Department of Resources, Energy & Tourism (DRET)
ENERGY EFFICIENCY ADVISORY GROUP (EEAG)

CONSULTATION: ENERGY EFFICIENCY & ENGINEERING EDUCATION

Final Report (Ver. 2)

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ENGINEERS AUSTRALIA

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Acknowledgements & Project Team Declarations

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This collaborative project has been managed by Dr Cheryl Desha, lecturer in the Faculty of Built Environment and Engineering at the Queensland University of Technology, and a member of The Natural Edge Project (TNEP), an academic partnership for research and capacity building for sustainable development. Ms Fiona McKeague provided research assistance, with assistance from other members of the TNEP research team on logistics for phone interviews and workshops. The project was undertaken in collaboration with Mr Karlson 'Charlie' Hargroves, Sustainable Development Research Fellow at the University of Adelaide's Entrepreneurship, Commercialisation and Innovation Centre (ECIC).

Dr Desha and Mr Hargroves are members of RET's Energy Efficiency Advisory Group. Over the last several years, they have led and been involved in a range of energy efficiency education initiatives with the TNEP research group. This has included contributing to the development of 30 lectures on energy efficiency opportunities (by major economic sectors and technologies) as part of the CSIRO Energy Transformed Program. With funding support by the National Framework for Energy Efficiency (NFEE) Training and Accreditation Committee they led the 2007 TNEP investigation into the state of engineering education for energy efficiency, and subsequently the 2009 investigation into barriers and benefits for lecturers teaching energy efficiency in engineering programs. They also undertook the 2010 NFEE funded national survey of industry and academia regarding engineering graduate expectations, and a 2012 NFEE funded investigation into the state of energy efficiency education in post-graduate engineering studies in Australia.

Executive Summary

This report provides the Commonwealth Department of Resources, Energy and Tourism (RET) with a summary of consultation undertaken with representatives from industry and academia around Australia regarding mainstreaming energy efficiency within engineering education. Specifically, the report documents the purpose of the consultation process, key messages and emerging themes, industry-perceived gaps in energy efficiency related knowledge and skills, and academic considerations regarding graduate attributes and learning pathways to close these gaps.

This information complements previous reports by presenting the current thoughts and ideas of more than 100 engineering academic and practising professionals who are actively involved in building capacity through the education system or implementing energy efficiency improvements in companies/the workplace. Furthermore, the report describes the emergence of a potential 'community of practice' in energy efficiency capacity building that arose during the project.

Project Context

Energy efficiency will play a major role in helping Australia maintain its productivity and competitiveness in a low-emissions economy, and achieving its emission reduction targets in 2020 and beyond. The Council of Australian Governments (COAG) has recognised the important role energy efficiency will play through the development and implementation of the National Strategy on Energy Efficiency (NSEE). The Commonwealth Department of Resources, Energy and Tourism (RET) is responsible for implementing several measures in the NSEE relating to industrial energy efficiency. This includes working with industry and the tertiary education sector to increase the energy efficiency skills base of Australia's future workforce. RET has formed the Energy Efficiency Advisory Group (EEAG), comprised primarily of academics with expertise in engineering education and university curriculum renewal, to provide advice on this work.

In 2011, RET commissioned the Queensland University of Technology (QUT) to conduct a small project to identify attributes and associated learning outcomes required by engineering graduates to work effectively on energy efficiency. RET then commissioned QUT, with in-kind support from Engineers Australia, to conduct consultation to obtain industry perspectives on the findings of its previous work. This document reports on that consultation process, which:

1. Engaged with industry to identify key discipline-specific skills and competencies;
2. Engaged with engineering educators to identify graduate attributes and associated learning outcomes in order to deliver the skills and competences identified; and
3. Explored how links between industry and universities can be strengthened to support graduate learning outcomes that meet industry needs.

Previous research for RET and the National Framework for Energy Efficiency by organisations such as *The Natural Edge Project*, *Allens Consulting* and *GHD* have clearly shown that much more needs to be done to mainstream energy efficiency as a primary design principle within engineering practice. Specifically, there is a significant gap in the capacity of practicing professionals to identify and implement energy efficiency opportunities in the workplace. Furthermore, the development of this capacity in tertiary education is *ad hoc*, with few examples of energy efficiency being fully integrated into engineering education.

Project Significance

Despite its relatively small-scale, this project's contribution to the energy efficiency agenda is significant for several reasons:

⇒ The high-level collaboration with *Engineers Australia* as the peak engineering body in Australia and the authority responsible for accrediting undergraduate engineering programs in accordance with the international 'Washington Accord' (**Appendix A**). Support provided during the project included the institution's in-kind contribution of facilities and administration, and support for interaction with its college and technical society members;

⇒ The voluntary involvement of all eight *Engineers Australia* colleges (biomedical, chemical, civil, electrical, environmental, ITEE, mechanical, and structural) and some of their affiliated societies, along with the mining and metallurgy professional and education community representing a significant sector in the conversation. This included participation in phone conferences for each college, document review, and attendance at one of three workshops. Many participants provided additional thoughtful and detailed feedback (mostly via email);

⇒ The unprecedented opportunity for industry and academia to discuss curriculum development issues related to energy efficiency face-to-face through three workshops (118 registrations, 87 participants), and via nine phone consultations (28 participants). Through the project, a database of more than one hundred practising industry and academic professionals was produced, linking academics and professionals via a mutual interest in the future of energy efficiency in Australia.

Project Methodology

Initially, this project used a literature review and discussion of curriculum renewal processes from a previous project (EEAG Project 1) as a basis for consulting with academics and practising engineers, seeking their views on the previous findings and their ideas for improving engineering energy efficiency capacity. Draft 'briefing notes' were developed that were further refined during the project through the following consultations.

Consultation with Colleges (by Phone/ Email/ Face-to-Face): A multi-stage consultation process was conducted via phone, email and face-to-face interviews with representatives from each of the eight *Engineers Australia* colleges and with representatives from the mining and metallurgy sector. Detailed accounts of the opinions and emerging themes are attached in **Appendix C**.

Consultation with Industry and Academia (by Workshop/ Email Follow-up): Following the college consultation, three 1-day workshops were held with representatives from industry, academia, government and professional organisations (see **Appendix B)**. The purpose was three-fold:

1) to seek feedback on critical gaps in knowledge, skills and capacity in engineering practice;
2) to explore opportunities for addressing these gaps in engineering education; and
3) to encourage networking between academic and industry practitioners that might facilitate future collaborative capacity building projects. Detailed accounts of the central themes that emerged from the workshop consultation are attached in **Appendix D** and **Appendix E**.

Briefing Notes: Nine briefing notes were developed during the initial stages of this project to introduce participants to current issues in energy efficiency education relevant to each engineering discipline. These papers were refined with assistance from participant feedback, and consolidated into one 'Briefing Note' attached in **Appendix F**. Anecdotal comments from participants during the phone calls and workshops indicated that the briefing notes may have a powerful potential to contribute to the discussion around energy efficiency in a way that was initially unanticipated by the project team.

Discussion & Conclusions

Following the phone and workshop consultation, a number of knowledge and skill sets, and associated learning pathways were identified for three graduate attributes that are highly relevant for RET as summarised in Table E1 below. In the report (Tables 3-5) these are described in detail, including where they would be covered within the Engineers Australia Stage 1 Competency Standard.

Table E1: Consultation summary – numbers of gaps, knowledge and skill areas, and indicative learning pathways identified

Graduate Attributes (Focused on RET directives)	Industry Perceived Gaps	Component Knowledge & Skill Areas*	Learning Pathways – Engineering Education			
			Technical	Enabling	Discipline-Specific	Cross-disciplinary
The ability to participate in assessments	**9**	**9**	7	4	5	8
The ability to evaluate Energy Efficiency opportunities	**11**	**6**	2	4	1	6
The ability to implement Energy Efficiency opportunities	**7**	**5**	3	4	2	4

** This is not a total of the four columns. Rather, it records how many knowledge and skill areas were identified, where some belong to multiple categories in the previous columns (e.g. an area may have technical, discipline-specific and cross-disciplinary components)*

An important project finding was that participants from all disciplines frequently went beyond RET-directed energy efficiency considerations (i.e. process improvement opportunities), discussing the need for education about energy use, fossil fuel energy alternatives (e.g. renewables) and reducing overall consumption (see findings in the main report and raw data in appendices). This was despite all engagement questions being framed to address RET's scope. This points to a broader interpretation of the term "energy efficiency" in the academic and industry communities, where there appear to be a number of different understandings of energy efficiency in use. While the department and a number of professionals and academics working in the area view energy efficiency as a distinct and separable component of energy and sustainability considerations, others in the community of industry and academic professionals practicing within the sector often seem to view energy efficiency, energy use and sustainability as inseparably linked.

Furthermore, participants in the consultation often reflected that "energy efficiency" improved in many areas of their work places over time, as a result of energy efficiency initiatives, and sometimes as a result of actions aimed at other objectives, for example, reducing the size of equipment for space reasons, taking advantage of new materials or technologies (e.g. electronics), improving productivity, product quality, consumer acceptance, reducing injuries etc. .

These findings clearly indicate that engaging academics and industry in building capacity for energy efficiency in engineering, is most effectively achieved through a "whole of energy" approach to curriculum renewal, where a broad set of knowledge and skill areas are considered necessary to build the desired graduate attributes. Using the graduate attributes outlined in Table E1, the types of knowledge and skill areas (and corresponding pathways) that have been documented by this project demonstrate the need for whole of curriculum design to ensure that the full range of required knowledge and skills are embedded throughout engineering courses. This finding is also important to take into consideration with future projects, especially when drafting grants and tenders, to ensure that the resources developed address the department's intentions.

The consultation process highlighted differences between disciplines in relation to their awareness of, and engagement with energy efficiency. Participants from mechanical and electrical engineering colleges and mining and metallurgy considered it a priority. Participants from chemical engineering and ITEE were also significantly engaged and identified many points of connection with their disciplines. In contrast, participants from structural, civil, environmental and biomedical engineering did not, at that time, see their priorities as aligning with energy efficiency, although every college identified at least a few areas of connection.

In addition to the difference in appreciation of terms and priority differences between discipines, it is concluded that a key barrier to mainstreaming energy efficiency within engineering education has also been the general lack of interaction between academic and practising engineers. Indeed, industry practitioners perceive academic practitioners and university curriculum as lagging behind industry practice. This situation appears to stem from a suite of challenges, some of which might be targeted by the federal government to improve interaction between academics and industry professionals. These challenges include:

⇒ The gradual restructuring and 'streamlining' of the workforce over the past decade, resulting in fewer 'work placement' opportunities for undergraduate engineers
⇒ Copyright and confidentiality issues involved in project development, particularly where student/academic collaborative projects may produce potentially valuable intellectual property
⇒ The emergence of a 'pay to participate' expectation whereby universities ask industry to pay for work experience students (this includes an initial involvement fee, and can include student salaries while in the workplace)
⇒ Inadequate communication between academics and industry regarding student placement opportunities, and the need for industry-relevant projects on a semester-basis
⇒ Lack of funding for professional organisations such as Engineers Australia to allow them to facilitate discussion and debate between industry and academia on relevant engineering competencies and curriculum implications.

The consultation process identified a number of opportunities for future engineering capacity building projects which would increase their capability with energy efficiency (Table 6). These include (in order of prevalence of discussions in consultation):

⇒ Funding cross-disciplinary and discipline-specific learning resources for building capabilities
⇒ Supporting the professional body Engineers Australia to prioritise curriculum renewal for energy efficiency (e.g. as a 'priority area')
⇒ Facilitating student access to workplace experience
⇒ Supporting (funding and endorsement) of student competitions, academic teaching and research awards that include teaching incentives (e.g. monetary, fellowships, citations)
⇒ Incentivising industry interactions with academics, including funded industry placements, placement-based case study development support, and industry-led student projects with curriculum-friendly assessment opportunities
⇒ Creating project research funding with clear ownership requirements/ common access to results (project legacy materials for future curriculum resources)
⇒ Brokering access to industry data for student use in "real-life" projects
⇒ Initiating a business engineering forum/ round table on energy efficiency.

Through the consultation process, industry identified a clear gap in 'enabling skills' amongst graduates. Enabling skills are not specific to energy efficiency, but are fundamental to being able to effectively undertake a wide range of workplace activities. These skills enable activities such as investigating, auditing, reporting, presenting, working with teams, working across engineering sub-disciplines and with other disciplines, systems approaches and project management. It is clear from this project that industry have a dominant perception that graduates lack enabling knowledge and skills, in cross-disciplinary as well as discipline-specific areas.

With regard to technical knowledge and skills, it is concluded that important components of energy efficiency-related graduate attributes (as identified in the literature and by experts in the field) are not well understood by industry or academic practitioners. This is particularly problematic when developing curriculum renewal strategies for engineering, and necessitates raising awareness amongst the deliverers of the curriculum (academics), and recipients of the resultant graduates (industry) about the meaning and importance of these components. It is recommended that websites such as the RET-administered Energy Efficiency Exchange (EEX) website are used for these purposes, in addition to fostering the community of practice that was formed during this project.

Glossary

Accreditation
In Australia, external accreditation of university programs that lead to formative engineering qualifications is the responsibility of Engineers Australia (noting that the 'provider' is formally the educational authority for program accreditation, as required by 'TEQSA'. See 'TEQSA' below). The accreditation process focuses on the delivery of graduate outcomes as specified in the Engineers Australia Stage 1 Competency Standard for each program, using criteria that cover the teaching and learning environment, the structure and content of the program, and the quality assurance framework. Accredited programs must include 'exposure to engineering practice'. Engineers Australia 'Colleges' are involved through nominating members to accreditation panels. Accreditation is required on the introduction of a new program, and is reviewed every five years.

AQF
Australian Quality Framework. This is Australia's national policy for regulated qualifications including engineering, intended to provide national recognition and consistent understanding of what defines each qualification type. Under 'TEQSA' and in line with the AQF, providers may offer a higher education award which leads to a qualification which corresponds with an AQF level from 5 to 10. As of 2012, engineering programs in Australia are considering how to adapt existing curriculum to meet AQF requirements for 'Level 8' which requires an honours or equivalent experience.

Attribute
See 'Graduate Attribute'

Capability
A specific skill set that forms part of the 'competency standard'. (See 'Competency Standard' below). These may be described as 'technical', 'specialist', 'process', 'non-technical', 'common' or 'generic' capabilities depending on the engineering discipline.

College
Eight colleges are distinguished by Engineers Australia to broadly cover all areas of practice in engineering, and are supported by a number of 'technical societies'. The colleges are Biomedical, Chemical, Civil, Electrical, Environmental, Information Telecommunications and Electronics (ITEE), Mechanical and Structural. For the purpose of this consultation project, the discipline of 'Mining and Metallurgy' was added to the areas of practice, given the significance of this sector in Australia and the specific education delivered to engineers in this field.

Competency Standard
The Engineers Australia 'Stage 1 Competency Standard' for each engineering occupation consists of three broad competencies": knowledge and skills base, engineering application ability, and professional and personal attributes. Each competency is broken down into several 'Elements'(See 'Element of Competency' below), each elaborated with a number of 'Indicators of Attainment' (See 'indicator of attainment' below). Together, each 'competency' and 'elements of competency' represent the profession's expression of the knowledge and skill base, engineering application abilities, and professional skills, values and attitudes that must be demonstrated at the point of entry to practice (based on EA competency standard definition).

Course
A unit of work undertaken as part of the overall *Program* of study (i.e. 1/8 of a nominal full study year). This is also commonly referred to by universities as a 'Unit' or 'Subject', and may comprise of several 'modules'.

Curriculum (singular) or Curricula (plural)
All the courses of study offered by an educational institution (curricula), or a group of related courses (curriculum). For example 'the mechanical engineering curriculum'. Curricula renewal may involve the redevelopment of one or more *courses* in a *program*, the review of *syllabus*, the *pedagogy,* and *student assessment*.

Engineers Australia (EA)
Engineers Australia is the unified, national competency assessment authority for engineering practice in Australia. It is also Australia's professional body for engineers, and the national forum for the advancement of engineering and the professional development of its members.

Element of Competency	Elements of Competency are the sixteen components of the three Competencies in the *Engineers Australia* Stage 1 Competency Standard, that must be demonstrated for the accreditation of an engineering program to be achieved, or demonstrated by an individual seeking admission to membership of *Engineers Australia* without an accredited qualification. The Elements of Competency may be used by a university to create 'Learning Outcomes' (see 'Learning Outcome' below) for the engineering curriculum to align intended 'graduate attributes' (see 'Graduate Attribute' below) with the Competency Standard'.
Energy Efficiency	See 'Energy Efficiency Improvements' below.
Energy Efficiency Improvements	Using less energy input for an equivalent level of economic activity or service (European Commission definition).
Engineer / Engineering Occupation	A qualified professional specialising in one or more fields (disciplines) of engineering. Engineers are frequently required to apply their skills across a range of circumstances that require interdisciplinary co-operation, and to be work-ready upon completion of their engineering qualification. *Engineers Australia* has members in the occupational categories of Professional Engineer, Engineering Technologist and Engineering Associate. 'Stage 1' and 'Stage 2' Competency Standards are published for each occupation.
Exposure to Engineering Practice	All accredited engineering programs must include opportunities for students to gain understanding of engineering practice. This may include a prescribed period of practical experience in industry and or industry lectures, site visits, industry-based projects, and other forms of work-integrated learning.
Formative Engineering Qualification	The accredited qualification for entry to practice in each 'engineering occupation'. Generic award titles for formative qualifications for each occupation are: Professional Engineer: Bachelor of Engineering or Master of Engineering; Engineering Technologist: Bachelor of Engineering Technology; and Engineering Associate: Advanced Diploma or Associate Degree.
Graduate Attribute	A desirable quality that a graduate engineer will possess by the time they complete their 'Program'. This may be a specialist attribute specific to one discipline of engineering, a common attribute shared with other disciplines of engineering or a universal attribute shared across all students of any discipline. Educational institutions design their curricula so that the attributes of successful graduates will meet the *Engineers Australia* Stage 1 competency standards.
Indicator (of Attainment)	Each of the sixteen 'elements' of *Engineers Australia's* 'Stage 1 Competency Standard', is elaborated with 'indicators' of attainment. These provide insight to the breadth and depth of ability expected for each element of competency, thereby guiding the competency demonstration and assessment process, as well as curriculum design. The indicators of attainment should not be interpreted as discrete sub-elements of competency mandated for individual audit. Each element of competency must be tested in a holistic sense, and there may well be additional indicator statements that could complement those listed (EA definition).
Inverse Learning Pathway	An alternative 'learning pathway' or method of instruction where students learn as a direct result of experience. Termed an 'inverse pathway' because the training process occurs in the order of 'demonstrate', 'practice', 'learn', instead of 'learn', then 'practice' and 'demonstrate'.
Knowledge and Skills	Portions of a 'Graduate Attribute' that need to be developed over the duration of the 'Program', in order for the 'Graduate Attribute' to be achieved. They can be further broken down into 'Component Knowledge and Skills'.
Learning Outcome	A statement of what 'Knowledge and Skills' a student should have developed and to what extent, by the time they complete a 'Course'. The statement usually begins with a phrase such as, *"By the end of this course, you will be able to …"*

Learning Pathway	The way in which one or more 'Knowledge and Skills' are built through the course of a 'Program' to achieve a 'Graduate Attribute'. A learning pathway comprises a sequence of 'Courses' in a 'Program', where each Course has a 'Learning Outcome' that targets the development of one or more component 'Knowledge and Skills'. The development of 'Component Knowledge and Skills' is often instilled through the processes of 'learn', 'practice' and 'demonstrate', where: 'Learn' refers to the initial exposure to knowledge and theory about the knowledge or skill; 'Practice' refers to students repeatedly accessing the knowledge and theory; and 'Demonstrate' refers to the students applying the knowledge and theory to problem solving in a contextually appropriate way.
Program	The award that a student works towards, and which is made up of a certain number of approved courses. Universities sometimes refer to a program as a 'Course'.
School/ Department/ Faculty	The level of coordination within a university context, in which engineering programs are coordinated, and to which lecturers belong.
Stage 1 Competency Standard	The Stage 1 Competency Standard sets the outcome expectations for a formative educational qualification accredited or recognised by *Engineers Australia*, to enable entry to practice into each of the three 'engineering occupations'. Each Stage 1 Competency Standard comprises three 'Competencies', 16 'Elements' and a number of elaborating 'Indicators of Attainment'. Being 'ready for entry to practice' implies that in employment, individuals from accredited programs will typically work initially on tasks of limited scope and complexity, under the guidance of a more experienced person, while they develop practice competencies and experience.
Stage 2 Competency Standard	(See 'Stage 1 Competency Standard') The Stage 2 Competency Standards for each occupational category defines the requirements for independent practice. They are used as the basis of assessment for chartered membership of Engineers Australia and, for Professional Engineers, for registration on the National Professional Engineers Register (NPER). The Stage 2 Competency Standards embody both the enabling (Stage 1) and the practice competencies relevant to a field of engineering and an occupational category. Persons who are Stage 2 competent are *practice-experienced* and are capable of working autonomously under general direction in normal operating environments. Particularly complex, critical or innovative work might call for limited guidance while experience develops further. (based on EA definition). This standard is under review (2012).
Technical Society	Engineers Australia uses 'technical societies' to form a bridge between engineering and other practitioners, providing a forum for mutual technical development, networking, expanding and sharing knowledge with like-minded professionals (Engineers Australia definition).
TEQSA	Tertiary Education Quality and Standards Authority. Under the *Tertiary Education Quality and Standards Agency Act 2011* (TEQSA Act), all legal entities that meet the definition of a higher education provider in the Act are required to seek registration by TEQSA as a registered higher education provider.

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1. Introduction

Within the realm of 21st Century engineering practice, 'energy efficiency' as a principle is critical to explore and apply. Energy efficiency will play a major role in helping Australia maintain its productivity and competitiveness in a low-emissions economy, and achieving its emission reduction targets in 2020 and beyond. How we manage the energy used in delivering our activities, products and services will be a defining feature of our generation's success or failure at 'sustainable development'.

Phenomena such as rapid population growth and consumption pose a huge variety of challenges to our current generation of practicing engineers, and those who are still in training. In contrast to 20th Century perceptions of abundant and infinite resources, it is increasingly apparent that reducing the use of energy – including fossil-derived fuels as our current dominant source of energy – per unit of activity, product or service, is a primary mechanism to reduce greenhouse gas emissions. It is also increasingly evident that the finite nature of many resources is beginning to influence how we service society's demands.

With engineering being a key profession in addressing such demands, government, industry and the broader community have particular expectations of it to redesign processes in all aspects of the economy to be substantially more energy efficient. Indeed, countries around the world are considering, or already implementing, a range of structural adjustments that target greenhouse gas emissions from major emitters, which directly influences the scope of engineering practitioner roles. In Australia, the Council of Australian Governments (COAG) has recognised the important role energy efficiency will play through the development and implementation of the National Strategy on Energy Efficiency (NSEE). The Commonwealth Department of Resources, Energy and Tourism (RET) is responsible for implementing several measures in the NSEE relating to industrial energy efficiency. This includes working with industry and the tertiary education sector to increase the skills base of Australia's emerging workforce.

