

# Education & training for zero energy and lean manufacturing & construction of housing in Australia

Felix Kin Peng Hui<sup>1</sup>, Alessandra Akemi Yokota<sup>2</sup> and Lu Aye<sup>3</sup>

<sup>1,2&3</sup>Renewable Energy and Energy Efficiency Group, Department of Infrastructure Engineering, Melbourne School of Engineering,  
The University of Melbourne, Vic 3010, AUSTRALIA

E-mails: [hui1@unimelb.edu.au](mailto:hui1@unimelb.edu.au); [yokotaa@unimelb.edu.au](mailto:yokotaa@unimelb.edu.au); [lua@unimelb.edu.au](mailto:lua@unimelb.edu.au)

## Abstract:

For zero energy and efficient production of mass customised housing, good outcomes are possible only when it is supported by a good education curriculum and infrastructure. This paper reports on the status of education for zero energy and lean manufacturing and construction of houses in Australia by investigating offerings of Victorian schools, vocational training and higher education sectors in these respects. The courses currently offered within Australian Qualifications Framework (AQF) were assessed. It was found that there are still gaps in the education infrastructure that do not provide fully for opportunities to educate the workforce in these areas. Although the main knowledge areas of zero energy are sufficiently covered by courses involving sustainability, renewable energy, energy efficiency in buildings and infrastructure construction, the teaching of lean concepts are not widespread in all these education sectors in Australia.

## Keywords:

Australian Qualifications Framework (AQF), Education, Infrastructure, Lean Manufacturing & Construction, Zero Energy House.

## 1 Introduction

The production of energy efficient, mass customised houses offers good potential to solving the housing affordability problem in Australia. Zuhairi et al. (2016, p. 282) stated “Prefabrication and modular construction are believed to be the solution for constructing houses that meet the vast number of demands in urban areas in a short period of time”. Mass customised house manufacturing lends itself easily to application of lean principles such as waste and cost reduction, has been applied successfully in similar type of mass customised environment in the manufacturing sector. The quest for energy efficient homes are also important given that the costs of electricity and natural gas have been risen in the past few years. Prices for households increased on average by 72% for electricity and 54% for natural gas in the 10 years to June 2013 in Australia (Swoboda 2018).

### Zero Energy and Lean Construction - Why are these important?

Lean principles and practices can be applied to any business or production process, in any industry to reduce wastes and costs. They can be applied in realizing Zero Energy Demand Buildings (ZEDB). They can be used to promote energy savings throughout a building’s lifecycle. Sands (2010) argued that the emerging energy economy is demanding innovative, cost effective, high performance buildings. A lean and powerful construction industry that is resource efficient and cost effective is required to deliver affordable housing. Pulakka et al. (2016) concluded that the lean construction is a

collaborative working method and an innovative way to achieve nearly Zero Energy Buildings (nZEB) targets and good indoor environment. Ladhani and Parrish (2013) presented a case study of an existing 1536 m<sup>2</sup> office building retrofit in Phoenix, Arizona. They discussed the role of lean principles and construction practices in making the zero-net-energy retrofit project successful in terms of both energy efficiency and cost efficiency. Lausman (2016, para. 12) also reported “Lean methodologies reduced waste, increased value and delivered a ‘Net Zero’ energy facility (the Mosaic Center in Edmonton, Alberta) three months ahead of schedule and three percent under budget!”. Therefore, the application of lean principles and zero energy in construction may offer great potential in contributing to housing affordability in Australia.

### **Exploring the current state of zero energy and lean construction education in Australia**

Education, training and certification for zero energy and efficient work methods are generally delivered in parts at varying levels across some subjects or course programs. How much of these are delivered within the education system in Australia? What exactly is the status and how well do they equip students with knowledge and skills to be effective professionals in these areas?

## **2 Method**

The authors conducted a comprehensive review which included on-line contents of courses and subjects put up by education service providers in the areas of zero energy and lean construction. These are then compiled, compared and analysed for gaps where education has not met the requirements of industry. The review is divided along the educational framework specified in the Australian Qualifications Framework (AQF) i.e. schools, vocational education and training (VET) and higher education (HE) (AQFC, 2013). This study is limited to Australian education system and institutions.

