under controlled conditions simulating an average day and a bad weather day. The results obtained under the standard conditions described in this standard may be used for the prediction of system performance under other conditions. Appendix C provides a data correlation procedure for such predictions. The tests set out do not deal with durability, soundness of construction and safety aspects.

The test method described is applicable to the following types of solar water heating systems.

(a) Solar collector with remote hot water container system, both components supplied as a complementary and rated system, with the primary circuit piping arranged to suit site conditions when installed.

(b) Close coupled or integral unit system, which may be tested as a complete unit.

The primary water circuit flows between the collector and container may be either thermo-siphon or forced circulation for the type described in (a) above. Supplementary water heating may be incorporated in the solar water heating system and may be either integral with the solar water heater or remote from it. The test method is applicable to systems incorporating either glazed or unglazed collectors.

## **AS2984-1987**

### Solar Water Heaters – Method of Test for Thermal Performance – Outdoor Test Method

**Description:** This Standard sets out a method of determining the performance of a solar water heating system under natural outdoor conditions and prescribes a method of transforming the test results from the particular climate conditions of the test to long-term average conditions for the test location or for other locations with similar solar irradiation conditions.

The test involves drawing off specified quantities of water at intervals on a 24-hour basis with each test period covering a period of 5 days. Test periods are required for a range of weather conditions. A full test sequence typically requires 2 to 3 months to complete, depending on the weather conditions at the test site. The tests are carried out in typical operational conditions. The only restriction on the nature of systems that can be tested is that there can be no long-term energy storage. The total energy storage capacity in the solar pre-heat section of the system shall be less than twice the nominal system capacity (see Clause 3.4.2).

The Standard applies only to systems with an auxiliary heating system that can satisfy the load under no-solar input conditions. Types of solar water heating systems that can be tested include: solar collector with remote hot water container system, both components supplied as a complementary and rated system with the primary circuit piping arranged to suit site conditions when installed; close coupled or integral unit system, which may be tested as a complete unit. The primary energy transfer circuit between the collector and container may be either thermo-siphon or forced circulation for the type described in (a) above. Supplementary water heating incorporated in the solar water heating system may be either integral with the solar water heater or remote from it.

The International Standards Organisation as ISO9459-3 has adopted this Australian standard. The disadvantage of this procedure is that the results are only applicable to the product configuration tested. The alternative procedure based on AS2535, AS1056 and AS4234 allows a large mix of component configurations to be evaluated from the one set of component tests.

### **AS/NZS 4445.1:1997**

Solar Heating- Domestic water heating systems- performance rating procedure using indoor test methods.

**Description:** This standard was adopted from ISO 9459 – 1. It defines an indoor test method for rating solar domestic water heating systems for thermal performance, under benchmark conditions. This standard replaces AS2913-1985. It applies to solar water heating systems designed to heat potable water to be supplied for domestic water usage.

The test procedures described in this part of ISO 9459 are applicable to systems with solar storage capacity of 0.6 m<sup>3</sup> or less. It includes procedures for testing solar domestic hot water systems either with solar irradiance simulators or thermal simulation (non-irradiated) methods.

The test procedures in this part of ISO 9459, which employ a non-irradiated solar collector array in series with a conventional heat source, do not apply to integral collector storage systems, nor to systems in which thermo-siphon flow occurs, nor to any system employing a collector/heat transfer fluid combination, which cannot be tested in accordance with the collector test.

The test procedures in this part of ISO 9459 do not require the solar water heating system to be subjected to freezing conditions. Consequently, the energy consumed or lost by a system while operating in the freeze- protection mode is not determined. This part of ISO 9459 is not generally applicable to concentrating or evacuated tube systems, unless the collimation requirements of 6.3.1.3 are met.

The standard is not intended to be used for testing the individual components of the system, nor is it intended to abridge any safety or health requirements. There are currently no facilities available in Australia that can test to this standard.

**AS4234-1994**Solar water heaters – Domestic and heat pump – Calculation of energy consumption

This standard utilizes a collector efficiency curve produced to AS2535 and a storage tank loss coefficient produced to AS1056.1 (Storage Water Heaters – General Requirements) if applicable, or an appendix in AS4234 if it is not. Gas boosted systems utilise the tank standing heat loss tests from AG 102. These values are input into a TRNSYS simulation program supplied with the standard and the performance can be calculated for four regions in Australia.

This standard defines computer simulation models for the following systems.

Single tank solar water heaters with electric or gas in-tank boosting.

Solar pre-heater in series with an instantaneous electric or gas booster.

Solar pre-heater in series with a conventional storage water heater

Heat pump water heaters with a flat plate evaporator exposed to ambient air and/or solar radiation.

The original formulation of this standard included conventional electric and gas water heaters in order to provide a unified basis for rating the load cycle performance of all residential water heaters (solar, conventional electric and gas and heat pump water heaters). The Electric and Gas Utilities objected to the inclusion of electric and gas products in the one standard and consequently the scope of the standard was changed to exclude conventional water heating systems.

This standard is used to define the level of rebate offered for solar water heaters in Victoria and is used with slight modifications to define the level of MRET Renewable Energy Certificates

The support software for this standard is now rather dated and it needs to be upgraded to incorporate improved models and a graphical user interface.

***1.3 Standards relating to design and construction of SHW systems:***

AS2712-1993

Solar Water Heaters Design and Construction

This standard was first published as AS 2712-1984. The current version is the second edition 1993.

Description: This Standard specifies requirements for the design and construction of solar hot water supply systems for household premises and for commercial and industrial installations comparable with household installations, intended to deliver potable water of acceptable quality. It is intended to cover types of systems with a volumetric storage capacity up to and including 700 litres.

The Standard does not apply to solar hot water supply systems for space heating, swimming pool heating or for large buildings such as multiple dwelling buildings.

**NOTES:**

1. The requirements of this Standard are based on systems with fixed solar orientation and inclination, but they may be applied to tracking systems. Further requirements for tracking systems will be included in the Standard at a later date.

2. Rules for the installation of household solar hot water supply systems are given in AS 3500.4. For health and safety requirements the solar water heater shall comply with AS 3498(Int).

This Standard is applicable to the following types of solar hot water supply systems:

- (a) Solar collector with remote hot water container systems, with both components supplied as a complementary and rated system, and with primary circuit piping arranged to suit site conditions.
- (b) Close-coupled or integral unit systems.

The primary water circuit flow between the collector and the container may be either thermo-siphon or forced circulation for the type described in Item (a). Supplementary water heating may be incorporated in the solar water heater system and may be either integral with the solar water heater or remote from it. Clauses 1.5, 1.12, 2.1, 2.2 and 5.1.1(e) are not applicable to solar water heaters, which do not have any supplementary heating, as is the case with solar pre-heaters.

This standard is currently being revised to cover air-source heat pump water heaters. This standard is being used to define a solar water heater for eligibility for MRET renewable energy certificates

#### ***1.4 Other Standards relating to Solar Thermal systems***

##### **AS 3634-1989**

###### Solar heating systems for swimming pools

**Description:** This Standard sets out requirements for the design, installation and commissioning of solar heating systems for swimming pools, using direct circulation of pool water to the solar collectors. The Standard does not include electrical safety requirements, altered water treatment requirements, or performance requirements. Appendices are included dealing with system design, pool covers, calculation of heating load, and collector positioning. The Standard is applicable to domestic and commercial or public pools, which are heated by solar energy either alone or in conjunction with other heating.

The standard also specifies a procedure for computing the performance of solar swimming pool heating systems in different parts of Australia. This standard was adopted as the basis for an ISO technical report (ISO TR12596).

##### **AS 2369.1-1990**

###### Materials for solar collectors for swimming pool heating - Rubber materials

**Description:** This Standard specifies the properties of ethylene propylene diene rubbers (EPDM) used in the manufacture of unglazed collectors intended for solar heating of swimming pools. The Standard is applicable to materials used for collectors that take the form of tubing, or absorber strips comprising water passages joined by a web. The requirements of this Standard are based on the assumption that the solar pool heating systems in which these materials are used will be installed in accordance with AS 3634, and that the pool water will be maintained in accordance with AS 3633.

## AS 2369.2-1993

### Materials for solar collectors for swimming pool heating - Flexible or plasticized polyvinyl chloride

**Description:** This Standard specifies the properties of polyvinyl chloride (PVC) used in the manufacture of unglazed collectors intended for solar heating of swimming pools. The Standard is applicable to products used for collectors that take the form of flexible tubing, or absorber strips comprising water passages joined by a web. The requirements of this Standard are based on the assumption that the solar pool heating systems in which these materials are used will be installed in accordance with AS 3634, and that the pool water will be maintained in accordance with AS 3633.

#### *1.5 Issues related to the above standards for solar hot water systems*

##### **Need for standards laboratories**

In common with most standard test methods the standards for testing hot water systems require laboratories with the usual high level of traceability and precision of equipment. While the training manual for the Certificate IV in Renewable Energy Technologies – Solar Water Heating Systems (Brisbane TAFE) gives methodologies for testing both collectors and complete systems to Australian Standards it is doubtful that such testing could be carried out in a training mode strictly to the standards. At the moment only the UNSW is carrying out testing of solar collectors and solar hot water systems to Australian standards. The UNSW laboratory can also test storage tanks and heat pump water heaters in two large controlled climate rooms.

The outdoor solar thermal test laboratory at UNSW is now 20 years old and it is near the end of its operational life due to continual exposure of the mechanical structures and instrumentation to the weather. The outdoor test rigs and electrical wiring and control systems need to be replaced. Support for maintenance of the facility to the level required for QAS and NATA registration is no longer available through the University funding system. External support is required to continue the services provided through this laboratory. Currently this is the only fully operational independent solar collector and solar water heater test facility in Australia.

##### **Testing difficulties**

There are several important issues with regards to the existing Australian solar hot water standards that relate to difficulties with high costs of testing, long test procedures, non-applicability of test methodologies and lack of appropriate test equipment (for some tests) in Australia.

##### **Non-applicable test methods**

The AS4234 standard is applicable to solar hot water systems that can be separately evaluated as collector and storage components. Therefore it does not readily cover integrated systems where the collector and the storage tank are incorporated into one plastic structure made up of two separately moulded components. Two alternatives are possible in such a situation:

- Make the system conform to the requirements of AS4234 by separating the tank from the collector, creating viable entities from each part and then test as per the standard. This assumes that the performance of the actual system can be represented by the AS4234

simulation program with inputs for a separated tank and collector unit. This alternative, however would not work for a fully integrated system where the collector is the tank.

- Utilise AS2984 or AS4445.1 to estimate the thermal performance of the solar system.
- Adopt ISO9459-2 as an Australian standard and test these systems as solar pre-heaters

### **Time consuming tests and high test costs**

Solar water heaters with integrated collector and tank are usually used as solar pre-heaters. There is an International Standard ISO9459-2 (see AS/NZS 4445.1:1997 above) for rating such pre-heat systems. The difficulty that has recently developed is that some manufacturers have added an in-tank electric booster with the aim of developing a low cost solar water heater with 24-hour load capability. The outdoor test standard AS2984 (and ISO9459-3) was specifically designed to evaluate complete systems that are not covered by the other standards, however, the long test time and limitation to the product configuration tested reduces the usefulness of this procedure.

System performance evaluation procedures such as AS4445.1, using a solar simulator, or AS2984 using outdoor measurements, have the advantage that the systems are tested as a black box and hence the testing authority does not need to take the system apart, or need to know the internal operation in order to determine the performance. The disadvantage of these procedures is that they are expensive to carry out or require a long monitoring period.

### **Lack of test facilities**

Currently there are no laboratories in Australia that can test to AS4445.1 requirements. This standard requires an indoor solar simulator (or thermal simulator). At the date of this report there is only one large-scale solar simulator in Australia (VIPAC), which unfortunately does not meet AS4445.1 requirements. See earlier comments above regarding the facilities at UNSW.

### **High thermal Mass**

Solar collectors with very high thermal mass are very difficult to test using AS2535.1 because of the very long time periods required to satisfy steady state conditions and the requirements to maintain input variables within quite small tolerances. Some of the newer plastic collector systems fit into this category because of the very high amount of water contained within the collector itself. It is most appropriate for these high mass collectors to be tested as part of a system test, rather than as a collector as there may be some degree of storage within the collector.

### **Heat Pump Systems**

The solar boosted heat pump water heater is covered by AS2535 and AS4234 however, there is no performance standard for air-source heat pump water heaters. There are currently three manufacturers of this class of product in Australia and it is gaining wide spread acceptance particularly in the commercial area. These products require a large controlled climate chamber for performance testing. At present there is no standard test procedure for these products.

## Contacts

The main contact persons for the Standards Australia CS28 committee are:

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## 2.0 Standards Relating to Electricity Generating RE systems

### General

The area of electricity generating RE systems is the aspect of main concern for this report, particularly regarding the relative paucity of standards and a looming need to protect consumers. A recent ACRE market survey of remote areas in Australia has shown the present RE industry is suffering due to low reliability systems<sup>4</sup>. It is our opinion that in this sector there is a need for most work. In addition the situation must be seen in an international context and in the context of an industry, which has grown relatively rapidly from small beginnings and one that is in a state of continual search for leading edge products. A number of factors have precipitated the rapid growth in RE systems over the last few decades among which are a worldwide concern over greenhouse effects and need to provide electricity for the off-grid third world.

