Supporting Materials for Lecturers:
Multi-Media Bite Resources

Grounding Students in Energy Efficiency Assessment Knowledge and Skills

Produced by

Queensland University of Technology and

the University of Adelaide (The Natural Edge Project)

The EEERE Project:

Energy **E**fficiency **E**ducation **R**esources for **E**ngineering

Consortium Partners:

Project Partners:

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Consortium Project Team:

- Project Directors (QUT): Dr Cheryl Desha (Leader), Professor Doug Hargreaves and Associate Professor Les Dawes (Advisors)
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- EA Electrical College: Mr Mark Blundell
- EA Environmental College: Ms Anne Kovachevich
- EA Information, Telecommunications and Electronic Engineering College (ITEE): Mr Bolle Borkowsky
- EA Mechanical College: Dr Steven Goh
- EA Structural College: Dr Rob Heywood
- Mining and Metallurgy Discipline: Professor Peter Knights, University of Queensland; Diana Drinkwater, Sustainable Minerals Institute

Case-Study Contributions:

- Overview: Mr Alan Pears, Sustainable Solutions Inc
- Cook Medical: Ms Kelly Coverdale, Mr Jithendra Nair
- Carlton United Brewery: Paul Brodie
- QUT Precinct: Dr Gary Rasmussen, Dr Anne Brandt, Dr David Oakeshott, VAE Group, Anne Kovachevich, Arup
- Palabora Copper Mine: Mr Francis Barram, Ensight; Mr Rod Welford, Ensight
- Thiess: Mr Glenn Hedges
- Whitsunday Sewage Treatment Plant, Whitsunday Regional Council

Project Background

Energy efficiency is widely recognised as the simplest and most cost-effective way to manage rising energy costs and reduce Australia's greenhouse gas emissions. Promoting and implementing energy efficiency measures across multiple sectors requires significant development and advancement of the knowledge and skills base in Australia. Engineering has been specifically identified as a profession with opportunities to make substantial contributions to a clean and energy-efficient future.

To further enable skills development in this field, the Department of Industry commissioned a consortium of Australian universities to collaboratively develop four innovative and highly targeted resources on energy efficiency assessments, for use within engineering curricula. This includes:

1. Ten short **'multi-media bite'** videos for each engineering college of Engineers Australia and an introduction (led by Queensland University of Technology with the University of Adelaide);
2. Ten **'flat-pack'** supporting teaching and learning notes (led by University of Adelaide with QUT);
3. Two **'deep-dive case studies'** including worked calculations (led by University of Wollongong); and
4. A '**virtual reality experience'** in an energy efficiency assessment (led by Victoria University).

Specifically, these resources address the graduate attributes of '**identifying**', '**evaluating**' and '**implementing**' energy efficiency opportunities in the workplace, incorporating a range of common and discipline specific, technical and enabling (non-technical) knowledge and skill areas.

The four resources were developed with reference to the 2012 Industry Consultation Report and Briefing Note[1] funded by the Australian Government's former Department of Resources, Energy and Tourism (RET), and through further consultation workshops with project partners and industry stakeholders. At these workshops, participants confirmed the need for urgent capacity building in energy efficiency assessments, accompanied by **clear guidance for any resources developed**, to readily incorporate them into existing courses and programs. Industry also confirmed three key graduate attributes of priority focus for these education resources, comprising the ability to: **think in systems**; **communicate between and beyond engineering disciplines**; and **develop a business case** for energy efficiency opportunities.

[1] Desha, C. and Hargroves, K. (2012) *Report on Engineering Education Consultation 2012*, a report and accompanying Briefing Note, Australian Government Department of Resources, Energy and Tourism, Canberra.