## **3 Review**

### **The Australian Qualifications Framework (AQF)**

In order to address these questions, it is necessary to discuss briefly the Australian Qualifications Framework which describes the national policy for regulating qualifications in Australia, the broad aims at each level and the contents of zero energy and lean construction that are taught at various levels. It differentiates school, vocational education & training, and higher education. Educational outcomes for each of these levels are clearly defined so that qualifications can be consistently linked and student pathways to educational goals defined. This enables clarity and consistency to the qualifications and expected learning outcomes.

The aim of the Australian school sector is to provide students with a general education from Year 1 to Year 10. In terms of science learning inquiry skills, this is broadly categorised and translates into six key concepts of (1) pattern order and organisation, (2) forms and function (3) stability and change (4) scale and measurement (5) matter and energy and (6) systems (VCAA 2018).

The VET sector on the other hand, provides for skill-specific training in defined industries. In particular, graduates holding a Level 3 qualification have the ability to apply knowledge and skills to work autonomously in a known environment. Graduates holding a Level 4 qualification are able to demonstrate judgment in a changing context. At Levels

5 and 6, this includes applications in a broader context and the ability to provide highly specialised advice.

The HE (Level 7 and above) requires self-directed learning within broader parameters while Level 8 and 9 require expert judgement and specialist work as a practitioner. With these in mind, this paper seeks to explore the current status of zero energy and lean construction education in these three areas of educational focus. In general, the construction industry requires a skilled and adaptable workforce. People joining the industry should have generic and skill-specific workforce training and hold the required competencies in the sector. People joining the workforce in the design of systems need higher level cognitive skills and must also be adaptable and contextualise knowledge for applications.

### **3.1 Zero Energy Building Education and Lean Construction Education in Schools**

#### **The Australian School Curriculum**

The Australian school curriculum (ACARA, 2016) already provides basic understanding in relation to energy for general education in the physical sciences, chemistry, earth and environment up to Year 10. In fact, topics such as the origins of energy, energy transformation are covered in the physics and chemistry curricula while related topics in the areas of energy transformation, energy storage, usage are found in the earth and physical sciences which are taught at secondary school (Year 7 to 10). Specific units such as the ACES076 looks at renewable resources are those that are typically replenished at time scales of years to decades and include harvestable resources (for example, water, biota and some energy resources) and services (for example, ecosystem services) (ACES076). This curriculum is supplemented by a variety of teaching resources some even developed by external agencies and private organisations as part of their corporate social responsibility (CSR) program. Origin’s Energy for school targeted at as early Year 3 and provides materials to Year 8, on topics of awareness for origins of energy, ways to promote energy efficiency and solar energy, a source of renewable energy (Origin, 2018). These resources are free for teachers and students. Activity based learning such as the creation of a poster to promote energy efficiency and writeup of what it means to have a solar energy at your school, leading to a nation-wide competition.

ResourceSmart (2018) portal hosted by Sustainability Victoria contains various modules for school to promote good learning outcomes in sustainability. Among its contents, the energy module focuses on energy reduction and its links to the themes of sustainability and climate change. The contents include activity-based learning such as engaging students in energy audits (ResourceSmart 2018). In comparison, a developed nation such as the United States already has targeted educational energy consumption reduction programs and goals for a zero energy building (Zero Energy Resources 2018). The Australian School Curriculum do not specify any trade related topics such as construction much less a specialised area such as lean construction. Students in the school system do have a chance to undertake VET education as part of their subject options.

### **3.2 Zero Energy Building Education and Lean Construction Education in the VET/TAFE Sector**

In Australia, the Vocational and Technical Education or VET sector delivers workplace-specific skills and knowledge. The VET curricula cover a wide range of careers and industries, including trades and office work, retail, hospitality and technology. Different predefined sectors have industry skill councils that developed and standardised training

packages, qualifications, accredited courses, units of competency and skill sets which are standardised for use by the Technical and Further Education (TAFE) providers and Registered Training Organisations (RTOs).

In our review of the skillsets and workplace training the relevant training packages such as the Construction, Plumbing and Services Training Package (CPC08, 2017), Electrotechnology Training Package (UEE11), the Property Services Training Package (CPP, 2017), Sustainability Training Package (MSS, 2016), the Manufacturing Training Package (MSA07, 2014). The search revealed several “renewable energy” or “energy efficiency” qualifications at AQF Levels 3 (Certificate III), 4 (Certificate IV), 5 (Diploma) and 6 (Advanced Diploma). A search of the training packages showed at least 12 qualifications related to renewable energy and energy. Table 1 shows that most of these are found in the electrotechnology training packages.