Research funded by RET and the National Framework for Energy Efficiency has concluded that much more needs to be done to mainstream energy efficiency as a primary design principle within engineering practice. Specifically, there is a significant gap in the capacity of practising professionals to identify and implement energy efficiency opportunities in the workplace. Furthermore, the development of this capacity in tertiary education is *ad hoc*, with few examples of energy efficiency being fully integrated into engineering education.

In 2010, RET formed the Energy Efficiency Advisory Group (EEAG), comprised primarily of academics with expertise in engineering education and university curriculum renewal, to provide expert advice on this work. In 2011, RET commissioned the Queensland University of Technology (QUT) to identify energy efficiency related attributes and learning outcomes required by engineering graduates that would enable them to work effectively on EE. RET then commissioned QUT, with in-kind support from Engineers Australia, to conduct follow-on work to obtain industry perspectives on the findings of its previous work. This follow-on work consisted of a consultation process which:

⇒ Engaged with industry to identify key discipline-specific energy efficiency skills and competencies;

⇒ Engaged with engineering educators to identify associated graduate attributes and learning outcomes in order to deliver the skills and competences identified; and

⇒ Explored how links between industry and universities can be strengthened to support graduate learning outcomes that meet industry needs.

Despite its relative small-scale, this project's contribution to the engineering education-energy efficiency agenda is significant in that it provided an unprecedented opportunity for industry, Engineers Australia and academia to discuss curriculum development issues related to energy efficiency face-to-face through three workshops (118 registrations, 87 participants), and via nine phone consultations (28 participants). Through the project, a database of more than one hundred practising industry and academic professionals was produced, linking academics and professionals via a mutual interest in the future of energy efficiency in Australia.

College and Associated Technical Society Consultation (Pre-Workshops)

Previous research for RET in 2011 suggested that Engineers Australia could play a key role in promoting the significance of energy efficiency to professional engineering practice, by encouraging capacity building through the use of its accreditation processes, and through continuing professional development programs. Furthermore, Engineers Australia, its member colleges and their affiliated technical societies could play an active role in building capacity to deliver energy efficient solutions in Australia, by facilitating collaboration between industry and academia on developing education resources and learning experiences for undergraduate and postgraduate education, and professional development.

Within this context, the research team undertook phone and email-based consultation with the following discipline-based groups within Engineers Australia, through a series of 1-hour focus group sessions with 2-8 participants in each (total 28 participants). The current college chairs and other key individuals are acknowledged for coordinating and/or participating in these sessions:

Table 1. Focus group session participant groups

Engineering Discipline	College Chair/ Coordinator	Participants
Biomedical	Chair: Mr Graeme Macaulay	2 industry, 1 government
Chemical	Chair: Ms Georgie Wright	5 industry
Civil	Chair: Mr Matthew O'Hearn	1 industry (on behalf of several members)
Electrical	Chair: Ms Mai Yeung	2 industry
Environmental	Chair: Mr David Gamble	1 industry, 1 academic
Information, Telecommunications & Electronic	Chair: Mr Peter Hitchener	7 industry
Mechanical	Chair: Mr Earl Heckman	1 industry (on behalf of several members)
Mining and Metallurgy	Coordinator: Professor Peter Knights	1 association, 2 academics
Structural	Chair: Mr Richard Eckhaus	4 industry

Industry-Academia Consultation (Workshops)

Previous research for RET in 2011 (QUT, 2011) concluded that education is one important aspect of a multi-pronged approach to improving energy efficiency performance in Australia. Furthermore, government mandates/regulation, and financial intervention and market forces are important drivers of change, providing leverage points for building energy efficiency knowledge and skills amongst current professionals and undergraduate engineers.

Within this context, the research team held a series of workshops in Brisbane, Sydney and Melbourne to seek input from industry and academia regarding the emerging need for energy efficiency capabilities in the workforce, the specific knowledge and skills required, critical gaps evident in graduates (i.e. 'work readiness') and opportunities to address these gaps. The workshops were important for two reasons. The strategically important, high-level collaboration between Engineers Australia and the Department of Resources, Energy and Tourism on graduate attributes and issues was unprecedented. The workshops also provided valuable opportunities for discussions between industry and academia, which although important, are few and far between.

Each of the three workshops was hosted by Engineers Australia in its State Division offices, and included welcomes from the Executive Directors of these Divisions. Workshop registration was free, and managed via the Engineers Australia website, providing an important awareness raising opportunity for members about the initiative. The workshops were well attended by eighty-seven representatives from industry, professional bodies and academia. Participation was voluntary and open to all interested persons. Invitations were circulated to those who participated in the phone conferences, via emails to personal and professional networks through Engineers Australia, and to a range of RET contacts in industry and energy consultancies.

Interested parties who were unable to attend the workshops were invited to provide comments by email, and these were incorporated into the workshop findings.

Table 2. Summary of workshop participants

Location	Academia	Industry	Association	Government	Student	Total	Per cent of Registrants
Brisbane	8	11	5	3	0	**27**	**82%**
Sydney	14	15	1	1	0	**31**	**78%**
Melbourne	9	11	5	3	1	**29**	**64%**
TOTAL	**31**	**37**	**11**	**7**	**1**	**87**	

Specifically, the workshops considered the suite of energy efficiency knowledge and skills needed by practising engineers to effectively participate in energy efficiency initiatives i.e. assessing energy use, and identifying, evaluating and implementing energy efficiency opportunities. The workshops also considered corresponding learning outcomes that would allow engineering graduates to develop these competencies, and how these would fit within the Engineers Australia Stage 1 Competency Standard (see extracts in **Appendix A**).

2. Findings – Pre-Workshop Discipline-Based Consultation

The multi-stage consultation process included engagement with EA college representatives prior to the workshops as:

⇒ the project aimed to seek feedback on how curriculum renewal could improve the future skills of industry professionals, which required both industry and academics to be engaged in discussions of university curriculum. The college structure provided an existing mixed group of academics and industry representatives for each of the key engineering disciplines being considered

⇒ commencing the engagement process with active industry and academic members of Engineers Australia, before engaging with the broader industry and academic community through the workshops, allowed the project to seek detailed review and insights from a smaller group of individuals, which could directly inform the scope, focus and methodology of the three workshops, allowing them to be better targeted.

During this pre-workshop consultation, two findings emerged that were re-occurring themes throughout the project:

⇒ consultation with industry practitioners revealed a general perception that academic practitioners and university curriculum are lagging behind industry practice.

⇒ There are differences between disciplines in relation to their awareness of, and engagement with energy efficiency practices. This occurred partly – but not entirely – in accordance with traditional discipline domains. For example, participants from mechanical, electrical colleges and mining and metallurgy demonstrated significant engagement with these concepts. Participants from chemical engineering and ITEE were also significantly engaged with energy efficiency and saw many opportunities for their disciplines to contribute to this sphere. Other industry participants, such as those from civil, environmental, structural and biomedical engineering did not see their priorities as aligning significantly with energy efficiency, although each college generated at least a few points of connection.

The following paragraphs provide a discussion of the results of the pre-workshop engagement, including sample responses from participants. A summary of the consultation process can be found in **Appendix B**, with feedback received for each discipline/college attached in **Appendix C**.

The following five questions were asked of each focus group:

Q1) What pressure have you felt in your discipline to do energy efficiency work recently?

Q2) What are your thoughts on the one-page discipline briefing sheet?

Q3) What do you think of the provocation list of graduate attributes?

Q4) What would you consider to be the most pressing gaps for graduates in this area?

Q5) What do you think the most valuable contribution to this space could be from the federal government/ EA?

General Findings (Q1 – Q3)

⇒ The most well represented college was ITEE, with many ITEE participants engaging in feedback process.

⇒ Participants from the civil college in particular gave quite specific comments in relation to opportunities for future EA/ Federal government support of energy efficiency.

⇒ The answers to Q1-3 tended to include both discipline-specific and cross-disciplinary considerations.

⇒ A surprising number of comments in relation to Q4 and Q5 were both interdisciplinary and enabling in nature. Identification of technical skills as a 'pressing gap'/needing the involvement of EA/Fed govt, were uncommon.

⇒ Technical skills that did feature in participant's responses to Q4 and Q5 tended to relate to interdisciplinary core or foundational skills, rather than specialist skills.

Responses to Questions (Q4 – Q5)

Questions asked of the participant groups, and responses are summarised below. Individual college/ discipline differences and similarities are noted where this assists discussions of the themes:

Q4) What would each of you consider to be the most pressing gaps for graduates in this area?

The three most frequently occurring themes that emerged in response to this question were:

1) Understanding of, and ability to place things, in the context of the 'big picture', whole systems thinking.

Interestingly, one of the re-occurring suggestions to achieving this outcome was to place a skilled interdisciplinary expert in a position of collaboration with other professionals. This person would then keep the 'big picture' in perspective while making best use of the skills of others.

2) Core technical skills / understanding the fundamentals

This included statements about understanding the relationships between voltage, current and power, energy, metrics, and conversion and transportation of energy. It was unclear whether there was a need to further entrench the fundamentals in students (via the curriculum) during their studies, or if there was a need to provide refresher courses after graduation.

3) Financial incentives for energy efficiency improvements

This theme first emerged in the phone consultations, and was notably mentioned by several participants from several discipline areas (chemical, civil, electrical, structural) indicating it's importance as an industry-wide issue. It later became a very strong theme in the workshops.

Other themes that emerged were:

⇒ Knowledge of new or 'green' technologies
⇒ Communication skills (especially to non-engineers)
⇒ Future-mindedness
⇒ Stakeholder engagement
⇒ Familiarity with codes/ standards
⇒ Teamwork / interdisciplinary awareness
⇒ Familiarity with metrics / measurement tools / quantifying energy
⇒ Process modelling

Q5) What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

The four most frequently occurring themes that emerged across all disciplines in response to this question across all colleges were:

1) *The need for Government to mandate better energy efficiency requirements / changes to regulations and legislation*

This was by far the most frequent response to this question, including suggestions for government to:

⇒ Mandate (and enforce) higher energy efficiency standards
⇒ Standardize connectors/ interfaces/batteries and operating voltages, use metric-only systems, and enforce compliance to standards
⇒ Use trade-barriers to block imports of goods that do not meet standards.
⇒ Support an overhaul of the power distribution networks
⇒ Use financial incentives to encourage energy efficiency improvements
⇒ Not do anything to distort the economic imperative to use less energy (by distributing subsidies, permits, allowances, etc)

2) *Mandate a requirement for greater transparency or otherwise increase the availability of energy efficiency information, and also to improve public awareness via public outreach programs.*

The former appeared to be mostly directed at Federal Government while the latter was mostly directed at EA. Suggestions are recorded as noted by participants (source of contribution in brackets) included:

⇒ A clearer emphasis, and perhaps a requirement, for energy accounting. Each piece of equipment and each process should have its energy efficiency accurately and systematically defined. (*Chemical Engineering)*
⇒ Improving the public discourse around energy efficiency, avoiding political language and focusing on quantifying energy use and energy efficiency. For example, if operator X is using 10% less energy to produce some widget than operator Y, this could be disclosed – e.g. in annual reports – and rewarded. (*Chemical Engineering)*
⇒ Provide internet site with information on energy efficiency, product ratings, compliance standards to be used in product design, etc. Provide cross promotion to increase awareness of this site. (*ITEE)*
⇒ Incorporate a better understanding of energy use, energy efficiency and engineering in primary and high school curricula, including promoting engineering as an exciting career pathway. (*ITEE)*
⇒ EA to promote/market how Engineers have contributed to (and will continue to be a fundamental part of) a more energy efficient life. (*ITEE)*
⇒ Government to promote EA as partner/figure in energy efficiency (*ITEE)*
⇒ Engineers need to be seen as THE LEADERS of the energy solution, not merely as feeding in technical role. (*ITEE)*

3) *Suggestions for greater involvement of EA*

4) *Requests for additional teaching resources, provision of guest lecturers or the establishment of a guest lecturing program*

Other emerging cross-disciplinary themes included:

⇒ Need for education resources that involve integrating solutions / whole systems perspective / finances

⇒ Need for additional training programs that are attractive for academics (lecturers) and mature-aged engineers / internships

⇒ Need for industry mentoring/additional professional development once graduates are in the workforce

Three discipline-specific considerations for government and EA intervention were:

- Both government and EA have a role in promoting – even requiring – more industry experience from graduates. We see too little of it, and what we tend to see is frequently brief and potentially tokenistic. The government should help fund it, and the EA should help require it. (*Chemical)*
- Cloud computing will be a big draw card on saving energy as data centres can be located where the energy costs are the least. We can have data centres located close to the energy production centres thereby reducing transmission costs, coupled by efficient client server systems which will only require bare minimum data to be transmitted across the lines. (*ITEE)*
- Structural Engineers have a role as 'Building Economists'. (*Structural)*

3. Workshop Consultation - Methodology

The three workshops used a flexible facilitated-discussion to engage participants in identifying graduate competencies in relation to which would address industry needs, and considering how universities could developing learning pathways and teaching approaches to address these needs. This included clustering exercises using post-it notes in Brisbane and Melbourne, and white-board recorded discussions in Sydney. At each workshop emergent opportunities from the pre-workshop consultation were also checked with participants, after an initial brainstorm.

The format of each workshop was designed to gather individual attendees' perspectives, and also – through a series of guided group discussions - uncover which topics had the most 'resonance' with the group. Resonance was judged by both group consensus on the importance of a particular issue, and by how frequently it occurred in feedback forms and other media.

Accordingly, the programme for each workshop was set around a series of tasks aimed at either Industry or Academic participants. Some tasks occurred simultaneously (parallel processes) or at different times, and generally evolved into a guided group discussion with all participants. Morning sessions were industry-focused, while the afternoon generally provided an opportunity for academic participants to respond.

Morning Session – Industry Priorities

The workshop morning session involved the following tasks:

⇒ Industry participants were asked to write a list of knowledge and skills that came to the 'top of their mind' in terms of what they perceived as key gaps in a graduates' abilities to:

1) effectively participate in energy assessments
2) evaluate energy efficiency opportunities
3) implement energy efficiency opportunities.

Meanwhile, academic participants were invited to read appropriate discipline briefing notes, brainstorm, and make notes of what they perceived as important areas for engaging with industry and academic colleagues in renewing curriculum for energy efficiency.

⇒ Following this brainstorming session, industry participants were invited to identify the top two items that should be focussed on in the short term. Meanwhile, academic participants were asked to listen to industry participants' feedback and identify corresponding knowledge and skills particularly suited to their discipline.

⇒ All participants were then provided a hand-out with two lists of general energy efficiency knowledge and skills generated from previous reports (NFEE, 2009; RET, 2011). Industry participants were asked to rank the importance of each item as a graduate attribute, and academic participants were asked to indicate the level of current coverage in their programs.

Outputs generated as a result of these exercises include notes from the brainstorming session (as written by participants), notes from discussion (as written by workshop facilitators) and ranked lists of knowledge and skills. Detailed notes from the workshop (as written and recorded) are attached in **Appendix D** and **Appendix E**.

The break between the morning and afternoon sessions was structured to make the most of the unique opportunity for industry-academia collaboration. Before closing the morning session, the facilitator posed the question: '*How can these graduate attributes be developed through industry – academia collaboration?"* Participants were invited to form connections between industry and academics during the lunch break, and to identify three possibilities and write them on post-it notes. The post-it notes were used as a stimulus for a group discussion at the beginning of the afternoon session. In some locations, this led to an informal 'clustering' exercise, using a whiteboard to group the ideas around themes.

Figure 1. Facilitated clustering of post-it note activity, Brisbane Workshop

Afternoon Session - Implications for Education

The afternoon involved a discussion of the implications for embedding industry priorities into the curriculum. This was geared towards the academic participants, however many industry representatives also participated.

⇒ On returning from lunch, the participants were invited to join a 'discipline table' e.g. focussing on a particular engineering discipline. They were provided with the industry-ranked priority graduate attribute list, and associated discipline-specific knowledge and skills from the academics drafted in the morning session, and asked to identify some key knowledge and skill items for each graduate attribute.

⇒ The groups then considered how the identified graduate attributes could be developed in the curricula of particular disciplines. This was done using a pre-generated list of nineteen teaching methods that could be used by lecturers, which participants ranked according to their perceived impact and likelihood.

⇒ This led to a deliberation of the factors influencing the use of energy efficiency education resources, including the perceived value (if any) of using external resources in curricula. From this followed a discussion of what critical gaps could be addressed through targeted resource development, and what types of resources academics are likely to find most useful.

The format for the afternoon session was flexible, depending on the outcomes of the morning session, and the number of available participants. At some locations, this involved a less formal guided group discussion of the implications for education. The workshops ended with closing remarks and reflections on emergent issues and future opportunities, including possible next steps. Participants were thanked for their time and invited to join an emerging community of practicing professionals with an interest in addressing engineering energy efficiency issues.

4. Summary of Workshop Findings

The following paragraphs summarise the raw data from all three workshops, which is provided in **Appendices D and E**. It is important to recognise that frequency of a theme is not an absolute measure of its importance, as this can be confounded by other factors (e.g. the persuasive speaking style of other workshop participants). In the write-up, personal notes, audio-recordings and internal crosschecking were used to ensure the summary is representative of the workshops.

Industry Perceived Gaps and Education Implications

Several 'emergent themes' (i.e. ideas that had resonance) were apparent in the findings from the three workshops in relation to i) critical energy efficiency knowledge and skills gaps perceived by industry, and ii) curriculum considerations by educators. These findings have been aggregated in Tables 3-5 for each of the three key graduate attributes: Ability to effectively participate in energy assessments; Ability to evaluate opportunities; and Ability to implement opportunities (i.e. including design, construct, install, maintain).

The three tables have been constructed to provide a snapshot of current industry and academic community perceptions of what is needed and how this relates to current accreditation requirements. Reading from left to right column, the implications for each 'component knowledge and skill' for learning pathway and curriculum design have been identified by highlighting, whether they are technical or enabling, and discipline-specific or cross disciplinary. The final column shows how the industry perceptions relate to the Engineers Australia Stage 1 Competency Standard, and how subsequent curriculum considerations can address industry gaps, and thereby address Stage 1 Competency requirements (listed in **Appendix A**).

Future Opportunities for Capacity Building

Considering the emergent consensus around the term 'energy efficiency' as it relates to engineering, participants from all disciplines frequently went beyond RET-directed energy efficiency considerations (i.e. process improvement opportunities), discussing the need for education about energy use, fossil fuel energy alternatives (e.g. renewables) and reducing overall consumption (see findings in the main report and raw data in appendices). This was despite all engagement questions being framed to address RET's scope.

This points to a broader interpretation of the term "energy efficiency" in the academic and industry communities, where there appear to be a number of different understandings of energy efficiency in use. While the department and a number of professionals and academics working in the area view energy efficiency as a distinct and separable component of energy and sustainability considerations, other industry and academic professionals practicing within the sector also view energy efficiency, energy generation and use and sustainability as inseparably linked.

Themes for action identified in the workshops are summarised by issue, opportunity, and potential key role players in Table 6. Some participants viewed their discipline as playing a specific role in energy efficiency (e.g. chemical and mechanical engineering), while participants from other disciplines such as environmental engineering, envisioned a unique, future role for themselves in bringing together strands of knowledge from other disciplines in a collaborative way. Throughout the phone and workshop consultation, the ITEE college participants demonstrated a high level of awareness with regard to their relevance to energy efficiency in a variety of industries; from housing and electricity supply, to communications technology and transport programming. The action list in Table 6 does not explicitly mention these, but there is the potential for such discipline-based nuances to be accommodated in future measures.

Table 3: Workshop Findings - Ability to Effectively Participate in Energy Assessments

Graduate Attribute: Ability to Effectively Participate in Energy Assessments **Emergent Knowledge and Skill Areas (Industry), and corresponding component knowledge and skills (Academia)**	**Technical**	**Enabling**	**Discipline-specific**	**Cross-disciplinary**	**Mapping Gaps & Competencies**
Perceived Critical Gaps - Industry clustered themes ***(Ordered by extent of coverage by participants in discussions and written comments)***					**EA Stage 1 Competencies**
1. Communication skills (including engaging with personnel, report writing, presentation skills, listening skills, question-and-answer skills, ability to 'translate' to different business areas) ◊		●		●	**3.2, 3.4**
2. Systems awareness, whole systems thinking, holistic approaches (Framing systems) ◊	●			●	**1.1, 1.2, 1.5, 2.1, 2.2, 2.3, 3.1**
3. Collaboration, cross-disciplinary approaches, ability to work in a group ◊		●		●	**3.5, 3.6**
4. Understanding of the auditing process (including the importance of appropriately framing questions)	●	●	●	●	**2.4, 3.1, 3.4, 3.5**
5. Knowledge of measuring technologies and metrics, ability to identify inputs/outputs/losses	●		●	●	**1.2, 2.1**
6. Knowledge of energy principles, energy & relative amounts of energy needed for certain processes	●		●	●	**1.1**
7. Knowledge of benchmarking /best practice/standards and requirements	●		●		**1.5, 1.6**
8. Workshop facilitation skills		●		●	**3.3, 3.6**
9. Research skills		●		●	**2.1, 3.4**
Component knowledge and skills and learning pathways - Academic clustered themes ***(Ordered by number of industry gaps addressed)***					**Addressing Industry Gaps**
Ability to participate in design phase *Understanding design components, Working with team members, Communication, Making energy assessments of a proposed design/solution, Influencing design decisions*	●	●	●	●	**1, 2, 3, 5, 6, 7, 9**

Ability to conceptualise the "Big picture" *Systems awareness, Critical analysis, Process modelling, Awareness of the limits of software packages, Engaging a holistic, interdisciplinary approach to problem-identification, Consideration and identification of all inputs, outputs and control options, Awareness of human interaction with systems and potential for behavioural change*	●	●		●	**2, 3, 5, 6, 7**
Ability to apply core engineering technical skills to EE problems *Applying thermodynamics, Modelling processes, Evaluating energy consumption in signal reductions processes (ITEE), Identifying hidden losses*	●		●	●	**2, 5, 6, 7**
Ability to make and test assumptions *Working with imperfect data sets, Modelling processes, Conceptualising systems and representing them diagrammatically*	●			●	**2, 4, 5, 9**
Understanding of core energy principles and their connection to discipline-specific foundation knowledge	●		●	●	**5, 6, 7**
Ability to make energy measurements *Measuring and monitoring skills*, *Estimation skills*	●		●		**5, 9**
Understanding of industry 'best practice' *Awareness of regulatory requirements and industry programs, Researching similar scenarios and outcomes, Benchmarking and measuring*	●		●	●	**4, 7**
Ability to communicate verbally *Managing interpersonal relationships, Utilising appropriate questioning technique, Effective listening*		●		●	**1, 8**
Ability to communicate non-verbally *Summarising data and concise report writing, Accurate note-taking in the field, Proficient documentation skills*		●		●	**1, 8**

◊ These items (generated by industry), were perceived as important across all sectors, with certain industries appearing to rank them as particularly important. This was most apparent during the phone consultations. For example, the comments from some chemical engineers suggest that they perceived chemical engineering as having a special role as a facilitator of energy efficiency improvements, and some environmental engineers saw a particular role for their discipline in facilitating collaboration or being able to bring other disciplines together, while ITEE engineers were acutely aware of their discipline's application to a wide range of sectors and industries.