Contents

1. Introduction

1.1. Context

This project aims to provide resources and supporting materials to assist the higher education sector, in particular engineering, industry, and built environment related courses, to rapidly equip graduates with the ability to conduct energy efficiency assessments and improve energy performance across major sectors of the Australian economy. There is a growing volume of 'educational material' on energy efficiency now available on the internet, however this has previously been considered as insufficient for the following reasons:

- Much of the information available online comes from international examples in Europe, the United States or elsewhere. There is a need for educational materials that target specific needs within the Australian Economy.
- Internet searches for 'energy efficiency' tend to yield information on energy efficient products, appliances, processes or technologies. There is a need for educational materials that focus on developing the skills required to conduct energy efficiency assessments, namely the ability to identify, evaluate and implement opportunities for energy efficiency improvements.
- There is a perceived lack of quality energy efficiency educational resources relevant and suitable for undergraduate engineers.
- The complementary use of relevant, high-quality educational resources within university courses is ad hoc and highly variable. There is a need to dramatically increase the use of such materials in undergraduate engineering education.

For these reasons it was apparent that there existed a need for a new suite of energy efficiency educational resources for engineering.

1.2. Choice of media

In our rapidly changing world where YouTube is a dominant form of entertainment and 'infotainment', it is critical to provide students with resources that are in-line with the cultural context of today's undergraduate student cohort. Furthermore, previous surveys revealed that academics want bite-size pieces of information that can be spliced into existing course-work, and that alleviate some time and pressure in preparing their course-work. Academics want flexibility in splicing the resources into their teaching, with minimum fuss.

Within this context, this project has created 10 x 3 minute energy efficiency resources that introduce critical concepts in the field. They are designed to function as provocations, in 'bite-size' pieces that can be readily integrated into course-work, either in the classroom or online. Stylistically, these resources are a blend of the 'interview-style' YouTube resources, and 'in-the-field' reality TV, with some additional diagrams to highlight key points. The multi-media bites focus on delivering contextual energy efficiency knowledge ,skills, and examples. The set comprises of one introductory multi-disciplinary video-clip on energy efficiency assessments and engineering, followed by nine

video-clips for each of the disciplines identified in the 2012 Engineering Briefing Note (i.e. Biochemical, Chemical, Civil, Electrical, Environmental, Information Technology & Electronic, Mechanical, Mining & Metallurgy and Structural). The template for crafting multi-media messages has been informed by experts in teaching and learning pedagogy at QUT, where:

- The multi-media bites include a clear introduction, discussion/ presentation/ demonstration, and conclusion.
- The resources have a standard introductory dialogue detailing the title of the multi-media bite, project funding and open-use arrangements.
- The content of each media-bite includes interview footage with industry professionals in the field, disciplinary experts, and images taken from common-attribution sources to enhance the dialogue.
- The resources endeavour to be 'timeless' (i.e. avoiding temporal references)

In order to maximise outcomes from the developed resources, these multi-media bite resources have been designed for flexible use. They can be viewed selectively (for example, showing just the introduction clip and one or two others from relevant disciplines), or as a complete set. They can also be used independently or in conjunction with the flat-packs. The media bites 'click-in' with the flat-pack resources to expand upon the topics and concepts. Together or independently, the resources can serve as a provocation or introduction to the lecture and/or tutorials. Within this context, this document provides an overview of the Multi-Media Bites resource: Its objectives for engineering faculties, the graduate attributes and learning outcomes (both technical and enabling) to be developed through using this resource, potential learning pathways for developing the identified knowledge and skills, and engineering sub-disciplines for which the resources are relevant.

1.3. Choice of people and places

The multi-media bites include interviews with a wide range of engineering professionals and energy efficiency experts to introduce students to key energy efficiency concepts. Each video includes a discipline-specific introduction by energy efficiency expert Alan Pears, who has played a key role in the development and evolution of energy efficiency practice since the 1970s. In each video, this section introduces students to the significant challenges and exciting opportunities for energy efficiency improvements within each engineering discipline. Each video also includes a case study that provides students with a tangible example of an energy efficiency assessment within their specific discipline. Finally, each multi-media bite video also includes a short provocation from an Engineers Australia college or industry association highlighting the importance of energy efficiency and some emerging challenges.