Table 1 Examples of Australian energy-related VET qualifications

Course Code	Qualification	Training Package
UEE62011	Advanced Diploma of Engineering technology - Renewable energy	UEE Electrotechnology
UEE60911	Advanced Diploma of Renewable Energy technology	UEE Electrotechnology
UEE32011	Cert III in Renewable Energy – ELV	UEE Electrotechnology
UEE41911	Cert IV in Electrical - Renewable Energy	UEE Electrotechnology
UEE41611	Cert IV in Renewable Energy	UEE Electrotechnology
UEE50711	Diploma of Renewable Energy Engineering	UEE Electrotechnology
UEE22111	Certificate II in Sustainable Energy (Career Start)	UEE Electrotechnology
UEE42811	Certificate IV in Air-conditioning Systems Energy Management and Control	UEE Electrotechnology
CPP51012	Diploma of Residential Building Energy Assessment	CPP Property Services
UEE43111	Certificate IV in Energy Efficiency and Assessment	UEE Electrotechnology
UEE41011	Certificate IV in Energy Management and Control	UEE Electrotechnology
CPP51012	Diploma of Residential Building Energy Assessment	CPP Property Services
22311VIC	Course in Retrofitting for Energy and Water Efficiency	CPP Property Services

Numerous units of competencies were found. A further examination of the training packages found over 200 units of competencies related to energy while only 45 relates to renewable energy and only 15 relates to energy efficiency. Table 2 shows examples of some of these energy-related units of competencies.

From the review of the current training packages, it can be seen the curricula for the qualifications and topics related to zero energy such as renewable energy and energy efficiency exists. However, the number of institutions offering these are not many. While qualifications and unit of competencies are available, it is up to the TAFE and RTOs to when to offer courses and units of competencies for the courses.

There are no specific qualifications toward lean construction although there are many construction courses covered in the CPC Construction, Plumbing and Services Training Package (2017). Most of the qualifications have options for students to enrol in units of competency that teaches lean concepts such as 5S (term refers to five steps – sort, set in order, shine, standardize and sustain), Just-in-time and value stream. Most of these units are found in in the MSA07 Manufacturing Training Package (2014) such as MSS40203 Apply 5S Procedures, MSAPMSUP390A Structured Problem Solving. Although written primarily for the manufacturing industry, these can be used and contextualised for other training packages used in the building industry. More examples of such lean specific topics are listed in Table 3.

Table 2 Examples of Units of Energy-related Units of Competencies

Code	Unit of Competency
UEENEEK123A	Carry out basic repairs to renewable energy apparatus
UEENEEK110A	Co-ordinate maintenance of renewable energy (RE) apparatus and systems
UEENEEK133A	Design hybrid renewable power systems
UEENEEK129A	Design renewable energy (RE) heating systems
UEENEEK139A	Design stand-alone renewable energy (RE) systems
UEENEEK140A	Develop engineering solutions to renewable energy (RE) problems
UEENEEK127A	Diagnose and rectify faults in renewable energy control systems
AHCAGB508	Improve agricultural sustainability using renewable energy and recycle systems
ICTSUS401	Install and test renewable energy system for ICT networks
UEENEEK121A	Manage renewable energy (RE) projects
UEENEEK123A	Carry out basic repairs to renewable energy apparatus
UEPMNT369A	Monitor climatic conditions for renewable electricity generation
UEPOPS359A	Monitor climatic conditions for renewable energy production
UEENEEK122A	Plan renewable energy (RE) projects
UEENEEK128A	Solve problems in stand-alone renewable energy systems
UEENEEK149A	Verify compliance and functionality of an extra low voltage renewable energy installation
UEENEEE074B	Write specifications for renewable energy engineering projects

Table 3 Examples of commonly taught lean-related units of competencies

Unit Code	Competency Unit
MSS403021A	Facilitate a just-in-time system
MSS403040A	Facilitate and improve implementation of 5S
MSS403051A	Mistake proof an operational process
MSS405002A	Analyse and map a value stream
MSS405003A	Manage a value stream
MSS405021A	Develop a just-in-time system

Design of housing and energy systems requires higher level of cognitive and adaptable skills. Therefore, it is not surprising that the courses offered are at the trades level and targeted at the fabrication and maintenance of zero energy systems, efficient energy systems and efficient manufacturing of houses.