Table 4: Workshop Findings - Ability to Evaluate Energy Efficiency Opportunities

Graduate Attribute: Ability to Evaluate Energy Efficiency Opportunities **Emergent Knowledge and Skill Areas (Industry), and corresponding component knowledge and skills (Academia)**	**Technical**	**Enabling**	**Discipline-specific**	**Cross-disciplinary**	**Mapping Gaps & Competencies**
Perceived Critical Gaps - Industry clustered themes ***(Ordered by extent of coverage by participants in discussions and written comments)***					**EA Stage 1 Competencies**
1. Systems thinking - Identify all inputs and outputs, measurement and verification, create a baseline	●	●	●	●	**1.5**
2. Diagnostic skills, Critical thinking	●		●	●	**1.5, 2.2, 2.3**
3. Understanding of core engineering principles, including basic physics, thermodynamics and heat transfer, fluid mechanics, electrical machines			●	●	**1.1, 1.2**
4. Knowledge of EE technology	●		●		**1.1, 1.3, 1.4**
5. Ability to compare what has worked well elsewhere and how it could be applied to a similar situation (adaptable application). ‡	●		●	●	**2.1, 2.2, 2.4**
6. Financial education and evaluation skills, economic and business case analysis skills, ability to calculate expected Return on Investment (RoI), ability to communicate economic benefits of EE improvements (TBL/ Emissions Accounting) $^{\Delta}$	●	●	●	●	**1.1, 1.3, 1.4**
7. Knowledge of best practice/ legislation/ codes/ benchmarking/ (including social and ethical considerations), need to also be able to keep up to date	●			●	**1.5, 1.6, 3.1**
8. Creative/ lateral thinking / Innovative thought processes, understand how and where to draw on external knowledge sources, capitalising on collaborative approaches/ team work		●		●	**2.1, 2.3, 2.6**
9. Reporting skills / documentations skills (potential opportunities, recording calculations)	●	●		●	**3.2, 3.3, 3.4**
10. Mentoring / working with subject matter expert (novice and expert team)		●		●	**2.1, 2.3, 2.6**
11. Building professional networks and business relationships »		●	●	●	**3.1, 3.3, 3.5, 3.6**

Component knowledge and skills and learning pathways - Academic clustered themes *(Ordered by number of industry gaps addressed)*					**Addressing Industry Gaps**
Awareness of EE practices, ability to benchmark *Researching practices within other sectors, other industries and other companies, Knowledge of all available technologies, Researching abilities/constraints of new and emerging technologies*		●		●	1, 2, 3, 4, 5, 7, 10, 11
Ability to keep the 'big picture' in perspective *Knowledge of energy use on a broad scale in relevant industry (as opposed to knowledge of specifics related to their area of responsibility)*, *Relating systems within a broader system, Conceptualising the relative impact of an improvement (weighing potential barriers/benefits)*		●		●	1, 2, 5, 8, 10, 11
Ability to apply technical skills (mix of discipline-specific and cross-disciplinary skills) *Competence with engineering system/process in order to identify the root causes of inefficiency, Working with 'machine language', Design of HVAC systems for example*	●		●	●	1, 2, 3, 4
Understanding of financial considerations *Estimating return on investment vs. capital expenditure, Weighing costs vs. long term savings, Making a business case for improvements*		●		●	6, 8, 9
Ability to create robust assumptions *Auditing data quality and assessing confidence levels in results*	●			●	1, 2, 3
Ability to think laterally *Creative thinking, Critical thinking, Problem solving*		●		●	1, 2, 8

‡ Participants lamented that access to information about energy efficiency practices at other companies was often restricted or difficult to come by. Several participants suggested that there was a potential role for federal government to play in requiring transparency or creating a reference library of case studies. This theme emerged from both the phone consultation and the workshops.

∆ This theme emerged very strongly from the workshops. Limited ability to create business cases for improvements that accurately reflect factors such as capital expenditure and future payback periods was often cited as a major barrier to conducting 'investment grade' energy efficiency opportunity evaluations, although at least one participant commented that engineering students should not have to conduct in-depth financial analyses in order to effectively evaluate opportunities.

» This 'critical gap' appeared to occur most frequently (although not exclusively) in comments from participants with industry experience in buildings and residential housing, suggesting that it may be particularly relevant to this sector.

Table 5: Workshop Findings - Ability to <u>Implement</u> Energy Efficiency Opportunities

Graduate Attribute: Ability to Implement Energy Efficiency Opportunities **Emergent Knowledge and Skill Areas (Industry), and corresponding component knowledge and skills (Academia)**	**Technical**	**Enabling**	**Discipline-specific**	**Cross-disciplinary**	**Mapping Gaps & Competencies**
Perceived Critical Gaps - Industry clustered themes ***(Ordered by extent of coverage by participants in discussions and written comments)***					**EA Stage 1 Competencies**
1. Being able to present a sufficient business case for EE improvements, calculating return on investment, justifying investment on capital for future financial and efficiency benefits, relating cost per unit production	●	●		●	**1.5, 1.6, 2.3, 2.4, 3.2**
2. Multi-disciplinary project management skills *Understanding/ communicating scope, Engaging with stakeholders & clients, Procurement management, Physical resources management, OHS responsibilities, Change management, Contract and contractor management, HAZOP type assessments*		●	●	●	**2.4, 3.4, 3.5, 3.6**
3. Ability to engage and communicate with customers, clients and key stakeholders; understanding stakeholder motivations and how to interest them; ability to communicate with non-engineers in a straight-forward, non-judgemental way		●		●	**3.2**
4. Systems approach and future-mindedness		●		●	**1.5, 1.6**
5. Knowledge of regulation and codes	●	●	●	●	**1.1, 1.3, 1.4**
6. Change management and change *improvement* skills, interpersonal skills and ability to influence behaviour (considering future directions)		●		●	**1.4, 2.4, 3.1, 3.6**
7. Availability and awareness of mentoring and internship opportunities and funding programs that could assist in getting the project off the ground, Awareness of funding programs that customers may be able to access		●	●	●	**3.4, 3.5**
Component knowledge and skills and learning pathways - Academic clustered themes ***(Ordered by number of industry gaps addressed)***					**Addressing Industry Gaps**
Application of leadership skills *Belief that they are able to make a difference, Negotiation skills, Change management skills, Project management skills, Mentoring peers, Working in teams, Focused problem solving tasks*		●		●	**1, 2, 3, 6, 7**
Ability to consider opportunities in the context of the 'big picture' *Whole of systems approach, Broad awareness of issues, Future mindedness, thinking long-term, Ability to 'step back' and make a persuasive argument in context*	●	●	●	●	**1, 2, 4, 6, 7**

of broad industry energy use and cost (i.e. not just on small department budget or a segment of an operational budget), Thinking beyond a particular software/ discipline					
Ability to engage key stakeholders *Making value propositions, Using relevant/engaging key terms, Communicating financial incentives/ business case, Influencing behaviour and decisions*		●		●	**1, 2, 3, 6**
Ability to communicate with key stakeholders *Communicating simple (but not simplistic) message, without jargon, Communicating without judgement, Managing interpersonal relationships*	●	●	●	●	**1, 2, 3**
Good understanding of relevant core technical skills *Knowledge of control systems (HVAC) for example in mechanical engineering, Environmental science needs to include science*	●		●		**4, 5**

▼This was a variant on the theme of financial constraints and the necessity of presenting a convincing business case for energy efficiency improvements. It was not always clear whether participants were stating that new sources of external funding needed to be created, or if they knew of sources that were available, but were inaccessible to them. Although this theme was re-occurring, the amount of funding required was not discussed.

Table 6. Opportunities for moving forward with education for energy efficiency

Issue Raised	Opportunity for Action
Lack of peer network between Academics and Industry	Mentioned more often by built environment industry professionals during the workshops and in the phone consultations. Perhaps this is an indication of cultural differences between different sectors, and there is an opportunity to raise awareness about the benefits of networking between academics and industry. Barriers to research or teaching projects included issues related to commercial in confidence, copyright, licensing, commercialisation – layers of bureaucracy that limit interaction between industry and academics on research or teaching. ***Opportunity*** to facilitate collaboration, by creating project funding with clear ownership requirements/ common access results, to remove this barrier. ***Opportunity*** to initiate a business engineering forum/ round table on energy efficiency, generating momentum around breaking down barriers through other projects.
Academic's industry experience is not current	***Opportunity*** for supporting initiatives to connect educators with industry (i.e. encourage interactions). This could include for example, funded industry placements (teaching buy-out), case study development support (with the educator working directly with industry to develop the case study for a period of time), industry-led group projects with appropriate assessment that is curriculum friendly (received support in all workshops – willingness from industry to be a part of this). Current lack of funding options through Universities or Engineers Australia.
Limited access to industry information	***Opportunity*** for assisting academics in accessing up to date and relevant information to embed into their curriculum. This could be through requiring industry transparency around energy efficiency data (e.g public disclosure), making available a reference library of 'real' data online that can be used by students.
Lack of funds for curriculum renewal in budget constrained environments	***Opportunity*** for supporting the development of resources that address identified critical gaps in engineering. This includes the major emergent theme of communicating/ facilitation, making the business case for energy efficiency and self-awareness (i.e. 'knowing what you don't know'). This could be through supporting detailed 'real-world' case studies (connecting industry with academics and funding development) and promoting the resultant resource to educators and students.
Lack of industry mentoring network - students	***Opportunity*** to assist universities in developing enabling and technical knowledge and skills through industry mentoring. ***Opportunity*** to raise profile of enabling skills development and industry mentoring, through student workplace positions (through attaining their 12 week work experience requirement for graduation)
Silos limit sharing and cross-disciplinary teaching	***Opportunity*** to create cross-disciplinary learning resources for 'specialising' in energy efficiency capabilities e.g. financial training for <u>environmental/ civil/ electronic</u> engineering; e.g. communication/ systems thinking/ business planning/ facilitation training for <u>mechanical, chemical and environmental</u> engineers. There are examples of universities that do this around Australia (refer to 2012 NFEE report) – and it could be substantially expanded.
Accreditation review timeframe insufficient for rapid response to curriculum renewal	***Opportunity*** for encouragement through incentives in addition to accreditation, to catalyse curriculum renewal for energy efficiency education. This could include awards, competitions, academic teaching incentives and recognition of good work (energy efficiency teaching citations) ***Opportunity*** for accreditation-related communication between Engineers Australia and universities in between 5-yearly reviews, to promote action on an energy efficiency curriculum focus. e.g. as a 'priority area'

5. Discussion and Conclusions

There was a high level of consistency in the results, despite the variation in workshop attendees and composition of the phone consultation and workshops. Considering the findings of the pre-workshop and workshop consultation, there are a number of emergent key points relating to:

⇒ What appear to be the critical energy efficiency capability gaps
⇒ How these could be addressed in a curriculum development format (i.e. learning pathways)
⇒ Implications for teaching at universities.

These are now discussed in the following paragraphs, and conclusions are made with regard to moving forward.

What appear to be the critical gaps in energy efficiency capability?

In relation to RET's current focus areas of 'energy efficiency assessments, and identifying, evaluating and implementing opportunities', this consultation process has confirmed previous literature review findings that there are clear and significant gaps in engineering capability. Tables 3 – 5 show that critical knowledge and skills gaps fall into one or both of two categories:

⇒ Technical knowledge and skills, which include formulae, calculations, metrics, design and evaluation; and
⇒ Enabling knowledge and skills, which include communication, stakeholder engagement, project management, change management and leadership.

Figure 2 below diagrammatically represents the spectrum of knowledge and skills sets identified during consultations. In this figure, there are discipline-specific, technical and enabling knowledge and skills, within a larger context of whole systems thinking. Between the technical and enabling knowledge and skills can be observed a set of skills that are 'cross-disciplinary' in nature, i.e. they are important knowledge and skills that lend themselves to being taught across engineering disciplines, rather than within the silos of each discipline. In effect, the figure highlights that the curriculum renewal process for energy efficiency education is not about trying to ensure each student has mastery of 'everything', but rather, cultivating and utilising their inherent abilities to consider problems in context. This was raised as a common point of discussion in the three workshops and in the majority of pre-workshop consultations.

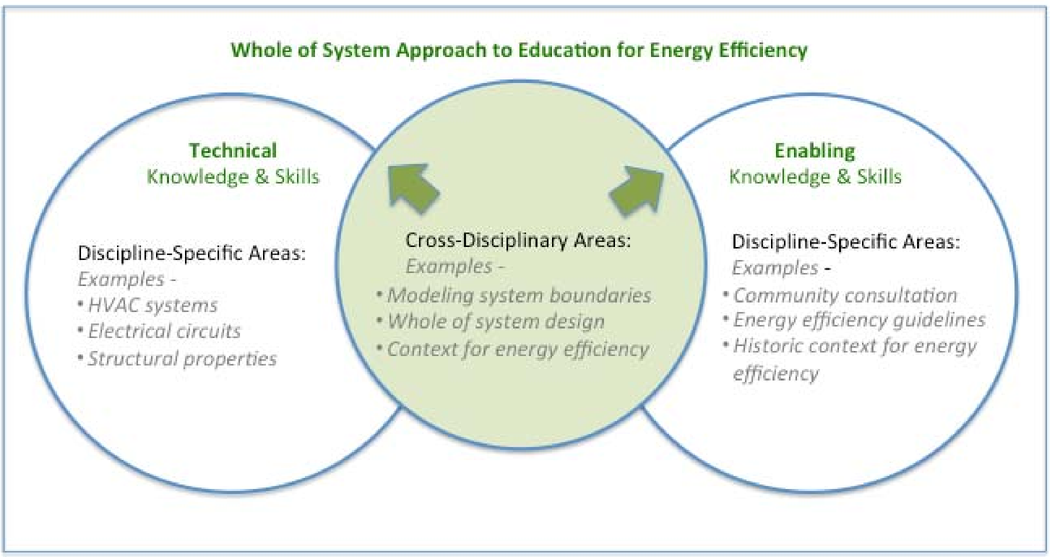

Figure 2. Diagram showing the variety of knowledge and skills gaps in energy efficiency education

In this consultation, participants with industry, government and professional association affiliations overwhelmingly nominated foundational, cross-disciplinary skill-sets as the capabilities most lacking in recent graduates, which also have the greatest potential to bring about improvements in energy efficiency (see also Handout 2 in **Appendix E** which highlights energy efficiency areas identified by workshop participants as most important). These include:

⇒ 'Big picture' thinking, whole systems design and whole-of-life analysis (in particular, the ability to weigh lifetime costs and cost savings of an asset, versus initial expenditure), which was frequently cited as the biggest barrier to achieving efficiency improvements.

⇒ The ability to effectively communicate efficiency opportunities to key stakeholders, and to present a basic financial case for initial up-front investment in more energy efficient technologies.

⇒ An awareness and capacity to draw upon the specialist skills of other disciplines (industry representatives considered this to be a foundational tool for achieving the best outcomes through interdisciplinary collaboration).

Consistent with previous literature reviews and survey investigations, the consultation process highlighted a general lack of familiarity amongst industry practitioners and academics about technical energy efficiency knowledge and skills that need to be embedded within the engineering curriculum. In this regard, it is recommended that focused brainstorming processes on discipline specific technical skills be undertaken by discipline specialists with expertise in energy efficiency. This could be undertaken by email correspondence, with a clear request for what needs to be brainstormed i.e. '*what technical knowledge and skills related to energy efficiency should the [insert discipline] be exposed to within the curriculum?*'

Within Table 5 (Implementing energy efficiency measures) it is interesting to note that there are only two technical skill identified as important for implementing opportunities (developing adequate business cases and knowledge of codes, but here other, such as to monitoring implementation to ensure it is done properly, and evaluating performance to verify anticipated performance and savings, which were identified in previous findings (NFEE 2009, RET 2011).

What are the implications for teaching energy efficiency in engineering?

Considering the range of knowledge and skills identified for the three graduate attributes used in the consultation, and findings from previous literature and survey investigations, the question arises: 'How do you teach this variety of knowledge and skills within an existing, highly regulated curriculum structure?'.

Project participants reflected on a range of learning and teaching tools that could be used to embed these component knowledge and skills within the existing curriculum, as well as the potential for shared curriculum where technical and enabling knowledge and skills are cross-disciplinary in nature, as shown in Figure 3. Opportunities arise here for shared curriculum development between disciplines for particular common component knowledge and skills.

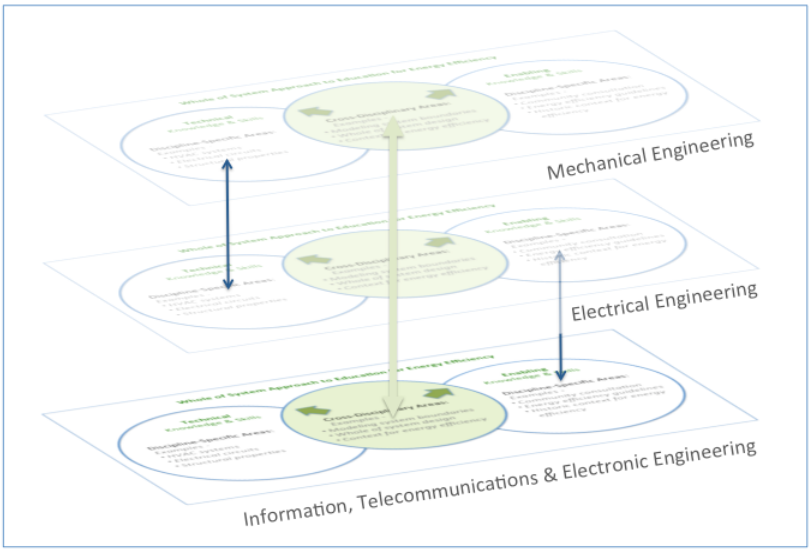

Figure 3. Diagram showing the potential for shared curriculum in energy efficiency education

This project did not intend to identify an optimum teaching style over others for bringing about curricula renewal (for example, the use of problem based learning, or standard versus inverse learning pathways). Within the context of a variety of pedagogies and education resource recommendations made in 2011 (University of Adelaide), the next step is to reduce barriers to taking action on increasing energy efficiency course content. As part of this project, the research team addressed a significant barrier by increasing awareness within academia and industry and engineering practitioners of what energy efficiency means for engineering education. **Appendix F** contains a 30-page 'Briefing Note' for engineering, which was developed in collaboration and consultation with all Engineers Australia colleges and their nominated technical societies. Given the extent of collaboration and commitment to the document's development, it is recommended that it be used as a principal communication tool by the federal government in discussions with stakeholders including Engineers Australia and its Colleges, and university academics and other educators, to share what is possible in embedding energy efficiency within the curriculum, and to inform efforts to achieve such possibilities.

A number of opportunities for reducing other barriers to mainstreaming energy efficiency in engineering curricula emerged from the consultation with government, industry, academia and professional associations,. These are summarised in Table 6 and span: **(**in order of prevalence of discussions in consultation):

⇒ Funding cross-disciplinary and discipline-specific learning resources for building capabilities
⇒ Supporting the professional body Engineers Australia to prioritise curriculum renewal for energy efficiency (e.g. as a 'priority area')
⇒ Facilitating student access to workplace energy efficiency experience
⇒ Supporting (funding and endorsement) of student competitions, academic teaching and research awards that include teaching incentives (e.g. monetary, fellowships, citations)
⇒ Incentivising industry interactions with academics, including funded industry placements, placement-based case study development support, and industry-led student projects with curriculum-friendly assessment opportunities
⇒ Creating project research funding with clear ownership requirements/ common access to results (project legacy materials for future curriculum resources)
⇒ Brokering access to industry data for student use in "real-life" projects
⇒ Initiating a business engineering forum/ round table on energy efficiency.

Given the extent of consultation, literature review and survey data that contributed to this list of actions, they could be regarded as providing a robust platform for action on embedding energy efficiency within the engineering curriculum (see also Handout 3 in **Appendix E** which highlights energy efficiency areas identified by workshop participants as most important). It is noted that considerable potential remains for further analysis and discussion of data and findings from the consultation.

In conclusion, consultation with key stakeholders has helped to describe a suite of knowledge and skills that, if possessed by practising engineers, would provide the basis for equipping them to effectively participate in energy assessments, and the processes for evaluating and implementing opportunities. The lists of knowledge and skills produced through the consultation – by high-level clustering, and also at the level of each discipline – will be useful in designing measures for future funding and support, including several measures identified by participants, such as strengthening links through accreditation, teaching and assessment strategies, and academic-industry collaboration..

Key References

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APPENDIX A:

Competency Standards - Extracts

Stage 1 Competency Standard for Graduate Engineers
Stage 2 Competency Standard for Chartered Engineer Status

Engineers Australia Stage 1 Competency Standard (Extract)

The following text summarises the expected competencies and elements of competencies, of graduating 'Professional Engineers' in Australia (see Engineers Australia website for component indicators that form the knowledge and skill base for these competencies):

The three Stage 1 Competencies are covered by 16 mandatory Elements of Competency. The Competencies and Elements of Competency represent the profession's expression of the knowledge and skill base, engineering application abilities, and professional skills, values and attitudes that must be demonstrated at the point of entry to practice.

The suggested indicators of attainment in Tables 1, 2 and 3 (not provided – but the example of engineering application is useful) provide insight to the breadth and depth of ability expected for each element of competency and thus guide the competency demonstration and assessment processes as well as curriculum design. The indicators should not be interpreted as discrete sub-elements of competency mandated for individual audit. Each element of competency must be tested in a holistic sense, and there may well be additional indicator statements that could complement those listed.

1. KNOWLEDGE AND SKILL BASE

- 1.1. Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.
- 1.2. Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.
- 1.3. In-depth understanding of specialist bodies of knowledge within the engineering discipline.
- 1.4. Discernment of knowledge development and research directions within the engineering discipline.
- 1.5. Knowledge of contextual factors impacting the engineering discipline.
- 1.6. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.

2. ENGINEERING APPLICATION ABILITY

- 2.1. Application of established engineering methods to complex engineering problem solving.
- 2.2. Fluent application of engineering techniques, tools and resources.
- 2.3. Application of systematic engineering synthesis and design processes.
- 2.4. Application of systematic approaches to the conduct and management of engineering projects.

3. PROFESSIONAL AND PERSONAL ATTRIBUTES

- 3.1. Ethical conduct and professional accountability
- 3.2. Effective oral and written communication in professional and lay domains.
- 3.3. Creative, innovative and pro-active demeanour.
- 3.4. Professional use and management of information.
- 3.5. Orderly management of self, and professional conduct.
- 3.6. Effective team membership and team leadership.

Engineers Australia Stage 2 Competency Standard (Extract)

The following text summarises the expected competencies required for 'Chartered Professional Engineers' in Australia (see Engineers Australia website for additional standards and descriptions comprise these competencies). Note that these are currently under review.