The following sections summarise the development and focus of the multi-media bites videos, and provide further detail on the choice of the strategies and technologies resources and tech to make most relevant) – In short, the multi-media bites provide a high quality 'course-ready' resource that will allow engineering educators to introduce students to the energy efficiency imperative and the key role of engineers in improving the energy performance of systems. They provide tangible examples of real-world energy efficiency assessments while highlighting the significant benefits to business and industry.

2. Statement of Coverage

This suite of multi-media bites goes beyond traditional information-laden content development by targeting specific graduate attributes to create an empowering platform for students to consider energy efficiency problems within the context of their own discipline. The multi-media bites focus on the use of personal insights from colleagues through case studies, in addition to college and industry partner interviews.

2.1. Resource Focus

A key finding from previous research is that graduating students lack knowledge in important technical topic areas essential for conducting energy efficiency assessments, and also have varying abilities in regard to important enabling skills such as communication, working in teams, and presenting a business case for investing in energy efficiency.

As shown in Figure 1, the following 'common' graduate attribute statements are emergent from the 2011 workshops, 2012 industry consultation and 2013 workshops for this project:

- The ability to ***identify*** energy efficiency opportunities;
- The ability to ***evaluate*** energy efficiency opportunities; and
- The ability to ***implement*** energy efficiency opportunities.

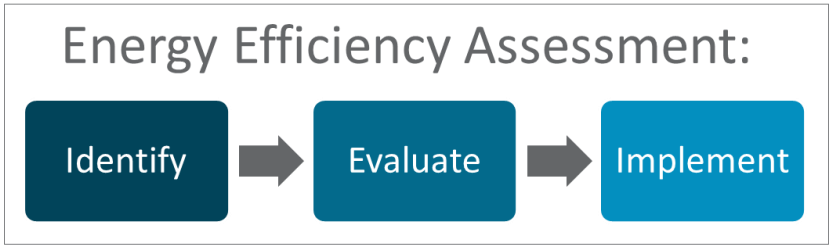

Figure 1. Core Graduate Attributes for energy efficiency assessments

Across these three common graduate attributes, we have focused on the following critical – or 'threshold' knowledge and skill areas, with the intention that once students are exposed, the concepts cannot be 'unlearned'. This is based on priorities identified in the Energy Efficiency Opportunities Program (specifically Requirements 3 and 4), the Engineers Australia Stage 1 Competency Standard, and the Office of Learning and Teaching's Five Threshold Learning Areas (See Appendix A).

Information, data and analysis

⇒ Energy Efficiency Principles, units of measure & limitations
⇒ Financial calculations and implications
⇒ Whole of life analysis
⇒ Whole system design
⇒ Individual and team work

Opportunity identification and evaluation

⇒ Big-picture context
⇒ Whole of life evaluation
⇒ Financial evaluation

⇒ Communication (verbal and non-verbal)

Through incorporating these cross-referenced and reinforcing knowledge and skill areas the multi-media bites have multi-disciplinary and multi-sectoral application, wherein students can apply the insights and understanding within their programs of study.

2.2. Relevant Industry Sectors

Given the focus on graduate attributes for energy efficiency assessments across each of the disciplines represented by Engineers Australia the resources and supporting materials draw on each of these sectors to provide 'real world' context. This focus is a key strategy to assist the greater uptake of education materials. Figure 1 highlights the use of six case study sites to target industry sectors for the nine discipline areas, with the case studies briefly described here:

- **QUT Science and Engineering Centre (SEC):** The structural engineering case study focuses on the impact of design considerations such as orientation, shading and façade performance on the energy performance of mechanical systems.
- **Carlton United Brewery (CUB)**: CUB implemented a significant energy efficiency program targeting multiple areas of inefficiency across the facility. The mechanical engineering case study focuses on CUB's refrigeration optimisation program. The environmental engineering case study focuses on the link between water and energy efficiency. The electrical engineering case study highlights energy efficiency improvements achieved through lighting upgrades.
- **Palabora Copper Mine (PCM)**: PCM is undertaking a program to reduce energy use across its operations. The chemical engineering case study focuses on improving the smelting process to reduce oxygen demand and coal consumption. The mining and metallurgy case study focuses on the use of energy and mass balances to identify energy intensive processes and improve performance in its underground mine, concentrators, and refining processes.
- **Cook Medical Facility:** The ITEE case study focuses on the use of virtualisation and server upgrades to reduce energy consumption across the organisation. The biomedical engineering case study highlights opportunities to improve the manufacture and performance of medical products that may have energy efficiency outcomes.
- **Thiess & Infrastructure**: Thiess have implemented Energy Efficiency Action Plans to help identify and implement energy efficiency improvements in its construction projects. The case study focusses on energy efficiency improvements achieved through more efficient site and tunnel lighting strategies and the use of hybrid equipment on their construction sites.
- **Orion Shopping Centre**: The ITEE case study focuses on the use of software systems to optimise lighting and daylighting strategies at Orion Town Shopping Centre, which resulted in significant energy efficiency improvements compared to standard designs.
- **Whitsunday Sewage Treatment Plant Upgrade**: The environmental engineering case study may also feature the DownerTenix Whitsunday Sewage Treatment plant, which used a sustainability rating tool to identify and drive energy efficiency opportunities for the plant's upgrades.

These case study sites were targeted for their interesting energy efficiency journeys, in addition to the proximity of potential interviewees to the project team (i.e. South East Queensland).

Table 1. Selection of case studies to address content needs for the multi-media bites

Case Study	Biomedical	Chemical	Civil	Electrical	Environmental	ITEE	Mechanical	Mining & Metallurgy	Structural
Cook Medical Facility	✓					✓			
Palabora Copper Mine		✓						✓	
Thiess			✓						
Carlton United Brewery				✓	✓		✓		
Whitsunday Regional Council Sewage Treatment Plant					✓				
Orion Town Shopping Centre						✓			
QUT Science & Engineering Centre									✓

2.3. Relevant Technologies

The multi-media bites include reference to a variety of technologies to demonstrate to each discipline the context and application of energy efficiency assessments, across Biomedical, Chemical, Civil, Electrical, Environmental, ITEE, Mechanical, and Structural Engineering fields, along with mining and Metallurgy. The constraints of the media genre (YouTube Clips) have dictated that references to technical details are necessarily brief. However, these are supported in more detail within the Flat-pack resources:

- *Combustion engines, turbines, boilers, and electric drive systems*, featured due to the large potential for energy savings and the proliferation of such technology across all sectors.
- *Ventilation systems, fans and blowers, motors, lighting systems, and HVAC*, featured due to the prolific opportunities across all sectors including manufacturing, and buildings, ability for students to relate to such technology and learning and teaching potential.
- *Information and Communications Technologies*, featured due to the growing opportunity to reduce the energy consumption of such technologies and to use such technologies to reduce the energy consumption of a number of sectors.
- *Industrial and Commercial Industry Buildings and Envelopes*: featured due to the significant potential for energy efficiency improvements, the visual appeal for students and subsequent learning and teaching potential of interactive 3 dimensional learning programs.
- *Civil construction associated with roads and transport infrastructure*, featured due to the need to respond to resource price increases and reductions in raw material availability.

Where possible, case studies were chosen to enable their use for more than one discipline. In some instances the flat-pack resources provide additional examples that are not included in the multi-media bites. The selection of case studies addresses technologies used throughout the industrial and commercial building sector and includes many references to non-technical 'enabling' considerations that complement these technology innovation areas, including reducing energy use, systems design, process optimization, scheduling, energy management planning etc.