### 3.3 Zero Energy Building and Lean Construction in The Higher Education Sector

Climate change is a major concern and energy supply plays a significant role in terms of environmental damages due to its high greenhouse gas (GHG) emissions. To tackle this issue, Australia has offered various dedicated courses related to renewable energy across the country since 1998. In 2008, Thomas et al. (2008) documented available courses related to energy in both Australia and New Zealand. At that time, 4 undergraduate, 17 postgraduate and 8 research degrees were available in Australia. Due to public policies and targets established for increasing the use of renewables, the country has continued investing in education for the area in the last twenty years. To update those numbers, available courses and subjects which are related to Zero Energy, Energy Efficiency and Sustainable Energy in Australia were investigated. As of today, 10 undergraduate courses and 19 postgraduate courses are offered. Research higher degrees were excluded in this analysis. Some of the courses available today are the same ones that were reported back in 2008 by Thomas et al. (2008), while others were replaced by new courses with a more robust or specific area of knowledge. For instance, the Murdoch University offers a Master Degree in Energy studies since 2008. However, the course is now named ‘Energy



- one Associate Degree of Applied Engineering in Renewable Energy Technologies;
- nine Bachelor Degrees, being the majority in Engineering, one in Science and one in Technology;
- one Graduate Certificate in Energy and Carbon Studies;
- four Graduate Diplomas;
- two Master Degree specialisations, being the first in Energy Efficiency Modelling and Implementation and the second in Renewable and Sustainable Energy Engineering;
- twelve Master Degrees, being seven in Engineering, one in Science, one in Energy efficient and Sustainable Building, one in Energy Systems, one in Sustainable Energy, and one in Environment.

Despite energy efficiency being a priority, construction is another major concern nowadays as the country has been experiencing significant population growth in the last decades. Lean Construction combines lean manufacture principles applied to construction, ensuring higher quality, potential cost reduction and reduced time of construction. In relation to Lean Construction, no graduate nor postgraduate course was found. The search included certificate, diploma, undergraduate, and postgraduate courses in Australia. Besides the lack of undergraduate and postgraduate courses in the area, trainings and events related to this topic are provided by the Lean Construction Institute Australasia (LCIA) and Engineering Education Australia (EEA). It highlights the fact that the area is emerging and there is a potential for developing courses for higher education in Lean Construction. Considering the combination of teaching in energy and construction, only one specific course provides a Master Degree which is specifically related to energy efficiency and construction. Royal Melbourne Institute of Technology (RMIT) offers a Master of Energy Efficient and Sustainable Building to both local and international students.

Coursework subjects were also explored with the aim of investigating the specific areas of study for each one of the offered courses in Australia. Seventy coursework subjects were identified according to the syllabus of each discipline. Coursework subjects related to energy were excluded as the area of knowledge was sometimes not relevant to Zero Energy. The subjects which includes teaching in specific areas related to Zero Energy, Renewable Energy and Sustainable Energy were considered.

The findings show that:

- There is no specific undergraduate and/or postgraduate course offered with certificate in Zero Energy, Lean Construction, or Energy Management.
- There is no specific undergraduate and/or postgraduate course in energy which includes 'Lean Construction'.
- Thirteen coursework subjects related to energy are related to buildings.
- Two coursework subjects related to energy are related to construction.
- Thirteen coursework subjects related to energy include management.
- None of the coursework subjects related to energy includes lean construction.

The list of courses and coursework subjects are provided in Appendix A and B.

## 4 Discussion

From our review of online contents of the Australian school systems, schools from Year 3 to Year 10 have sufficient contents related the origins of energy, the conversion of energy, and even topics such as sustainability of the continued use of fossil fuel-based energy and effects such as climate change. This result indicates that students should generally be able to undertake specialist studies in TAFE's and universities due to having previous basic knowledge on the topic.

A review of the VET system on the other hand, shows the traditional skill specific training is well developed. However, energy-related trainings are only available in certain sectors such as the Electrotechnology and the Property Services training and not specifically found in the Construction, Plumbing and Service Training Package. Lean construction unit of competencies are also not listed in the CPC Construction, Plumbing and Services Training Package (2017). It should be noted that although students can nominate units of competencies found in other training packages, it is up to the educational institution to offer them and these have to be contextualised to the building industry.

In the higher education sector where higher level cognitive skills such as design skills are developed, there are no currently specific qualifications offered in zero energy or lean construction however there are numerous universities offering coursework subjects related to energy management, energy in buildings and there are notably fewer universities offering subjects related to energy related construction. Lean construction topics may currently be offered as part of subjects as specific lean construction courses were not found in any universities in Australia.