The Stage 2 competency standards are generic in the sense that they apply to all disciplines of engineering in four units, spanning 16 elements. Each unit contains 3-5 elements of competencies and associated indicators of attainment. The units and elements are summarised here:

A. SELF

1. Deal with ethical issues - *means you demonstrate an understanding of the ethical issues associated with your work or practice area, and how these are managed collectively by your organisation, project or team, and you demonstrate an ability to identify ethical issues when they arise, and to act appropriately*
2. Practise competently - *means assessing and applying the competencies and resources appropriate to the engineering task*
3. Responsibility for engineering activities - *means adopting a personal sense of responsibility for your work*

B. COMMUNITY

4. Develop safe and efficient solutions - *means that you are aware of current workplace health and safety requirements, and you take into consideration short and long-term implications of the engineering activities*
5. Engage with the relevant community and stakeholders - *means that you recognise the relevant community and stakeholders, and can identify and respond to relevant public interest issues*
6. Identify, assess and manage risks - *means that you should develop and operate within a hazard and risk framework appropriate to the engineering activity*
7. Meet legal and regulatory requirements - *means that you should be able to identify the laws, legislation, regulations, codes and other instruments which you are legally bound to apply*

C. WORKPLACE

8. Communication - *means that you communicate efficiently, honestly and effectively*
9. Performance - *means that you work within an operational system to achieve corporate objectives while recognising personal obligations to the profession*
10. Taking action - *means that you initiate, plan, lead or manage engineering activities*
11. Judgement - *means that you exercise sound judgment in engineering activities*

D. CREATING VALUE

12. Advance engineering knowledge - *means that you comprehend and apply advanced theory-based understanding of engineering fundamentals*
13. Local engineering knowledge - *means that you comprehend and apply local engineering knowledge*
14. Problem analysis - *means that you define, investigate and analyse engineering problems and opportunities*
15. Creativity and innovation - *means that you develop creative and innovative solutions to engineering problems*
16. Evaluation - *means that you evaluate the outcomes and impacts of engineering activities*

APPENDIX B:

Project Consultation Documents

Copies of the run sheets and handouts used during project consultation

PHONE RUN SHEET: COLLEGE DISCUSSION GROUP

1. Introduction (0 – 10 mins)

- Personal Introduction: Cheryl & research team, acknowledge sponsor & focus on reducing greenhouse gas emissions, & industry context:
    - o Aim is to get generic and specific graduate attributes (getting at the complexity) and learning outcomes. "Foundation attributes for energy efficiency" that are missing for each discipline … undergraduate engineering focus but also might have future application in postgraduate and PD space.
    - o Our role is not to guess what is relevant for your discipline with regard to energy efficiency. Rather than doing a web/online search to do this list, we are working to help representatives from the disciplines to create the list.
    - o This began in 2011 with a focus group on considering energy efficiency education – produced some examples & a 1-page summary of 'what's so'
    - o Note: Today we will use a mixture of conversation and writing for documenting your thoughts. Please can you have with you the **10 page draft document**, and **email/ pen and paper** to make notes that you can then pass to us after the call.
- Note taking: Notes will be taken during this phone call, and it will be audio-recorded to assist with compiling the information after the phone call. All audio recordings will be deleted at the conclusion of the project.
- Anonymity: All information that you provide will be kept confidential, and any findings will be reported anonymously.
- Phone participant introductions: Ask phone participants to introduce themselves, their place of work, and why they are interested in this consultation.
- Introduction: "Time will be quite tight for this call – it is content rich and we can follow up with you after the call if there are extra items to cover". Ask all participants to introduce themselves (Name, where they work, and their interest in energy efficiency) "in just a few sentences"

2. Discussion Items – Briefing Note (10 – 40 mins)

The discussion will focus on getting feedback on the briefing note, to ensure that the phone participants are familiar with the intent and content of each part (they may or may not have read the document in detail in advance). For each part the questioning route will be as follows:

⇒ (5-10 mins - prompt) What pressure have you felt in your discipline to do energy efficiency work recently (related to Section 1)?

⇒ (5-10 mins - conversation) What are your thoughts on our one-page briefing sheet (Section 2)

⇒ (5-10 mins - conversation) As a starter for the workshop (Section 4.2), what do you think of the generic list?

⇒ (5-10 mins - top of mind, written) What do you think of the specific list - would each of you consider to be the most pressing gaps for graduates in this area (Allow 3 mins of silence). Then read-around (I'll document & language is critical. If you hear someone and like it, leave a couple of lines and note them down too)

⇒ (5-10 mins - conversation) What do you think the most valuable contribution to this space could be from the federal government/ EA?

3. Complete Phone Call

- Summarise call key points back to participants, to check comments are interpreted as intended. Ask participants for any questions arising from discussions (relating to the briefing note) that have not been dealt with in the call so far.
- We invite you to attend one of the workshops in Brisbane, Melbourne or Sydney in the coming weeks, to continue to work on this document (provide link and subsequently forward the invitation by email to each participant).
- Thank you for your time – if you have any questions or further queries please contact me on (give mobile & email address)

BUILDING CAPACITY FOR ENERGY EFFICIENCY IN ENGINEERING EDUCATION

Workshop Consultation Run Sheet

Timing	Topic
9:45 – 10:00	**Registration and Tea/coffee refreshments**
10.00 – 10.10	**Welcome, Housekeeping and Introduction**
10:10 – 10:30	**Background and Context**
10:30 – 12:00	**Discussion Session 1: A Suite of Energy Efficiency Knowledge and Skills** Discussion of industry needs (priorities) for energy efficiency capacity building and consideration of discipline relevance: • *Industry (Top-of-Mind) Question: "What do you perceive as key gaps in graduate ability to: 1) participate in energy assessments, 2) evaluate energy efficiency opportunities, and 3) implement energy efficiency opportunities."* • *Academics Task: Read appropriate discipline briefing notes.* • *Facilitated discussion*
12:00 – 1:00	**Working Lunch: Collaboration Opportunities** Opportunities for industry assisting universities and vice–versa: • *How can these graduate attributes be developed through industry – academia collaboration?*
1:00 – 2.30	**Discussion Session 2: Implications for Education** Discussion of curriculum implications for embedding industry priorities into the curriculum: • *Consideration of industry key knowledge and skills for each discipline.* • *How could the identified attributes be developed in the curriculum of particular disciplines?* • *Considerations when selecting energy efficiency education resources* • *What critical gaps could be addressed through targeted resource development?*
2.30 – 3.00	**Workshop Wrap-Up** Closing Reflections & Future Projects: • *Emergent issues/ opportunities* • *Articulation of next steps (including on-going consultation/engagement with industry stakeholders?)*

Handout 1

Graduate Attribute List – Provocation Sheet

(Industry & Academia)

The ability to effectively participate in energy assessments

The ability to evaluate energy efficiency opportunities

The ability to implement energy efficiency opportunities

These graduate attribute statements have been generated from the focus of the federal Department of Resources, Energy and Tourism on building Australian capacity to undertake and implement energy efficiency assessments.

Handout 2

Key Areas & Topics of Considerations

Industry/ Academic Discipline: ____________________

Key Areas	Importance				
	Very Low	Low	Med	High	Very High
The identification of energy efficiency opportunities					
Synergies between energy efficiency and other aspects of environmental performance					
The quantification of the economic benefits of energy efficiency					
The ability to communicate the business case for energy efficiency					
Undertaking energy auditing and energy assessment					

Key Topics	Importance				
	Very Low	Low	Med	High	Very High
Efficiency, resource efficiency, and energy efficiency					
The link between energy and greenhouse gas emissions					
Life Cycle Analysis / Assessment					
Energy efficiency & low carbon technologies (renewable energy)					
Heat transfer management (particularly insulation and thermal capacity)					
Incremental efficiency versus whole system design (for overall efficiency gains)					
Energy efficiency & low carbon technologies (fuels)					
Energy generation, transmission and distribution losses					
Product stewardship and responsibility					
Energy security					
Fundamentals of Thermodynamics					
Energy Mass Balances					
Embedded water in energy generation					
Resource productivity					
Embedded energy of materials					
Embedded energy of water distribution					
Decoupling energy utility profits from kilowatt-hours sold					
Climate neutrality or emission mitigation					
Sustainable energy supply - energy storage					
Distributed generation of electricity (reducing transmission losses)					
The difference between 'Peak' and 'Base' energy load					
Energy management of electronic components and systems					
Link between friction losses and energy consumption					
Sustainable energy supply - standby energy					
Energy recovery					
Energy rating					
Performance at part and full load					

These tables have been sourced from: Hargroves, K. and **Desha, C.** (2011) *Energy Efficiency Resources for Undergraduate Engineering Education: Energy Efficiency Advisory Group – Project 2*, Lead Member: University of Adelaide, Report to the Department of Resources, Energy and Tourism, August 2011, Canberra

Handout 3

Teaching Options: Energy Efficiency Education

Industry/ Academic Discipline: ______________________

Item	Description	Likelihood (Average)	Impact (Average)
1	Include a case study on energy efficiency	4.1/5	3.2/5
2	Include a guest lecturer to teach a sub-topic	4.0	3.6
3	Offer supervised research topics on energy efficiency themes	4.0	3.2
4	Offer industry placements in energy efficiency (Work Integrated learning)	4.0	2.9
5	Offer energy efficiency as a topic in a problem-based learning course	3.7	3.7
6	Include assessment that aligns with the energy efficiency theme within the course (e.g. exam questions and assignments)	3.7	3.4
7	Include tutorials that align with the energy efficiency theme in the course (e.g. presentations/ discussions/ problem solving)	3.7	3.3
8	Show a DVD of a related documentary	3.6	2.8
9	Overhaul the course to embed energy efficiency	3.4	3.7
10	Include one workshop on energy efficiency in the course (i.e. laboratory-style experiments)	3.1	3.5
11	Include a field trip related to energy efficiency	3.1	3.5
12	Add energy efficiency readings to the required reading list	3.1	2.2
13	Show a DVD of a keynote lecture on energy efficiency	3.0	2.6
14	Develop a new course on energy efficiency	2.9	4.1
15	Include a topic-specific lecture set (i.e. a sub-topic) within the course	2.8	3.2
16	Include elective modules on energy efficiency within the course	2.4	3.3
17	Offer a ‘major’ stream in the engineering degree on energy efficiency	2.2	4.2
18	Include several workshops on energy efficiency in the course (i.e. including laboratory-style experiments)	2.0	3.6
19	Develop a new degree program on energy efficiency (e.g. B Energy Eng)	1.1	4.1

This table has been sourced from: **Desha, C.,** Hargroves, K. and Reeve A, (2009) *An Investigation into the options for increasing the extent of Energy Efficiency Knowledge and Skills in Engineering Education,* Lead Member: Queensland University of Technology, Report to the National Framework for Energy Efficiency, p1-128

APPENDIX C:

Pre-Workshop Discipline-Based Consultation Summary

Compiled in alphabetical order from the multi-stage consultation with members from each EA College, associated technical societies, in addition to Mining and Metallurgy

NOTE: These comments are not representative of the Colleges. Rather they are individual remarks from College members that provide additional useful insight into discipline-based considerations.

Biomedical Engineering

Participants pointed out the complications of energy use in hospitals, machines and medical devices, but also the added benefits of making lower energy use equipment more accessible.

Participant reflections (Q1-Q3):

- Biomedical engineering comprises primarily Electrical Engineering (imaging and diagnostics), Mechanical Engineering (technologies) and some Chemical engineering (processes). In Australia there are 6-7 universities offering biomedical engineering. The current number of annual graduates seems to meet market needs.
- Current pressures for energy efficiency improvements mainly revolve around:
  - Quality control processes (particularly during manufacture and the rejection of many defective products)
  - The issue of single-use vs. multiple use devices and instrumentation
  - cost-benefit analysis (how to provide best health care with finite resources/ equipment)
- Emergence of disposable implements and packages has led to current industry discussion about the logistics of cleaning and re-use, versus cost/ energy effectiveness of producing a 'package deal' (sterilised instrument & tools coupled together in a vacuumed sealed package). Alternatively, the company could have the instruments in-house and 'service' of the tools with the implant (costs get passed to the implant).
- There are further complications about the reuse of disposable/single-use devices in terms of safety, reliability, quality control processes and environmental impact. Recycling, re-engineering and re-manufacturing products are also options, each with their pros and cons.
- Health care is in general very wasteful (some related to safety, some of which is not)
- Other issues:
  - the embodied versus operational energy consumption for appliances/equipment (imaging and radiation therapy equipment are very energy intensive),
  - usability and practicality of equipment – OH&S is an issue for employees
  - Whether retrofitting is possible to add capabilities – imaging devices all have different functions, but to acquire the capability you buy a new machine - more equipment.
  - Scans are often available electronically rather than in printed versions, but it is unclear what is the most energy efficient solution
  - Some procedures now streamlined but number of recipients increasing – rebound effect?

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Understanding that applied technology in health care is energy intensive (and that this has implications)
- Being aware of opportunities to consider making things more energy efficiently/ making energy efficient procurement choices

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- **Guest lecturers:** Within biomedical engineering programs there is a push to bring in specialists from outside –a team of specialists/ experts could come in to talk about specific issues with students. E.g. Design for manufacture type processes, systems approach to design with energy in mind, etc
- **Additional teaching resources:** Providing case studies and worked examples, showing device design & energy impacts, then re-use versus disposal energy implications.
- Other industry bodies (for example, Medical Technologies Association of Australia (MTAA)) could be assisted to act as a champion for energy efficiency, collaborate on teaching resources, and give advice on best practice.

Chemical Engineering

Participants reported recent industry pressures to make energy efficiency improvements, and noted that current business models were a hindrance and resistant to change, but new funding and tax mechanisms were significant triggers for improvements. In light of this a recurring theme in the consultation process was a requirement for graduates to able to present a business/financial case for investment in energy efficiency improvements. Another major theme was a lack of tools (or understanding of available metrics) to be able to appropriately quantify energy savings. A recent IChemE global survey suggested members strongly believe that this area is a top priority.

Participant reflections (Q1-Q3):

- The traditional business model does not lend itself well to doing anything.
- Margins are pretty thin and energy intensity is pretty high – economic incentive to make sure that things (furnaces, boilers, turbines, compressors) work as efficiently as possible. Also, the range of temperatures that processes operate under (e.g. -120degrees) makes insulation very important.
- Energy costs are low in comparison to labour. In this environment, what can be done cheaply to save energy? Carbon tax etc may help justify projects better, but it's really about capturing opportunities from the company's perspective.
- Chemical engineering is uniquely placed to answer the challenges in sustainable development and the sub-topic of energy efficiency. Chemical engineering provides the tools required to accurately quantify resource use, energy efficiency, chemical conversions, recycling opportunities, waste minimisation (in all its forms), and assessment of novel process options.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Fundamental understandings – they physics behind energy use/conversion/waste.
- Framing systems and understanding whole-of-system. Graduate engineers appear very task driven and less likely to look at the whole process.
- Long-term views and long-term effects such as maintenance, wear, corrosion, leaks/seals.
- Communicate business, financial and environmental advantages to varied stake holders. Framing outcomes in business terms and presenting a business case for improvements
- Ability to assess and audit plant operations and equipment to identify areas for energy efficiency improvements, understanding of energy intensity of different equipment for new and aging plants and the CO_2 equivalent emissions
- Tools to quantify energy efficiency. That is, be able to answer the questions 'how much energy will this save [per tonne/hour/repetition]?', 'how much money will that save?', 'how much more will it cost?', 'will it need more maintenance?', and so on.

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- Both government and EA have a role in promoting – even requiring – more industry experience from graduates. We see too little of it, and what we tend to see is frequently brief and potentially tokenistic. The government should help fund, and the EA should require it.
- A clearer emphasis, and perhaps a requirement, for energy accounting. Each piece of equipment and each process should have its energy efficiency accurately and defined.
- Improving the public discourse around energy efficiency, avoiding political language and focusing on quantifying energy use and energy efficiency. For example, if operator X is using 10% less energy to produce some widget than operator Y, this could be disclosed – e.g. in

annual reports – and rewarded.

Civil Engineering

The feedback gave an impression of a skills shortage due to shifts away from the public and into the private sector, and a strong idea of what attributes the participants believed a graduate should have.

Participant reflections (Q1-Q3):

- College is supportive of engineers being taught about energy efficiency in design and construction in the field.
- There is a perception of a current skills shortage industry-wide as a result of outsourcing what used to be Government and utility provider jobs and the excellent training ground that these types of institutions offered. Employers are faced with a competitive environment to win this type of contract work and then have very limited ability to train the engineers.
- The current 5-yearly review of university programs is insufficient for ensuring quality and that the requirements are met for Stage 1 competency.
- The Stage 1 does require some sustainability baseline items to be addressed – appear to be being addressed at the level of 5-year review.
- The programs are becoming more crowded as a result of the closing down of so many training opportunities in the public sector for young graduates and undergraduates, leading to the state where companies are forced to put their graduates through in-house training programs, or to do second qualifications to become useful.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- An idea of contribution of materials to greenhouse gas emissions in the context of large construction processes, and how to calculate those emissions.
- Understanding how recycled materials can reduce greenhouse gas emissions
- Awareness of greenhouse gas emissions, properties and relation to energy efficiency (to then be fine-tuned as postgraduates)
- Ability to take abstract results and apply them to real-world contexts
- Overall appreciation of what is trying to be achieved by energy efficiency (Reducing greenhouse gas emissions)
- Awareness of the key vocabulary in this space (I.e. How energy efficiency relates to sustainability, and the business case, etc).

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- The feeling from the Board is that there is enough in the courses already, big push from consultants to prune down the core training and to move into postgraduate training. This is the case for the structural and civil engineering profession.
- The sandwich courses are invaluable in providing students with relevant training that actually prepares students for the real-world.
- The curriculum needs an overhaul, rather than additional content.

Electrical Engineering

Participant reflections (Q1-Q3):

Participants responded with many generalised comments about energy efficiency. These included applications, the potential for electrical engineering to deliver improvements, and ways of thinking about energy efficiency that could be summed up as a ‘whole of system’ approach. Many of these ‘overlap’ questions 1 & 2 and would be applicable to both EA/Federal government and university curricula.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Appreciation and application of energy efficiency
- Systems and process thinking, whole systems design concepts, an appreciation that ‘life cycle’ involves the input of many resources other than electrical (human, materials, etc).
- An understanding of life cycle design Vs. Capital expenditure of an asset
- Customer interaction/requirements can be the enemy of good outcomes. ie. The customer may want the solution with the lowest up-front cost even though it is not the most efficient. Need to teach this, and how to deal with it.
- Interdisciplinary skills, an appreciation of other disciplines and the ability to work together with professionals from other areas on shared problems.
- Familiarity of the present metrics such as ISO14001, NABERS, green star,
- Knowledge of standards such as AS3000
- Understanding the distinction between Energy Waste and Energy Efficiency. Most savings can be achieved by finding and eliminating waste. Efficiency is part of that process.
- Ability to keep the big picture in perspective - focus on the areas of big waste and big savings first
- Understanding of the depth of capability they have to contribute to energy efficiency. The most significant gains that can be made are not to do with point solutions around specific items of plant and equipment; rather it’s at the process level where the significant gains are possible. This thinking is not taught at university nor supported by government.

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- There was a perception of academics as out of touch with industry needs.
- The curriculum can incorporate / embed energy efficiency without a new subject called Energy Efficiency. The only “new” subject may be renewable energy such as geothermal, solar, wind, current – which can apply to a range of disciplines.
- Lack of academic staff trained in renewable energy and in energy efficiency
- There is a need for graduates to work with more experienced engineers. Generally graduates do not have enough experience to recognise the big picture issues and focus on the important things. They need to be guided in this.
- Government to support/mandate energy efficiency requirements
- Curriculum re-design: course subjects not always relevant to energy efficiency
- A need for someone to play the role of solution integrator who can adopt a larger whole systems perspective (this could potentially come from the field of environmental engineering)

Environmental Engineering

Several participants were from the fields of both Environmental and Electrical engineering, hence there is some repetition in the following feedback.

Participant reflections (Q1-Q3):

- This is a valuable initiative, worthwhile pursuing
- There was a perception among Environmental Engineers that Electrical Engineers are currently best-placed to make efficiency improvements as they learn more about energy systems, machines, processes and efficiency than the other Engineering streams.
- However, [according to environmental engineers] electrical engineers don't always understand the depth of capability they have to contribute around energy efficiency
- The most significant gains that can be made are at the process level, rather than point solutions
- There was a perception among participants that this type of process-level thinking is not being taught in universities, and is not understood or supported by Government.
- Participant's reported a perception of an opportunity for a large 'step-change' around efficiency of processes. This stemmed from their own experiences in business process re-engineering, applied at the technical/systems level.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Participants believed that understanding processes and 'big picture thinking' is where Environmental Engineers come into their own. They have the potential to play the role of solution integrator and can adopt a larger whole-systems perspective; however some basic educational gaps will need to be overcome to allow this to happen. Furthermore, many environmental engineers come from widely differing backgrounds. This pre-disposes some more than others to tackle energy efficiency in accordance with how they perceive the relevance for their background and the area in which they work. The non-homogenous experiences of Environmental Engineers are both an asset and a liability when addressing energy efficiency.
- Environmental engineering can be a bit 'grey and fuzzy' – in many ways harder to define than other professions. Some of the 'soft' skills developed in this discipline were perceived as being highly beneficial to making energy efficiency improvements. These skills were:
  - *flexibility and interdisciplinary skills,*
  - *ability to understand and concentrate on the 'big picture' and 'whole system',*
  - *ability to asses multiple forms of environmental impact,*
  - *ability facilitate and integrate solutions involving inputs from multiple disciplines*
  - *ability to deal with clients and 'sell' greener solutions based on long-term financial benefits*

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- Participants identified that an opportunity exists for Engineers Australia and the technical societies to act as champions for the cause and assist the flow of info & ideas across disciplines/institutions/societies. There may be a potential to offer course/professional development (not necessarily accredited) through tech societies.
- Federal government rebates are powerful motivators and drivers for change.

Information Telecommunications & Electronic Engineering

Participant reflections (Q1-Q3):

For the most part this included generalised comments about energy efficiency in the ITEE sector, applications for energy efficiency and 'whole of systems' approaches to energy efficiency. Participants responded enthusiastically in regard to the potential for ITEE to deliver energy efficiency improvements in many diverse industries, in addition to making clear statements in response to questions 4 & 5.

Q4: What gaps would you consider to be most pressing for graduates in this area?