2.4. Engineering Sub-Disciplines

The multi-media bites focus on all of the disciplines identified in the College Briefing Note produced for RET[2] (i.e. the *2012 Engineering Briefing Note*), including Biomedical, Chemical, Civil, Electrical, Environmental, ITEE, Mechanical, Structural Engineering, along with Mining and Metallurgy.

2 Department of Resources, Energy and Tourism (2012) Briefing Note for Engineering Practitioners and Educators – Increasing Energy Efficiency Knowledge and Skills, Canberra.

3. Teaching guide to content

The following paragraphs describe the resource and how it is intended for use, to maximise engagement with students. The multi-media bites have been created as stand-alone video clips, with clear structure that enables lecturers to start and stop at various places within the resource. To assist lecturers in splicing the resource into the teaching program, Tables 2-10 provide an overview of the individuals and case studies used in each multi-media bite.

3.1. Introduction Video

The introduction video introduces students to the concept of energy efficiency and the potential it has to radically improve the sustainability of business and industry. It includes interviews with a range of energy efficiency experts and key engineering professionals who discuss the importance of energy efficiency. The introduction is presented in two parts, namely:

- Introduction Part 1 'The energy efficiency imperative and the key role of engineers': Part 1 introduces students to the concept of energy efficiency and the significant potential for radical improvements across industry and business. It highlights the key role of engineers in achieving significant energy efficiency improvements and the importance of gaining energy efficiency skills in their engineering education.
- Introduction Part 2 'energy efficiency and the importance of whole system thinking': Part 2 follows on from Part 1 and focusses on the importance of whole system thinking in achieving energy efficiency improvements. It introduces students to the idea that taking a systems approach can help deliver multiple benefits, and highlights the importance of working in multidisciplinary teams to optimise systems. To provide students with a tangible example of systems thinking in practice, the video highlights the systems engineering approach employed by Carlton United Breweries to identify, evaluate and implement energy efficiency initiatives in their brewery that are saving the company over $10 million dollars annually.

Table 1. Summary of video composition – Introduction

Multi-Media Bite	Details – Speakers and Case Studies
PART 1: Introduction to Energy Efficiency Assessments: The energy efficiency imperative and the key role of engineers.	Stephen Durkin – CEO, Engineers Australia.
	Rod Welford – Former Minister for Education & Training and Minister for the Arts; Executive Chairman, Ensight Energy Solutions.
	Alan Pears – RMIT
	Doug Hargreaves – President, Engineers Australia (YEAR-YEAR)
	Lyn Brodie – President, Australian Association of Engineering Educators (YEAR-YEAR)
	Tom Roper – Australian Sustainable Built Environment Council (ASBEC)
	Paul Brodie – Engineering Manager, Carlton United Breweries.
	Luke Menzel – Energy Efficiency Council
PART 2: Energy efficiency and the importance of whole system thinking.	Alan Pears – RMIT.
	Rod Welford – Former Minister for Education & Training and Minister for the Arts; Executive Chairman, Ensight Energy Solutions.
	Paul Brodie – Engineering Manager, Carlton United Breweries.
	Stephen Durkin – CEO, Engineers Australia.

3.2. Biomedical Engineering Video

The biomedical engineering video introduces students to the role of engineers in improving the energy efficiency of biomedical systems whilst continuing to meet clinical needs and deliver improved services. It includes a short case study on Cook Medical on the benefits of considering energy efficiency opportunities when designing and manufacturing components.

Table 2. Summary of video composition – Biomedical Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Biomedical Engineering	Overview: Alan Pears – RMIT.
	Case study: Cook medical (Kelly Coverdale – Cook Medical)
	College/Industry: Izmir Congo – Engineers Australia Biomedical College.

3.3. Chemical Engineering Video

The chemical engineering video introduces chemical engineering students to energy efficiency assessments and the benefits that can come from optimising chemical processes. It includes a short case study on Palabora Copper in South Africa, which implemented an Energy Efficiency Management Plan that is reducing energy consumption by 20 per cent, saving AUD$0.5M annually.