These may perhaps leave gaps that should be filled up either by industry - associations or by private education providers offering non-for-credit or non-award type courses such as Continuing Professional Development (CPD) courses which is offered by Engineers Australia. The difficulty with such courses is that there are usually unregulated and therefore lacking in quality control. These courses also tend to be offered only when there is sufficient demand to justify organising the courses.

## 5 Conclusions

Two important current topics in the buildings are lean construction and zero energy buildings. These development and education of practitioners skilled in these concepts will have and influence on the industry's ability to reduce in the quest for affordable housing development. In our investigation we found that although the main knowledge areas of zero energy are sufficiently covered by courses involving sustainability, renewable energy, energy efficiency in buildings and infrastructure construction, there are still gaps as teaching of lean concepts are not widespread for achieving affordable housing and infrastructure in all these sectors in Australia. The increase of housing demand and challenges in relation to energy supply forecasted for the future in Australia shows the importance of bringing together zero energy and lean construction concepts into the forefront of schools and universities curriculum. Therefore, new course and subject offerings in the construction, facilities management and energy management areas should include not just topics on lean construction and zero energy but whole subjects which are standalone units.

## 6 References

- ACARA – The Australian Curriculum, Assessment and Reporting Authority (2016), *The Australian Curriculum*, ACARA, Sydney, Australia.
- AQFC – The Australian Qualifications Framework Council (2013), *Australian Qualifications Framework*, 2<sup>nd</sup> edition, the Australian Qualifications Framework Council, Australian Government Department of Education and Training, Canberra, Australia.
- CPC Construction, Plumbing and Services Training Package (2017), Release 3.0. Australian Government, URL: [https://training.gov.au/TrainingComponentFiles/CPC/CPC\\_R3.0.pdf](https://training.gov.au/TrainingComponentFiles/CPC/CPC_R3.0.pdf), viewed: 25 May 2018.
- CPP Property Training Package (2017), Release 1.0, Australian Government, URL: [https://training.gov.au/TrainingComponentFiles/ CPP/ CPP\\_R5.0.pdf](https://training.gov.au/TrainingComponentFiles/ CPP/ CPP_R5.0.pdf), viewed: 25 May 2018.
- Ladhad, A. and Parrish, K. (2013), The role of lean practices for zero net energy retrofits. in: Formoso, C.T. & Tzortzopoulos, P., *21<sup>st</sup> Annual Conference of the International Group for Lean Construction*. Fortaleza, Brazil, 31 July-2 August 2013. pp 895-904.
- Lausman, K. (2016), *Lean to Be 'Green'*. <http://www.lcicanada.ca/lean-to-be-green/>, viewed: 2 June 2018.
- MSA07 Manufacturing Training Package (2014), release 8.4, Australian Government, URL: [https://training.gov.au/TrainingComponentFiles/MSA07/MSA07\\_R8.4.pdf](https://training.gov.au/TrainingComponentFiles/MSA07/MSA07_R8.4.pdf), viewed: 25 May 2018.
- MSS Sustainability Training Package (2017), Release 1.0, Australian Government, URL: [https://training.gov.au/TrainingComponentFiles/MSS/MSS\\_R1.0.pdf](https://training.gov.au/TrainingComponentFiles/MSS/MSS_R1.0.pdf), viewed: 25 May 2018.
- Origin (2018), *Energy for Schools*, URL: <https://www.originenergy.com.au/about/community/energy-for-schools.html>, viewed: 30 May 2018.
- Pulakka, S., Vares, S., Nykänen, E., Saari, M., and Häkkinen, T. (2016), Lean production of cost optimal wooden nZEB. *Energy Procedia*, vol. 96, pp.202-211.
- ResourceSmart, Sustainability Victoria URL: <http://www.sustainability.vic.gov.au/School/Modules>, viewed: 30 May 2018.
- Sands, M.S. (2010), Standards and measures--whole-building metrics driving innovation and high performance. *Lean Construction Journal*, pp. 1-17.
- Swoboda, K. (2018), Energy prices—the story behind rising costs, URL: [https://www.aph.gov.au/About\\_Parliament/Parliamentary\\_Departments/Parliamentary\\_Library/pubs/BriefingBook44p/EnergyPrices](https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/BriefingBook44p/EnergyPrices), Parliament of Australia, viewed: 16 June 2018.
- Thomas, C. Jennings, P.J. and Lloyd, B. (2008), Renewable energy courses in Australian and New Zealand universities, *Solar Progress*, pp. 1-6.
- UEE Electrotechnology Training Package (2017), Australian Government, release 1.0. URL: [https://training.gov.au/TrainingComponentFiles/UEE/UEE\\_R1.0.pdf](https://training.gov.au/TrainingComponentFiles/UEE/UEE_R1.0.pdf), viewed: 25 May 2018.
- VCAA (2018), Learning in Science: The key concepts, Victorian Curriculum Foundation-10, URL: <http://victoriancurriculum.vcaa.vic.edu.au/science/introduction/learning-in-science> viewed: 16 June 2018.
- Zero Energy Resources (2018), URL: <https://www.zeroenergy.org/zero-energy-schools/>, viewed: 30 May 2018.
- Zuhairi, A.H., Beng, G.H. and Hung, F.C. (2016), Design revolution for affordable housing in tropical country, in *Proceedings of the CIB World Building Congress 2016*, Volume V, Advancing products and services, Edt. Nebil Achour, pp. 282-301.