In contrast to industry development, standards development cannot occur rapidly. Standards development involves a considerable amount of experience being developed with a product over some time to understand the most relevant issues that need to be addressed. This is needed to create meaningful standards, which improve quality of systems and components without stifling innovation and placing an unreasonable burden on an emerging industry.

The process of standards development involves someone drafting an initial document and then the document being taken by a committee of industry experts and reviewed and revised and then sent

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<sup>4</sup> ACRE Final Report, “*Renewable Energy in Remote Australian Communities (A Market Survey)*” Authors Bob Lloyd, David Lowe and Laurence Wilson. June, 2000.

out through a public consultation and review process before returning to committee for review and then an industry ballot before publication. Testing may also need to be carried out to validate a standard and/or to develop test methodology. The process usually takes considerable time. The initial stages involved in gathering of experience and initial drafting of a document can take many years depending on the knowledge base and the amount of change occurring in an industry. In the renewable energy industry there has been a rapid change in technology and an increase in the range of applications covered by systems in the field. This has made development of standards difficult. There are areas where sufficient knowledge has been acquired over the past few years to now be able to develop workable standards in some areas. These are identified under "short term goals". Other areas require further experience and these are being tackled internationally. It is vital for Australia to gain experience by participating in these international developments.

ACRE has been a major contributor to development of standards over a number of years through its project 5.31 "*Testing and Development of Standards Methodology and Protocols*" and Ted Spooner's involvement in Australian Standards committee EL42 and in the International Electrotechnical Commission's (IEC) technical committee TC82 which covers photovoltaics, systems and system's components. Standards are only as good as the laboratories in place that can test to the standards. Having standards without a competent testing facility can only frustrate industry that is expected to comply without having the ability to do so. In the area of testing and certification of renewable energy systems and components ACRELab is a major new initiative. This laboratory is equipping Australia to test renewable energy components and systems as standards develop. ACRE also continues support for Australian representation on Australian and international standards committees.

To consider where Australia is in relationship to standards for renewable energy systems it is necessary to first consider the international context. This report identifies many of the developments that are taking place internationally and identifies short and long term goals for Australia to assist in improving the reliability of renewable energy systems.

### **International developments**

The development of international standards for electricity producing RE systems is a very important area and one that has been of considerable concern because of lack of reliability of systems. It is also a very large and non-trivial area due to the extent of the number of different combinations of systems and the size variation from 20 W solar home systems to hybrid systems of several hundred kilowatts.

A number of important international efforts are in train to develop standards in this area. It must be emphasised that it is not possible to immediately put pen to paper and start writing standards in this area. The reason for this is that there is still a considerable amount of learning taking place on what are the most important aspects and parameters that affect the performance and reliability of systems. The situation is exacerbated by the large diversity of system designs and configurations in the field and more being developed in the research area (eg AC bussed RAPS systems). The other aspect is that systems are being installed in a diverse range of climatic conditions, from very cold climate alpine environments, to very hot tropical environments. To have equipment that covers the entire range of operating environments may require military specified components thus driving up the cost of systems.

Internationally standards are in various stages of development as seen in a very useful International Energy Agency (IEA) survey<sup>5</sup>. A number of international initiatives are under way to start addressing the issue of standards development in this area, and these are described below under headings of the organising bodies.

### **International Electrotechnical Commission (IEC)**

The IEC has very recently (in 2000) formed a joint working group of three technical committees, TC82 *Photovoltaics*, TC88 *Wind*, TC21 *Batteries*, to work on classification of RAPS systems, specification, contractual and technical issues. Two delegates from Australia are on this joint working group, Bob Lloyd and Ted Spooner, both from ACRE. Bob Lloyd is very much involved in the classification of systems and Ted Spooner is the technical liaison between the joint working group and TC82 technical committee. This joint working group is an important initiative as it brings a very well structured approach to the development of a range of documents covering the whole range of applications and system designs. The various technical committees will then carry out the technical work. One of the most important of these committees is TC82, which covers not only photovoltaics but also systems and balance of systems components. Ted Spooner is a member of TC82 and also a member of the working groups on systems and balance of systems components. ACRE is currently funding both Bob Lloyd and Ted Spooner's participation in these activities.

The IEC initiative is to turn the PAS 62111 document, "*General Directives for the use of REN in Decentralized Rural Electrification*", into an IEC standard or series of standards. PAS stands for Publically Available Specification and is a relatively new IEC product. It is a means by which a consortium, utility or other body can have a technical document published if a simple majority of the voting of National Committees of the applicable IEC technical committee approve. After a PAS is approved, a technical committee can chose to work on it to convert it to an IEC standard or Guide or can allow it to exist as a PAS indefinitely. The PAS document in question was a French initiative primarily focused on giving the French Utility (EDF) a guideline for implementing Decentralised *Rural Electrification* (DRE) projects in developing countries. The PAS document was written to be used by project supervisors and all those responsible for calling tenders for RE projects, mainly in developing countries. The initial document (June 1997) was voluminous with over 600 pages and the revised versions (Dec 2001) even larger. The IEC was adamant that the PAS be divided into smaller sections, which would allow the conversion to take place on an incremental basis.

The IEC have assigned a project number (IEC 62257) to the conversion work program and it has been officially included in the Programme of Work for the IEC. Normally the working group (JCG) is given 18 months to complete the "*Committee Draft*" (CD). Thus the IEC has set a target date of July 2002 for the first CD, after which the CD needs to be reviewed by National Committees (3 months) from which a new version, the CDV is prepared. The CDV is then reviewed and voted on (5 months) and the Draft International Standard (DIS) prepared and voted on (2 months).

IEC TC82 committee is also committed to producing a standard for solar home systems (SHS). ie small PV, battery, DC load style systems. The SHS is a very large international market and one where systems have had many failures in the past. ACRELab is currently testing some SHS under the draft of this new standard to verify the indoor test methodology. The TC82 committee is also carrying out work on inverters, charge controllers and grid connected systems.

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<sup>5</sup> IEA Task 3 Report "*Survey of National and International Standards, guidelines and QA Procedures for Stand-alone PV Systems*"

In addition IEC TC82 also has a strong group working in developing standards for PV modules of all types. More Australian input into this committee would be desirable in light of Australian interests in some emerging technologies i.e. PV concentrators and photochemical cells. The conventional PV technologies and even now the thin film technologies are already well covered by this committee.

The IEC initiatives are probably the most significant of the international developments in the area of standards and it is one that will have full Australian participation.

### **EU Project " Development of test procedures for benchmarking components in RES applications, in particular energy storage systems"**

The EU project is the subject of a current application for funding to the European Commission Fifth Framework Convention. The project was developed in Europe to assist manufacturers to identify important system design issues for renewable energy systems. The project is aimed at initially collecting a large amount of data from systems, which are installed worldwide. The data will be collected in a database and then used to learn how to classify systems and identify reasons why systems work or don't work in various environments and under various load profiles. The aim of the project is to provide manufacturers and system designers with data that will assist systems design and provide the industry with test philosophies and meaningful load profiles with which to test and classify systems and components. Australia has put its hand up to be involved in this project through ACRELab along with the National Renewable Energy Laboratories (NREL) in the US with which ACRELab has a formal cooperation agreement. Both ACRELab and NREL require their parts of the project to be self funded because we are outside of the EU funding arrangement. If this project does receive EU funding it is very important for Australia to be a party to the project as it will generate a considerable knowledge base which our manufacturers and industry can use for Australian and overseas projects.

### **IEA-PVPS International Energy Agency- Photovoltaics Power Systems.**

This group has provided extremely valuable survey work on a number of issues relating to implementation of PV systems. The latest work of "Task 3" within this group is particularly relevant and is a " *Survey of National and International Standards, guidelines and QA Procedures for Stand-alone PV Systems*". This document is in draft form at present but will be finalised in 2001 and published by IEA. Australia is a member of the IEA-PVPS program through a consortium of members, which include ACRE, representations from the renewable industry and electricity utilities. These members contribute financially to support a minimum participation in the IEA activities. Through this process valuable information has flowed to the members of the consortium but because of the way the consortium is funded the information has not flowed universally to Australian industry.

### **PV GAP**

The Global Approval Program for Photovoltaics (PV GAP), a not-for-profit international organisation, is dedicated to the sustained growth of global photovoltaics (PV) markets to meet energy needs worldwide in an environmentally sound manner. PV GAP's mission is to promote and encourage the use of internationally accepted standards, quality management processes and organisational training in the design, fabrication, installation, sales and services of PV systems. To this end, it partners with PV and related industries, international organisations, testing laboratories, government agencies, financing institutions, non-governmental organisations, and private

foundations, in developing and developed countries. PV GAP has been involved in developing some interim standards for PV systems and has implemented a system of laboratory certification for testing under this program. ACRELab is aiming at certification under this program by first becoming certified by the National Association of Testing Authorities (NATA) within Australia.

### **International RE Testing Laboratories**

Standards are only as good as the capabilities of the laboratories that can test to those standards. There are a number of internationally recognised testing laboratories in the renewable energy field. These laboratories include the National Renewable Energy Laboratory (NREL) and SANDIA National laboratories in the USA, Fraunhofer (Germany), ECN (Holland), Rutherford Appleton Laboratories (UK) and CANMET (Canada) to name a few of the most significant. Australia has been tardy in establishing an equivalent facility but now has one in ACRELab. ACRELab is positioning itself to become a significant force both nationally and internationally by participating in cooperative programs with the best of the international laboratories. ACRELab has a formal agreement for cooperation with NREL and Fraunhofer and will be exchanging staff in 2001 to assist in this cooperation and with obvious benefits to staff in broadening their knowledge base in the hybrid systems testing area. ACRELab also has a good working relationship with SANDIA and is exchanging ideas on test methodology and standards.

All these programs are working towards increasing the knowledge base in the RAPS systems area with the result being increased reliability of systems worldwide. Again we must emphasise that it is critical for Australia to participate in these processes internationally. Without this participation Australia will not obtain the important information needed for Australian industry to be at the forefront of international developments.

### **The Australian Situation**

#### **Existing Australian Standards**

This section contains short descriptions of the standards in Australia that specifically address renewable energy issues under headings relating to technology areas. The Australian Standards committee which is specifically charged with the development of renewable energy standards is committee EL42. Where standards are under development the contact person and the funding source for development is identified.

**Contacts:** The main contact persons for EL42 committee are currently:

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## ***2.1 Photovoltaic Panels***

### **AS 2915-1987**

#### Solar photovoltaic modules - Performance requirements

**Description:** This standard specifies the performance requirements for two types of terrestrial flat-plate solar photovoltaic modules suitable for use throughout Australia to produce electricity directly. A method of characterising photovoltaic module performance is specified. Techniques for measuring module performance are described. Environmental and mechanical tests are specified. Some of the tests and measurements described may not be suitable for application to all types of photovoltaic cells or modules, e.g. thin-film cells or photo-chemical cells.

**Status:** This is a current standard but in need of review in the light of development of many IEC standards in this area. Review of and adoption of IEC standards in this area is probably the best option.

## ***2.2 Batteries***

### **AS 4086.1-1993**

#### Secondary batteries for use with stand-alone power systems - General requirements

**Description:** This Standard specifies requirements for secondary batteries for use with stand-alone power systems. This Standard specifies requirements for all types of batteries including lead-acid and nickel-cadmium and covers both vented and sealed cells. The Standard includes tests designed to verify the capacity, efficiency and life of batteries.

**AS 4086.2-1997**Secondary batteries for use with stand-alone power systems - Installation and maintenance

**Description:** This Standard sets out recommended practices for the installation, maintenance, testing and replacement of secondary batteries, having nominal voltages not exceeding 115 V d.c., for use with stand-alone systems. This Standard applies to the installation of all types of batteries including lead-acid and nickel-cadmium and covers both vented and valve-regulated cells. NOTE: AS 3011.1 and AS 3011.2 cover requirements for batteries having nominal voltages exceeding 115 V d.c.

**Status:** This area of batteries needs more work in the future to develop classifications of batteries and testing procedures relevant to different categories of applications. Outcomes of the EU international project and the IEC joint working group are very relevant in this area. There is also a great deal of work needed in the future to develop standards for redox flow batteries which are moving out of the research area into demonstration systems.

**2.3 RE Systems****AS 4509.1-1999**Stand-alone power systems - Safety requirements

**Description:** This Standard sets out safety requirements for stand-alone power systems used for the supply of extra-low and low voltage electric power to a single residence or a small group of residences or buildings and associated items, with energy storage at extra-low voltage. Equipment up to, and including, the system output terminals is covered by this Standard.

**Status:** Current.

**AS4509.2 2001?**Draft Stand-alone power systems - Part 2 System Design Guidelines

**Description:** This standard sets out guidelines for the design of stand alone power systems with energy storage at extra low voltage (ie less than 120V dc) and used for the supply of extra low voltage and low voltage electric power in a domestic situation. Equipment up to the system output terminals is covered. Methodologies and formulae are given for assessing loads and renewable energy input from PV, wind and micro hydro sources. The principles in this Standard can be applied to other systems including commercial and industrial applications.

**Status:** DRAFT. This document is in the final review stages before publication later this year dependent on the results of a industry ballot.

**AS Committee:**

EL42

**Entity Responsible for Development:**

EL42, SEIA, ACRE

**Contact Person:**

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**Funding Source for Development work:**

NSW Department of Energy  
 Australian CRC for Renewable Energy ACRE  
 Australian Greenhouse Office  
 Department of Mines and Energy, Queensland.

