Flexible Delivery Flat-Pack Module

Introduction to Undertaking Energy Efficiency Assessments

Produced by

The University of Adelaide and Queensland University of Technology (The Natural Edge Project)

The EEERE Project:

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

Consortium Partners:

Queensland University of Technology
The University of Adelaide
Victoria University Melbourne Australia
RMIT University
University of Wollongong
La Trobe University Australia

Project Partners:

Engineers Australia
aced
Australasian Association for Engineering Education
energy efficiency council
asbec Australian Sustainable Built Environment Council

Funded and Advised by:

Australian Government
Department of Industry

Citation Details

Hargroves, K., and Desha, C. (2014) *Introduction to Undertaking Energy Efficiency Assessments*, The University of Adelaide and Queensland University of Technology (The Natural Edge Project), commissioned by the Australian Government Department of Industry, Canberra.

Acknowledgements

The team from Adelaide University and QUT that developed this document acknowledge the work of our colleagues at QUT David Sparks, Fiona McKeague, and Cheryl Desha who we supported to develop the accompanying video resources, along with the partners involved. The consortium thanks the 40 workshop participants (Brisbane, Sydney and Melbourne) including stakeholder partners, Engineers Australia College Members, industry and academic colleagues, who provided their time and ideas so generously during the stakeholder engagement parts of the project, and to those who have assisted in reviewing the drafted resources, in particular Alan Pears, energy efficiency expert, and the following Engineering educators from the University of Adelaide, Dr Seth Westra, Professor Michael Griffith, Professor John Sturgul, Dr Cristian Birzer, Dr Philip Kwong, Dr Nickolas Falkner and Associate Professor Nesimi Ertugrul. We would like to thank the students at the University of Adelaide who provided review comments on the lecture and the accompanying video resource. The consortium thanks our project partners for their continued commitment to building capacity in delivering sustainable solutions, and the federal government for funding the initiative, in particular Mr Stuart Richardson, Mr Luiz Ribeiro, Ms Denise Caddy and Mr Nick Jackson, for their contribution to engineering capacity building. Material contained in this document includes content drawn from The Natural Edge Project (TNEP) Sustainable Energy Solutions Program and is adapted herein as per licencing agreements with CSIRO and Griffith University.

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, and around the world. 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. These include the following resources informed by national stakeholder engagement workshops coordinated by RMIT:

1. *Ten **'flat-pack'** supporting teaching and learning notes for each of the key disciplines of engineering (University of Adelaide and Queensland University of Technology);*
2. *Ten short **'multi-media bite'** videos to compliment the flat-packs (Queensland University of Technology and the University of Adelaide);*
3. *Two **'deep-dive case studies'** including worked calculations (University of Wollongong); and*
4. *A '**virtual reality experience'** in an energy efficiency assessment (Victoria and LaTrobe Universities).*

These resources have been developed with reference to a 2012 investigation into engineering education[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 and communication the business case for energy efficiency opportunities.

Content

1. 'Allen Key' Learning Points

Engineers have critical skills the economy needs to thrive in a carbon constrained future. The following learning points provide a summary of the introductory video – our 'Allen keys' to building the flat-pack content!

Watch the '***Introductory***' MMB

1. Australia is at a real turning point in terms of our industrial future with many of the old assumptions about manufacturing, industry, and in fact our economic and social well-being being challenged every day. If Australia is to transition from a resource dependent economy to a high-tech, high-value economy our energy needs are definitely going to change.
2. The demand for energy efficient products and processes is increasing with consumers, industries, and policy makers pushing for changes that will allow us to make better use of our resources, and minimise environmental impacts for future generations. Engineers are central to solving the global challenge of reducing carbon emissions, avoiding the biggest impacts of climate change, and making industry more efficient around the world.
3. Engineers are involved in the design, production, operation, maintenance, and the eventual decommissioning of equipment. All of these steps represent critically important opportunities for us to save energy and capture a lot of the benefits that flow on from that energy saving. Energy efficiency measures can achieve a lot of outcomes that are worth far more than the actual energy they save. If you're able to save significant energy you're actually reducing your emissions and as well getting rid of unnecessary costs for the business.
4. Energy management is good business. When considering the return on investment there are multiple benefits such as energy savings, time and labour savings, water and other materials and resource savings, and reduced transport costs. Ultimately decision makers want to know how much will a proposed energy efficiency measure save, what it will cost to achieve that saving, and the time frame in which the savings will be delivered A key component of the success of energy efficiency measures is the ability of engineers to communicate with a variety of key stakeholders. Engineers need to be able to understand complex situations and questions; and give clear and concise input that engages with stakeholders and supports decision making.
5. With a clear move towards environmentally friendly energy generation the public will understandably be looking to engineers to inform and educate them about the feasibility and availability of innovative technologies. As engineers we often tend to focus on the technical aspects of our work but we must also remember that we're members of a community, and the social and environmental aspects of what we do are just as important.
6. There are numerous opportunities now for engineering graduates to be involved in exciting and inspiring projects where their knowledge of engineering can used to deliver productive and sustainable solutions to society. Many are now of the view that energy efficiency is a strategically important area where concerns about the environment, about quality of life, about worker conditions, can be addressed in a way that underpins a successful economy.
7. Engineers have been central players in major technological changes over the last 100 years, and engineering is now firmly embedded in virtually every aspect of our daily lives. There's no doubt that engineers are central players in creating a more sustainable future.