Responses included many interdisciplinary skills sets as well as ITEE specific 'gaps'. These responses overwhelmingly related to foundational skill sets and overarching principles of energy efficiency:

- Holistic System thinking- look at big picture, think outside of square, context analysis, understand the need for standardisation and inter-operability of equipment to reduce waste
- Lifecycle approach: energy use over 'whole of life' including durability (useable life), energy storage and maintenance (including maintainability), minimisation of standby energy consumption and maximisation of standby times, efficiency of energy converters and effects on associated infrastructure must all be looked at through the prism of energy efficiency.
- Understanding fundamental principles of energy efficiency. It is necessary that energy efficiency thinking is embedded early in the course because the specifics of how the principles are implemented and applied will change in the future in ways we cannot foresee.
- An understanding of value analysis system, optimization and "Value Based Planning"
- Understanding of distributed processing (e.g. when applied to power generation: modern ICT provides the means to exploit small, diverse 'generate at the user's premises' systems).
- Understanding what electronics can do and the ability of programs, systems and computer modelling to improve efficiency in other areas and industries. Eg using computer tools, cybernetics, etc
- Ability to communicate energy efficiency concepts to the public and to understand the motivations behind behavioural changes.
- Understanding of conversion and transportation of energy from one form to another and the efficiencies/losses involved
- Have understanding of 'clean' energy sources (solar, wind, wave, geothermal) and how to tap into them.
- Clear understanding of the relationships between voltage, current, power, energy. - Emphasize that low voltage does not mean low power consumption (many, including some electricians think that low voltage means low power).
- Ability to make sound judgements/justifications around the concept of 'good enough' – utilising a 'near enough' algorithm can provide an immense saving in time and energy while giving comparable results.
- No such thing as free lunch, law of entropy/thermodynamics must be obeyed!

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

Support and legislate in favour of mandatory efficiency standards and green technologies, especially for transport, building standards and renewable power generation.

- Support an overhaul of the power distribution networks to reduce waste and improve EE.
- Cloud computing will be a big draw card on saving energy as data centres can be located where the energy costs are the least. We can have data centres located close to the energy production centres thereby reducing transmission costs, coupled by efficient client server systems which will only require bare minimum data to be transmitted across the lines.
- Enforce compliance to standards, including standardisation of connectors/ interfaces/batteries to allow for interoperability of equipment and reduced duplication.
- Standardize operating voltages to allow sharing of low voltage sources. Where practicable all equipment to operate from 12V so it can run directly from solar panel/battery.
- Enforce a complete conversion to metric units and pressure government to block imports and advertising that does not use metric units. Having to deal with dual systems is inefficient.
- Speed up conversion to digital TV, digital radio. Force closure of analogue TV/radio (AM/FM) transmissions on 12/24 months notice. Supporting multiple formats is wasteful.
- Support the monitoring of energy consumption and use of smart meters as a standard business practice
- Government to alter tax rules – especially depreciation – to force business to invest in a sustainable, long-term manner.
- With the ever increasing cost of energy, the market will force energy efficiency. Govt should not do anything to distort the economic imperative to use less energy, except for protection of basic needs for disadvantaged citizens, etc.
- Initiate a program to review completed infrastructure projects from an energy efficiency perspective. This would be useful in informing future infrastructure investments to consider "lessons learnt" or alternative costed options in energy efficiency.
- EA to send volunteer Engineers to Universities to act as guest lecturers: talk about practical examples, projects, etc.
- EA to promote/market how Engineers have contributed to (and will continue to be a fundamental part of) a more energy efficient life.
- Government to promote EA as partner/figure in energy efficiency
- **Public outreach:** Campaign to inform the public how much ITEE has actually reduced energy consumption for a given standard of living.
  - Acknowledge the current successes in energy efficiency caused by electronics/computing etc.
  - Provide internet site with information on energy efficiency, product ratings, compliance standards to be used in product design, etc. Provide cross promotion to increase awareness of this site.
  - Incorporate a better understanding of energy use, energy efficiency and engineering in primary and high school curricula, including promoting engineering as an exciting career pathway.

Mechanical Engineering

This consultation involved several (self-described) ‘mature-aged’ engineers, who related the current drive for energy efficiency improvements to their experience of the oil crisis and ‘energy crunch’ of the 1970s.

Participant reflections (Q1-Q3):

- Energy crunch came in the 1970s – always looking for ways to improve design to retain heat. Energy efficiency concerns are not just a recent development - decades old. Energy efficiency was once a part of core education!
- Across industry more broadly energy efficiency improvements are also a core focus. Energy prices are rising and the only way to address this is to cut costs.
- Experience of the aluminium industry, which is notably power hungry.
- Fuel costs increasing – can save fuel and design better equipment to use less fuel (gas/ diesel). This wasn’t the only shortage of the past, it also related to coal.
- Current greenhouse gas emissions are staggering
- The generic list of engineering attributes for energy efficiency is a very good start – nothing much to add at present.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Developing “Expensive” university courses isolates many experienced engineers from getting involved. Lack of money & time to go back to university.
- Also new graduates, will have other priorities to deal with before they can make an impact on improving the energy efficiency of their particular industry.
- They will be worried about paying off their student loans and other expenses.
- They will be doing everything they can to impress their new employer and finding their way in life.
- Mature aged workers have been there and done that. We can see the need for making improvements but don’t have access to the latest technology.

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- An opportunity for RET and EA to capitalise on the experience and passion of older engineers by providing educational opportunities.
- Workshops and seminars freely available (at no cost) to all EA members would help to bring us up to speed on this important issue.

Mining and Metallurgy Engineering

This consultation involved two industry participants who have been recognised for their contributions to energy efficiency improvements.

Participant reflections (Q1-Q3):

Participants commented on the specialised education provided to engineering students studying mining or metallurgy, and the silos even between these two curricula. By far and away the largest energy user of all processes in this field is the communition (crushing and grinding) of rocks for processing. This is an area where there is significant conversation about energy efficiency opportunities, in addition to the whole of site design (where energy use is locked in), maintenance and decommissioning.

The participants reflected some frustration in their field, where consultants would promote ‘energy efficiency opportunities’ in attaching solar panels to site office roofs – such efforts are miniscule in comparison to the energy usage in rock processing and transportation – these are the areas that need to be discussed with students and embedded within the curriculum.

Q4: What gaps would you consider to be most pressing for graduates in this area?

The participants responded by identifying critical gaps and energy efficiency issues with the industry at large, some of which apply to recent engineering graduates:

- Lack of, or gaps in, energy impact statements in conceptual and pre-feasibility stages of mining studies
- Failure to understand or apply continuous improvement methodologies (Lean, 6 sigma etc)
- Lack of change management techniques.
- Lack of consideration of alternative technologies
- Lack of understanding of process engineering techniques (included energy balances)

Participants also responded with comments that specifically reflected gaps in the skills and abilities of recent engineering graduates. These tended to relate to fundamental concepts with far-reaching outcomes.

Many recent graduates are unaware:

- that they have power to change established behaviour. This can be addressed by encouragement of innovative thinking and awareness of new technology on the horizon
- that consequences of engineering decisions are far reaching and that they involve more than financial outcomes

Many recent graduates do not have:

- a clear understanding energy implications of specific technologies. This could be addressed in design projects, and by teaching about tools for modelling life-of-project energy relationships as well a financial modelling.

Structural Engineering

Participant reflections (Q1-Q3):

- Participant responses related to foundational skill sets and overarching principles of energy efficiency (as per the existing notes in the briefing note).
- Participants discussed energy efficiency improvements as part of a philosophical shift toward sustainability.

Q4: What gaps would you consider to be most pressing for graduates in this area?

- Life cycle costing – Appreciation for whole of life/life cycle analysis
- Understanding the basic energy efficiency proposition (insulation properties, thermal mass properties and stored energy, etc)
- Understanding the relationship between energy efficiency and Structural Engineering. This must be done in a tangible (or numerical) way that can be articulated to others.
- Commercial acumen around client's needs, supply chain, TBL to inform design form and materials selection.
- Knowledge on how to determine how energy efficient a given structural solution is
- Knowledge (and empowerment?) of what they can do to reduce energy efficiency as a Structural Engineer

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

- Structural Engineers have a role as 'Building Economists'
- They should have "commercial acumen" about the whole-of-life implications for their designs/solutions.
- Engineers need to be seen as THE LEADERS as of the energy solution, not merely as feeding in technical role.

Data Cluster Analysis - Summary

Participant reflections (Q1-Q3):

Themes with cross-disciplinary relevancy:

⇒ Some procedures are now more streamlined but the number of recipients is increasing – rebound effect? **Biomedical** *Originally mentioned by a participant from Biomedical Engineering, this phenomenon may have relevancy for the uptake of more efficient procedures across many sectors.*

⇒ Energy costs are low in comparison to labour. In this environment, what can be done cheaply to save energy? Carbon tax etc may help justify projects better, but it's really about capturing opportunities from the company's perspective. **Chemical**

⇒ The traditional business model does not lend itself well to doing anything. **Chemical**

⇒ There is a perception of a current skills shortage industry-wide as a result of outsourcing what used to be Government and utility provider jobs. This is a concern for the college as:

- Current training programs are viewed as inferior, or the competitive environment means that employers can only provide limited training in-house.
- Public sector jobs and associated training is seen as overcrowded or inaccessible. **Civil**

⇒ Whole systems thinking is very important to understand the issue **electrical**

⇒ This is a valuable initiative, worthwhile pursuing **Environmental**

⇒ The most significant gains that can be made are at the process level, rather than point solutions **Environmental** There was a perception among participants that this type of thinking is not being taught in universities, and is not understood or supported by Government. **Environmental**

⇒ Participant's reported a perception of an opportunity for a large 'step-change' around efficiency of processes. This stemmed from their own experiences in business process re-engineering, applied at the technical/systems level. **Environmental**

⇒ 'Mature aged workers' (with experience of the 1970s 'energy crunch') have valuable experience with EE, but they don't always have access to the latest technology. **Mechanical** *This could be a valuable opportunity for an experienced engineer – new graduate mentoring program to capitalise on 'mature' experience*

Discipline-specific themes:

⇒ Health care is in general very wasteful (some of which is related to safety, some of which is not) **biomedical**

⇒ Emergence of disposable implements and packages has led to current industry discussion about the logistics of cleaning and re-use, versus cost/ energy effectiveness of producing a 'package deal' (sterilised instrument & tools coupled together in a vacuumed sealed package) **…** Some procedures are now more streamlined but the number of recipients is increasing – rebound effect? **Biomedical**

⇒ There was a perception among Environmental Engineers that Electrical Engineers are currently best-placed to make efficiency improvements as they learn more about energy systems, machines, processes and efficiency than the other Engineering streams. **Environmental**

⇒ However, [according to environmental engineers] electrical engineers don't always understand the depth of capability they have to contribute around energy efficiency **Environmental**

Q4: What would you consider to be the most pressing gaps for graduates in this area?

Themes with cross-disciplinary relevancy:

Knowledge of new or 'green' technologies

⇒ Have understanding of 'clean' energy sources (solar, wind, wave, geothermal) and how to tap into them. **ITEE**

Communication skills (especially to non-engineers)

⇒ Ability to communicate energy efficiency concepts to the public and to understand the motivations behind behavioural changes. **ITEE**

Core technical skills / understanding fundamentals

⇒ No such thing as 'free lunch', law of entropy/thermodynamics must be obeyed! **ITEE**

- Fundamental understandings – they physics behind energy use/conversion/waste. **Chemical**
- Understanding fundamental principles of EE. It is necessary that energy efficiency thinking is embedded early in the course because the specifics of how the principles are implemented and applied will change in the future in ways we cannot foresee. **ITEE**
- Clear understanding of the relationships between voltage, current, power, energy. - Emphasize that low voltage does not mean low power consumption (many, including some electricians think that low voltage means low power). **ITEE**
- Understanding of conversion and transportation of energy from one form to another and the efficiencies/losses involved **ITEE**
- Understanding the basic energy efficiency proposition (insulation properties, thermal mass properties and stored energy, etc) **Structural**

Big picture, whole systems, need for skilled 'big picture' facilitator

- Framing systems and understanding whole-of-system. Graduate engineers appear very task driven and less likely to look at the whole process. **Chemical**
- Overall appreciation of what is trying to be achieved by energy efficiency (Reducing greenhouse gas emissions) **Civil**
- Ability to keep the big picture in perspective - focus on the areas of big waste and big savings first **Electrical**
- Systems and process thinking, whole systems design concepts, an appreciation that 'life cycle' involves the input of many resources other than electrical (human, materials, etc). **Electrical**
- Understanding of the depth of capability they have to contribute to energy efficiency. The most significant gains that can be made are not to do with point solutions around specific items of plant & equipment; rather it's at the process level where the significant gains are possible. This thinking is not taught at university nor supported by government. **Electrical**
- Participants believed that understanding processes and 'big picture thinking' is where Environmental Engineers come into their own. They have the potential to play the role of solution integrator and can adopt a larger whole-systems perspective; however some basic educational gaps will need to be overcome to allow this to happen. Furthermore, many environmental engineers come from widely differing backgrounds. This pre-disposes some more than others to tackle energy efficiency in accordance with how they perceive the relevance for their background and the area in which they work. The non-homogenous experiences of Environmental Engineers are both an asset and a liability when addressing EE. **Environmental**

- Environmental engineering can be a bit 'grey and fuzzy' – in many ways harder to define than other professions. Some of the 'soft' skills developed in this discipline were perceived as being highly beneficial to making energy efficiency improvements. These skills were:
    - *flexibility and interdisciplinary skills,*
    - *ability to understand and concentrate on the 'big picture' and 'whole system',*
    - *ability to asses multiple forms of environmental impact,*
    - *ability facilitate and integrate solutions involving inputs from multiple disciplines*
    - *ability to deal with clients and 'sell' greener solutions based on long-term financial benefits* **Environmental**
- Holistic System thinking- look at big picture, think outside of square, context analysis, understand the need for standardisation and inter-operability of equipment to reduce waste **ITEE**
- Lifecycle approach: energy use over 'whole of life' including durability (useable life), energy storage & maintenance (including maintainability), minimisation of standby energy consumption & maximisation of standby times, efficiency of energy converters and effects on associated infrastructure must all be looked at through the prism of energy efficiency. **ITEE**
- An understanding of value analysis system, optimization and "Value Based Planning" **ITEE**
- Life cycle costing – Appreciation for whole of life/life cycle analysis **Structural**

Future mindedness

- Long-term views and long-term effects such as maintenance, wear, corrosion, leaks/seals, etc. **Chemical**

Financial incentives for energy efficiency improvements

- Communicate business, financial and environmental advantages to varied stake holders. Framing outcomes in business terms and being able to present a business case for energy efficiency improvements **Chemical**
- Awareness of the key vocabulary in this space (I.e. How energy efficiency relates to sustainability, and the business case, etc). **Civil**
- An understanding of life cycle design Vs. Capital expenditure of an asset **electrical**
- Commercial acumen around client's needs, supply chain, TBL to inform design form and materials selection. **Structural**

Stakeholder engagement

- Customer interaction/requirements can be the enemy of good outcomes. ie. The customer may want the solution with the lowest up-front cost even though it is not the most efficient. Need to teach this, and how to deal with it. **electrical**

Familiarity with codes/ standards

- Familiarity of the present metrics such as ISO14001, NABERS, green star, **electrical**
- Knowledge of standards such as AS3000 **electrical**

Teamwork / interdisciplinary awareness

- Interdisciplinary skills, an appreciation of other disciplines and the ability to work together with professionals from other areas on shared problems. **electrical**

Familiarity with metrics / measurement tools / quantifying energy

- Ability to assess and audit plant operations and equipment to identify areas for energy efficiency improvements, understanding of energy intensity of different equipment for new and aging plants and the CO_2 equivalent emissions **Chemical**

- Tools to quantify energy efficiency. That is, be able to answer the questions 'how much energy will this save [per tonne/hour/repetition]?', 'how much money will that save?', 'how much more will it cost?', 'will it need more maintenance?', and so on. **Chemical**
- Awareness of greenhouse gas emissions, properties and relation to energy efficiency (to then be fine-tuned as postgraduates) **Civil**

Process modelling

- Ability to take abstract results and apply them to real-world contexts **Civil**
- Ability to make sound judgements/justifications around the concept of 'good enough' – utilising a 'near enough' algorithm can provide an immense saving in time and energy while giving comparable results. **ITEE**

Discipline-specific themes:

⇒ Understanding that applied technology in health care is energy intensive (and that this has implications) **biomedical**

⇒ An idea of contribution of materials to greenhouse gas emissions in the context of large construction processes, and how to calculate those emissions. **Civil**

⇒ Understanding how recycled materials can reduce greenhouse gas emissions **Civil**

⇒ Understanding of distributed processing (e.g. when applied to power generation: modern ICT provides the means to exploit small, diverse 'generate at the user's premises' systems). **ITEE**

⇒ Understanding what electronics can do and the ability of programs, systems and computer modelling to improve efficiency in other areas and industries. Eg using computer tools, cybernetics, etc **ITEE**

⇒ Understanding the relationship between energy efficiency and Structural Engineering. This must be done in a tangible (or numerical) way that can be articulated to others. **Structural**

⇒ Knowledge (and empowerment?) of what they can do to reduce energy efficiency as a Structural Engineer **Structural**

Q5: What do you think the most valuable contribution to this space could be from the federal government and Engineers Australia?

Themes with cross-disciplinary relevancy:

Additional teaching resources / guest lecturers

⇒ **Additional teaching resources:** Providing case studies and worked examples, showing device design & energy impacts, then re-use versus disposal energy implications.

⇒ Other industry bodies (for example, Medical Technologies Association of Australia (MTAA)) could be assisted to act as a champion for energy efficiency, collaborate on teaching resources, and give advice on best practice. **Biomedical Engineering**

⇒ **Guest lecturers:** Within biomedical engineering programs there is a push to bring in specialists from outside –a team of specialists/ experts could come in to talk about specific issues with students. E.g. Design for manufacture type processes, systems approach to design with energy in mind, etc **Biomedical Engineering**

⇒ EA to send volunteer Engineers to Universities to act as guest lecturers: talk about practical examples, projects, etc. **ITEE**

Solutions integrator / whole systems perspective / finances

⇒ A need for someone to play the role of solution integrator who can adopt a larger whole systems perspective (this could potentially come from the field of environmental engineering) **electrical**

⇒ They should have "commercial acumen" about the whole-of-life implications for their designs/solutions. **Structural**

Requirement for transparency/ energy accounting / availability of energy efficiency information/public outreach

⇒ A clearer emphasis, and perhaps a requirement, for energy accounting. Each piece of equipment and each process should have its energy efficiency accurately and systematically defined. **chemical**

⇒ Improving the public discourse around energy efficiency, avoiding political language and focusing on quantifying energy use and energy efficiency. For example, if operator X is using 10% less energy to produce some widget than operator Y, this could be disclosed – e.g. in annual reports – and rewarded. **Chemical**

⇒ Initiate a program to review completed infrastructure projects from an energy efficiency perspective. This would be useful in informing future infrastructure investments to consider "lessons learnt" or alternative costed options in EE. **ITEE**

⇒ **Public outreach:** Campaign to inform the public how much ITEE has actually reduced energy consumption for a given standard of living … Acknowledge the current successes in energy efficiency caused by electronics/computing etc.

- Provide internet site with information on energy efficiency, product ratings, compliance standards to be used in product design, etc. Provide cross promotion to increase awareness of this site. **ITEE**
- Incorporate a better understanding of energy use, energy efficiency and engineering in primary and high school curricula, including promoting engineering as an exciting career pathway. **ITEE**
- EA to promote/market how Engineers have contributed to (and will continue to be a fundamental part of) a more energy efficient life. **ITEE**
- Government to promote EA as partner/figure in energy efficiency **ITEE**

⇒ Engineers need to be seen as THE LEADERS as of the energy solution, not merely as feeding in technical role. **Structural**

Curriculum / Engineering program structure

⇒ The feeling from the Board is that there is enough in the courses already, big push from consultants to prune down the core training and to move into postgraduate training. This is the case for the structural and civil engineering profession. **Civil**

⇒ The sandwich courses are invaluable in providing students with relevant training that actually prepares students for the real-world. **Civil**

- The curriculum needs an overhaul, rather than additional content. **Civil**
- The current 5-yearly review of university programs is insufficient for ensuring quality and that the requirements are met for Stage 1 competency. **Civil**
- The Stage 1 does require some sustainability baseline items to be addressed – appear to be being addressed at the level of 5-year review. **Civil**
- The curriculum can incorporate / embed energy efficiency without a new subject called EE. The only "new" subject may be renewable energy such as geothermal, solar, wind, current – which can apply to a range of disciplines. **electrical**
- Curriculum re-design: course subjects not always relevant to energy efficiency **electrical**

Need for additional training programs for academics (lecturers) / internships

⇒ There was a perception of academics as out of touch with industry needs. **electrical**

⇒ Lack of academic staff trained in renewable energy and in energy efficiency **electrical**

⇒ An opportunity for RET and EA to capitalise on the experience and passion of older engineers (industry-based, not academics) by providing up-to-date educational opportunities. **Mechanical**

Need for Govt to mandate better requirements / changes to regulations and legislation

⇒ Government to support/mandate energy efficiency requirements **electrical**

⇒ Fed government rebates are powerful motivators and drivers for change **environmental**

⇒ Support and legislate in favour of mandatory efficiency standards and green technologies, especially for transport, building standards and renewable power generation. **ITEE**

⇒ Enforce compliance to standards, including standardisation of connectors/ interfaces/batteries to allow for interoperability of equipment and reduced duplication. **ITEE**

⇒ Standardize operating voltages to allow sharing of low voltage sources. Where practicable all equipment to operate from 12V so it can run directly from solar panel/battery. **ITEE**

⇒ Speed up conversion to digital TV, digital radio. Force closure of analogue TV/radio (AM/FM) transmissions on 12/24 months notice. Supporting multiple formats is wasteful. **ITEE**

⇒ Support the monitoring of energy consumption and use of smart meters as a standard business practice **ITEE**

⇒ Government to alter tax rules – especially depreciation – to force business to invest in a sustainable, long-term manner. **ITEE**

⇒ With the ever increasing cost of energy, the market will force energy efficiency. Govt should not do anything to distort the economic imperative to use less energy, except for protection of basic needs for disadvantaged citizens, etc. **ITEE**

⇒ Enforce a complete conversion to metric units and pressure government to block imports and advertising that does not use metric units. Having to deal with dual systems is inefficient. **ITEE**

⇒ Support an overhaul of the power distribution networks to reduce waste and improve EE. **ITEE**

Need for industry mentoring/additional professional development for graduates in the workforce

⇒ There is a need for graduates to work with more experienced engineers. Generally graduates do not have enough experience to recognise the big picture issues and focus on the important things. They need to be guided in this. **Electrical**

⇒ Participants identified that an opportunity exists for Engineers Australia and the technical societies to act as champions for the cause and assist the flow of info & ideas across disciplines/institutions/societies. There may be a potential to offer course/professional development (not necessarily accredited) through tech societies. **environmental**

Discipline-specific themes:

⇒ Both government and EA have a role in promoting – even requiring – more industry experience from graduates. We see too little of it, and what we tend to see is frequently brief and potentially tokenistic. The government should help fund it, and the EA should help require it.**Chemical**

⇒ Cloud computing will be a big draw card on saving energy as data centres can be located where the energy costs are the least. We can have data centres located close to the energy production centres thereby reducing transmission costs, coupled by efficient client server systems which will only require bare minimum data to be transmitted across the lines. **ITEE**

⇒ Structural Engineers have a role as ‘Building Economists’ **Structural**

APPENDIX D:

Workshop Consultation Summary

Compiled from workshops held in Brisbane, Sydney and Melbourne, and written comments received

BRISBANE WORKSHOP DATA

Brisbane, A.M. Industry/ Government/ Association – Critical Gaps (As Written)

Mechanical, HVAC engineer

The ability to effectively participate in energy assessments:

- Knowledge and case study in HVAC/ mechanical system
- Data gathering skills
- Thinking to reduce cost and energy consumption together

The ability to evaluate energy efficiency opportunities:

- Knowledge of thermodynamics and heat transfer
- Knowledge of the economic in design of HVAC/ mechanical equipment and system
- Equipment design for HVAC/ mechanical
- Knowledge of cost impact of the change in the design and thinking to reduce them

The ability to implement energy efficiency opportunities:

- Gaining knowledge of control system and smart control system
- Being familiar with current HVAC/ mechanical designs and try to improve them
- Machine monitoring and maintenance skill
- Skill so mixing cost and energy phenomenon together

Electricity retails and distribution

The ability to effectively participate in energy assessments:

- Understanding of M&V processes, base lining and benchmarking
- Appreciation of seasonal, geographical etc. Variations which may affect the outcomes
- Awareness of demand management reduction/ opportunities
- Facilitation of workshop skills
- Build industry contacts
- Ability to create/ document assumptions
- Understanding of audit process

The ability to evaluate energy efficiency opportunities:

- Working to Australian or international standards → codes of best practice
- Calculate expected ROI → financial education skills
- Data collection and analysis
- Business case writing
- Identify all inputs and outputs
- All costs, not just implementation but also maintenance
- Not just technical but behavioural opportunities exist

The ability to implement energy efficiency opportunities:

- The engagement of the customer and how to communicate the value proposition so they can understand the financial significance (plus other potential benefits)
- Awareness of funding programs that customers may be able to access
- Ability to work across multiple disciplines and operation level

ITEE Industry

The ability to effectively participate in energy assessments:

- Understand audit questions
- Holistic approach
- To find all input measurements and assess the make up of energy inputs and outputs
- Understand units and energy
- To search out and find losses and waste
- Assess the process to determine whether it is the most efficient alternative and assess alternatives
- To find contributions to inefficiencies (e.g. wild fluctuations in energy usages are less efficient than steady usage.
- Collaborative approach
- Cross discipline

The ability to evaluate energy efficiency opportunities:

- Can the process be done in a different (more efficient) way
- Can the losses be recycled
- Mentoring
- New and emerging technologies

The ability to implement energy efficiency opportunities:

- Need to be able to describe and communicate in simple language to non engineers
- Financial evaluation skills
- Business case development
- Key words to interest specific stakeholders
- Change managements skills
- Report skills

<u>Rail</u>

The ability to effectively participate in energy assessments:

- Knowledge and skills
- Measurement before (baseline) and after (proof)
- System awareness, system boundaries, energy balance
    - o Multi-disciplinary knowledge: thermo, electrical
    - o Quantification/ measurement of energy
    - o Conversion of units
- Ability to document/ create assumptions
    - o Understand business drivers (link energy efficiency with other outcomes)
    - o Fault scenarios

The ability to evaluate energy efficiency opportunities:

- Machine losses (efficiency)
- Diagram representation of system
- Process flow
- Knowledge of typical “best practice” outcomes (new technologies)
- Team working with subject matter expert (novice and expert discussion)
- Baselining and benchmarking
- Lateral thinking

The ability to implement energy efficiency opportunities:

- Lateral thinking
- Challenge of assumptions/ model
- Alternative solutions and evaluations
    - o Desktop study
    - o Validation of model
- Business case (financial)
- Communication skills
- Stakeholders
- System modification rather than “clean slate”
- Behavioural change – impacts.

<u>ESD building design – environmental</u>

The ability to effectively participate in energy assessments:

- Group assignments
- Basic problem solving skills
- Often need a good understanding of the system itself (e.g. eng efficiency of HVAC systems)
- Good understanding of energy, relative amounts of energy. How much energy is 1KW? How much energy does it take to ride a bicycle? ATV use?
    - o Relates to impact and why do it

The ability to evaluate energy efficiency opportunities:

- Through a holistic understanding of the system → needs the ability to have the mechanical understanding of how things function
- Knowledge of options/ best practice of emerging technologies
- Have an understanding or grasp on the quantities of energy
- For buildings (specific industries may be taken from industry)

    - HVAC vs natural ventilation vs ceiling fans
    - Class spec and building seating

The ability to implement energy efficiency opportunities:

- This is harder as it requires specific knowledge of products available
- Financial assessment

<u>Manufacturing sector (sugar)/ engineering and EE</u>

The ability to effectively participate in energy assessments:

- Communication skills
    - Ability to engage process personnel who are responsible for control, purchase, use of energy within the process.
    - Ability to influence management personnel regarding technologies required to complete appropriate assessments
    - Ability to report potential from energy efficiency in overview and detailed post assessment
    - Ability to communicate and report and operate within a “whole of business” environment (ISO 9000, 14000, 4000 etc)
- Benchmarking skills
    - Ability to assess the actually energy used in processes to achieve “best practice”

The ability to evaluate energy efficiency opportunities:

- Basic engineering principles
    - Basic physics
    - Thermodynamics and heat transfer
    - Fluid mechanics
    - Electrical machines
- Report writing skills
- Ability to relate energy efficiency outcomes to a whole of business case

The ability to implement energy efficiency opportunities:

- Cross functional interactive skills:
    - Contract and contractor management
    - OHS, Enviro impacts of energy efficiency implementation
    - HAZOP type assessments
    - Implement for maintain ability on costs (RCM??)
- Behaviours
    - Being right does not mean people do what you want
    - Influence is more important than directing

<u>Electricity, retail and distribution</u>

The ability to effectively participate in energy assessments:

- Global awareness of energy needs and responses to issues
- Global awareness of potential future opportunities for improved energy use
- Genuine desire to seek improved energy use
- Ability to create assumptions
- Ability to understand business
- Ability to best practice outcomes
- Ability to use assessment tools

The ability to evaluate energy efficiency opportunities:

- Ability to relate local business’s energy and requirements with similar businesses that are connected to the local energy retailer
- Financial evaluation skills
- Knowledge of control systems
- Ability to develop business case

The ability to implement energy efficiency opportunities:

- Ability to communicate freely with clients in a language free from jargon and judgment
- Ability to seek better energy alternatives (futuristic view)

<u>Mechanical (oil and gas)</u>

The ability to effectively participate in energy assessments:

- Understanding of energy flow through a process/ equipment/ plants
- System awareness
- Ability to document or map energy flows

The ability to evaluate energy efficiency opportunities:

- Technology (USD)
- Ability to make robust and fair assumptions
- Innovative thought process, understand how and where to draw on external knowledge sources i.e. collaborative approach
- Documentations skills (report writing, calculations)
- Control system, more practical

The ability to implement energy efficiency opportunities:

- Strong communication skills
- Ability to develop business case useful but not essential i.e. financial side
- Understand business drivers

<u>Energy</u>

The ability to effectively participate in energy assessments:

- Understand what is EE
    - Economic
    - Social
    - Environment
    - Political
    - Licensing restrictions
    - Legislation
- Change management
- Understand greater implications
    - Built environment
    - HVAC
- Understanding of energy efficiency controls
- Assessment skills
- Awareness of standards in specific
- Communications
    - Translator to different business areas
    - Report writing

The ability to evaluate energy efficiency opportunities:

- Client/ stakeholder consultation skills
- Modelling of different possibilities
- Benchmarking skills

The ability to implement energy efficiency opportunities:

- Project management
    - Scope
    - Stakeholder/clients
    - Procurement management
    - Physical resources management
    - OHS responsibilities
    - Change management

<u>Manufacturing steel</u>

The ability to effectively participate in energy assessments:

- Knowledge of legal and government expectations especially for old plant and equipment
- Tools to measure and monitor
- Cost impact/ unit
- System awareness

The ability to evaluate energy efficiency opportunities:

- Use existing tools USDOE and industry guides
- Team work
- Network

- Change management

The ability to implement energy efficiency opportunities:

- Proposal writing – integrating financial safety production, environmental and energy benefits

Energy

The ability to effectively participate in energy assessments:

- Facilitation/ workshop skills
  - Collaborative approach
  - Broad knowledge across colleges/ disciplines
  - Identification of inputs/ outputs/ losses
  - Energy and mass balance development
  - Auditing skills/ listening/ open ended questioning
  - Knowledge of voluntary programs (NABERS, Green steps

The ability to evaluate energy efficiency opportunities:

- Data collections and analysis
- Measurement and verification
- Research skills
- Network building (specific contacts)
- Modelling/ calculation skills
- Facilitations/ workshop skills
- Financial evaluation skills
- Business case development

The ability to implement energy efficiency opportunities:

- Presentations, development, delivery
- Clear delivery/ low jargon
- Project management
- Facilitation/ workshop skills
- Communication appropriate to audience
- Change/ risk management skills

Energy – Education

The ability to effectively participate in energy assessments:

- Technical knowledge of energy fundamentals (eg energy production, distribution and usage)
- Knowledge of energy standards and regulations (particularly pertaining to EE)
- Audit/ assessment skills and knowledge including understanding of audit processes (ask open ended questions, “show me”, questions)
- Quality systems knowledge
- Report writing and presentation skills
- Systems and key equipments (eg machines, house appliances)

The ability to evaluate energy efficiency opportunities:

- Technical energy efficiency problem solving skills/ knowledge of the range of available solutions/ options
- Holistic approach
- Economic and business case analysis skills (knowledge of costs including implementation costs, maintenance costs etc and benefits analysis)
- Research and best practice analysis/ identification (including benchmarking)

The ability to implement energy efficiency opportunities:

- Change management skills (knowledge of economic, social and environmental barriers and opportunities – including customer and community behavioural aspects and project management
- Risk management knowledge and skills (risk identification, role of occurrence, consequences of failure)
- Communication skills

Energy – Education

The ability to effectively participate in energy assessments:

- Practical knowledge
- To measure/ monitor
- Research internet

- ISO systems/ ISO 5000
- Legals and government expectations
- Do not reinvent wheel

The ability to evaluate energy efficiency opportunities:

- Understand implications of energy charts
- Knowledge of industry

The ability to implement energy efficiency opportunities:

- Integrate financial safety productive requirements
- Relate to cost/ unit production

<u>Not stated</u>

The ability to effectively participate in energy assessments:

- Understand context, how energy efficiency provides multiple outcomes. For example: money savings, GHG savings, internal comfort in buildings
- Integration of disciplines/ systems thinking
- Set up monitoring programs to benchmark and evaluate EE
- Awareness of any regulatory energy efficiency requirement, for example for building – Greenstar, NABERS

The ability to evaluate energy efficiency opportunities:

- Analyse the "how" and "why" of various components
- Link through productive systems
- Ability to compare what's worked well elsewhere and how it could be applied to a similar situation

The ability to implement energy efficiency opportunities:

- Understanding of technical aspects into plain English implications
- Ability to input into providing a business case for change
- Communicate effectively across disciplines

<u>Residential, Housing and industry training</u>

The ability to effectively participate in energy assessments:

- Background in specific software packages
- Thorough training in up-to-date software relative to assessment
- Access to support networks
- Communication "keywords"
- Benchmarking vs groundbreaking technology table
- Facilitation workshop skills

The ability to evaluate energy efficiency opportunities:

- Mentoring to fellow engineering staff
- Build networks and business relationships

The ability to implement energy efficiency opportunities:

- Business case development
- Communication skill

<u>Brisbane, A.M. Academia – Addressing component knowledge and skills gaps (As Written)</u>

<u>Cross-disciplinary</u>

The ability to effectively participate in energy assessments:

- Holistic approach/ inputs and outputs and control options (spread knowledge across all colleges, multidisciplinary)
- Practical knowledge e.g. ppm and knowledge of available tools
- System awareness (boundaries, energy balances, energy flow through a plant/ energy losses)
- Conversion of units
- Modelling
- Diagram representation of systems
- Knowledge of regulatory requirements and industry programs
- Background/ understanding/ ability to use software and assessment tools

- Support/ access networks
- Understanding of energy terms, quantities and impacts. Global awareness/ potential improved energy use
- M+V processes/ seasonal and locational variations
- Data sets aren't perfect
- Knowledge of costs (implementation)
- Modelling abilities against benchmarking (HVAC)

The ability to evaluate energy efficiency opportunities:

- Financial evaluation skills (business case development)
- Knowledge of design of HVAC equipment
- Ability to document/ create assumptions
- Lateral thinking/ innovation/ future thinking
- Specific examples and problem solving tasks
- Relate similar businesses/ local networks
- ROI
- Behaviour/ social aspects
- Look at tables/ benchmarking/ case study analysis/ transferring knowledge
- Safety/ admin/ operation/ financial implication
- Ability to make robust, fair assumptions

The ability to implement energy efficiency opportunities:

- Knowledge of control systems (HVAC)
- Mentoring peers
- Communication skills to non-engineers/ without jargon
- Engagement of customers/ with Facilities Managers/ value proposition
- Change/ improvement management skills including risk management, procurement mgt, OH and S.
- Ability t think beyond a particular software/ discipline
- Systems
- Soft skills
- Communication/ cross disciplinary
- Environmental science needs to include science

<u>Metallurgy and Mining industry</u>

The ability to effectively participate in energy assessments:

- Solid engineering technical skills in:
  - Thermodynamics
  - Process modelling
  - Energy consumption in signal reductions different processes including awareness of "hidden losses"
- "Big picture" system analysis and process modelling (thinking, not using software packages. → system awareness. Thinking about what the various packages are producing in context.
- Listening skills

The ability to evaluate energy efficiency opportunities:

- Knowledge of energy use on a broad scale in their industry (as opposed to knowledge of specifics related to their area of responsibility)
- Knowledge of what others are doing
  - Other sectors
  - Other industries
  - Other companies sometimes
- Probably not much skills required that they don't already get; creative thinking, problem solving
- Awareness of new and emerging technologies

The ability to implement energy efficiency opportunities:

- Communication skills
- Leadership skills → the belief that they ARE able to make a difference
- Negotiation skills
- Ability to step back and make a persuasive argument in context of broad industry energy use and cost
    - i.e. often their business case context is just on small department budget or a segment of an operational budget

- Change management skills.

Engineering, spatial science, electronic, electrical engineer

The ability to effectively participate in energy assessments:

- Provision of resources
- Understanding of energy concepts (quality and low) → benchmarking
- Communication skills (interpersonal) → reporting
- Communication skills (engineering documents)
- Critical system analysis
- Software tools
- Holistic – cross disciplinary
- Find hidden parameters (losses etc)
- Global awareness of energy and future use
- Understanding non-perfect data sets
- Auditing knowledge
- Instrumentation knowledge

The ability to evaluate energy efficiency opportunities:

- Lateral thinking – problem solving
- Relate systems individually within a broader system
- Appreciation of fiscal aspects e.g ROI
- Financial impacts

The ability to implement energy efficiency opportunities:

- Communication skills (especially to non engineering people)
- Focused problem solving tasks
- Future view
- Project management skills

Mechanical

The ability to effectively participate in energy assessments:

- The majority of energy efficiency is relating to mechanical efficiency. Thus, monitoring the operating and health condition of engineering asset is critical to improve energy efficiency. Engineering students should be equipped with condition monitors and maintenance techniques and practices when they graduate

The ability to evaluate energy efficiency opportunities:

- Students should know the different condition monitoring and signal processing technique to be able to understand the machine "language" in the signal to have a better maintenance practices to improve EE.

The ability to implement energy efficiency opportunities

- See answers to the previous questions:
    - For example: Diesel engines, turbine, generators are some of the mechanical systems where the mechanical efficiencies will largely impact the energy consumption. By properly maintaining their health condition will not only reduce carbon emission but increase the EE

Brisbane – A.M. Facilitated Discussion: Participant reflections (As Recorded)

Participate in Energy Assessments

Technical -

- System awareness (boundaries, balance)
- Ability to document/create assumptions
- Understanding that data sets are not perfect – limitations
- Understanding of/ability to use relevant software/assessment tools
- Holistic approach, cross-discipline understanding
- Understanding of energy and relative amounts of energy, including impacts
- Global awareness of energy needs and responsibilities
- Global awareness of potential opportunities for future improvements

- Understanding audit processes (asking open-ended questions – "show me") of an auditor perspective – quality systems approach to participate effectively in assessments (about listening, not jumping to conclusions)
- Knowledge of regulatory requirements and how rapidly they are changing, plus emergence of rating schemes and how they are being taken up
- Ability to assess energy used in a given process and compare it to a benchmark for that process

Enabling -
- Open to mentoring
- Access to support networks
- Skills in facilitation and workshops
- Accepting of the fact that they 'don't know what they don't know'
- Understanding energy flows through the process or plant
- Communication skills – ability to engage process personnel who are responsible for using the energy
- Being right doesn't mean people will do what you want! Need skills in working with people

<u>Evaluate Energy Efficiency Opportunities</u>

Technical -
- Financial evaluation skills
- Knowledge of control systems, ability to design control systems
- Identify inputs/outputs and energy losses (even hidden ones)
- Understanding of energy and relative amounts of energy, including impacts (in order to prioritise outcomes)
- Ability to relate local business energy requirements to similar businesses connected to local energy retailer
- Understanding the wider implications of decisions (environmental, social, economic)
- Diagnostics skills. This includes discipline specific requirements as well as requirements for all engineers
- Modeling abilities against benchmarking standards (finding out answers to what they don't know)

Enabling -
- Ability to make robust and fair assumptions
- Ability think beyond the individual software package to the bigger picture (a whole systems perspective)
- Being able to communicate opportunities as a business case that makes sense to the community
- Ability to compare what has worked somewhere else, and apply it to a new context

<u>Implement Energy Efficiency Opportunities</u>

Technical -
- Knowledge of all of the cost elements as well as the benefits analysis of proposals
- Awareness of funding programs that could assist in getting the project off the ground
- Ability to use tools for e.g. doing energy analysis, benchmarking existing technologies with break-through technologies (data is out there – need access to it)
- Practical appreciation of what metrics mean & finding sensible tools to use (eg PASTE/ AIRCHIEF) – rather than reinventing the wheel, using what is available.

Enabling -
- Communication skills
- Future mindedness
- How value propositions are communicated to the customer
- Ability to use words/ language appropriate to the context – knowing what key words need to be said to the different stakeholders/ shareholders
- Change management skills and knowledge (customer and community behavioral aspects) – not just technical solutions (project/ risk management)
- Strong project management skills, and the ability to communicate across industry players
- Cross-functional interactive skills (Contractors, contracts, implementing for maintainability)
- Ability to enquire into behavioral impediments to implementing the identified opportunities, and to then act on these (e.g. identifying champions to lead)

General comments arising through discussion
- Perhaps an issue of generational problems, not technical/ enabling issues
- Perhaps an issue of universities teaching the 'market' / 'clients' rather than training them to think differently
- From an educational perspective – difficult to tell the students what they should learn (different to industry choosing to employ/ not employ)
- Skills in handling change management
- Getting the concept of 'Change Management' rather than students getting it after they graduate
- Shouldn't be putting all responsibility on universities to create 'management' mindsets – the important thing coming out of universities is ***understanding*** what they don't know (i.e. with regard to soft skills) – this will speed up their learning curve once they hit the workforce
- Understanding the organisational structure and the differences of approaches depending on the context
- Context of calling 'change' management "improvement" – *all improvement is change, but not all change is improvement*
- Universities not endorsing 'general' experiences of students as counting towards their 'work experience', even though during this time the students are getting industry 'enabling' experience

- *N/b Engineers Australia accreditation opportunity for 12-week work experience directions (in addition to technical agenda in competencies evaluation)*
    - *E.g. 60 days with professional engineer, 30 days 'other' @ UQ*
    - *E.g. Professional engineering placement scheme (industry placement) @ UQ*
    - *E.g. IAP program at Griffith University*
    - *E.g. UQ 5-year program*

Brisbane – P.M. Post-It Note Activity (As Clustered)

Participant comments in italics

1. Collaborative projects

- *Industry collaborative project, Writing report, Communication skill, Financial skill*

Postgraduate

Assistance? →commercial (?)issues and fees

2. Creating tools

- *Benchmarking tool to determine where a process/unit op (?) sits, and what the options are*
- *Communication of multiple advantages to multiple stake holders → Tools*

3. Change/improvement management

- *Behavioural - mentoring/support network*
- *Mentoring – skill & handling change management*
- *Change management skills*
- *Change management skills - Establish imperative, Find champions (early adopters)*
- *Behavioural skills – enabling, soft skills; change management skills*
- *Change = risk. Why change unless forced?*
- *Ability to influence the behaviour of others*
- *Behaviour – role models (champions), existing employees; mentoring*

Influence others

Research connections and investment (?)

4. Engineering/business/law student interactions

- Engineering students conducting sessions for bachelor of business students

Research in business – 6 months

5. Communication

- *Communication*
- *Communication with all stakeholders*
- *Communication with different audiences, eg operators, managers, executives, suppliers/salespersons*

6. Industry on panels & linked to assessment (pathways?)

- *Multi-disciplinary attitude, seeking for mentoring*
- *College →workplace, transition expectation, mentoring →pathway*
- *Collaborative (?) opportunities, vacation work, report on dealing with people/stakeholders – EA requirement report*

7. Industry sharing experiences with students on change process

- *Collaborative opportunities, visiting industry lecturers to speak of behavioural/people aspects of improvement – include in assessment*
- *Modelling/benchmarking skills*
- *Project management – scope, stakeholder/clients, HR management, Procurement, Physical Resources, Change management*

8. Undergraduate? Interdisciplinary courses – systems focus (non-engineering and engineering) case studies, guest lecturers, site visits

- *Teach thermodynamics to electrical engineers*
- *Enabling soft skills – listening and influencing skills*
- *Non-technical: understanding the business model, financial constraint, communication idea, project management skills*

Sharing knowledge

Data access (for students)

Industry and academic

Assessing energy efficient topics (?)