**AS 4509.3-1999**Stand-alone power systems - Installation and maintenance

**Description:** This Standard sets out requirements for the installation and maintenance of stand-alone power systems used for the supply of extra-low and low voltage electric power to a single residence or a small group of residences or buildings and associated items, with energy storage at extra-low voltage. Equipment up to, and including, the system output terminals is covered by this Standard.

**Status:** Current.

**2.4 Solar Water Pumps**

No Australian standards currently exist for solar water pumps; components may be covered by other standards.

**2.5 Wind Generating Systems**

Apart from a brief mention in AS 4509.1 – AS4509.3, there is little coverage of wind generating systems (taken here to comprise the turbine and tower) in Australian standards. For large, grid-connected turbines, which are normally installed in wind farms, most Australian authorities require design certification and type approval to IEC 61400-1 Wind turbine generator systems – Part 1: Safety requirements. The corresponding standard for small turbines is IEC 61400-2 Part 2: Safety of small wind turbines, which has been available since 1996. This standard, however, is widely perceived as inadequate. Independent correspondence has been received from Poul Hoejholdt (RISO wind test centre Denmark) also complaining about this standard. Experience here is in short supply as only about six small turbines in the world have currently been approved to this standard. The main problem is that it can cost up to \$100,000 to obtain full type approval for a small turbine. IEC 61400-2 is currently under revision by IEC committee MT2, of which David Wood is a member. It is unlikely that compliance with the revised standard will be any cheaper. However, it is noted that the U.S. Department of Energy's small wind turbine program, which is funding the development of four turbines of 40 kW output or less, will include testing to IEC 61400-2. IEC committee, MT2, will probably make significant changes to IEC 61400-2. The first is to redefine "small turbine" to have a rotor area less than 200 m<sup>2</sup> equivalent to a diameter of 16 m, and a nominal power of less than about 80 kW. There is a further subdivision in that micro-turbines of area less than 2 m<sup>2</sup> (less than 1 kW in output) will not need to have the tower included in the certification. Of course, the tower would still have to comply with AS 1170.2-1989 and AS 3995-1994.

Noise output is covered by a number of standards, of which NZS 6808:1998, Acoustics- The Assessment and Measurement of Sound from Wind Turbine Generators is probably the most used in Australia. The Australian Wind Energy Association is pushing for its formal adoption for large turbines. There are no inherent difficulties in applying this standard to small turbines. It should be noted that in all noise standards, the permissible noise levels are left to the local authority covering the turbine site.

**International Contact:** MT2, which is charged with revising IEC 61400-2, is chaired by

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### **AS 1170.1-1989**

Minimum design loads on structures (known as the SAA Loading Code) - Dead and live loads and load combinations

**Description:** This Standard sets out requirements for establishing the minimum dead, live, wind, and snow loads, as well as load combinations to be used in the limit state design of structures and members. This Standard does not provide criteria on load combinations for permissible stress design.

### **AS 1170.2-1989**

Minimum design loads on structures (known as the SAA Loading Code). Part 2: Wind loads

**Description:** This Standard sets out procedures for determining design wind speeds and wind loads to be used in structural design of all buildings and components of buildings, bridges (minimum design wind speed only), and other structures subjected to wind. Major offshore structures remote from the coast and transmission lines are not covered, nor are the effects of tornadoes, which are special-event winds. The design wind loads for structures containing high-risk contaminants, such as some nuclear or biological materials is considered outside the scope of this Standard. This Standard does not attempt to account for possible future climatic changes.

In the context of wind turbines, the main difficulty with this standard is its lack of detail on micrometeorological effects. For example, Figure 2.5.1 of the standard defines a number of regions in Australia to account for the large-scale variation in wind loads, but no information is given on a finer scale. It would be unfair to require this from the standard, but it does point to a problem in that it is relatively expensive to determine local wind conditions prior to installing a small turbine.

**AS 1170.3-1990**Minimum design loads on structures (known as the SAA Loading Code) - Snow loads

**Description:** This Standard sets out data and procedures for determining snow loads to be used in structural design.

**AS 3995-1994**Design of steel lattice towers and masts

**Description:** This Standard sets out procedures for the determination of design wind speeds and wind loads to be used in the structural design of steel lattice towers and masts for communication purposes. It further sets out the basis for the strength assessment of members and connections of lattice towers and masts. This Standard incorporates design and analysis of guyed lattice towers and masts, design of cable tension members, footing design and criteria for assessment of existing structures. Guidance relating to maintenance and inspection, and access to steel lattice towers and masts is given in the Appendices. It is not intended to apply to the structural design of transmission line structures. The design of aluminium and cold-formed steel, other than those complying with AS 1163, is not covered by this Standard, except in relation to access to the lattice towers and masts.

Small wind turbines exert a gravity load and a thrust load on the tower. The first is easy to determine and the second can be estimated according to the procedure being developed for IEC 61400-2. In addition, the blade rotation and the yawing of the turbine may cause dynamic interactions with the tower that are unique to this application of lattice towers and masts. For example, it may be impossible to prevent the tower from having natural frequencies less than that corresponding to the blade passing frequency at rated power. This issue will be addressed in IEC 61400-2.

**2.6 Micro Hydro generating systems****General**

Micro-hydro systems have been classified as systems with peak electrical outputs of 100 kW or less, although sometimes mini-hydro systems (100 kW to 1 MW) are grouped with the smaller systems. This discussion deals with both micro- and mini-hydro-electric systems. Low-voltage (12 to 100V), direct current micro-hydro systems are available at the smaller end of the range (less than 2.5 kW). These small turbines are available 'off-the-shelf'. Very small AC systems 0.8 to 7 kW are also available. The larger AC turbines (up to 1 MW) are generally designed for the specific site and application (i.e. one-off designs). The larger units are particularly attractive for applications where pressure reduction valves can be replaced with mini-hydro systems. The requirements for standards and training differ depending on the size of the system being considered.

**Standards**

There are no Australian Standards dealing with micro- or mini-hydro systems or turbines. If the system produces 240V AC or higher voltages, the Australian Standards AS3000 series applies.

This series deals with electrical wiring, general requirements for equipment and test specifications (AS 3100+ standards).

The market for the smaller size micro-hydro systems with DC outputs is price driven. There are no formal quality controls. There appears to be no industry call for turbine standards for these smaller units.

The larger units (say 5 kW to 1 MW) are engineered for specific applications. In some cases, clients are requesting commissioning tests to IEC (International Electrotechnical Commission<sup>6</sup>) standards (for example IEC62006 *Hydraulic Machines – acceptance tests of small hydro turbines*). The IEC standards are intended for much larger systems. For mini-hydro systems the costs of testing to IEC standards can be larger than all other costs associated with an installation. Thus, there is a need for more appropriate commissioning standards for mini-hydro systems in Australia. One difficulty is timing, as it is expected that the demand for mini-hydro systems in Australia will peak within the next five years. Thus if a Standard is to be developed it would have to progress quickly if it is to meet the immediate demands of the industry.

## **2.7 Grid connect devices**

No standards currently exist for grid connect devices (inverters). Guidelines do, however, exist.

### Guidelines for grid connection of energy systems via inverters

**Description:** This guideline describes the requirements for installation of systems and requirements for the inverter. The guideline was written with a focus on PV systems but is general enough to cover all forms of generation provided the connection to the grid is via an inverter.

This guideline specifies installation requirements for inverter energy systems with ratings up to 10kVA for single-phase units or up to 30kVA for three phase units, for connection to the low voltage distribution network. The guidelines also specify performance requirements for inverters and grid protection devices used in these energy systems. These standards would improve the quality and consistency of systems being installed and also assist suppliers and utilities in streamlining the approval of systems.

**Status:** This is currently a generally accepted industry guideline. The subcommittee EL42/3 is in the process of converting these guidelines into two standards. One standard will address the inverter and protection requirements for these systems and the other will address installation requirements. An important meeting of the subcommittee on 12/12/2000 discussed the approval process for inverters.

It was agreed that the process using Certificates of suitability was the best path to expedite approval of inverters for grid connection. Certificates of suitability are issued by most states and are recognised mutually. They provide identification of approved items as well as a formal data base of approved items. They are issued under authority of “electrical safety acts” by bodies in each state. There is a strong preference for a relevant Australian Standard(s) to which the inverters should be tested but other (international) standards or documents can be used.

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<sup>6</sup> IEC information is available at <http://www.iec.ch/>

Because of this there is an urgent need to expedite the drafting of these standards and money has been supplied by AGO to fund a technical writer to assist in this process.

**Contacts: AS Committee:**

Sub committee EL42/3

**Entity Responsible for Development:**

Initially ESAA and ACRE. ACRE and EL42 is continuing the development.

**Contact Person:**

Mr Ted Spooner (ACRE)

**Funding Source for Development work:**

Australian CRC for Renewable Energy ACRE

Australian Greenhouse Office.

**2.8 Backup gensets**

Although the backup generating set (usually diesel) are not of course RE systems they are standard components of most hybrid RE systems and so will be covered in this report to the extent they are needed for hybrid systems.

**AS 3010.1-1987**Electrical installations - Supply by generating set - Internal combustion engine driven sets

**Description:** This Standard sets out the minimum safety requirements related to the use of generating sets for the supply of electricity at voltages normally exceeding 32 V a.c. or 115 V d.c. It applies to electricity generating sets that are driven by internal combustion engines, and which are used for the supply of fixed electrical installations in buildings or items of electrical equipment. This Standard does not (a) set out performance and constructional requirements for generating sets; or (b) specifically apply to specialised automatic sources of supply, e.g. no-break systems or generating sets belonging to Electricity Generating or Supply Authorities.

NOTES: 1. Requirements for the performance and construction of transportable generating sets up to 25 kW are given in AS 2790. 2. Requirements for the design, installation and operation of emergency power supplies in hospitals are given in AS 3009. 3. Attention is drawn to the fact that some Regulatory Authorities have requirements for limitation of noise and pollution generation.

## 3.0 Wood-heaters

### General

A suite of Australian Standards has been prepared over the past 15 years dealing with safe installation of solid-fuel burning appliances, appliance quality, appliance performance (efficiency, heat output rate), and emission of particulates. The safety, performance and emissions standards are widely used by most sectors of the industry and have shaped the on-going development of wood-heaters in Australia.

The domestic solid fuel burning appliances standards are aimed specifically at residential wood-heaters<sup>7</sup>. However, the safety and construction standards also apply to solid-fuel burning cooking stoves, water heaters and central heating furnaces. Virtually all the solid-fuel used in the residential sector in Australia is firewood (including small quantities of extruded logs made from wood-waste). Very small quantities of brown-coal briquettes and black coal are also used.

### Testing

Testing to Australian Standards for wood-heaters is carried out in two NATA registered commercial laboratories, one in Victoria and one in South Australia. Initial development of the wood-heater standards and commercial testing was carried out at the University of Tasmania supported by grants from the National Energy Research and Development Program and private industry. All testing is now carried out on a strictly commercial basis without any specific government subsidy.

### AS2918-1990

#### Domestic solid fuel burning appliances - Installation

**Description:** This Standard specifies requirements for the installation of domestic solid fuel burning appliances, which can be fully assembled prior to being transported to the installation site. It does not cover the installation of appliances, which must be assembled in situ, or appliances with electrically-driven fuel stoker systems.

**Comment:** The installation standard for residential solid-fuel burning appliances was first published in 1987. It was revised in 1990 to remove some ambiguities that became apparent once it became widely used throughout Australia. The Standard adopts a performance based approach to safe installation, allowing appliance manufacturers and importers to specify their own installation requirements provided they pass a stringent test conducted by a NATA registered laboratory<sup>8</sup>. The test procedure is detailed in an appendix to the Standard. Certain critical safety features of an installation are specified (i.e. not determined by test), such as the minimum size of the floor protector (hearth). The Standard also sets out requirements for untested installations (i.e. worst case criteria) to cater for the small number of appliances that have not been tested.

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<sup>7</sup> The term 'wood-heaters' is used in this report to refer to a solid-fuel burning residential space-heating appliance in which the combustion air can be controlled. In North America the term 'woodstove' is commonly used for these appliances.

<sup>8</sup> There are two laboratories in Australia registered by NATA (National Association of Testing Authorities, Australia) for testing to AS2918: Amdel in Adelaide and HRL in Churchill, Victoria.

Appliances covered by this standard include wood-heaters, prefabricated open fireplaces, wood/coal fuelled cooking stoves, solid-fuel burning water heaters, and solid-fuel burning central heating appliances. The standard does not cover appliances that are assembled on-site (e.g. masonry fireplaces) or appliances with electrically driven fuel stoking systems. The standard applies to the appliance itself and the associated flue system.

This Standard was prepared in response to urgent requests by the insurance industry and the wood-heaters industry following a large number of house fires caused by poorly installed wood-heaters in the early 1980s. The Australian Standards Committee CS/62 has been responsible for preparation and revision of this standard. The Standard has been called up in building regulations in all states and territories and is called up in the Australian Building Regulations.

**Status:** The Standard is undergoing a second major revision. It is intended to revise the Standard as a joint Australia/New Zealand Standard. However, the revision has been slow because of failure to reach agreement between Australia and New Zealand representatives on the Committee on safe ceiling penetration systems for flues. The present Australian requirements are more stringent than in New Zealand. The Standard has reached the pre-publication voting stage. The revised Standard will also pick up the International Standards test method for determining whether or not a specified installation is safe. The International Standard ISO10774:1992 (*Solid fuelled heaters -- Test method for determining allowable clearances from combustible surfaces*) was developed by ISO Committee TC116/SC3 and is based on both the Australian and US Standards. Including the International Standard, as an approved test method within the Australian Standard will be an advantage for local appliance manufacturers because their testing will be recognised in other countries, thus reducing costs associated with export.