## Appendix A- List of Courses available in Australia

Course	University	Level
Associate Degree of applied engineering (renewable energy technologies)	TAFE NSW	Undergraduate
Bachelor of Technology (Renewable Energy Systems)	University of Newcastle	Undergraduate
Bachelor of Engineering Honours (BE(Hons)) in Renewable Energy Engineering	Murdoch University	Undergraduate
Bachelor of Engineering Majoring in Renewable Energy Systems	Australian National University	Undergraduate
Bachelor of Engineering (Electrical and Renewable Energy) Honours	Edith Cowan University	Undergraduate
Bachelor of Engineering (honours) Major in Photovoltaics and Solar Energy	University of New South Wales	Undergraduate
Bachelor of Engineering (Honours) Major in Renewable Energy Engineering	University of New South Wales	Undergraduate
Bachelor of Engineering (Sustainable Energy Systems)	Griffith University	Undergraduate
Bachelor of Engineering Sustainable Energy Systems	Australian National University	Undergraduate
Bachelor of Renewable Energy Engineering (Honours)	Monash University	Undergraduate
Graduate Certificate in Energy and Carbon Studies (GradCertEnCbSt)	Murdoch University	Postgraduate
Graduate Diploma in Energy and Carbon Studies (GradDipEnCbSt)	Murdoch University	Postgraduate
Graduate Diploma in Energy and the Environment (Energy, Emissions and Environment)	Murdoch University	Postgraduate
Graduate Diploma in Energy Efficient and Sustainable Building	RMIT	Postgraduate
Graduate Diploma in Sustainable Energy	RMIT	Postgraduate
Master of Energy Efficient and Sustainable Building	RMIT	Postgraduate
Master of Energy Systems	The University of Melbourne	Postgraduate
Master of Sustainable Energy	Queensland University of Technology	Postgraduate
Master of Engineering (Electrical and Renewable Energy Engineering)	Deakin University	Postgraduate
Master of Engineering (Sustainable Energy)	RMIT	Postgraduate
Master of Engineering in Renewable Energy	Australian National University	Postgraduate
Master of Engineering in Sustainable Systems	University of New South Wales	Postgraduate
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	University of New South Wales	Postgraduate
Master of Engineering Science Specialisation in Renewable Energy	University of New South Wales	Postgraduate
Master of Environment (Energy Efficiency Modelling and Implementation)	The University of Melbourne	Postgraduate
Master of Philosophy in Engineering - Photovoltaics and Solar Energy	University of New South Wales	Postgraduate
Master of Science Renewable and Sustainable Energy (MResSusEn)	Murdoch University	Postgraduate
Specialisation - Energy Efficiency Modelling and Implementation	The University of Melbourne	Postgraduate
Specialisation - Renewable and sustainable energy engineering	Monash University	Postgraduate