9. Open mindedness

- *Behavioural, open minded approach*

ACED – Energy efficiency as a national priority

EA Accreditation Process

10. Inquiry/self-awareness / beginner's mind

- *Questioning skills*
- *Intelligent questioning skills*
- *Behaviours – balance 'task' orientation of engineers (normal and natural preference) with 'people'/influencing skills (DISC profile)*
- *Humility – teach? Generational students becoming more humble in discussions with all groups, particularly senior engineers and management*
- *Confidence to challenge or to ask questions why things are done in a particular way*

Strategic context for action
- Clear to industry (purpose)
Vs's 'Tasks'
LIMS – Leadership I? Maintaining Systems

11. Professional body influence

- *Engineers Australia enforcement of sustainability in curricula*
- *Technical – understand the behaviours of a mechanical system, then improve the system*
- *The ability to influence people – identifying barriers and replacing them with benefits*
- *Behavioural – make a persuasive case → how do the facts relate to the customers*
- *Lack of reinforcing feedback – am I making a difference? No feedback creates a 'nothing changes, why bother' feeling*

Behavioural – poorly defined problem – influencing - dictating

<u>Brisbane – P.M. Facilitated Discussion: Participant reflections (As Recorded)</u>

Due to the small number of academics in the Brisbane workshop, the participants spent longer on the post-it note exercise, followed by a conversation with RET about current and future energy efficiency capacity building endeavours. This included comments on:

- ⇒ *Case studies: combining cases is difficult due to hidden values. What metrics are tangible and what are (something) useful(?)?*
- ⇒ *Resources: linked to hey energy efficiency principles. Embodies technical & enabling skills*
- ⇒ *Ret will create resources for delivery of energy efficiency eex.gov.au*
- ⇒ *Skills – Tech Energy data collection and analysis, Identifying Opportunities, Evaluating Opportunities*
- ⇒ *Enabling Skill – Innovative thinking - Project Plan & Manage - Communication Skills – pitching business case*
- ⇒ *Missing Skills – Eng understanding of energy - Project management - Report Writing*
- ⇒ *6 out of 10 do it in-house training for Energy Efficiency – clearly there is a need and a rapid response time for building capacity in Australia.*

SYDNEY WORKSHOP DATA

Sydney, A.M. Industry/ Government/ Association – Critical Gaps (As Recorded)

Information technology

- The ability to innovate
- The ability to mine data
- Understanding how data can be gathered, logged
- The ability to design energy efficient software

Cost and design

- The ability to communicate effectively, coordinate and work in parallel with other disciplines to achieve multiple level objectives

Electrical

- The ability to understand the interplay between systems of operations (base knowledge of these core areas would make them very attractive)
- 2. Project management and team leadership (change management)

Government

- Data entry & attention to detail; ability to communicate well with other stakeholders
- Financial analysis (NPV/ rate of return etc); understanding the different systems
- Communicate with a range of stakeholders to implement; project management skills

Electrical

- . Knowledge base of the potential of the market place (knowing what is available)

Consulting

- The ability to evaluate: understanding the limitations of the business and finding solutions that fit their situations
- Understanding how a business works

Electrical

- familiarity of 'sites' (e.g. manufacturing); ability to professionally interface with the customer to identify low hanging fruit; ability to manipulate large sets of data
- a basic understanding of systems (motors etc) from a systems point of view
- Ability to communicate

Consulting

- Understanding motor controls; understanding the different systems and how they fit together.
- Knowledge of operation parameters;
- Ability to develop innovative approaches; practical experience

Information Technology

- systems appreciation of 'energy' and embodied implications etc
- Understanding of the political context for energy efficiency options

Industry – Minerals

- systems thinking and how the parts and whole relate to each other; process knowledge
- minerals processing area – techniques for working with data "Handling large volumes of data (pulling it off the SCADA) – rather than teaching students fundamental handling skills the employer can then focus on specific packages; considering all parts of a particular process (e.g. process risk and design implications, where the costs will be incurred
- Procurement – graduates should understand some of the principles (e.g. the process associated with how things are bought – graduates won't then get flummoxed by bureaucracy)

- Ability to get decision makers to create funds! (in between evaluate and implement) – business case development

Mining and Metallurgy

- Energy mass balance and analysis – key to have individuals who fully understand the system; Bringing innovation to the table (not bitter and twisted yet!)
- Fundamental to be able to calculate basic cash flows and accountant language. Have to be able to express the key business benefits to the budget holders who are going to give you approval (CAPex, OPex).
- Understanding the business cycles (maintenance) – e.g. fit for business program – understanding what business needs are – piggy-backing off existing initiatives (collaborate, presentation skills); project management skills – monitoring and tracking initiatives that are being implemented.

Education Support

- students need to be motivated and have a passion for sustainability – demonstrate that energy efficiency has opportunities for graduates (to excite them); ability to communicate about energy efficiency in a systems perspective; sufficient skills to do the fundamentals – then apply this to other situations
- Overcoming capital costs & bring up other items

Consulting

- I want everything from a graduate ☺ … Ultimately its about systems – all comes down to energy. E.g. lighting affects space highlighting, reduced water usage, increased comfort – need to know the whole system (knowing a little bit about everything to bring it all together)

Built Environment

- data mining and asking the right questions – what sort of questions should be asked to get the best answers; ability to evaluate opportunities (pro at excel!); ability to understand clients kpi and regulatory landscape.
- Understanding policies of the organization – need to be aligned with company requirements.

Environmental Accounting

- ability to engage with other stakeholders and establish warmth – honesty & strength of character – being authentic
- Ability to communicate – presentations

Energy Consulting

- ability to work in teams; facilitation and questioning skills
- ability to find information (search it out); ability to construct a credible business case
- ability to influence others with ideas

Government

- Consider data availability
- project experience/ research work experience which demonstrates knowledge/ skills
- Project management skills and implementation skills

Shipping and Transport

- appropriate technical knowledge is given! Willingness to learn (Blank sheet metaphor);
- Ability to think innovatively and look outside the square – be creative in applying knowledge
- Understanding what the industry is (there are so many variations) – ability to interpret the context (not possible to understand all the variations);
- Ability to understand the company’s cost structure/ profits and loss models.

Additional Comments:

- Ability to monitor performance of energy efficiency
- It's a misnomer to imagine that the finance team is going to support the initiative getting across the line – the business case capability really needs to be pushed – otherwise great ideas wont get funding.
- A whole range of skills that are expected to come out of with Stage 1 competencies. N/b the issue of risk – ability to understand the concepts

- Gratifying to hear the key attributes being reinforced. (Included in the 16 elements) – elaborated in the 50 or so indicators of performance that are used to assist individuals (program designers) to create curriculum with the right coverage. For example risk is embedded in these. What is of concern is the apparent gap in current attainment versus expectations. Good to hear that graduates aren't expected to exhibit everything at once! But need to have the base ability (to enter supervised practice) … then a question of going from graduate to fully qualified practitioner. A tremendous input from the room today.
- If you had someone with all these skills – please pass them our way! There is a danger of producing 'someone for everyone'. Have turned from poacher to gate keeper. I have managed teams right across the board – there are individuals with personalities; and others with other expertise. Finding fit for inherent personalities of students.
- To what extent are our expectations driven by deficits in the people around us? Is there a major deficit in broader industry right now – should we be addressing our colleague's capabilities right now. … providing a context for graduates to exhibit the skills that are being sought.

Sydney, P.M. Academia – Addressing component knowledge and skills gaps (As Recorded)

In your discipline groups, discuss what was written by the academics in this morning's session. What are the key emerging knowledge and skills for the three graduate attributes?

ITEE

- team work (between discipline specialists); a systems view understanding; collecting, mining and analyzing large and diverse data sets;
- All of the above, plus expanding on systems thinking, integrating technical, business and regulatory and other constraints; ability to do modelling (writing software) and presenting information in the best possible way; integrating emerging technologies
- All of the above plus project management, communication skills, developing a business case.

Mechanical

- Ability to do an energy mass balance for a process/ company; understanding heat transfer and thermodynamics fundamentals
- Understanding current and upcoming technologies (to know what's available); understanding fundamentals to evaluate options; research skills; design skills in HVAC area; simulation and modelling; (case studies and examples for students + set problems where they can evaluate things)
- Project management, risk analysis, LCA, innovative thinking, and communication skills (case studies, illustrative examples, looking at the problems of trying to implement and seeing what enables those improvements.
- Students need to be impressed with the fact that we are huge guzzlers of energy in our every day life – scary when we look at how much energy we are using.

General (not civil/ envi)

- Relevance in the business world – giving engineers exposure to those sorts of issues
- Communication skills – not sure whether enough is still done around that!)
- N/b the need for embedding energy efficiency into postgraduate education and continuing education – upskilling people at a later date, post-graduation.
- Benefit of having some work experience prior to graduation (e.g. UTS example – John/ David). Sending students abroad/ into industry to do projects (question from Peter regarding how easy it is to support … David – very few students have difficulties in securing an industry arrangement [university invests resources into finding them … potential for federal government assistance with student placements … perhaps universities could bandy together to provide this HR support for these graduate placements.]
- Problems being posed by industry – for example shipping containers and logistics – any problem that is an issue for industry could be put into universities as assignment tasks for students (Vassalios – generic competency development in CV writing skills – perhaps EA could play a role in supporting this kind of skill development? At the moment EA is not a visible association at the moment but could be – this could be supported by the federal government … Robin: not an official spokesperson for EA, but EA does run a PD program for graduates to progress to Stage 2 … if programs increase, then subscriptions increase … would need external support for this type of thing to happen – EA could be persuaded to address the needs of 1/3 of its members - students) ... Carl – lots of pan-European partnerships in looking at energy efficiency and carbon mitigation (resource efficiency) – taking from ground roots upwards – some of funding was provided to start-ups that needed seed funding – doesn't seem to be something similar over here (academic partnerships working with industry to get traction … Need to focus on Research, Development & Demonstration (RD&D) – providing funding for)

- Tony - Major industry placement scheme – in 4th year, top 5% of students go out to industry to work on projects in industry (industry pays $20,000 ½ to students, ½ to university) – very often projects are about ee. Full time 6-month industry placement – development of practical skill in energy analysis & energy efficiency

Chemical

- Energy efficiency literacy – where is energy derived from, state specificity (re. energy production/ source etc); energy and mass balance, and thermodynamics – students need to be well trained in this (top 5% get this exposure at Macquarie).
- Risk assessment; data analysis with large data sets; building the technical solution
- communication skills – cross-disciplinary, knowing what questions to ask of other engineers and other disciplines.
- N/b Q from Chris – does chemical engineering also look at chemical processes in transportation? Tony – starting to do this .

Electrical

- Basic requirement is energy flow and loss
- Basic business skills – cost benefit analysis; having appropriate equipment available and using the appropriate equipment to do the calculations/ measurements
- Control loop knowledge in both a business and technical environment.
- Overall – to provide opportunity to develop both business and technical case in a complex environment.

Sydney – P.M. Facilitated Discussion: Participant reflections (As Recorded)

Due to the length of time taken to discuss the academic component knowledge and skills gaps, the participants did not undertake the post-it note exercise separately, rather combined it within their reflections on academic opportunities for moving forward. This was followed by a conversation with RET about current and future energy efficiency capacity building endeavours. This included comments on:

- Formation of a network of individuals – collaborating and interacting
- Potential to establish – who might be in the network/ what could we offer …
- Potential for “Crowd-sourcing” for solutions – through universities and students
- Students in the work place – (Industrial assessment centres in the US)
- Qualified supervision of students (if the supervisors are effective, the students can grow and the industry can have valuable output)
- Potential for a competition style approach;
- Energy Efficiency Council (buildings/ built environment) – could expand this to include industry …, Energy saving alliance

MELBOURNE WORKSHOP DATA

Melbourne, Industry/ Government/ Association – Critical Gaps (As Written)

Chemical

The ability to effectively participate in energy assessments:

- Bigger picture, holistic training
- Reverse approach, getting industry involved; academia; creating networks and placements.

The ability to evaluate energy efficiency opportunities:

- Each student would have a different sector of industry as work placement experience; however each student would need to present their experiences with others because somebody else might be working in that industry in the future (industry is very broad)

The ability to implement energy efficiency opportunities:

- Top down approach – e.g. assessment already done show money first.]
- Understand ROI
- Maybe have role play in presenting their project.

Environmental

The ability to effectively participate in energy assessments:

- Relationship between energy and the environment/ ecosystems – systems approach.
- But think of meting energy needs as just getting more electricity. Water, waste etc.
- Who are the key contextual players, policies, issues in the area - it's a system.
- Think wider and back to first principles (energy powers us).
- Research and communicating the objective. Why are we doing the assessment? Have a problem based scaffolding for teaching engineering concepts.

The ability to evaluate energy efficiency opportunities:

- Energy permeates virtually all fields of interest to env college so work with this.
- Establish work teams
- Research capability, particularly from a multidisciplinary point of view.

The ability to implement energy efficiency opportunities:

- Project management plans
- Risk matrices
- Can build these areas, assess etc. Into a couple of years of a course
- Systems approach
- Implementation context

Mechanical

The ability to effectively participate in energy assessments:

- No practical experience
- Where to start
- Standards
- Belief in parties that have a self interest

The ability to evaluate energy efficiency opportunities:

- Current systems used in industry
- Assumptions, challenging methodology
- NPV, ROI, KPI
- Challenge processes, "Always done that way".

The ability to implement energy efficiency opportunities:

- Understand processes

Manufacturing (refining)

The ability to effectively participate in energy assessments:

- To take the theory of heat and mass balances and translate that into completing actual plant balances
- Time/priority management → understanding when sufficient time has been invested relative to the potential prize.
- Industry experience
- Key communication skills – written, working within a team.

The ability to evaluate energy efficiency opportunities:

- Understanding of best practices vs assessed energy efficiency (or at least know "what makes sense as an opportunity)
- For industry, it is all about the business case so its important for the following:
    - Communication of business/ financial advantages to key stakeholders (being able to complete cost/ benefit analysis, indentify alternatives)

The ability to implement energy efficiency opportunities:

- Project management skills, in particular for time/ budget management.

Local Government

The ability to effectively participate in energy assessments:

- Needs to learn about planting trees, vegetation which can contribute to improving environment
- Use of recycled materials
- Reduce waste
- Water sensitive urban design (WSUD)
- Industry based learning – compulsory

The ability to evaluate energy efficiency opportunities:

- Cost analysis (assets vs removing trees)
- Suitability of materials
- Machinery selection
- Recyclce vs new
- Site visits to WSUD

The ability to implement energy efficiency opportunities:

- Include WSUD in projects
- Industry based learning, encourage employers
- Assessed the students after ISL (reports) so that they are serious in learning
- Encourage companies to allocate budget for it.

Not stated

The ability to effectively participate in energy assessments:

- Knowledge of standards
- Knowledge of energy mass balance for building, process, industry
- Knowledge of best practices for EE
- Knowledge of national program related to energy efficiency assessment
- Skills: interview skills, data collection.

The ability to evaluate energy efficiency opportunities:

- Knowledge of energy efficiency technologies
- Life cycle of energy efficiency solution

- Economic benefit and ROI
- Impact on business performance
- Government program/ funding

The ability to implement energy efficiency opportunities:

- Project management skills applied to EE
- Technology
- Management
- Operational issues knowledge
- Change management

Food and Beverage

The ability to effectively participate in energy assessments:

- Knowledge of metering/ measurement technologies
- Conversion of units
- Mass/ energy balances
- Communication skills
- Heat ion calculation
- Impact on weather

The ability to evaluate energy efficiency opportunities:

- Quantifying opportunities include money savings from other benefits
- Mass/ energy balances
- Heat transfer/ heat losses
- Financial skills
- The need to look at impact of other resources
- Knowledge of impact of EEO on product quality, health and safety and environment

The ability to implement energy efficiency opportunities:

- Change management/ resource
- Project management skills
- Negotiation skills
- Financial skills
- People skills
- HSEQ
- Knowledge of local, state, federal codes, regulations etc.
- Review of projects

Energy Efficiency project implementation

The ability to effectively participate in energy assessments:

Participants should have the basic knowledge of the requirements that either company requirements, legislative requirement and benefits. These key points assist the auditors that will generally have a specific objective or requirements that they are seeking to achieve.

- Knowledge of site
- Process
- Legislative requirements
- Corporate commitment
- Project financing

The ability to evaluate energy efficiency opportunities:

A thorough understanding of the process or opportunity and what benefit that can be derived from implementation.

- Benefit, ROIs, best practice principles
- What are the hurdles? Data analysis

- Are the projects the right fit
- Has the capacity to increase production, throughout less wastage
- Risk analysis. Target object analysis.

The ability to implement energy efficiency opportunities:

Fundamental understanding of what is involved. Benefit, functionality, realistic costing, training, ongoing benefits, corporate participation.

- Business case to upper managements
- Specific project management skills
- Stakeholder involvement
- What are the ROIs for specific projects

Air processing

The ability to effectively participate in energy assessments:

By not only doing mass and energy balances around process units, but doing a whole project on a bigger process/ plant with many process units and parameters. For all students (not just for those who specifically chose that project)

The ability to evaluate energy efficiency opportunities:

By teaching students about all the various government bodies that are out there NGERS, ERPS, EED and specifically using material from EED to highlight the difficulties and importance of evaluating an EED

The ability to implement energy efficiency opportunities:

By taking student out of the good old fashioned engineering lab with venturi tubes and other important fundamental practicals and taking them out on “excursions” to real plants with real pipes, valves, components, other units etc and doing a case study around them.

The idea is for students to implement the EED around real engineering which can look very different to paper.

Manufacturing process (Air)

The ability to effectively participate in energy assessments:

- Both knowledge of metrics for measuring energy forms
- Skills in using measuring instruments
- Industry process knowledge

The ability to evaluate energy efficiency opportunities:

- Earlier exposure to heat and mass balancing
- Use of thermodynamics to current one form of energy to another.

The ability to implement energy efficiency opportunities:

- Exposure to in industrial project management systems.
- Estimation of costs and savings in both knowledge and skill (perhaps an internship would help).

Energy (consulting engineering)

The ability to effectively participate in energy assessments:

EEO assessments:

- Knowledge of law to apply tools such as regression analysis, EMB.
- Ability to validate and filter large amounts of energy production data i.e. identify and account for missing, incorrect or inaccurate data.
- Communication skills i.e. ability to talk to, draw information from production, staff, to senior management in companies

Energy audits, develop business case for opportunities that is compelling.

The ability to evaluate energy efficiency opportunities:

- Opportunities often fall across several disciplines i.e. heat recovery, electrical motors, lighting, HVAC, steam production. One Person needs to understand at a high level how these interact and delegate to experts for detailed assessment.
- Ability to factor operational risk into business case development.

The ability to implement energy efficiency opportunities:

- Ability to sell a business case to management. This means pitching the opportunities using the KPI's and business measure used by decision makers. (contact me for more details: >>>
- Project management skills to successfully scope, schedule and budget a project including project risks.
- Ability to accurately cost a project including process interruptions, lost production, risk, WACC etc.

<u>VET – industry training</u>

The ability to effectively participate in energy assessments:

- Teamwork and understanding of different viewpoints, systems thinking
- Technical skills:
    - Metrics, data collection
    - Product/ equipment/ process knowledge
    - Energy literacy, basic and technical.

The ability to evaluate energy efficiency opportunities:

- Data analysis, systems thinking
- Development of business case
- Communication of business case to management and accountants
- Knowledge of external drivers (compliance, legislation, current and future incentives)

The ability to implement energy efficiency opportunities:

- Teamwork: management and floor staff
- Change management (including training for new processors etc. → behaviour, occupancy etc.)
- Project management
- Data collection, monitoring, reporting and communication

<u>Energy (consulting)</u>

The ability to effectively participate in energy assessments:

- Basic engineering, problem solving skills

The ability to evaluate energy efficiency opportunities:

- As above
- Researching effectively
- Assessing credibility

The ability to implement energy efficiency opportunities:

- Financial planning, project management
- Project based learning: the problem with PBL is it is very time consuming to set up and badly suited for assessment.

<u>Government</u>

The ability to effectively participate in energy assessments:

- An understanding of a holistic/ systems approach rather than a sectoral approach in undertaking assessments → need for rethinking different streams of engineering
- Demonstrated practical experience not lecture based

The ability to evaluate energy efficiency opportunities:

- Demonstrated practical experience as above
- General: understanding of language of CFO's for examples to able to present the business case

The ability to implement energy efficiency opportunities:

- Demonstrated project experience

General thoughts: don't forget the fact that more students articulate from HED to TAFE than do from TAFE to HED. This is something which could be a basis for fundamental change in the HED sector. i.e. TAFE offers the practical skills not offered in HED to combine both would be a great way forward.

We also tend to forget the role that experience plays, therefore perhaps there is a tendency for employers to have greater expectations of new graduates than is reasonable.

<u>Mechanical</u>

The ability to effectively participate in energy assessments:

- Skills to carry out → Energy audits: experience, to identify the best projects
- Environmental risk studies (big in civil)
- Real world issues – awareness of other effects, interactions (systems approach)
- Cost saving safety, alternative energy sources – evaluation.

Challenging processes; create change; modelling.

The ability to evaluate energy efficiency opportunities:

- Ability to work with imperfect data/ where do you get it from

The ability to implement energy efficiency opportunities:

- Communicate business case (accountants)

<u>Roadwork</u>

The ability to effectively participate in energy assessments:

- System approach to problem solving
- Physics fundamentals/ EMB
- What is energy and how is it used (not just KW, but HHV, LHV etc.)
- EMB

The ability to evaluate energy efficiency opportunities:

- The concept of risk and risk assessment
- LSA
- Where to find data/ info (carbon factors, energy contents etc.)
- Costing (supply, commodity charges, carbon exposure)
- Visual representation of process (to aid discussion)
- Ranking projects/ rate of return
- Develop a business case/ project proposal
- Lateral thinking

The ability to implement energy efficiency opportunities:

- Real world/ industry limitations
- Awareness of cross functional implications.

<u>Civil</u>

The ability to effectively participate in energy assessments:

- Essential knowledge of energy principles
- Skills to undertake accurate metrics in the field or to precise filed measurements for accuracy

The ability to evaluate energy efficiency opportunities:

- Need to know HOW to measure, WHAT to measure
- Knowledge of basic financial analysis
- Understand complete system + look at full picture

The ability to implement energy efficiency opportunities:

- Need to be effective communicator
- Need good presentation skills
- Need to understand "enabling" processes to make EEO change effective
- Build business case for
- Select appropriate KPIs

<u>Local government (green buildings)</u>

The ability to effectively participate in energy assessments:

Re 1-3:

- Yes, obviously very important however a simplistic "tick box" approach that is implied here is not adequate. The "consultant" needs extensive training/ understanding of building energy efficiency – requires training in technical methodologies + understanding of regulatory framework and excellent collaboration/ communication skills and ability to "sell" the business case to CEO/ CFO/ direct level executives and project management skills. The more highly trained, the better the outcome.

The ability to evaluate energy efficiency opportunities:

I cannot stress highly enough that the level of expense required to achieve good results and an understanding of building lifecycle and an intimate knowledge of each building unique characteristics.

Engineers need to be the GPs of the engineering world.

- Good/ effective communications
- Project managers

The ability to implement energy efficiency opportunities:

- General understanding of mechanical, chemical, hydraulic, structural, civil disciplines
- Latest technologies and appropriate applications.
- Facility managers are best placed to affect economically viable solutions.
- Holistic approach

EXTRA: Ability to maintain or achieve efficiency interventions

This is where industry is ahead of academics (CH2 example)

- New category of engineer – building services engineer (civil, mechanical)
- Mentoring/ apprenticeship built into course – like medicine, perhaps needs to be longer period.

<u>Building and energy efficiency</u>

The ability to effectively participate in energy assessments:

- Whole of system, operational, communication

The ability to evaluate energy efficiency opportunities:

- Technology knowledge, components and whole of system
- Report writing
- Business case
- Make recommendations and knowledge of where to find a relevant legislation
- Practical operational knowledge not just theoretical design and specs.