**Contacts/funding:** No funding is available for the revision of the standard. Costs have been met by CS/62 Committee Members. The contact person for the Committee is the Executive Officer, Mr Anthony Hayward-Bryant ([Anthony.Hayward-Bryant@standards.com.au](mailto:Anthony.Hayward-Bryant@standards.com.au)).

## **AS/NZS 3869:1999**

### Domestic solid fuel burning appliances – Design and construction

**Description:** This Standard specifies requirements for the design and construction of domestic solid fuel burning appliances, which can be fully assembled prior to being transported to the installation site. The design and construction standard for residential solid-fuel burning appliances was first published in 1991 as AS3869-1991. It was revised in 1999, creating a joint Australian/New Zealand Standard. The Standard specifies materials (e.g. the type of steel and thickness) for various components of solid-fuel burning appliances based on the maximum temperatures reached during a specified test process. The aim of the Standard is to ensure the durability of the appliance. The Standard applies to space heating appliances (including central-heating furnaces), cooking appliances, and water heating appliances. It does not apply to appliances with flue outlets with a cross-sectional area greater than 100 000mm<sup>2</sup> or to the ducting used in central heating units.

The Standard was based on the experience of manufacturers represented on the Standards Committee and feedback from researchers, other sections of the industry and steel manufacturers during the public comment periods. Overseas Standards, particularly US and Canadian, also provided background information during development of the Standard.

**Status:** This standard has not been called up in any Australian legislation (i.e. it is purely voluntary). No manufacturer has had any appliance model tested to this Standard by NATA registered laboratories. However, the Standard is widely used by manufacturers when designing new models as a guide to materials and components. It appears the commercial benefits of gaining the “Standards Mark” for an appliance have not been seen by the industry as exceeding the cost of testing to the Standard. In practice, the durability of wood-heaters appears good, with an average lifetime of around 15 years.

### **AS/NZS4012:1999**

#### Domestic solid fuel burning appliances – Method for determination of power output and efficiency.

**Description:** This Standard sets out a method for the determination of the average efficiency and average thermal power output from a batch-fed domestic solid fuel burning appliance. The performance test method standard was first published in 1992 as AS4012-1992. It was revised and published as a joint Australian/New Zealand Standard in 1999. The Standard provides a test method, using a calorimeter room<sup>9</sup>, for accurate measurement of heat output rate (power) and efficiency of residential solid-fuel burning heating appliances. The Standard specifies design parameters, measurement accuracy and calibration procedures for a calorimeter room. It also specifies a ‘real-world’ fuel and operating procedure for the appliance<sup>10</sup>.

The Standard applies to solid-fuel burning space-heating appliances (including those fitted with water heating devices). It does not apply to masonry fireplaces, cooking stoves, central heating appliances or water-heating-only appliances.

The Standard was developed in response to industry and consumer group requests for a standard method of measuring and reporting appliance performance due to some misleading claims by manufacturers/retailers about appliance performance. For example, some appliances were claimed to achieve 99% efficiency, which is possible if only combustion efficiency is reported, ignoring heat transfer efficiency. The Standard measures and requires reporting of the total efficiency, which is the product of the combustion and heat transfer efficiencies. Also, the Standard requires labelling of the appliance with the average efficiency measured at high, medium and slow burn rates and the average heat output rate for the high burn rate cycle.

**Status:** This Standard is indirectly called up in State legislation because it is an integral part of the emission standard (see next section). Testing for emission certification purposes must be carried out in a NATA certified laboratory, but several manufacturers have constructed their own calorimeter rooms for product development purposes.

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<sup>9</sup> A calorimeter room is a well-insulated enclosure with a known flow of air through it. By measuring the air flow out of the enclosure (some air enters the appliance and exits through the flue, this air is excluded from the calculation) and the temperature rise of the air an accurate measurement of heat output of the appliance can be determined.

<sup>10</sup> Some overseas performance measurement standards specify ‘artificial’ fuel loads (e.g. zero free moisture and sawn timber) so that fuel parameters can be closely controlled. The Australian Standard specifies air-dry, split logs and reduces statistical error by requiring repeat testing (a minimum of three duplicate tests at each of high, medium and slow burn rates).

The Australian Standard formed the basis for an International Standard for performance testing of solid-fuel burning appliances.

**AS/NZS4013:1999**

Domestic solid fuel burning appliances – Method for determination of flue gas emission.

**Description:** This Standard specifies a test method for determining the rate of particulate emission from batch-fed domestic solid fuel burning appliances and the associated particulate emissions acceptance criteria. The emissions test method standard was first published in 1992 as AS4013-1992. It was revised and published as a joint Australian/New Zealand Standard in 1999. The Standard provides a test method, using a dilution tunnel, for accurate measurement of particulates emitted by residential solid-fuel burning heating appliances. The Standard specifies design parameters, measurement accuracy and calibration procedures for a dilution tunnel<sup>11</sup> that must be operated in conjunction with a calorimeter room (AS/NZS4012). Emission testing can be carried out simultaneously with performance (power and efficiency) testing.

The Standard applies to solid-fuel burning space-heating appliances (including those fitted with water heating devices). It does not apply to masonry fireplaces, cooking stoves, central heating appliances or water-heating-only appliances. Nor does it apply to heating appliances that have heat output rates greater than 25kW or appliances where the carbon dioxide concentration in the flue at high burn rates is less than 5% by volume. These last two exceptions relate to the difficulty in carrying out tests in the laboratory, rather than any suggestion that emissions from these appliances are less significant.

The Standard was developed in response to requests from pollution control authorities and others concerned about the impact of wood-smoke on urban air quality. The Australian Wood Heating Association<sup>12</sup> also supported development of the Standard.

The Standard includes an upper limit for acceptable particulate emissions of 4 grams of particles per kilogram (oven-dry weight) of fuel burnt. This emission factor was reduced from 5.5 g/kg (in the 1992 Standard) to 4 g/kg at the request of pollution control authorities.

**Status:** The emission Standard has been called up in legislation in most Australian states and territories<sup>13</sup>. The legislation varies from state to state, but generally it applies at point of sale (i.e. it is not retrospective). In some cases the legislation does not allow modification of the pollution reduction features of the appliance (e.g. in Western Australia), but in other cases modification is legal (e.g. Tasmania).

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<sup>11</sup> A dilution tunnel consists of a hood and exhaust duct system that captures all the smoke emitted from the top of a 4.6m high flue and dilutes and cools the smoke with excess air from the test laboratory. The cooling process condenses volatile organic compounds forming ultra-fine particles, as occurs in the free atmosphere. A sample of the air/smoke mix is extracted from the dilution tunnel and particles captured on a filter for subsequent analysis.

<sup>12</sup> Now the Australian Home Heating Association (AHHA).

<sup>13</sup> At time of writing (February 2001) Victoria and South Australia did not have legislation calling up this standard, but in both cases legislation was proposed.

**AS/NZS4014:1999****Domestic solid fuel burning appliances – Test Fuels**

- Part 1: Hardwood
- Part 2: Softwood
- Part 3: Lignite briquettes
- Part 4: Sub-bituminous coal
- Part 5: Semi-anthracite coal briquettes

**Descriptions:** This set of Standards sets out a method for the determination of hardwood [softwood/ brown coal or lignite briquette/ coal/ semi-anthracite coal briquette] test fuels to be used when applying the test methods described in AS/NZS 4012 and AS/NZS 4013. The set of five standards dealing with test fuels is an integral part of the performance and emission test standards. The standards set the acceptable range for physical parameters of each fuel type for use in the appliance testing. Parameters such as density, moisture content, calorific value, and piece size are specified. Virtually all the testing done in Australia is done with hardwood fuel.

**Inadequate Existing Australian Standards****Solar Hot Water Systems****AS4234-1992**

This standard needs to be updated to include improved models and to incorporate a graphical user interface for the included software.

**AS2712-1993**

This standard is currently being extended to include air source heat pump water.

**Electricity generating systems****Solar****AS 2915-1987****Solar photovoltaic modules - Performance requirements**

This standard is probably out of date and needs to be revised or replaced by newer IEC standards, which already exist. This requires reviewing of the IEC standards by Australian manufacturers for adoption in Australia. The other existing Australian standards are relatively new and probably do not need revising at this stage but there are many standards, which need to be developed.

**Wind**

The present standards relate only to the towers and support structures, there is a need to adopt the international IEC standard to cover small turbine systems.

## **Wood-heaters**

The suite of standards available appears to meet current industry and control authority needs (subject to revision of the installation Standard as discussed below). No new standards have been proposed.

## **New Australian Standards to be Developed**

Because of the considerable time involved in standards development the discussion below will be framed in terms of short and long-term goals. The short-term goals relate to more urgent objectives or ones that are partly in place and so could be completed more easily. The longer-term goals should also be pursued but may need more interaction with the appropriate institutions and so need to be framed over a longer time span.

### **Short Term Goals**

There are a number of standards for which we already have adequate knowledge to enable workable standards to be drafted. These standards could be rapidly developed provided adequate resources were made available.

### **Solar Hot Water systems**

#### **Heat Pump Systems**

There is a need for a new performance standard for air source heat pump water heaters. Ideally this would be a procedure based on component tests and a simulation to predict the annual performance of a range of models assembled from the tested components. This will require considerable development and access to large controlled condition test rooms.

### **Electricity generating systems**

#### **DC PV arrays**

There are no standards in Australia, which cover the connection, safety and protection of PV arrays. It might be noted here that PV has completely different characteristics to conventional sources of electrical energy. It has limited fault capacity (i.e. it can be short circuited without any problems) and it is powered continuously while exposed to sunlight (this source can not be turned off easily). There are specific requirements for safety and installation requirements for wiring of PV arrays, which are not addressed, in the Australian wiring rules (AS 3000). These issues are being addressed by IEC in draft standards and are covered in the US by a specific section of their NEC. The need for this standard has been identified by Australian standards committee the E1 42 and a sub-committee chairman Mr Paul Edwards of the Queensland Office of Mines and Energy, has been appointed to address these issues but due to pressure of other work in E1 42 this committee has not been convened as yet.

#### **Grid connected inverters**

A standard relating to this topic is already under development as mentioned earlier. There is a current document entitled "Guidelines for grid connection of energy systems via inverters". It is in

the process of conversion to a standard under the direction of Standards Australia committee EL42/3. Technical writing has been funded by AGO to accelerate this process.

### **Basic inverter performance and safety for RAPS systems.**

An initial standard could be rapidly developed covering safety, isolation and basic performance of inverters as a start to a broader more all encompassing document in the future. This document needs more research and consultation with manufacturers and suppliers of systems but is a document that could be written now with a little background research.

Further work would be required on other parts of this document in the future to improve quality of inverters from the point of view of ruggedness of construction, and ability to withstand an often hostile environment ie vibration, dust, heat and humidity.

Minimum Standards may also be able to be developed in the area of user interface, which would greatly assist consumers in understanding these products.

### **Industry Contracting**

A standard form of industry contract is needed similar to that which is used in the building industry. The contents of this contract need to be developed so that purchasers of RAPS systems and other renewable energy systems are aware of exactly what they are getting and are fully aware of the limitations of systems. This could be done by or in consultation with the industry body SEIA. It would also be useful to include in this contracts package an information booklet for purchasers, which would make them aware of the important issues associated with the purchase and longer-term use and maintenance of these systems.

### **Wind**

The main urgency here is to first satisfactorily revise the international standard, IEC 61400-2, and then have it adopted by Australia. If it is adopted then some other Australian standards will need revision for compliance – see comments relating to AS 4509.3- 1999

### **Micro-hydro**

A standard is needed fairly quickly for micro-hydro systems as industry feedback suggests that the lack of a standard is a problem now and that installation work will peak within 5 years.

### **Long Term Goals**

#### **Solar Hot water**

There is a need for a unified water heater test standard. The performance standards for all forms of residential water heaters should be combined to give a common rating measure for all products and a unified CO<sub>2</sub> rating. This work needs to also address consumer information labeling.

#### **Electricity generating**

#### **RAPS: New System Standards Needed**

The most important area of reliability is in the area of Remote Area Power Supply (RAPS) systems and components. This is a very large and non-trivial area. A number of important international efforts are in train to develop standards in this area as mentioned earlier. It is important that

Australia maintains and preferably increases its participation in this international effort. It is through this sort of participation that Australians become intimately aware of all the issues needed to produce reliable systems. Suggested standards, which need to be developed longer term, are listed below. Note that it is thought that a considerable amount of research data gathering and technical writing is required before some of these standards can be produced.

### **Inverter Standard**

The Basic inverter performance and safety standard mentioned in "short term goals" needs to be expanded to cover ruggedness of construction, and ability to withstand hostile environments i.e. vibration, dust, heat and humidity. Participation in the current project of IEC TC82 on inverters and charge controllers will assist in the development of a useful standard in this area.

### **Charge controller standard**

Currently there is no Australian or international standard for charge controllers. This is one of the reasons for poor reliability of systems as charge controllers can directly affect the life of battery systems. This is a non trivial area because there are a number of battery types used and a number of applications and environments under which these controllers are used but a basic standard should be able to be written which would improve the general performance and weed out very poor performers.