## Appendix B – Coursework subjects available in Australia

Course	Subject	University	Level of degree	Construction /Building	Management
Bachelor of Engineering Honours (BE(Hons)) in Renewable Energy Engineering	Applied Photovoltaics	Murdoch University	Graduate	-	-
Bachelor of Engineering Honours (BE(Hons)) in Renewable Energy Engineering	Renewable Energy Systems Engineering	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Energy System	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Case Studies of Renewable Energy Systems	Murdoch University	Graduate	-	Yes
Master of Science Renewable and Sustainable Energy	Renewable Energy Resource	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Renewable Energy Devices	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Renewable Energy Systems Design	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Energy Efficiency, System Analysis and Auditing	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Industrial and Commercial Energy Efficiency Technologies	Murdoch University	Graduate	-	-
Master of Science Renewable and Sustainable Energy	Energy Efficient Buildings	Murdoch University	Graduate	Yes	-
Bachelor of Engineering Sustainable Energy Systems	Engineering Sustainable Systems	Australian National University	Undergraduate	-	-
Bachelor of Engineering Sustainable Energy Systems/ Bachelor of Engineering Majoring in Renewable Energy Systems/Master of Engineering in Renewable Energy	Energy Resources and Renewable Technologies	Australian National University	Undergraduate	-	-
Bachelor of Engineering Majoring in Renewable Energy Systems/ Master of Engineering in Renewable Energy	Photovoltaic Technologies	Australian National University	Undergraduate	-	-
Bachelor of Engineering Majoring in Renewable Energy Systems	Solar Thermal Technologies	Australian National University	Undergraduate	-	-
Master of Engineering in Renewable Energy	Photovoltaic Power Plants	Australian National University	Postgraduate	Yes	-

Course	Subject	University	Level of degree	Construction /Building	Management
Master of Engineering in Renewable Energy	Integration of Renewable Energy into Power Systems and Microgrids	Australian National University	Postgraduate	-	Yes
Master of Engineering in Renewable Energy	Urban Energy and Energy Efficiency	Australian National University	Postgraduate	Yes	-
Master of Engineering in Renewable Energy	Industrial Energy Efficiency and Decarbonisation	Australian National University	Postgraduate	-	-
Master of Engineering in Renewable Energy	Solar Thermal Technologies	Australian National University	Postgraduate	-	-
Bachelor of Engineering (Electrical and Renewable Energy) Honours	Sustainability and Renewable Energy	Edith Cowan University	Undergraduate	-	-
Bachelor of Engineering (Electrical and Renewable Energy) Honours	Renewable Energy Conversions 1	Edith Cowan University	Undergraduate	Yes	-
Bachelor of Engineering (Electrical and Renewable Energy) Honours	Renewable Energy Conversions 2	Edith Cowan University	Undergraduate	-	-
Associate Degree of applied engineering (renewable energy technologies)	Foundation studies in renewable energy and sustainability	TAFE NSW	Undergraduate	-	-
Associate Degree of applied engineering (renewable energy technologies)	Renewable energy resource analysis	TAFE NSW	Undergraduate	-	-
Associate Degree of applied engineering (renewable energy technologies)	Grid connected photovoltaic power systems	TAFE NSW	Undergraduate	-	-
Associate Degree of applied engineering (renewable energy technologies)	Solar and thermal energy systems	TAFE NSW	Undergraduate	-	-
Bachelor of Engineering (honours) Major in Photovoltaics and Solar Energy/ Sustainable Systems	Sustainable and Renewable Energy Technologies	University of New South Wales	Undergraduate	-	-
Bachelor of Engineering (honours) Major in Photovoltaics and Solar Energy	Low Energy Buildings and PV	University of New South Wales	Undergraduate	Yes	-
Bachelor of Engineering (Honours) Major in Renewable Energy Engineering	Renewable Energy Policy and International Programs	University of New South Wales	Undergraduate	-	-
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	Sustainable Energy for Developing Countries	University of New South Wales	Postgraduate	Yes	-
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	Photovoltaic Technology and Manufacturing	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	Advanced Photovoltaic Manufacturing	University of New South Wales	Postgraduate	-	-



Course	Subject	University	Level of degree	Construction /Building	Management
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	Managing Energy Efficiency	University of New South Wales	Postgraduate	Yes	Yes
Master of Engineering Science Specialisation in Photovoltaics and Solar Energy	Photovoltaic Stand-Alone System Design and Installation	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Renewable Energy/ Photovoltaics and Solar Energy/ Bachelor of Engineering (Honours) Major in Renewable Energy Engineering	Low Energy Buildings and Photovoltaics	University of New South Wales	Postgraduate	Yes	-
Master of Engineering Science Specialisation in Renewable Energy/ Photovoltaics and Solar Energy	Grid-Connected Photovoltaic Systems	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Renewable Energy/ Bachelor of Engineering (Honours) Major in Renewable Energy Engineering	Energy Efficiency	University of New South Wales	Postgraduate	Yes	-
Master of Engineering Science Specialisation in Renewable Energy/ Photovoltaics and Solar Energy	Photovoltaics	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Renewable Energy	Renewable Energy System Modelling and Analysis	University of New South Wales	Postgraduate	Yes	-
Master of Engineering Science Specialisation in Renewable Energy/ Photovoltaics and Solar Energy	Hybrid Renewable Energy Systems	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Renewable Energy	Integrated Design Studio 4 High Performance Buildings	University of New South Wales	Postgraduate	Yes	-
Master of Engineering Science Specialisation in Renewable Energy	Solar Thermal Energy Design	University of New South Wales	Postgraduate	-	-
Master of Engineering Science Specialisation in Renewable Energy/ Photovoltaics and Solar Energy	Advanced Photovoltaics	University of New South Wales	Postgraduate	-	-
Bachelor of Renewable Energy Engineering (Honours)	Solar energy	Monash University	Undergraduate	-	-