The ability to implement energy efficiency opportunities:

- Communication
- Business case
- Project management

<u>Industry mining:</u>

The ability to effectively participate in energy assessments:

- Knowledge of EEO Act
- Knowledge of Australian standard that forms minimum standard and what it means in practice
- Skills in interpreting assessments against priorities
- Skills in energy mass balances

The ability to evaluate energy efficiency opportunities:

- Skills in cost-benefit, risk in discriminating or value adding energy efficiency opportunities.
- Knowledge and skills of industry best practice
- Skills in developing and selling business case.

The ability to implement energy efficiency opportunities:

- Knowledge of legislative requirements with the EEO
- Skills in sharing the outcomes with other parts of the business
- Skills in change management and project management

Industry mining:

The ability to effectively participate in energy assessments:

- Understand energy consumption more completely including:
    - Direct energy used in a process/ system
    - Indirect energy used to produce consumables for the process e.g. diesel to run trucks and replacing rubber tyres
- Understand process of selection: feasibility studies
- Understanding/ appreciation of units of measure, metrics
- Understand carbon impact, trading, CO2

The ability to evaluate energy efficiency opportunities:

- Be able to sell these ideas on a financial basis e.g. NPV analysis/ trade off studies
- Be aware of alternative sources of energy
- Learn how to research what other groups are doing in this space

The ability to implement energy efficiency opportunities:

- Its all about the sell and the ability to convince/ influence decision makers technically and provide financial impact analysis.

KEY ITEMS: (highest priorities)

- Understand units of measure
- Financial impact analysis NPV etc.
- Research what others are doing in this space

Energy Efficiency Professional Association

The ability to effectively participate in energy assessments:

- Education tole for graduates. Improving the knowledge of building owners, CFOs etc.

The ability to evaluate energy efficiency opportunities:

- These two competencies are greatly enhanced by experience implementing
- Energy efficiency opportunities
- Graduates and practitioners who only have experience in auditing and evaluation are at a significant disadvantage when it comes to understanding the site specific nuances – knowledge that is greatly enhanced by participation in implementation.

The ability to implement energy efficiency opportunities:

- Ensuring that graduates have had practical experience implementing energy efficiency opportunities is critical. Learning by doing is a fundamental requirement for the problem solving on creative skills that one necessary for effectively implementing EE.
- Maintain and use communication and people
- Facility managers

Melbourne, Academia – Addressing component knowledge and skills gaps (As Written)

Mining and metallurgy

The ability to effectively participate in energy assessments:

- Data collection across mining operations, that can be fed into aggregator corporate KPIs.
- Whole system approach to energy assessment (silo approach)
- Risk with energy assessments (loss of power, efficiency, alternative power sources)
- Measurement/ estimation of energy use (proxies, incomplete data set)
- Understand value of energy measurements.

The ability to evaluate energy efficiency opportunities:

- Language of business financial/ economic measurement (more than NPV – product interruption, process risk, alternative energy sources, costs of capital)
- Not challenging the process (status quo)/ benchmarking
- Responsibility to "look for problems" not junk. Provide solutions to problems.

The ability to implement energy efficiency opportunities:

- Whole systems, communication, project managements
- Communication/ personal relationships
- Find ways to make things work
- Exceptional maturity of your engineers focused on company performance and personal relationships, rather than just on their ambition.

Civil

The ability to effectively participate in energy assessments:

- Skills for energy assessment in the design process
- Could be gained through industry based learning

The ability to evaluate energy efficiency opportunities:

- Opportunities in design – evaluate options; present business case.

The ability to implement energy efficiency opportunities:

- Road design – min energy/ cost and freight analysis
- Water supply and treatment – compare rain tanks with cost of drinking water
- Green buildings – materials; cooling etc.
- Street lighting
- Cement manufacture (and alternatives).

Electrical

The ability to effectively participate in energy assessments:

- Electrical mass balance, ability to develop and interpret it.
- Metering and measuring awareness
- Design on energy efficiency project
- Understanding component impacts on energy use in design

The ability to evaluate energy efficiency opportunities:

- Understanding changes in technology (high efficiency motors) (outdated understanding)
- Critical analysis of claims of efficiency – critical thinking skills.

The ability to implement energy efficiency opportunities:

- Broader awareness of other opportunities that is able to be linked into a discrete project.

Bring all skills into one course or unit that integrates other streams of knowledge (beyond electrical) into thinking of graduates.

Melbourne – A.M. Facilitated Discussion: Participant reflections (As Recorded)

1. The ability to effectively participate in energy assessments

⇒ A good understanding of what an energy mass balance is – having a broader understanding of the cross-functional areas (electrical, automation)
⇒ Knowledge of metering and measurement technologies (this is lacking at the moment) – eg. Flow meters and monitoring devies
⇒ Heat and mass balances on paper, and understand what this actually means in the plant
⇒ Industry exposure (e.g. through work experience) – knowing what is practical, versus what is useful for business (cost analysis)
⇒ What are the alternatives – cost-benefit analysis
⇒ Understanding/ awareness of the different forms of energy (electricity/ gas/ chilled water ... all of these things that are energy interdependent)
⇒ Concept of risk and risk assessment – how reliable is the project/ process
⇒ Visual representation of the process – as soon as we communicate results to the business, results are lost on the wider community – how do we ensure that these vital steps are not missed ...
⇒ Knowledge of standards and knowledge of existing programs for Energy assessment
⇒ Skills for data collection/ Skills in data analysis
⇒ Life cycle of energy efficiency consideration
⇒ Impact on business performance

2. The ability to evaluate energy efficiency assessments

⇒ Data collection metrics
⇒ Knowledge of external drivers
⇒ A good understanding of the energy markets and trends (its all about money)
⇒ Understanding energy solutions and applicability/ emergence
⇒ Heat transfer calculations and heat losses
⇒ An awareness of other benefits/ risks of improving energy efficiency
⇒ Real-life experience – understanding how the standards/ guidelines apply to what is being seen in an assessment
⇒ (as opposed to 'magic black boxes' of programs/ models/ conversions which are not challenged , excluding downstream equipment, not understanding how to analyse the raw data)
⇒ Understanding the KPIs of what is driving the energy efficiency opportunities
⇒ Not challenging the processes (e.g. using compressed air, rather than vacuum technology)
⇒ Understanding energy skills, but also understanding really crappy data sets – this takes time and experience
⇒ Developing a business case – understanding NPV (x 2 people), internal rate of return (understanding the language that they will use/ units of measure – particular with the new carbon trading system coming out – would be good to have an understanding of the key terms that people are using
⇒ Analysis of the trade off – financial trade-off study/ comparison ... how do we compare these three equally. Need the bigger picture and trade offs between the options.
⇒ Analytics – dealing with big data sets, modelling, and being able to interpret it – social science skills

3. The ability to implement energy efficiency opportunities

⇒ Change management
⇒ Project management
⇒ Ability to create business skills/ presentation skills and communication skills
⇒ An understanding of project management skills
⇒ An understanding of federal requirements
⇒ Project management skills – how much effort is required versus the potential benefits
⇒ Developing a business case
⇒ Awareness of upstream and downstream effects of the processes (e.g. dust suppression)
⇒ Knowledge of best practice
⇒ Project management skills are missing (e.g. in course work, students do an energy audit – problem with this problem based learning, is that it takes a long time to set up and difficult to mark)

4. Other

⇒ Could there be a - Fourth category – ability to achieve interventions
⇒ Perhaps there could be a new category of engineering – building services engineer
⇒ Need to get better communication between industry and academia

⇒ Energy audits need to be tied into company audits – we want to make sure that we have some sort of integrated process – a better understanding across disciplines, within and across – so that the CFO can talk about what's so, then integrate it across the company and opportunities syncing.
⇒ Students also need to understand what is happening – why the skills are being taught.
⇒ Business needs to be seen to be doing it, so that universities can then follow up with being taught.

Going forward – Considerations/ Ideas:

⇒ Companies who want job-ready graduates need to put up their hands and say we want job-ready graduates.
⇒ Question: Would companies be willing to have more work experience/ company placements
⇒ Might be value in having a third party assisting the parties to work with each other, coordinate this process, rather than expecting the universities to do it themselves
⇒ Perhaps specialised workshops with up-skilling for job-ready professionals to keep them job-ready, but not to be industry based (to avoid self-interested training)
⇒ From an industry standpoint, seems straightforward to offer programs in engaging students to engage in what is being done anyway
⇒ (lack of phone calls to industry – haven't got time to go and chase engineering students – difficult to coordinate)

Melbourne – Post-It Note Activity (As Clustered)

Comments in italics are from participant's post-it notes

Current critical gaps in graduate abilities/ Engineering education

Whole systems approach and fundamental skill sets

- *Design Skills: Whole of life. Assessment of energy and other costs, e.g. road/design/freight carriage*
- *Whole systems approach – not just one technical expertise*
- *Focus on mass balance and energy use, loss, production (over-arching skill)*

Decision making/ critical thinking

- *Teach a decision-making framework: 1. Technical 2. Economic 3. Environmental. 4. Social*
- *Case studies incorporating real-world 'crap' data to highlight perfect information is not available to make decisions*
- *Lack of critical thinking in engineering education*
- *Triple bottom line (sustainability) focus/outcomes ... not just financial*
- *Is the importance of energy efficiency really understood? Energy risks – CO2/GHG, shortages, water use, renewable, ↑ costs*

Energy assessments, measuring outcomes

Outcomes based, energy reduction, throughput performance, safety, quality, ROI, NPV, Risk Assessment
Energy audit/assessment experience is a skill

Industry placement, practical industry experience, learning pathways

Value of project based learnings with the teaching of modern (sustainability) focused engineering
Post Grad certification – based on real workplace projects. Sponsorship, tax incentives

Exploitation of learning grads. Report/business cases/practical, Practice

Project Management – Practical Field
Get young engineers on the 'field' as early as possible so that they learn about engineering from practice not theory in books!

Industry ↑ work placements, " Giving back"
- *need to consider other issues, e.g. review of work placement and what is acceptable, what is exploitation*
- *Pathway, year 1 TAFE (practical skills) →university*

Increased scope for hons/masters projects within companies
International - China. 1000 Companies, 20% reduction, 10,000 companies

Behavioural change/mentoring

Behavioural? Psychology? Mentoring

Cross-disciplinary focus

Energy Efficiency – civil – materials, mechanical – process, chemical – chemical, electrical – energy, environmental – water/environment.
Cross- disciplinary focus on solving sustainability/energy efficiency problems with discipline specific engineers!

Industry/academic collaboration

CEO/Decision maker industry association/roundtable with college of VCs/Deans
Ongoing conversation via round table involving business, industry, university & government
Learning communities to share industry learning – is there an EA/EEA role?

Communication skills

Importance of social skills to engage stakeholders
Communication skills across organisation...from CEO/ Stakeholder/finance/marketing...haul prck (something??) driven

Melbourne – P.M. Facilitated Discussion: Participant reflections (As Recorded)

CHEMICAL

⇒ Reverse approach – industry talking about what is possible and letting that be known to academia
⇒ What can industry give classrooms in terms of personal experiences, that relates to students of all types
⇒ Taking ideas from students along the way – not loosing this knowledge capture opportunity, helping students convert this to something that is implemented. (energy auditors have brick marks on their head!)
⇒ Round tale conferencing idea
⇒ Top down opportunities approach

MINING & METALLURGY

⇒ Outcome = to save energy – get a project implemented – get a project evaluated – measure (backwards design) .. graduates cant have all of these skills, but can touch on them early on:
⇒ Data collection across mining operations and understanding how the KPIs work; whole of systems approach to energy efficiency assessment; including understanding process risks within energy assessment; Understanding that some things are not currently measured – think creatively about how this can be captured
⇒ Using the language of the business and think about this all the way through; ability to challenge the process
⇒ Consider the whole systems approach – how will this project influence other projects in general; communication and interpersonal skills (From truck to design table)

MECHANICAL

⇒ Having experience in doing energy audits – enabling students to identify best project
⇒ Ability to work with imperfect data (and know where to get the data from)
⇒ Environmental risk taking – need to consider the impacts
⇒ Real world issues – affects of project on other aspects (Systems approach)
⇒ Ability to consider alternative energy sources and evaluate the costs using comparable metrics
⇒ Ability to challenge processes and create change
⇒ Modelling expertise

CIVIL

⇒ Not really something civil engineers have ever had to think about – "Civils deal with materials" (5% of global energy used by manufacturing concrete)
⇒ Seeing nice case studies in what is mentioned below – could be excellent.
⇒ For example – considering how a road could be designed from an energy perspective, not a cut/fill perfect information.
⇒ Evaluate and Implement - Implementing (road design) to minimize transport costs, materials selection and manufacture, Water treatment, green buildings and cement manufacture

ELECTRICAL

⇒ Interesting higher level discussions – possibility that opportunities might be missed at a discipline level
⇒ One of the most important attributes is to engage with critical thinking – looking at a scenario and thinking through the different aspects, drawing in different knowledge and fields of expertise
⇒ Ability to do mass balances

⇒ Ability to design an energy efficient project, considering the various components
⇒ Ability to keep up to date with technology and advances (to avoid duplication)
⇒ Critically analyse claims about energy efficiency
⇒ Ability to see beyond the discipline for other opportunities – linking back into their learning

ENVIRONMENTAL

⇒ Energy permeates all fields of interest within this discipline – take advantage of this
⇒ Ability to work in teams to address the energy efficiency opportunities (e.g. Melbourne Water is the 2nd largest water user VIC/ largest in WA, largest in Townsville)
⇒ Relationship between the environment and ecosystem – ecosystem approach
⇒ Understanding key contextual players (who is in the field)
⇒ Thinking about the first principles
⇒ Thinking about the problem to be solved
⇒ Scaffolding for teaching engineering concepts
⇒ Critical thinking and critical analysis
⇒ Project management plans – practice developing
⇒ Have a project that can be tracked over a number of semesters – systems approach – understanding the boundaries, barriers, change management requirements

Additional Comments:

⇒ In depth technical understanding versus in depth practice understanding (bringing together knowledge to develop skills)
⇒ Problem of designing from technical skill base, rather than process base (impact assessment/ audit/ design)
⇒ Rethink curricula from technical grounding to practical experience.

Other Comments Received (Offline, Post Workshops)

Please list as many examples of knowledge and skills that you think engineering graduates should have to effectively engage in each of the four activities below.

Overall we believe that engineering graduates generally have the hard skills necessary (physics, heat transfer, combustion, electromagnetism, etc) to understand equipment and process energy efficiencies. This allows them to assess the energy efficiency of one piece of equipment or design, over another.

However some of the gaps tend to be on the:-
⇒ “Bigger picture” energy optimisations around understanding the processes being dealt and where the opportunities in the process energy cycle efficiencies, energy recovery, cost effectively. E.g. reuse of waste heat in the processes
⇒ Understanding the energy costs (including carbon tax implications, government incentives) and the business accruement to justify spending of additional capital (rate of return). Finding a solution on the right point of the energy savings versus capital cost curve
⇒ Managing the complexity of “retro-fitting” the efficiency ideas to existing plant, which tend to limit opportunities due to restrictive plant configuration. So rather than further theory, practical examples and case studies on decision making processes for retro-fitting would be useful.
⇒ Understanding and utilisation of benchmarking (including limitations) is useful in terms of process performance and value of energy reductions relative to the change or investment decision making process.

Effectively participate in energy assessments

⇒ Be aware and/or capable of taking field measurements of energy consumption from existing operating systems to be able to determine efficiency.
⇒ Be aware of the methods for modelling, measuring and verifying process energy and material flows.
⇒ Understand the types of data that are useful for energy efficiency assessments and techniques for analysing the data eg determining base line data and effects of production, regression analysis, etc.

Identify and evaluate energy efficiency opportunities
⇒ Understand whole of system approach to energy efficiency, ie impacts of changes upstream on the energy balance and potential implications to associated and downstream processes, for the ‘whole system’, and for particular assets e.g. energy use under different conditions.
⇒ Utilise data analysis to identify opportunities for saving energy, including use of specific efficiency optimisation tools such as pinch analysis.

⇒ Know and understand how energy is consumed by different systems e.g fan and pump electric motor systems compared to constant torque electric motor systems, and more specifically, how to make these more efficient. Energy efficiency should be included as a specific design goal for engineers and engineering projects.

Communicate energy efficiency opportunities

⇒ Understand business drivers for making decisions on selecting energy efficient options.

⇒ Be able to develop business cases for process changes or capital investment implementing energy efficient options.

⇒ Understand the importance of communicating any change and the value of it to the people that will be directly affected by the change.

Implement energy efficiency opportunities

⇒ Understand the importance of ensuring that the systems and procedures are in place to support the energy efficiency opportunity and that the relevant personnel are trained sufficiently.

What would you consider to be the most valuable contribution the federal government/Engineers Australia could make to developing skills in this area?

It seems that the last 12 months has seen a relatively uncoordinated flood of training opportunities provided by government departments, universities, TAFE, and a range of other ASPs. Almost getting to “spoilt for choice” across the whole range from basic training to professional development. This may be improved through some structure and clear definition of the training outcomes, either incorporated in to the engineering curriculum, or in professional development options, so employers can ensure they are maximising the return on invested time and or money in training.

APPENDIX E:

Workshop Handouts – Collated Data

Raw data from workshop handouts

Handout 1:

[See Appendix C]

Handout 2:

In what city do you live?		
Answer Options	Response Percent	Response Count
Brisbane	33.8%	26
Sydney	39.0%	30
Melbourne	27.3%	21
	answered question	77
	skipped question	1

Are you		
Answer Options	Response Percent	Response Count
Industry	66.7%	52
Academic	34.6%	27
No answer	0.0%	0
Which sector or discipline		71
	answered question	78
	skipped question	0

Please indicate how important you think the following key areas are								
Answer Options	**Very low**	**Low**	**Medium**	**High**	**Very High**	**No answer**	**Rating Average**	**Response Count**
The identification of energy efficiency opportunities	1	4	13	36	21	3	4.04	78
Synergies between energy efficiency and other aspects of environmental performance	2	5	14	40	14	3	3.87	78
The quantification of the economic benefits of energy efficiency	2	4	7	29	32	4	4.24	78
The ability to communicate the business case for energy efficiency	4	3	12	18	37	3	4.17	77
Undertaking energy auditing and energy assessment	1	9	15	38	11	3	3.75	77
Other (please specify)								2
							answered question	**78**
							skipped question	**0**

This table was reproduced from the NFEE 2007 Survey.

Please indicate how important you think the following key topics are								
Answer Options	Very low	Low	Medium	High	Very high	No answer	Rating Average	Response Count
Efficiency, resource efficiency and energy efficiency	1	4	13	32	25	3	4.09	78
The link between energy and greenhouse gas emissions	2	9	18	35	11	3	3.68	78
Life Cycle Analysis/ Assessment	1	10	16	31	16	4	3.81	78
Energy efficiency and low carbon technologies (renewable energy)	2	6	22	30	15	3	3.76	78
Heat transfer management (particularly insulation and thermal capacity)	4	3	25	23	18	5	3.81	78
Incremental efficiency versus whole system design (for overall efficiency gains)	2	3	19	30	18	6	3.99	78
Energy efficiency and low carbon technologies (fuels)	1	8	29	34	2	4	3.51	78
Energy generation, transmission and distribution losses	1	6	25	28	11	7	3.81	78
Product stewardship and responsibility	4	13	31	17	3	10	3.41	78
Energy security	6	11	31	17	6	7	3.35	78
Fundamentals of thermodynamics	3	5	21	19	23	7	3.96	78
Energy Mass Balances	4	6	21	23	16	8	3.83	78
Embedded water in energy generation	6	15	30	19	0	8	3.21	78
Resource productivity	3	9	30	21	7	8	3.56	78
Embedded energy of materials	4	11	33	18	4	8	3.40	78
Embedded energy of water distribution	6	19	28	17	1	6	3.08	77
Decoupling energy utility profits from kilowatt-hours sold	4	19	28	13	6	8	3.28	78
Climate neutrality or emission mitigation	2	13	23	22	8	10	3.65	78
Sustainable energy supply - energy storage	2	9	15	41	7	4	3.69	78
Distributed generation of electricity (reducing transmission losses)	1	9	26	26	11	5	3.67	78
The difference between 'peak' and 'base' energy load	1	7	27	24	13	6	3.76	78
Energy management of electronic components and systems	4	11	25	18	10	9	3.60	77
Link between friction losses and energy consumption	5	8	31	19	7	7	3.47	77
Sustainable energy supply - standby energy	2	12	25	28	5	6	3.51	78
Energy recovery	1	5	21	27	16	6	3.92	76
Energy rating	1	9	21	31	6	9	3.77	77
Performance at part and full load	2	3	24	28	15	6	3.88	78
Other (please specify)								10
							answered question	78
							skipped question	0

This table was reproduced from the NFEE 2007 Survey.

Handout 3:

In what city do you live?		
Answer Options	Response Percent	Response Count
Brisbane	30.0%	9
Sydney	56.7%	17
Melbourne	13.3%	4
	answered question	30
	skipped question	1

Are you		
Answer Options	Response Percent	Response Count
Industry	46.7%	14
Academic	10.0%	3
No answer	46.7%	14
Which sector or discipline		13
	answered question	30
	skipped question	1

Please indicate the likelihood and impact of the following						
Answer Options	Likelihood High	Likelihood Low	No Answer	Impact High	Impact Low	No Answer
Include a case study on energy efficiency	10	1	19	9	0	20
Include a guest lecturer to teach a sub-topic	10	1	19	8	0	21
Offer supervised research topics on energy efficiency themes	6	0	24	5	0	24
Offer industry placements in energy efficiency (work integrated learning)	5	5	20	9	2	18
Offer energy efficiency as a topic in a problem-based learning course	9	0	21	6	0	23
Include assessment that aligns with the energy efficiency theme within the course (e.g. exam questions and assignments)	4	0	26	3	0	26
Include tutorials that align with the energy efficiency theme in the course (e.g. presentations/ discussions/ problem solving)	5	0	25	4	0	25
Show a DVD of a related documentary	2	5	23	2	1	26
Overhaul the course to embed energy efficiency	4	0	26	3	0	26
Include one workshop on energy efficiency in the course (i.e. laboratory-style experiments)	5	0	25	3	0	26
Include a field trip related to energy efficiency	6	1	23	6	0	23
Add energy efficiency readings to the required reading list	2	1	27	1	0	28
Show a DVD of a keynote lecture on energy efficiency	0	4	26	0	2	27
Develop a new course on energy efficiency	4	2	24	1	1	27
Include a topic specific lecture set (i.e. sub-topic) within the course	2	1	27	0	1	28
Include elective modules on energy efficiency within the course	8	0	22	4	0	25
Offer 'major' stream in the engineering degree on energy efficiency	5	1	24	2	1	26
Include several workshops on energy efficiency in the course (i.e. include laboratory-style experiments)	3	0	27	3	0	26
Develop a new degree program on energy efficiency (e.g. B Energy Eng)	4	1	25	2	2	25

This table was reproduced from the NFEE 2007 Survey.

APPENDIX F:

Briefing Note on Energy Efficiency Education

A note to the Australian Engineering Profession on energy efficiency and capacity building needs, by major discipline

[APPENDIX F exists as a separate document]