### **System Controller standard**

Currently there is no Australian or international standard on system control. There is a longer-term need for such a standard but a large amount of information, system data and experience needs to be gathered to develop a standard. The IEC joint working group and the EU project are aimed at increasing the knowledge base in areas, which will assist in developing this standard.

### **RAPS Battery standards**

Work is required in the future to develop classifications of batteries and testing procedures relevant to different categories of applications. Outcomes of the EU international project and the IEC joint working group are very relevant in this area. In addition there is a need for a standard which covers battery banks above 115 Vdc for use in RAPS applications i.e. in larger packaged systems such as are becoming available. Currently there is only a RAPS battery standard which covers batteries not exceeding 115 Vdc. i.e. AS4086 pt 1 and 2. There are battery standards, which cover batteries with voltages above 115V, which are mounted in buildings, i.e. AS2676 pt 1 and 2 and AS3011 pt 1 and 2 but not for RAPS applications

### **Redox flow batteries**

Australia is involved in the Zinc Bromine and in the Vanadium batteries. There is a need in the future to develop standards for redox flow batteries, which are moving out of the research area into demonstration systems.

### **Rating system for PV modules.**

Good international standards exist in the areas of conventional PV technology with a possible exception of a rating system, which covers a more realistic set of operating conditions other than

Standard Test Conditions (STC) at 25°C. This is currently the subject of a comprehensive new work item proposal to IEC TC82. If this is developed then Australia should adopt this standard.

### **Standards relevant to new PV technology**

Australian companies and research organisations have been at the forefront of PV developments for many years and are currently developing a number of new technologies. eg concentrator systems, thin film and photochemical cells. It is important for those Australian companies to keep in touch with and be involved with the development of international standards which influence design, qualification, type approval and rating of modules to ensure that these new technologies are not disadvantaged by existing or new standards.

### **Adoption of International PV standards**

It is important that all PV manufacturers in Australia be involved in a review of international PV standards with a view to adoption of these standards in Australia.

### **Standards for Solar Home System (SHS)**

Solar home systems are not common in Australia but are a potential major export market. These systems are distributed extensively through developing countries. IEC has a draft standard for design, qualification and type approval of these systems. It is important that when this becomes available that Australian manufacturers and suppliers have their systems tested to this standard before exporting product.

### **Fluorescent Lights and other DC loads for Solar Home Systems**

The efficiency and reliability of DC loads connected to solar home systems can significantly affect the reliability and life of these systems it is important to put in place some standards for DC loads for use in these systems. This situation is particularly true for fluorescent lights, which are used extensively and are of very variable quality and performance.

### **PV water pumping systems**

There is a need for a standard for design, qualification and type approval of PV water pumping systems. IEC identified this need in 2000 with a new work item proposal. These systems are used in Australia and in developing countries but are generally more reliable than systems, which include batteries so the need is not as pressing as for other standards.

Guidelines on metering of grid connected and RAPS renewable energy systems.

It would probably assist the industry if a document existed discussing the options available for metering of renewable energy systems connected to the grid and for RAPS applications. The electricity utilities control the metering arrangements and these are not uniform across Australia for renewable energy systems. This causes some confusion and increased cost for installers and can have significant implications for obtaining yield figures for the renewable energy component of systems. The standardised metering will also assist CO<sub>2</sub> emissions certification.

## **PART 2: Training**

Australia is a recognised world leader in renewable energy education with well-developed courses available at all levels including university research training, undergraduate and postgraduate coursework, TAFE (Technical and Further Education) and short courses for industry and Government. While ACRE staff have been intimately involved with teaching and organising education and training opportunities for RE in Australia over all these sectors for the last four years or so, it was thought prudent to carry out a national survey to make sure no areas were left uncovered. This report does not, however, include courses run at secondary level including secondary level vocational courses.

### **Methodology**

A survey was carried out covering three main sectors that is:

- Universities - courses and research training
- TAFE Colleges
- Industry and Government agencies

A questionnaire was sent to key people in each of these sectors to identify possible course offerings and this was followed up with email and telephone discussions.

A tabulated summary of the results for each sector is attached as Annex B.

### **Courses Offered and Training Needs**

The current education and training offerings in renewable energy have developed largely in response to student demand and industry needs. Considerable course development is now occurring in response to increasing demand. This demand has arisen from acceleration in deployment of systems due to several Government initiatives. These initiatives in turn have been driven largely by global environmental concerns and both local and international pressure to meet a more sustainable energy scenario within Australia.

#### **University Courses**

University level courses include undergraduate and postgraduate degrees in renewable energy and research degrees on various aspects of renewable energy technology. They include science and engineering degrees but we have not included single units or parts of units that do not form part of a clearly identifiable and coherent program of study in renewable energy technology and systems. Similarly courses in energy management and energy policy and planning have not been included because they fall outside the terms of reference. Although not clearly specified in the terms of reference we have included those universities that offer research degrees and training in the area of renewable energy technology.

The University courses are generally aimed at the initial or further training of engineers and scientists who wish to work in the renewable energy industry or to undertake research and development.

In the University sector new courses, specifically aimed at renewable energy technology, have been introduced over the past three years by Murdoch University, the University of Melbourne, Curtin University of Technology and the University of NSW. At the undergraduate level, Murdoch University offers a Bachelor of Engineering in Renewable Energy and UNSW offers a Bachelor of Engineering in Photovoltaics and Solar Energy. Murdoch University will offer a new undergraduate Bachelor of Science course in Energy Studies commencing in 2002. At the postgraduate level, Murdoch University offers a Master of Science by coursework in Renewable Energy.

The University of Melbourne has had, for a number of years, a well-established Masters by coursework in Development Studies with a renewable energy stream. It recently introduced a Master of Energy Studies with more of an emphasis on renewable energy technology. The University of New South Wales and Curtin University have recently introduced a major, in Photovoltaics and Renewable Energy respectively, in their Master of Engineering degrees. In addition many Universities offer one or two units at undergraduate or postgraduate level, mostly in engineering that cover renewable energy technologies and applications. Several Universities are now considering the further development of their offerings into full courses.

These existing and proposed courses are striving to cater for current demand for highly trained scientists, engineers and policy analysts to support the growth of the renewable energy industry. The Murdoch University MSc course is available on line and via print based correspondence to external students throughout Australia and overseas, without the need to attend the campus. The proposed Murdoch BSc in Energy Studies will also be available on line in the same way. All of the other courses (including the Bachelor of Engineering degree at Murdoch) are offered in face-to-face mode only and require on-campus attendance. It is considered that there is a need for more courses at both the initial training BSc/BEng level as well as advanced courses, such as MSc/MEng, for continuing education of professional people in the workforce. These courses by their nature will need to be available by flexible delivery, including distance education (on line) and flexible arrangements for completion of experimental/competency requirements. This is an area where the Commonwealth Government has special responsibilities and where Government policy can directly influence the quality and quantity of the outcomes.

The enrolment of professionals in advanced courses in renewable energy has been hampered by the introduction of full fees, payable in advance, for higher degrees by coursework. The recent change in Commonwealth Government policy on this issue, proposing the introduction of student loans and deferred repayments from 2002, may help to make this option more attractive to professionals wishing to redirect their careers into renewable energy. In addition there has been reluctance by utilities, industry bodies (such as ESAA) and government bodies to assist their staff with the cost of the fees for further study or professional development in the area of renewable energy, with most students having to fund the costs themselves.

Research training in the area of renewable energy design and installation at the MSc/MPhil/PhD level was identified at 10 universities but could obviously be carried out, with regard to some aspects, at many more. ACRE and the Key Centre for Photovoltaic Engineering at UNSW have major responsibilities in this area with both these bodies providing postgraduate training programs and offering scholarships to attract high quality graduates into the field. There is a strong demand from high quality applicants for these scholarships. A supply of well-trained renewable energy researchers is essential to support the research and development needs of the renewable energy industry and to provide advanced level teaching capability in the Universities. This is an area where Commonwealth initiatives have been very important and additional support is needed urgently to overcome the severe shortage of specialist researchers in this field.

## **TAFE Courses**

The Technical and Further Education (TAFE) courses in renewable energy are generally offered at the two-year duration Certificate IV level of qualification. These are designed to prepare trades people to design, install and maintain renewable energy systems. TAFE also offers some short courses on specific technologies or applications, which are designed for further, in-service training of people working in various areas of the industry.

In the TAFE sector renewable energy design, installation and maintenance courses are available only in Queensland, Victoria, WA and the Northern Territory. Chisholm TAFE in Victoria has started to provide two modules (Introduction to Renewable Energy Technology and Solar Water Heating Systems) leading to a Certificate level IV course on-line.

Renewable Energy training at TAFE level is currently being accredited nationally by the Australian National Training Authority (ANTA) through incorporation into the Electrotechnology National Training Package. This includes the extension of the Certificate IV to Diploma Level and the introduction of several new renewable energy related modules. This process, including the completion of the module descriptors and competencies, is expected to be completed by the end of 2001.

The Brisbane Institute of TAFE (BIT), with assistance from ACRE, is developing materials for external and on line study to Certificate IV level. Some of these materials are already available and all of the required Certificate IV modules are due to be fully available by the end of 2001. The availability of these materials will help to address deficiencies in other States but there is clearly a need for a coordinated national approach to TAFE training in renewable energy technology. The appropriate materials are available from BIT but they need to be provided in each State in order to address the need for qualified trades people to support the growth of the industry and to maintain high standards of design, performance and maintenance of renewable energy systems.

One of the outstanding issues in this area is the testing of competencies required under the new National Training Package (NTP), and for Sustainable Energy Industry Association (SEIA) accreditation. Generally SEIA accreditation is required for trades people who wish to participate in Government-sponsored renewable energy programs. Both the Australian National Training Authority (ANTA) National Training Package and SEIA accreditations are based on competency based learning, where applicants must not only complete coursework learning but demonstrate specified practical competencies. For SEIA accreditation for example, as well as completion of the SEIA short course, students must also show documentary evidence of three successful system design and installations they have individually done.

One way this accreditation issue could be addressed is the provision of one or more centres in each state (most likely attached to a TAFE offering the coursework component) with suitable equipment for competency testing after completion of the coursework component of the training. Although it is also possible to achieve this competency testing through accredited industry members, the industry is small and its members are not always willing, or able, to provide this service. This is an area where the States/Territories and Commonwealth could cooperate to ensure a coordinated network of competency testing centres across the country to support both the face-to-face and distance education delivery.

**Indigenous communities:** Another area of major concern is that there are no TAFE or industry courses currently available that meet the specific needs of Indigenous communities in remote areas. These communities are major users of renewable energy technology and training is needed to ensure quality is maintained in energy supply from renewable sources. Funding recently announced by the Commonwealth Government may address this area.

**Wood stoves:** The Holmesglen College of TAFE prepared a training program for installers of residential solid-fuel burning appliances in 1991. The program was developed from training carried out in TAFE colleges since about 1988 (following publication of the Installation Standard (AS 2918-1987). The 1991 program was prepared in conjunction with the Australian Solid Fuel and Wood Heating Association and the Victorian Plumbers, Gasfitters and Drainers Registration Board.

Prior to development of the formal TAFE program, legal difficulties were occurring because woodheater installation often involved roof penetration, a task that could only legally be performed by a registered plumber. Most plumbers showed little interest in woodheater installation and calling in a plumber simply to check the roof penetration of the flue added significantly to installation costs. The TAFE program gave woodheater installers a limited plumbing accreditation for roof penetration, thus making installation by trained woodheater installers legal.

The program was run successfully for several years in several states, but declining woodheater sales reduced demand for the training and the program has not been run in recent years.

The industry has now stabilised and an urgent need for a new training package exists. The number of new installers entering the industry each year is small, and likely to remain small in the foreseeable future. Thus, a TAFE based training program, where students must attend courses, is unlikely to be viable in any individual state. A preferred option would be to have a program that could be completed by distance training, such as an Internet program backed up by on-site training.

The Sustainable Energy Industries Association, SEIA, has expressed interest in managing such a training program. The Australian Home Heating Association supports this approach. Substantial revision of the earlier training program would be required. The training must provide detailed knowledge of safe woodheater installation practice, consistent with AS2918, information on installation to promote good dispersion of smoke, and advice on correct appliance operation to minimise smoke emissions.

Without a viable training package, it is possible that safety standards and the skills necessary to deal with problem smoke emission situations will decline.

**Mini-hydro:** For mini-hydro systems, existing TAFE training is appropriate because systems must be custom designed for each application. This involves trained engineers. Skilled technical staff must carry out manufacturing. Qualified electricians must make electrical connections. A separate training package for mini-hydro systems is totally impractical.

**Micro-hydro:** For micro-hydro systems, development of a suitable training package does seem justified. At present the *Energy from Nature* training course offered by SEIA and TAFE includes a brief, superficial coverage of micro-hydro. It does not provide training on pipe sizing (an important part of system installation) or related installation requirements. A training package, either stand-alone or as a supplement to the general renewable energy package, is required.

## Industry Training

Industry training is carried out by a number of firms and agencies. These courses are generally directed at providing in service training for industry and Government personnel on new developments in quite specific areas.

A questionnaire was distributed to 180 companies and agencies that had expressed an interest in renewable energy technology. This questionnaire asked for their views on training needs (see annex E). Forty-eight responses were received. All recognized the need for a more comprehensive national training program in RE technology. Industry respondents emphasised the need to create a better understanding and awareness within the community of renewable energy and greenhouse gas technologies. Many respondents expressed the need for an education/training program for policy makers and the user sector, with local government authorities, architects, builders and engineering consultants being most vocal on this point. Industry respondents did not, however, suggest that internal training was needed for industry itself or for their staff.