2. Industry Demand for Energy Efficiency Graduate Attributes

In 2006 the Australian Government created the Energy Efficiency Opportunities (EEO) Act with the objective to '*improve the identification, evaluation, and public reporting of energy efficiency opportunities by large energy-using businesses, to increase the uptake of cost effective energy efficiency opportunities*'. The EEO Act was applicable to corporations that used over 0.5 petajoules of energy per year; this represented some 300 companies and just over half of Australia's total energy use. Participating companies were required to undertake an energy efficiency assessment and report to the government on the findings. Between 2006 and June 2011 participants in the program identified the potential for annual energy savings of 164.2 PJ through a focus on energy efficiency across each major sector, as shown in Figure 1. As part of the program 89 PJ of energy was saved, the equivalent of 24 billion kWh's per year.

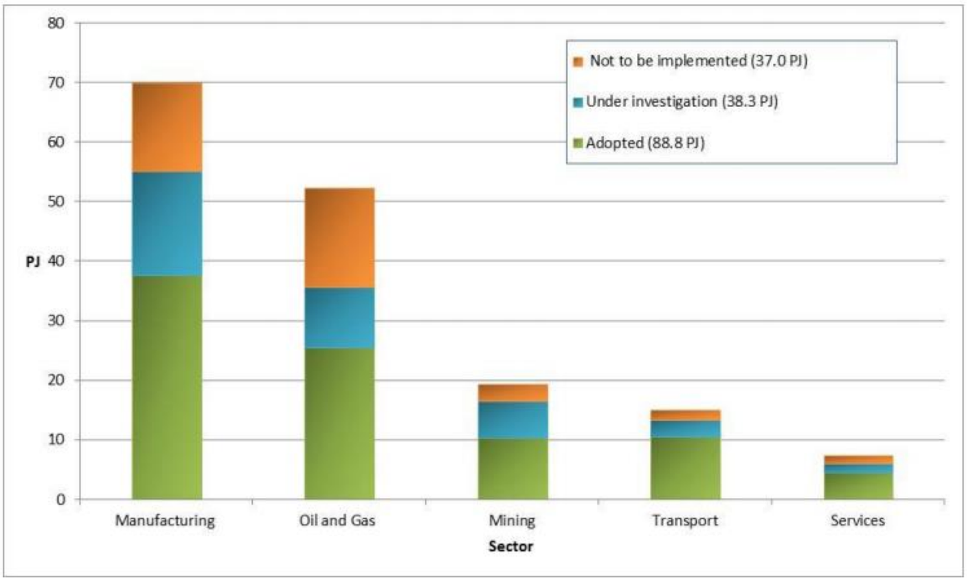

Figure 1: Summary of energy efficiency achievements in by participants in the Australian Government Energy Efficiency Opportunities (EEO) program (2006-11)[2]

This energy saving is estimated to have resulted in an annual economic benefit of just over $800 million, with the majority of investments to achieve the energy savings having either a 1 year or 2 year return on investment.[3] The significance of this program for engineering graduates is that the largest energy using companies in the country have developed processes to undertaken energy efficiency assessments and the ability to contribute to such assessments is likely to become a part of graduate recruitment preferences given the strong economic results from the EEO program.

> ***In 2011 an investigation found that 6 out of the 10 largest engineering companies operating in Australia provided in-house training on energy efficiency to supplement graduates formal training, and 4 out of the 10 had included energy efficiency requirements in graduate recruitment criteria.***[4]

Of further interest to engineering students is that the participants in the program listed an aggregate of 38.3 PJ of energy saving opportunities (or some 10 billion KWh per year) as being 'under investigation', meaning that graduates can differentiate themselves by ensuring they are well versed in energy efficiency. (Note: *Students are asked to identify specific energy efficiency opportunities in each of the industries listed in Figure 1 as part of the discipline flat-packs*.)

3. A Framework for Energy Efficiency Assessments

Building on the 2006 Energy Efficiency Opportunities Act and the EEO program, in 2011 the Australian Federal Government released an '*Energy Efficiency Opportunities Assessment Handbook*' to support Australian businesses to undertake energy efficiency assessments in a way that optimised business outcomes.