Course	Subject	University	Level of degree	Construction /Building	Management
Specialisation - Renewable and sustainable energy engineering	Sustainable energy systems	Monash University	Postgraduate	-	-
Specialisation - Renewable and sustainable energy engineering	Energy efficiency and sustainability engineering	Monash University	Postgraduate	Yes	-
Specialisation - Renewable and sustainable energy engineering	Renewable energy systems	Monash University	Postgraduate	-	-
Engineering PhD students.	Advanced photovoltaics and energy storage	Monash University	Postgraduate	-	-
Master of Energy Efficient and Sustainable Building	Sustainable Energy Fundamentals	RMIT	Graduate	-	-
Master of Energy Efficient and Sustainable Building	Building Systems	RMIT	Graduate	Yes	-
Master of Energy Efficient and Sustainable Building	Sustainability in the built environment: A focus on building and design	RMIT	Graduate	Yes	-
Master of Energy Efficient and Sustainable Building	Sustainable Building technologies	RMIT	Graduate	Yes	-
Master of Energy Efficient and Sustainable Building	Energy Water and Airflow in Buildings	RMIT	Graduate	Yes	-
Master of Energy Efficient and Sustainable Building	Sustainable Energy Systems and design	RMIT	Graduate	-	-
Graduate Diploma in Sustainable Energy	Energy Efficiency and Demand Management	RMIT	Graduate	-	-
Graduate Diploma in Sustainable Energy	Photovoltaic Systems	RMIT	Graduate	-	-
Master of Sustainable Energy	Energy Principles and Renewable Energy	Queensland University of Technology	Graduate	-	-
Master of Sustainable Energy	Low Emission Technologies and Supply Systems	Queensland University of Technology	Graduate	-	-
Master of Sustainable Energy	Energy Efficiency and Transport	Queensland University of Technology	Graduate	-	-
Others	ZEMCH Sustainable Design Workshop	The University of Melbourne	Graduate	Yes	-
Others	Energy Efficiency Technology	The University of Melbourne	Graduate	-	-
Others	Environmental Systems	The University	Graduate	Yes	-

Course	Subject	University	Level of degree	Construction /Building	Management
Others	Renewable Energy	of Melbourne The University of Melbourne	Graduate	-	-
Others	Renewable Energy	Swinburne University	University Degree	-	-
Others	Solar Energy	The University of Melbourne	Graduate	-	-
Others	Energy Efficiency Technology	The University of Melbourne	Graduate	-	-
Others	Renewable Energy Principles	Curtin University	Graduate	-	-
Others	Introduction to Renewable Energy	Curtin University	Graduate	-	-
Others	Sustainable Energy Systems and Technologies	Curtin University	Graduate	-	-
Others	Renewable Energy Systems	Curtin University	Graduate	-	-





Minerva Access is the Institutional Repository of The University of Melbourne

**Author/s:**

Hui, KP; Akemi Yokota, A; Aye, L

**Title:**

Education & training for zero energy and lean manufacturing & construction of housing in Australia

**Date:**

2018-09-27

**Citation:**

Hui, K. P., Akemi Yokota, A. & Aye, L. (2018). Education & training for zero energy and lean manufacturing & construction of housing in Australia. Do, K (Ed.) Sutrisna, M (Ed.) Jonescu, E (Ed.) Zaman, A (Ed.) 42nd AUBEA Conference 2018: Educating Building Professionals for the Future in the Globalised World, pp.47-60. Curtin University.

**Persistent Link:**

<http://hdl.handle.net/11343/216763>

**File Description:**

Published version