Very few companies (11) had their own in-house training courses. Some relied on TAFE or SEIA for training courses. Most preferred short courses of one to five days duration although there was also some interest in University and TAFE award courses for initial training of staff. SEIA currently offer accreditation of trade/technical level designers and installers, requiring a combination of coursework and a demonstration of competency (usually through presentation of 3 successful system installations). Most Government schemes require installation by a SEIA accredited designer/installer for funding.

The industry respondents expressed a need for courses in energy policy, energy management and energy efficiency as their highest priority. There was limited interest in courses on renewable energy technology with the main areas of interest being solar hot water systems and RAPS design. Most expressed an interest in an ongoing program of short courses to maintain awareness of new developments. Their preference was for accredited courses.

There is an important role for SEIA and the Institution of Engineers Australia (IEAust) and other professional organisations in catering for these needs, possibly with Government assistance on a case-by-case basis. Engineering Education Australia already offers continuing professional development courses in renewable energy for graduates by arrangement with ACRE and Murdoch University. TAFE and SEIA are discussing arrangements for short training courses for designers, installers and maintenance personnel. Some Government assistance for attendance at these courses and the introduction of accreditation requirements for participation in Government sponsored programs could be an effective way of helping to develop and sustain this capability.

The strong interest from industry in energy management and energy policy indicates the relevance of these related areas to the development of the renewable energy industry. There is a need to include such units in the current and proposed award courses and for the professional associations to liaise with the Universities and TAFE about accreditation needs and curriculum content. Government has an important role as the funding agency for Universities and TAFE to coordinate this process to ensure that the training offered meets the needs of industry and national development.

## **Annex A: Terms of Reference**

### **Standards**

1. Identify, list and describe existing Australian Standards together with standards in the process of development that relate to renewable energy equipment and installation.

For standards in development the information should also include the name of the entity responsible for development, the name of a contact person and the funding source for development work.

2. Identify inadequate existing Australian standards.
3. Identify any new standards, which need to be developed.

### **Training**

4. Identify, list and describe existing training programs for installation and maintenance of renewable energy equipment and systems.

In the description of each program include:

- Target audience;
- Objectives;
- Level – community, short course (for industry development), certificate, diploma or degree;
- Course time required;
- Who offers this course;
- Availability on line;
- National accreditation (if appropriate);
- Cost;
- Date of establishment and number of times course has been offered; and
- Any other relevant information

5. Identify needs that are not covered by training in Australia and existing courses that may need further development.

### **Target areas**

Renewable energy installations that should be included in this study include but are not limited to:

- Solar hot water systems;
- Remote area power systems and components (including: inverters, batteries, solar panels and cells, fixed array frames and trackers for solar panels, battery chargers, maximum power point trackers, wind turbines and turbine towers, micro hydro turbines);
- Solar water pumping;
- Grid connected inverters; and
- Wood stoves.

## **Annex B**

### **Part 1: University Level Coursework, Training For Renewable Energy In Australia**

#### ***Institution***

Curtin University of Technology.

#### ***Address***

School of Electrical & Computer Engineering, Kent St, Bentley, WA, 6102.

#### ***Contact Person***

Dr W W L Keerthipala, Phn:+61 (08) 9266 7901; Fax: +61 (08) 9266 2684; Email rkeerthi@cc.curtin.edu.au

#### ***Name and Type of Award Offered***

Master of Engineering Science in Renewable Energy Engineering.

#### ***Level of Award***

Postgraduate degree by coursework.

#### ***Objectives of Course***

Designed to provide engineers and scientists with specific training in advanced areas of renewable energy technologies and engineering applications. Emphasis on design, analysis, simulation and implementation of energy systems with specific attention to renewable energy systems.

#### ***Target Audience***

Graduate Engineers.

#### ***Frequency of Offering***

Once a year.

#### ***Course Duration***

One year full-time, two years part-time.

#### ***Number of Students Currently or Most Recently Enrolled***

7 - 10

#### ***Method of Study***

Face-to-face. 500 hours of contact time - students use directed learning to progress in their chosen field

#### ***Accreditation***

Not applicable.

#### ***Cost of Course***

Tuition fees: Australian students, \$9100; International students, \$15500.

#### ***Date of Establishment of Course***

First offered 1999.

Website for More information

<http://www.postgrad.curtin.edu.au/>

#### ***Units/subjects Specifically Related to Renewable Energy Design/installation***

Renewable Energy Principles 601, Renewable Energy Engineering 604

***Other Relevant Information***

***Institution***

University of Melbourne.

***Address***

Faculty of Engineering, Gate 10 Grattan Street, Parkville, VIC, 3052.

***Contact Person***

Postgraduate Officer, Phn:+61 (03) 8344 6715; Fax: +61 (03) 9349 2182;  
Email: i.brown@eng.unimelb.edu.au

***Name and Type of Award Offered***

Graduate Certificate of Engineering (Energy Studies).

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The graduate program in Energy Studies has been designed to meet the theoretical and practical needs of professionals working in the field of energy use and planning, both in government and private sectors.

***Target Audience***

Graduate engineers or scientists responsible for energy technology.

***Frequency of Offering***

Two intakes per year for Australian students, anytime for international students.

***Course Duration***

Six months full-time.

***Number of Students Currently or Most Recently Enrolled***

Not available

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$8000; International students, \$9250.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

[http://www.eng.mu.oz.au/courses/pgrad/p\\_prosp.html](http://www.eng.mu.oz.au/courses/pgrad/p_prosp.html)

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Design of Energy Systems 421-626, Water Sources of Energy 421-648, Wind Energy Systems 36-466, Renewable Energy 436-466, Solar Energy Engineering 436-805

***Institution***

University of Melbourne.

***Address***

Faculty of Engineering, Gate 10 Grattan Street, Parkville, VIC, 3052.

***Contact Person***

Postgraduate Officer, Phn:+61 (03) 8344 6715; Fax: +61 (03) 9349 2182; Email: i.brown@eng.unimelb.edu.au

***Name and Type of Award Offered***

Graduate Diploma of Engineering (Energy Studies).

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The graduate program in Energy Studies has been designed to meet the theoretical and practical needs of professionals working in the field of energy use and planning, both in government and private sectors.

***Target Audience***

Graduate engineers or scientists responsible for energy technology.

***Frequency of Offering***

Two intakes per year for Australian students, anytime for international students.

***Course Duration***

Twelve months full-time.

***Number of Students Currently or Most Recently Enrolled***

Not available

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$16000; International students, \$18500.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

[http://www.eng.mu.oz.au/courses/pgrad/p\\_prosp.html](http://www.eng.mu.oz.au/courses/pgrad/p_prosp.html)

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Design of Energy Systems 421-626, Water Sources of Energy 421-648, Wind Energy Systems 36-466, Renewable Energy 436-466, Solar Energy Engineering 436-805.

***Institution***

University of Melbourne.

***Address***

Faculty of Engineering, Gate 10 Grattan Street, Parkville, VIC, 3052.

***Contact Person***

Postgraduate Officer, Phn:+61 (03) 8344 6715; Fax: +61 (03) 9349 2182; Email: i.brown@eng.unimelb.edu.au

***Name and Type of Award Offered***

Master of Energy Studies.

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The graduate program in Energy Studies has been designed to meet the theoretical and practical needs of professionals working in the field of energy use and planning, both in government and private sectors.

***Target Audience***

Graduate engineers or scientists responsible for energy technology.

***Frequency of Offering***

Two intakes per year for Australian students, anytime for international students.

***Course Duration***

Twelve months full-time.

***Number of Students Currently or Most Recently Enrolled***

Not available.

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$16000; International students, \$18500.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

[http://www.eng.mu.oz.au/courses/pgrad/p\\_prosp.html](http://www.eng.mu.oz.au/courses/pgrad/p_prosp.html)

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Design of Energy Systems 421-626, Water Sources of Energy 421-648, Wind Energy Systems 36-466, Renewable Energy 436-466, Solar Energy Engineering 436-805.

***Institution***

University of Melbourne.

***Address***

Faculty of Engineering, Gate 10 Grattan Street, Parkville, VIC, 3052.

***Contact Person***

Postgraduate Officer, Phn:+61 (03) 8344 6715; Fax: +61 (03) 9349 2182; Email: i.brown@eng.unimelb.edu.au

***Name and Type of Award Offered***

Master of Engineering (Energy Studies).

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The graduate program in Energy Studies has been designed to meet the theoretical and practical needs of professionals working in the field of energy use and planning, both in government and private sectors.

***Target Audience***

Graduate engineers or scientists responsible for energy technology.

***Frequency of Offering***

Two intakes per year for Australian students, anytime for international students.

***Course Duration***

Eighteen months full-time.

***Number of Students Currently or Most Recently Enrolled***

Not available.

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$24000; International students, \$27750.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

[http://www.eng.mu.oz.au/courses/pgrad/p\\_prosp.html](http://www.eng.mu.oz.au/courses/pgrad/p_prosp.html)

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Design of Energy Systems 421-626, Water Sources of Energy 421-648, Wind Energy Systems 36-466, Renewable Energy 436-466, Solar Energy Engineering 436-805.

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Dr Chris Lund, Phn: +61 (08) 93602102; Fax: +61 (08) 9360 6183; Email: [C.Lund@murdoch.edu.au](mailto:C.Lund@murdoch.edu.au)

***Name and Type of Award Offered***

Postgraduate Certificate in Energy Studies.

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The Postgraduate Certificate in Energy Studies is designed to cater for graduates of any discipline who wish to acquire knowledge and skills in the area of energy systems or policy, with an emphasis on renewable energy systems.

***Target Audience***

Those with a degree from any discipline wishing to receive a training in the area of Energy Studies and renewable energy in order to work in the industry.

***Frequency of Offering***

Each semester.

***Course Duration***

6 months full-time, 1 year part-time.

***Number of Students Currently or Most Recently Enrolled***

5

***Method of Study***

Face-to-face, print based correspondence or online (no on campus attendance required).

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$3729; International students, on-campus, \$7000, online, \$4635.

***Date of Establishment of Course***

First offered 1997.

***Website for More information***

<http://www.acre.murdoch.edu.au/education/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Energy in Society M292, Energy Systems M492.

***Other Relevant Information***

Sponsored by the Australian CRC for Renewable Energy (ACRE).

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Dr Chris Lund, Phn: +61 (08) 93602102; Fax: +61 (08) 9360 6183; Email: [C.Lund@murdoch.edu.au](mailto:C.Lund@murdoch.edu.au)

***Name and Type of Award Offered***

Postgraduate Diploma in Energy Studies and Bachelor of Applied Science in Energy Studies.

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The Postgraduate Diploma in Energy Studies (PgDipEnSt) and Bachelor of Applied Science (BAppSci) in Energy Studies are designed to cater for graduates of any discipline who wish to acquire knowledge and skills in the core areas of energy studies.

***Target Audience***

Those with a degree from any discipline wishing to receive a training in the area of Energy Studies and renewable energy in order to work in the industry.

***Frequency of Offering***

Each semester.

***Course Duration***

12 months full-time, 2 to 3 years part-time.

***Number of Students Currently or Most Recently Enrolled***

65

***Method of Study***

Face-to-face, print based correspondence or online (no on campus attendance required).

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, BAppSci available under HECS, PgDipEnSt, \$7458; International students, on-campus, \$14,000, online, \$9270.

***Date of Establishment of Course***

First offered 1997, replaces a Graduate Diploma which was first offered in 1992.

***Website for More information***

<http://www.acre.murdoch.edu.au/education/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Energy in Society M292, Energy Systems M492.

***Other Relevant Information***

Sponsored by the Australian CRC for Renewable Energy (ACRE).

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Dr Chris Lund, Phn: +61 (08) 93602102; Fax: +61 (08) 9360 6183; Email: [C.Lund@murdoch.edu.au](mailto:C.Lund@murdoch.edu.au)

***Name and Type of Award Offered***

Master of Science in Renewable Energy.

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

The Master of Science (Renewable Energy) program offers advanced training in the area of renewable energy systems or policy.

***Target Audience***

Those with a degree from any discipline wishing to receive an advanced training in the area of renewable energy systems or policy in order to work in the industry.

***Frequency of Offering***

Each semester.

***Course Duration***

2 years full-time, 4 to 6 years part-time.

***Number of Students Currently or Most Recently Enrolled***

10

***Method of Study***

Face-to-face, print based correspondence or online (no on campus attendance required).

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, \$14,916; International students, on-campus, \$30,000, online, \$11,108.

***Date of Establishment of Course***

First offered 1998.

***Website for More information***

<http://www.acre.murdoch.edu.au/education/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Energy in Society M292, Energy Systems M492, Case Studies of Renewable Energy Systems M520, Renewable Energy Devices M521, Renewable Energy Resources M522, Renewable Energy Systems Design M523.

***Other Relevant Information***

Sponsored by the Australian CRC for Renewable Energy (ACRE).

***Institution***

University of New South Wales.

***Address***

Centre for Photovoltaic Engineering, Anzac Pde, Kensington NSW 2033.

***Contact Person***

Director of Academic Studies, Phn: +61 (02) 9385 4002; Fax: +61 (02) 9385 5993; Email: [elec.eng@unsw.edu.au](mailto:elec.eng@unsw.edu.au)

***Name and Type of Award Offered***

Graduate Diploma in Electrical Engineering (majoring in Photovoltaics).