Table 3. Summary of video composition – Chemical Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Chemical Engineering	Overview: Alan Pears – RMIT.
	Case study: Palabora Copper Mine (Francis Barram – Ensight Energy Solutions).
	College/Industry: Dr Gareth Forde – Institute of Chemical Engineers.

3.4. Civil Engineering Video

The civil engineering video introduces civil engineering students to the opportunities for significant energy efficiency savings in the design, construction and operation of civil structures. To provide students with a tangible example of energy efficiency assessments in the real world, the video includes a case study on engineering construction and services provider Thiess, who implemented Energy Efficiency Action Plans to help identify and implement opportunities in construction projects.

Table 4. Summary of video composition – Civil Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Civil Engineering	Overview: Alan Pears – RMIT.
	Case study: Thiess (Glenn Hedges – Environment and Sustainability Practices Manager, Thiess).
	College/Industry: Tom Roper – Australian Sustainable Built Environment Council (ASBEC).

3.5. Electrical Engineering Video

The electrical engineering video introduces electrical engineering students to the concept of energy efficiency and the key role of electrical engineers in improving the energy efficiency of a wide range of areas. To provide students with a real-world demonstration of energy efficiency assessments the

video includes a case study of Carlton United Breweries, who used energy efficiency assessments to identify opportunities for significant energy efficiency improvements through lighting systems.

Table 5. Summary of video composition – Electrical Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Electrical Engineering	Overview: Alan Pears – RMIT.
	Case study: Carlton United Breweries (Paul Brodie – Engineering Manager Northern Operations, Carlton United Breweries).
	College/Industry: Mark Blundell – Engineers Australia Electrical College; Mike Griffin – Australian Power Institute.

3.6. Environmental Engineering Video

The environmental engineering video introduces students to the importance of energy efficiency for environmental engineers. The video includes two case studies. Firstly, it highlights a case study on the Whitsunday Sewage Treatment Plant upgrades, which utilised the ISCA Infrastructure Sustainability tool to identify energy efficiency improvements during the upgrade of two existing wastewater treatment plants. The energy efficiency improvements delivered energy and materials savings, reducing annual operating costs by over AUD$75,000. Secondly, it presents a case study of Carlton United Breweries, who identified energy efficiency opportunities from water treatment and pumping in its brewing operations.

Table 6. Summary of video composition – Environmental Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Environmental Engineering	Overview: Alan Pears – RMIT.
	Case study: 1. Carlton United Breweries (Paul Brodie – Engineering Manager Northern Operations, Carlton United Breweries); 2. Whitsunday Sewage Treatment Plant Upgrade (Risk Walters – Infrastructure Sustainability Council of Australia; Damien Morley – Senior Design Manager, DownerTenix; Matthew Brennan – Group Sustainability Manager, DownerTenix)
	College/Industry: Anne Kovachevich – Engineers Australia Environmental College.

3.7. ITEE Engineering Video

The ITEE video discusses the importance of energy efficiency to information, telecommunications, and electronics engineering (ITEE) systems. The interviews also highlight the key role of ITEE in delivering radical energy efficiency improvements across a wide variety of projects and sectors. The video includes two case studies to provide students with tangible examples of energy efficiency assessments in the ITEE field. The case study on Cook Medical showcases the process the company undertook to identify energy efficiency improvements through virtualisation. The case study on Orion Town Centre highlights the role of software and software optimisation in contributing to improve air-conditioning and lighting systems in the shopping centre.

Table 7. Summary of video composition – ITEE

Multi-Media Bite	Details – Speakers and Case Studies
ITEE Engineering	Overview: Alan Pears – RMIT.
	Case study: Cook Medical (Jithendra Nair – Director of IT Asia-Pacific, Cook Medical); Orion Town Centre (Francis Barram – Ensight Energy Solutions).
	College/Industry: Bolle Borkowsky – Engineers Australia ITEE College.