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

To engineering graduates with an exceptional basis in advanced concepts and research in the photovoltaics area.

***Target Audience***

Engineering or science graduates with an appropriate background for electrical engineering (communications, electronics, electric power, systems & control).

***Frequency of Offering***

Each year.

***Course Duration***

1.0 year full-time, 2.0 years part-time.

***Number of Students Currently or Most Recently Enrolled***

Not available.

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, HECS; full-fees, \$7,500 per annum; International students, \$17,000 per annum.

***Date of Establishment of Course******Website for More information***

<http://www.pv.unsw.edu.au/bepv/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Renewable Energy Engineering SOLA3055 , Applied Photovoltaics SOLA3540, Solar Cells and Systems SOLA3507, Renewable Energy Product Reliability SOLA3054, Building Integrated Photovoltaics SOLA4010, Grid Connected Photovoltaic Systems.

***Other Relevant Information***

Sponsored by the Photovoltaics Special Research Centre and Key Centre for Teaching and Research in Photovoltaic Engineering.

***Institution***

University of New South Wales.

***Address***

Centre for Photovoltaic Engineering, Anzac Pde, Kensington NSW 2033.

***Contact Person***

Director of Academic Studies, Phn: +61 (02) 9385 4002; Fax: +61 (02) 9385 5993; Email: [elec.eng@unsw.edu.au](mailto:elec.eng@unsw.edu.au)

***Name and Type of Award Offered***

Master of Engineering Science in Electrical Engineering (majoring in Photovoltaics).

***Level of Award***

Postgraduate degree by coursework.

***Objectives of Course***

To engineering graduates with an exceptional basis in advanced concepts and research in the photovoltaics area.

***Target Audience***

Engineering or science graduates with an appropriate background for electrical engineering (communications, electronics, electric power, systems & control).

***Frequency of Offering***

Each year.

***Course Duration***

1.0 year full-time, 2.0 years part-time.

***Number of Students Currently or Most Recently Enrolled***

Not available.

***Method of Study***

Face-to-face.

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, HECS; full-fees, \$10,000 per annum; International students, \$18,000 per annum.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

<http://www.pv.unsw.edu.au/bepv/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Renewable Energy Engineering SOLA3055 , Applied Photovoltaics SOLA3540, Solar Cells and Systems SOLA3507, Renewable Energy Product Reliability SOLA3054, Building Integrated Photovoltaics SOLA4010, Grid Connected Photovoltaic Systems.

***Other Relevant Information***

Sponsored by the Photovoltaics Special Research Centre and Key Centre for Teaching and Research in Photovoltaic Engineering.

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Dr Chris Lund, Phn: +61 (08) 93602102; Fax: +61 (08) 9360 6183; Email: [C.Lund@murdoch.edu.au](mailto:C.Lund@murdoch.edu.au)

***Name and Type of Award Offered***

Bachelor of Science (Energy Studies).

***Level of Award***

Undergraduate Bachelors degree.

***Objectives of Course***

The Bachelor of Science (Energy Studies) is an interdisciplinary course which provides the broad understanding of energy supply and use needed to work in today's rapidly changing energy industry. It addresses the social, environmental and economic aspects as well as the scientific and technical aspects.

***Target Audience***

School leavers and TAFE graduates wishing to receive an undergraduate training in the area of Energy Studies and renewable energy in order to work in the industry.

***Frequency of Offering***

Each year.

***Course Duration***

3 years full-time, 6 to 9 years part-time.

***Number of Students Currently or Most Recently Enrolled***

Not available until 2002.

***Method of Study***

Face-to-face, print based correspondence or online (no on campus attendance required).

***Accreditation***

Not applicable.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, on-campus, \$15500/year, online, \$9270/year.

***Date of Establishment of Course***

To be offered from 2002.

***Website for More information***

<http://www.acre.murdoch.edu.au/education/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Energy in Society M292, Energy Systems M492.

***Other Relevant Information***

Sponsored by the Australian CRC for Renewable Energy (ACRE).

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Dr Graeme Cole, Phn: +61 (08) 93606181; Fax: +61 (08) 9360 6505; Email: [graeme@eng.murdoch.edu.au](mailto:graeme@eng.murdoch.edu.au)

***Name and Type of Award Offered***

Bachelor of Engineering (Renewable Energy Engineering).

***Level of Award***

Undergraduate Bachelors degree.

***Objectives of Course***

To provide graduates with the skills to design, construct and operate energy systems using renewable energy systems such as wind, solar hydro, geothermal or biomass.

***Target Audience***

School leavers wishing to work as Renewable Energy Engineers.

***Frequency of Offering***

Each year.

***Course Duration***

4 years full-time.

***Number of Students Currently or Most Recently Enrolled***

6

***Method of Study***

Face-to-face, with some on line.

***Accreditation***

IEAust accreditation will be sought for the degree.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$16,500/year.

***Date of Establishment of Course***

First offered 2001.

***Website for More information***

<http://www.eng.murdoch.edu.au>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Energy in Society M292, Applied Photovoltaics G2xz, Biomass Engineering G3yz, Wind Energy Engineering G3xy, Building Integrated Photovoltaics and Life Cycle Assessment G3xz, Design of Stand-alone Renewable Energy Systems Gyy, Grid Connected Renewable Energy Generation G4xy, Case Studies of Renewable Energy Systems M520.

***Other Relevant Information***

Sponsored by Western Power Corporation and the Western Australian Alternative Energy Development Board.

***Institution***

University of New South Wales.

***Address***

Centre for Photovoltaic Engineering, Anzac Pde, Kensington NSW 2033.

***Contact Person***

Professor Stuart Wenham, Phn: +61 (02) 9385 5171; Email: [s.wenham@unsw.edu.au](mailto:s.wenham@unsw.edu.au)

***Name and Type of Award Offered***

Bachelor of Engineering (Photovoltaics and Solar Energy Engineering).

***Level of Award***

Undergraduate Bachelors degree.

***Objectives of Course***

To provide training in technology development, manufacturing, quality control, reliability and lifecycle analysis, cell interconnection and encapsulation, the full range of solar cell applications, system design, maintenance and fault diagnosis, marketing, policy development and the use of all renewable energy technologies.

***Target Audience***

School leavers wishing to work as Photovoltaic and Solar Energy Engineers.

***Frequency of Offering***

Each year.

***Course Duration***

4 years full-time. After completing one year it is possible to progress on a semi-part-time basis with a reduced program.

***Number of Students Currently or Most Recently Enrolled***

80

***Method of Study***

Face-to-face.

***Accreditation***

IEAust accreditation will be sought for the degree.

***Cost of Course***

Tuition fees: Australian students, HECS; full-fees, \$15,500 per annum; International students, \$16,500 per annum.

***Date of Establishment of Course***

First offered 2000.

***Website for More information***

<http://www.pv.unsw.edu.au/bepv/>

***Units/subjects Specifically Related to Renewable Energy Design/installation***

Renewable Energy Engineering SOLA3055 , Applied Photovoltaics SOLA3540, Solar Cells and Systems SOLA3507, Renewable Energy Product Reliability SOLA3054, Building Integrated Photovoltaics SOLA4010, Grid Connected Photovoltaic Systems.

***Other Relevant Information***

Sponsored by the Photovoltaics Special Research Centre and Key Centre for Teaching and Research in Photovoltaic Engineering.

## **Part 2: University Level Research, Training For Renewable Energy In Australia**

### ***Institution***

Curtin University of Technology.

### ***Address***

School of Electrical & Computer Engineering, Kent St, Bentley, WA, 6102.

### ***Contact Person***

Postgraduate Coordinator, Phn: +61 (08) 9266 2575; Fax: +61 (08) 9266 2584; Email: tfungcc@curtin.edu.au

### ***Name and Type of Award Offered***

Master and Doctor of Philosophy

### ***Level of Award***

Postgraduate degree by research

### ***Target Audience***

Graduate Engineers.

### ***Frequency of Offering***

Yearly.

### ***Course Duration***

Two (MPhil) or three (PhD) years full-time. Four (MPhil) or six (PhD) years part-time.

### ***Method of Study***

On-campus

### ***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$15500/year.

### ***Website for More information***

<http://www.postgrad.curtin.edu.au/>

### ***Areas of research training***

Renewable energy systems and devices, hybrid energy, electrical generators for wind power plants, stand-alone and grid-connected photovoltaic systems, remote area power, power electronics and power systems.

### ***Other Relevant Information***

***Institution***

Royal Melbourne Institute of Technology.

***Address***

Department of, Mechanical and Manufacturing Engineering,  
Bundoora East Campus,  
PO Box 71,  
Bundoora, VIC, 3083.

***Contact Person***

Research Coordinator, Phn:+61 (03) 9925 3528; Fax: +61 (03) 9639 1105; Email:  
aleksandar.subic@rmit.edu.au

***Name and Type of Award Offered***

Master of Engineering and Doctor of Philosophy.

***Level of Award***

Postgraduate degree by Research.

***Target Audience***

Graduates with Bachelors Degree with first class honours or equivalent.

***Frequency of Offering***

Yearly.

***Course Duration***

Two (MEng) or three years (PhD) full-time. Four (MEng) or six years (PhD) full-time

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$46020.

***Website for More information***

<http://www.rmit.edu.au/departments/aa/highdegr.htm>

***Areas of research training***

The use of renewable energy and energy which is currently wasted as low grade heat. This includes remote area power supply systems and cogeneration, solar hot water systems and other solar and wind energy equipment and solar electric vehicles.

***Other Relevant Information***

***Institution***

University of Melbourne.

***Address***

Faculty of Engineering, Gate 10 Grattan Street, Parkville, VIC, 3052.

***Contact Person***

Postgraduate Officer, Phn:+61 (03) 8344 6715; Fax: +61 (03) 9349 2182; Email: i.brown@eng.unimelb.edu.au

***Name and Type of Award Offered***

Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Graduate engineers

***Frequency of Offering***

Yearly

***Course Duration***

Three to four years full-time, six to eight years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$21200/year.

***Website for More information***

<http://www.unimelb.edu.au/postgrad/>

***Areas of research training***

Solar and wind energy, including solar thermal hot water systems and biomass.

***Other Relevant Information***

***Institution***

Murdoch University.

***Address***

Division of Science and Engineering, South Street, Murdoch, WA, 6150.

***Contact Person***

Postgraduate Admissions Officer, Phn: +61 (08) 9360 6506; Fax: +61 (08) 9360 6503; Email: randell@central.murdoch.edu.au

***Name and Type of Award Offered***

Master and Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Graduates in Science and Engineering.

***Frequency of Offering***

Yearly

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) or six (PhD) years part-time

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$17,150/year.

***Website for More information***

<http://wwwadmin.murdoch.edu.au/research/>

***Areas of research training***

Analysis and monitoring of renewable energy systems; design, performance and economic analysis of hybrid RAPS systems, simulation and control of renewable energy systems and solar thermal systems, photovoltaics, energy storage, fuel cells..

***Other Relevant Information***

***Institution***

University of New South Wales.

***Address***

Centre for Photovoltaic Engineering, Anzac Pde, Kensington NSW 2033.

***Contact Person***

Dean, Phn: +61 (02) 9385 5000; Fax: +61 (02) 9385 5456; Email: [m.wainwright@unsw.edu.au](mailto:m.wainwright@unsw.edu.au)

***Name and Type of Award Offered***

Master and Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Graduates in Engineering.

***Frequency of Offering***

Yearly.

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) or 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$19,000/year.

***Website for More information***

<http://www.pv.unsw.edu.au/bepv/>

***Areas of research training***

A range of projects available across the whole of the photovoltaic field including array design and protection, the application of power conditioning, power systems interaction and remote area power supply, solar thermal and energy storage.

***Other Relevant Information***

***Institution***

Australian National University

***Address***

Department of Engineering,  
Faculty of Engineering and Information Technology,  
Australian National University,  
Canberra, ACT, 0200.

***Contact Person***

Dr Zbigniew Stachurski, Phn: +61 (02) 6125 5681; Email: [engineering.gradprog@anu.edu.au](mailto:engineering.gradprog@anu.edu.au)

***Name and Type of Award Offered***

Bachelor of Science (Energy Studies).

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Graduate Engineers.

***Frequency of Offering***

Yearly

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) to 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$17,000/year.

***Website for More information***

<http://www.anu.edu.au/graduate/>

***Areas of research training***

Photovoltaic systems and solar cells, solar thermal and thermochemical engineering

***Other Relevant Information***

***Institution***

Northern Territory University

***Address***

Northern Territory University,  
Darwin, NT, 0909.

***Contact Person***

Associate Dean, Postgraduate and Research Studies, Phn: +61 (08) 8946 6389; Fax: +61 (08) 8946 6993;  
Email: [dean.patterson@ntu.edu.au](mailto:dean.patterson@ntu.edu.au)

***Name and Type of Award Offered***

Master of Engineering and Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Graduate Engineers.

***Frequency of Offering***

Yearly

***Course Duration***

Two (MEng) or three (PhD) years full-time, four (MEng) to 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$14000/year.

***Website for More information***

<http://www.ntu.edu.au/corporate/research/postgrad.htm>

***Areas of research training***

Electrical renewable energy systems, control systems, machines and drives and power electronics including, wind turbine generators, hybrid system simulation & modeling, hybrid remote area power systems , biomass power generation, photovoltaic performance testing and wind diesel hybrid power supply.

***Other Relevant Information***

***Institution***

University of Newcastle

***Address***

Faculty of Engineering,  
University of Technology, Sydney,  
PO Box 123,  
Broadway, NSW, 2007.

***Contact Person***

Research Higher Degrees, Phn: +61 (02) 4921 6537; Fax: +61 (02) 4921 6908; Email:  
[grad.schol@newcastle.edu.au](mailto:grad.schol@newcastle.edu.au)

***Name and Type of Award Offered***

Master and Doctor of Philosophy.

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Engineering, surveying, or computer science graduates. Physics and chemistry graduates may be acceptable in some cases.

***Frequency of Offering***

Yearly

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) to 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$46800.

***Website for More information***

<http://www.newcastle.edu.au/research/research.htm>

***Areas of research training***

Electrical variable speed drives, and generation of electricity using rotating machines and renewable sources (wind, hydro, solar)., including electric generators and controllers for wind turbines for remote area power supplies and hydroelectric schemes for the developing countries.

***Other Relevant Information***

***Institution***

University of Tasmania

***Address***

University of Tasmania ,  
GPO BOX 252-,  
Hobart, Tasmania, 7001.

***Contact Person***

Administrative Officer, Research Higher Degrees, Phn: +61 (03) 6226 2764; Fax: +61 (03) 6226 2765;  
Email: [J.J.Todd@utas.edu.au](mailto:J.J.Todd@utas.edu.au)

***Name and Type of Award Offered***

Master and Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Postgraduates in science

***Frequency of Offering***

Yearly

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) to 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$14,500/year.

***Website for More information***

<http://www.research.utas.edu.au/postgrad.htm>

***Areas of research training***

Wood heaters and solar cooking.

***Other Relevant Information***

***Institution***

University of Sydney

***Address***

The University of Sydney,  
Sydney, New South Wales, 2006.

***Contact Person***

Coordinator for Postgraduate Studies, Phn: +61 (02) 9351 7084; Fax: +61 (02) 9351 7082; Email:  
[j.harty@eng.usyd.edu.au](mailto:j.harty@eng.usyd.edu.au)

***Name and Type of Award Offered***

Master and Doctor of Philosophy

***Level of Award***

Postgraduate degree by research.

***Target Audience***

Research candidates with a strong research background.

***Frequency of Offering***

Yearly

***Course Duration***

Two (MPhil) or three (PhD) years full-time, four (MPhil) to 6 (PhD) years part-time.

***Method of Study***

Face-to-face.

***Cost of Course***

Tuition fees: Australian students, HECS; International students, \$48000.

***Website for More information***

<http://www.usyd.edu.au/su/reschols/welcome.html>

***Areas of research training***

Solar thermal electricity systems.

***Other Relevant Information***

### **PART 3: TAFE Level Coursework, Training For Renewable Energy In Australia**

#### ***Institution***

Brisbane Inst. of TAFE, ITHACA Campus

#### ***Address***

Fulcher Road, Red Hill QLD 4059

Postal address: Locked bag 10, Kelvin Grove, DC 4059

#### ***Contact Person***

Trevor Berrill/Sasha Giffard Ph: 07-3259 9072

Email: trevor.berrill@detir.qld.gov.au; [sasha.giffard@detir.qld.gov.au](mailto:sasha.giffard@detir.qld.gov.au)

#### ***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology,

Short Courses in Specific Technical Areas,

Starting from July 2002 Certificate II in Electro-technology Servicing (Renewable Energy Specialisation),

Electro-technology Cert IV in Renewable Energy and a Diploma in Renewable Energy.

#### ***Level of Award***

TAFE Certificate IV and after July 2002 Certificate II, Certificate IV and Diploma

#### ***Objectives of Course***

Training for design, installation & maintenance of RE Systems,

#### ***Target Audience***

Tradespeople, Professionals, Sales people, Home Builders, Policy Makers, Information Officers etc.

#### ***Frequency of Offering***

Face to face - Feb & July Semesters,

Distance Learning - start any time,

Short Course on demand (usually 2 per year)

#### ***Course Duration***

Cert IV- 2.5 yrs part time, 1.5 yrs full time (distance learning only) Short Courses 2 days-1 week

#### ***Number of Students Currently or Most Recently Enrolled***

230

#### ***Method of Study***

Class room, face to face and

On-line and print based distance learning (fully available from Sep 2001)

#### ***Accreditation***

ANTA, SEIA

#### ***Cost of Course***

\$63 per 60 hour module+Resource material (approx. \$90)

#### ***Date of Establishment of Course***

1989 for face to face and 1999 for distance learning

#### ***Website for More information***

[www.brisbane.tafe./ren\\_energy](http://www.brisbane.tafe./ren_energy)

Units/subjects Specifically Related to Renewable Energy Design/installation

***Core***

Introduction to Renewable Energy Technologies (60hrs\*),  
DC and AC Electrical Fundamentals (60hrs),  
Extra Low Voltage Wiring and Practice (40hrs)  
Electronics for Renewable Energy Systems (40hrs)

***Elective***

Energy Efficient Building Design (60hrs),  
Solar Water Heating Systems (60hrs),  
Photovoltaic Power Systems (60hrs)  
Hybrid Energy Systems (60hrs)  
Wind Energy Conversion Systems (60hrs)

Note \* All times are a guideline only)

***Other Relevant Information***

Areas not covered at present include:

Micro Hydro as a detailed module (it is contained in the intro subject), Industry work experience, Biomass  
Industry Training

***Institution***

Central TAFE, Perth

***Address***

25 Aberdeen St. Perth WA6000

***Contact Person***

Ian Dawson Ph:08-9235 6565 Email: dawsoi@ECENTRAL.training.wa.gov.au

***Name and Type of Award Offered***

Certificate IV in Ren. Energy Tech, Short Courses and SEIA accreditation

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training for design, install & maintain RE Systems

***Target Audience***

Any suitably qualified person

***Frequency of Offering***

Each Semester

***Course Duration***

1 year full time

***Number of Students Currently or Most Recently Enrolled***

>50

***Method of Study***

Classroom, Correspondence, Workshop

***Accreditation***

Dept. Of Training, SEIA

***Cost of Course***

\$500-\$1000

***Date of Establishment of Course***

1997

***Website for More information***

[www.central.wa.edu.au](http://www.central.wa.edu.au)

Units/subjects Specifically Related to Renewable Energy Design/installation

***Other Relevant Information***

Areas not covered at present include:

Hybrid System Design & Installation

***Institution***

NTU/TAFE

***Address***

NTU Darwin

***Contact Person***

Keith Presnell Ph: 03-8946 6883

Email: keith.presnell@ntu.edu.au

***Name and Type of Award Offered***

Certificate IV in Ren. Energy

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Support for Service Industry

***Target Audience***

System Designers &amp; Installers

***Frequency of Offering***

Each semester

Course Duration

2 Years

***Number of Students Currently or Most Recently Enrolled***

10

***Method of Study***

Classroom, Distance Education

***Accreditation***

SEIA

***Cost of Course***

\$660

***Date of Establishment of Course***

\$660

***Website for More information***[www.ntu.edu.au](http://www.ntu.edu.au)***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

Areas not covered at present include:

Hybrid Tech &amp; Integrated Load Mgt. Systems

***Institution***

Swinburne Uni/TAFE

***Address***

Mech & Automotive Tech, TAFE School of Engineering, Victoria

***Contact Person***

Keith Deed Ph: 03-9214 8504

Email: keith.deed@swin.edu.au

***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training for system design, installation & maintenance

***Target Audience***

Engineering Degree Graduates, Electricians, Plumbers, Architects.

Sales people, Personal Interest.

***Frequency of Offering***

Each Semester

***Course Duration***

1 year full time, 2-4 yrs part time

***Number of Students Currently or Most Recently Enrolled***

20 full time, 80 part time

***Method of Study***

Mainly Classroom

***Accreditation***

SEIA

***Cost of Course***

\$800 per year approx.

***Date of Establishment of Course***

1996

***Website for More information***

[www.swin.tafe.edu.au](http://www.swin.tafe.edu.au)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

Course to be expanded to Advanced/Higher degrees

***Institution***

NMIT Victoria

***Address***

Electrical Technology Department.

***Contact Person***

John Sakalauskas Ph: 03-9269 1093

Email: johns-elt@nmit.vic.edu.au

***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training Consultants capable of designing, installing, commissioning & maintaining RE Systems.

***Target Audience***

Broad based intake

***Frequency of Offering***

Each Semester

***Course Duration***

2-3 years part time

***Number of Students Currently or Most Recently Enrolled***

50-60 Students

***Method of Study***

Classroom delivery with few courses through distance education

***Accreditation***

SEIA

***Cost of Course***

\$1 per subject hour +\$35 amenities fee+books

***Date of Establishment of Course***

Late 1980's

***Website for More information***

[www.nmit.vic.edu.au](http://www.nmit.vic.edu.au)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

***Institution***

Chisholm TAFE (Berwick Campus) Victoria

***Address***

Natural & Applied Science Department

***Contact Person***

Jenny Ireland Ph: 03-9238 8350

Email: j.ireland@chisholm.vic.edu.au

***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training Consultants capable of designing, installing, commissioning & maintaining RAPS and other RE Systems.

***Target Audience***

Any suitably qualified people

***Frequency of Offering***

Every Year

***Course Duration***

1 year full time, 2-3 years part time

***Number of Students Currently or Most Recently Enrolled***

15

***Method of Study***

Classroom delivery with few modules through distance education plus Introduction to RE Technology and solar hot water systems modules available on-line

***Accreditation***

SEIA

***Cost of Course***

\$1.15 per student contact hour (Max fee \$575) \$20 material fee for off campus studies

***Date of Establishment of Course***

1997

***Website for More information***

[www.chisholm.vic.edu.au](http://www.chisholm.vic.edu.au)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

***Institution***

Gordon TAFE Victoria

***Address******Contact Person***

Ray Black Phone: 03-5225 0500

Email: rblack@gordontafe.edu.au

***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology, and

Certificate IV in Environmental Management

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training middle level Managers & Technical people for installation and maintenance of Solar systems

***Target Audience***

Architects and general public

***Frequency of Offering***

Every Semester

***Course Duration***

1 year full time, 2-3 years part time

***Number of Students Currently or Most Recently Enrolled***

7

***Method of Study***

Classroom study

***Accreditation***

SEIA

***Cost of Course***

\$600 full time

***Date of Establishment of Course***

2000

***Website for More information***

[www.gordontafe.edu.au](http://www.gordontafe.edu.au)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

***Institution***

CSIT TAFE, Nambour Campus, Queensland

***Address***

CSIT (Nambour Centre) 89 Windsor Rd, Nambour QLD 4560

***Contact Person***

Alex Thorogood Ph: 07-5459 3538

Email: alex.thorogood@detir.qld.gov.au

***Name and Type of Award Offered***

Certificate IV in Renewable Energy Technology

***Level of Award***

TAFE Certificate IV

***Objectives of Course***

Training for system designers, maintenance and sales

***Target Audience***

Trades people and general public with an interest or background in renewable energy

***Frequency of Offering***

2 programs a year

***Course Duration***

6 months full time study

***Number of Students Currently or Most Recently Enrolled***

16

***Method of Study***

Classroom study

***Accreditation******Cost of Course***

\$600 approx.

***Date of Establishment of Course***

1997

***Website for More information***

[www.csit.tafe.net](http://www.csit.tafe.net)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

***Institution***

Centre for Appropriate Technology CAT, Alice Springs

***Address***

Alice Springs, NT

***Contact Person***

Laurence Wilson,  
Email: catsbb@ozemail.com.au

***Name and Type of Award Offered***

Currently running Cert III level Aboriginal Technical Worker Program (ATWORK) and considering including renewable energy stream within each of the three certificates. Also considering starting Cert IV level Renewable Energy program from Yr 2002.

***Level of Award***

TAFE Certificate III

***Objectives of Course***

Not yet decided on

***Target Audience***

Indigenous people in remote communities

***Frequency of Offering***

Annual

***Course Duration***

Depending on offering

***Number of Students Currently or Most Recently Enrolled***

Not yet running

***Method of Study***

Mixture of coursework and hands on practical work

***Accreditation***

None

***Cost of Course***

Not known

***Date of Establishment of Course***

Not yet established

***Website for More information***

<http://www.iCAT.org.au>

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

***Institution***

Holmesglen TAFE Victoria

***Address***

PO Box 42 Chadstone Vic 3148

***Contact Person***

Ph: 03-9564 1555

***Name and Type of Award Offered***

The woodheater installers program is not running at present. It was running until 1991. It is being revised for reintroduction in 2002/3.

***Level of Award***

TAFE Certificate II

***Objectives of Course***

Ensure skills in safe installation and maintenance of woodheaters in accordance with AS 2918

***Target Audience***

Woodheater installers and repairers

***Frequency of Offering***

Annually

***Course Duration***

6 months

***Number of Students Currently or Most Recently Enrolled***

Not offered at present

***Method of Study***

Classroom

***Accreditation***

Recognised by plumbing Registration Boards,  
SEIA accreditation sought

***Cost of Course***

N/A

***Date of Establishment of Course***

1980

***Website for More information***

[www.holmesglen.vic.edu.au](http://www.holmesglen.vic.edu.au)

***Units/subjects Specifically Related to Renewable Energy Design/installation******Other Relevant Information***

Discussions are underway about restarting this course in 2002.