3.8. Mechanical Engineering Video

The mechanical engineering video introduces mechanical engineering students to the concept of energy efficiency and the importance of mechanical engineers in identifying energy improvements in the design, manufacture and operation of systems. The video includes a case study on Carlton United Breweries, who implemented an Energy Management program to help identify and implement improvements in its brewing operations that are saving the company AUD$0.5M annually.

Table 8. Summary of video composition – Mechanical Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Mechanical Engineering	Overview: Alan Pears – RMIT.
	Case study: Carlton United Breweries (Paul Brodie – Engineering Manager Northern Operations, Carlton United Breweries).
	College/Industry: Dr Steve Goh – Engineers Australia Mechanical College.

3.9. Mining & Metallurgy Engineering Video

The mining and metallurgy video introduces students to the significant potential for energy efficiency assessments to deliver energy efficiency improvements and cost savings within mining and metallurgical operations. The video highlights the key challenges and the significant opportunities to develop more efficient processes. The video includes a case study on Palabora Copper in South Africa, who implemented an Energy Efficiency Management Plan that allowed it to identify energy efficiency improvements in its undergrounding mine, concentrator, and refining processes. The efficiency improvements are reducing energy consumption by 20 per cent, saving the company AUD$0.5M annually.

Table 9. Summary of video composition – Mining and Metallurgical Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Mining and Metallurgy	Overview: Alan Pears – RMIT.
	Case study: Palabora Copper Mine (Francis Barram – Ensight Energy Solutions).
	College/Industry: Diana Drinkwater – Sustainable Minerals Institute; Professor Peter Knights – University of Queensland

3.10. Structural Engineering Video

The structural engineering video introduces structural engineering students to the significant energy efficiency opportunities that come from doing energy efficiency assessments during the design of structures. The video includes a case study on the Science and Engineering Centre at Queensland

University of Technology, where energy efficiency assessments were used to identify opportunities to reduce the energy consumption of mechanical plant by focussing on improving the efficiency of the building façade.

Table 10. Summary of video composition – Structural Engineering

Multi-Media Bite	Details – Speakers and Case Studies
Structural Engineering	Overview: Alan Pears – RMIT.
	Case study: QUT Science and Engineering Centre (Gary Rasmussen – QUT; Anne Kovachevich – Engineers Australia Environmental College; David Oakshot – VAE Group).
	College/Industry: Rob Heywood – Engineers Australia Structural College.

4. Adapting resources for varying contexts

Varying background Knowledge levels

- The material in the MMB's is designed to be suitable for introductory level education for engineering students and does not assume pre-requisite knowledge other than that provided in existing engineering programs.

Catering for different audiences

- The resource flexibility facilitates lecturers in incorporating the multi-media bites as hyperlinks within lecture course notes, within PowerPoint slides, within html text on a course website, or within an email to students. Such flexibility permits the resources to be used as provocations that are easily digested and which can form a welcome media-change within a standard lecture timeslot. Alternatively, these resources could provide a point of reference for tutorial discussions or background materials for assignments.

Varying class sizes

- There are a number of opportunities to use the multi-media bites for provocation in various classes. For very small classes, the students could discuss the multi-media bite with regard to themes such as key messages, most interesting aspect, questions arising, and emergent opportunities for energy efficiency assessments. As student numbers increase, such discussions could be in the form of tutorials or reflective writing in journals or portfolios.

Multi-disciplinary audiences

- The multi-media bites have been specifically designed to cater both to a broad audience through the introduction video, and technical audiences through the targeted discipline-specific videos. The language within the multi-media bites is appropriate from first through to final year engineering, where it is anticipated that students at varying stages in study will identify with different content.

Online audiences

- The resource is highly suited to online audiences, and will be fully scripted to assist people including those with English as a second language, hearing difficulties, or who are without access to audio on their devices.

APPENDIX A: Priority Graduate Attributes and Knowledge & Skill Areas

EEO Program: Assessment Framework Requirements (2013)[3]

Information, data and analysis (Requirement 3)

- Understanding of core energy principles and their connection to discipline-specific foundation knowledge
- Ability to apply core engineering technical skills to energy efficiency problems (interdisciplinary and discipline-specific)
- Familiarity with the variety of energy efficiency data available, units of measurement and limitations for use
- Ability to make robust assumptions and test them
- Ability to participate in design phase, individually and in teams
- Ability to collect and analyse data to determine lifetime costs and cost savings of an asset, versus initial expenditure
- Understanding of current practice, best practice and optimum energy efficiency solutions

Opportunity identification and evaluation (Requirement 4)

- Awareness of the role of energy efficiency within the larger context of energy considerations (i.e. including the need for energy and peak demand, fuel switching, storage and demand management, energy recovery, cogeneration, tri-generation, and renewables)
- Awareness and capacity to draw upon the specialist skills of other disciplines
- Ability to conceptualise the 'big picture', including the contribution of technical and non-technical solutions to energy efficiency improvements
- Ability to weigh lifetime costs and cost savings of an asset, versus initial expenditure
- Ability to effectively communicate efficiency opportunities to key stakeholders (verbally and non-verbally)
- Ability to present a basic financial case for initial up-front investment in more energy efficient technologies

Office of Learning and Teaching: Threshold Learning Outcomes (2010)[4]

1. ***Needs, Context and Systems:*** identify, interpret and analyse stakeholder needs, establish priorities and the goals, constraints and uncertainties of the system (social, cultural, environmental, business etc.), using systems thinking, while recognising ethical implications of professional practice.
2. **Problem Solving and Design:** apply problem solving, design and decision making methodologies to develop components, systems and/or processes to meet specified requirements, including creative approaches to synthesise alternative solutions, concepts and procedures, while demonstrating information skills and research methods.
3. ***Abstraction and Modelling:*** apply abstraction, mathematics and discipline fundamentals to analysis, design and operation, using appropriate computer software, laboratory equipment and other devices, ensuring model applicability, accuracy and limitations.
4. ***Coordination and Communication:*** communicate and coordinate proficiently by listening, speaking, reading and writing English for professional practice, working as an effective member or leader of diverse teams, using basic tools and practices of formal project management.

[3] Department of Industry (2013) Assessment Framework, http://energyefficiencyopportunities.gov.au/eeo-steps/conducting-assessments/assessment-framework-2/

[4] Australian Learning and Teaching Council (2010) Engineering & ICT: Five Threshold Learning Standards, www.olt.gov.au/system/files/Engineering%20poster%20A4.pdf.

Self-management: manage own time and processes effectively by prioritising competing demands to achieve personal and team goals, with regular review of personal performance as a primary means of managing continuing professional development (lifelong learning).

Engineers Australia: Stage 1 Competency Standard (2013)[5]

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 engineering design practice and contextual factors impacting the engineering discipline.
1.6	Understanding of the scope, principles, norms, accountabilities and bounds of sustainable 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 demeanor.
3.4	Professional use and management of information.
3.5	Orderly management of self and professional conduct.
3.6	Effective team member and team leader.

In the 2010 revision of the competency standards, a second level of descriptors were added to provide additional explanation about the intention of the competency standards statements, termed 'elements' and 'indicators'. These include the following references:

- *1.5a) Identifies and understands the interactions between engineering systems and people in the social, cultural, environmental, commercial, legal and political contexts in which they operate, including both the positive role of engineering in sustainable development and the potentially adverse impacts of engineering activity in the engineering discipline*
- *1.6d) Appreciates the social, environmental and economic principles of sustainable engineering practice.*
- *2.3c) Executes and leads a whole systems design cycle approach including tasks such as:… systematically addressing sustainability criteria*
- *2.4f) Demonstrates commitment to sustainable engineering practices and the achievement of sustainable outcomes in all facets of engineering project work.*

[5] Engineers Australia (2013) Stage 1 Competency Standard for Professional Engineer,