> **According to the Department of Industry, *'Energy efficiency is widely recognised as the simplest and most cost-effective way to reduce Australia's greenhouse gas emissions and manage rising energy costs... Engineers play a key role in improving energy efficiency by designing and installing energy efficiency measures and technologies, particularly in companies that use large amounts of energy. Equipping engineers with sound energy efficiency knowledge and skills will enable them to better identify and implement significant energy efficiency opportunities.'*[5]**

Given the strong results achieved by businesses participating in the EEO program, some $800 million or returns, many businesses in Australia have as a result of this program a structured approach to energy efficiency improvements based on the handbook, hence it will be important for engineering graduates to be have a working knowledge of the framework presented in the Handbook,[6] as shown in Figure 2.

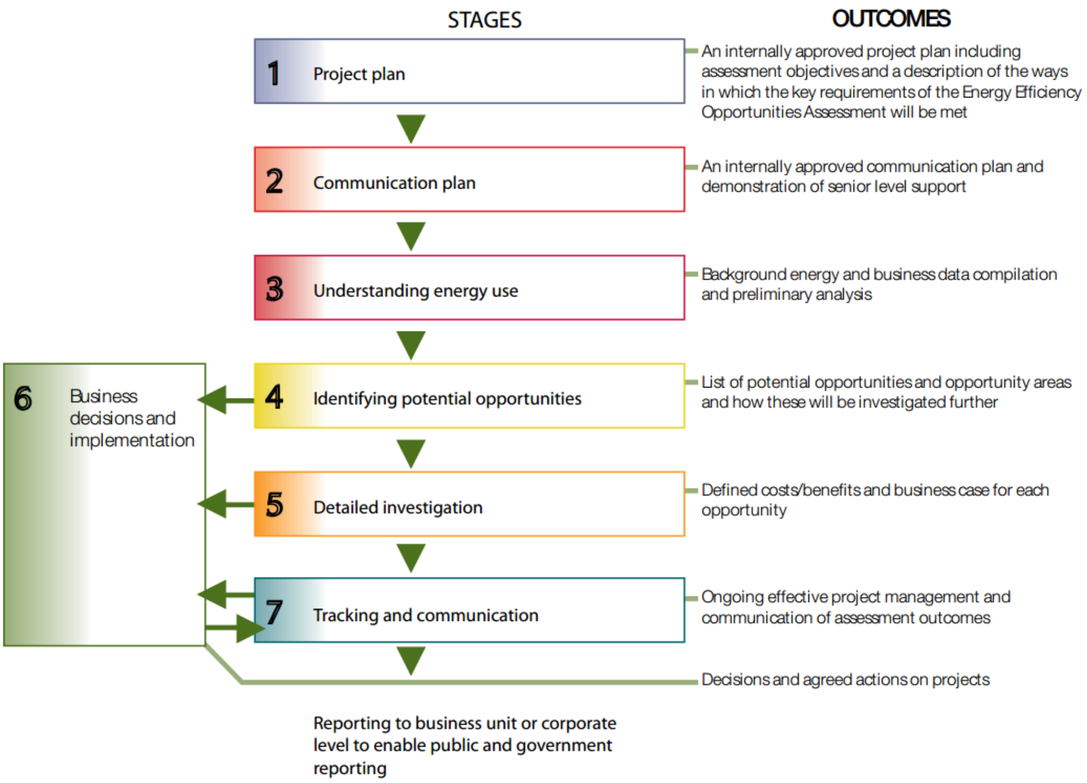

Figure 2: Overview of Australian Government Energy Efficiency Opportunities Assessment Handbook process for undertaking energy efficiency assessments[7]

The 'Energy Efficiency Education Resources for Engineering' (EEERE) project has been developed to focus on providing education materials to support the development of knowledge and skills in '*Element 3: Understanding energy Use*', '*Element 4: Identify Potential Opportunities*', and '*Element 5: Detailed Investigation*', as reflected in the following sections.

4. Key Elements of an Energy Efficiency Assessment

4.1 Element 3: Understanding Energy Use

Overview

The key to successful implementation of appropriate and value for money energy efficiency measures begins with the ability to understand how energy is being used. According to the Department of Industry EEO, '*The objective of an energy efficiency assessment is to build a greater understanding of how energy is used within a company and to identify ways to reduce costs through the more efficient use of energy. It involves the comprehensive analysis of energy use within a process, facility, site or organisation and using that analysis to identify and evaluate ways to improve energy performance.'* The demand for energy in industry comes from a range of appliances, equipment and processes, each providing the opportunity to improve energy efficiency through innovative approaches and new technologies, such as:

Combustion engines, turbines or electric drive systems

Boiler systems

Mining, earth moving and other mobile materials handling/excavation equipment

Flaring systems, venting and leaks

Furnace/Kilns

Gas compression equipment

Blast furnaces

Co-generation or Tri-generation

Electrolytic processes

Dryers

Pumping systems

Communition (crushing and grinding) and blasting systems

Ventilation systems, fans and blowers

Electric arc furnaces

Stationary materials handling systems

Compressed air systems

Refrigeration

Conveyors

Ovens

Lighting systems

Motors

Non-transport machinery

Steam systems

HVAC Systems

IT, communications and other electronic equipment

Filtration/distillation/absorption/stripping

Water treatment and purification systems

Cooling towers

The EEO Handbook suggests that the creating of an energy-mass balance is a core component of an energy efficiency assessment of a plant or site and suggests that the following questions be asked that are of direct relevance to engineering:

- What is the critical service being provided by the area/process (e.g. melting metal, driving a chemical conversion process)?
- What is the theoretical minimum energy required to provide the service – considering latent heat if melting, or theoretical energy for a chemical change?
- What is the actual amount of energy used to provide the service?
- What is the critical mechanism to provide the service?

Tutorial Exercise 1: Identify potential data types to inform an energy efficiency assessment

Choose an energy using technology or system from the above list and answer the 4 questions posed in the EEO Handbook for your discipline.

A primary resource available to inform the answers to such questions and capitalise on energy efficiency opportunities is the 'Energy Efficiency Exchange' (EEX). The EEX, is an online resource that was created as a joint initiative of the Australian, state and territory governments and is was administered by the Department of Industry. Although the EEO Program (that was linked to EEX) has now been formally discontinued, the EEX remains an active database of current energy efficiency information and projects in Australia.

Data Collection

The intent of Element 3 of the Framework, namely '*Understanding Energy Use*', is to see that:

- Sufficient data, in suitable forms, is used to quantify and understand energy use, identify and quantify energy saving opportunities, and track performance and outcomes (where actions are implemented), and that
- Energy data is analysed from different perspectives to understand relationships between activity and consumption, and identify energy efficiency opportunities.

Each of these intentions will involve engineers, in particular as part of the data collection process where engineers will be asked to identify a range of data to support the investigation of energy efficiency opportunities, with the following of particular relevance to the EEERE project:

1. Energy consumption and cost data for each energy source,
2. Energy consumption data for each of the key site processes, systems, and activities,
3. Production (or output or service) data for a total of 24 months, and
4. Information about the energy and material flows through the site or fleet and its processes, systems, and equipment.

The Framework suggests that data collection processes should prioritise the major energy using systems and processes, and lead to a more detailed focus on systems and processes which are likely to yield opportunities. The data is collected on a range of levels, from a high level aggregation of the total energy use for each energy source, and the associated costs, to detailed analysis of how much energy is used by each process, system and activity, and extending to energy and material flows. Across all disciplines of engineering the identification and analysis of energy performance data will be an important part of the engineer's role, with the EEO Framework identifying key data including data on the specific services and products that major energy using processes, systems, and equipment deliver (eg. steam flow rates for boilers, illumination levels for lighting, freight mass, volume or distance travelled for freight) and data on mass and fluid flow rates, densities, temperature profiles, changes in elevation, velocity, and viscosities.[1] Further the EEO Framework outlines potential data sources across commercial buildings, transport, and manufacturing and processing, including:

- For commercial buildings, energy inflows and outflows, including energy conversions and heat transfers such as thermal mass, solar gain, and heat losses from boilers and pipes. Mass flows and related data such as air flows, humidity and temperature variations affecting the heating, ventilation and air conditioning (HVAC) systems, hot water and steam flows, temperatures and pressure, mass flows through pumps and condensers.

[1] Commonwealth of Australia (2011) Energy Efficiency Opportunities Assessment Handbook, Department of Resources, Energy and Tourism, Canberra, Australia.

- In manufacturing and process industries, data relating to energy conversions, wastage and losses for sites, processes and systems, and items of equipment such as pipes and ducts (eg. temperatures, specific heats and conductivities of materials, surface areas, dimensions or distances).
- For transport operations, data describing mass moved, such as unloaded vehicle mass, vehicle loading, and other data and duty cycle characteristics that affect energy use when combined with mass (e.g. distance travelled, velocities, gradients, braking and cornering frequency, drag coefficients).

According to the EEO Handbook 'Gathering new data typically begins with high-level data that is readily available, such as invoices for energy purchases, however these can be at the level of aggregated energy spend for an entire facility or business unit and may need to be broken down using onsite metering [or other measurements such as equipment run time]. In this case it is often found that an initial analysis of available data can uncover data gaps where greater information is required, and identifies key energy-using areas or processes which should be prioritised for more detailed analysis. In addition to energy usage data, it is also important to collect detailed data on other variables such as production throughout, ambient temperature, process parameters, operating modes or profiles, and other business contextual data. Combining energy data with other business data can also provide a deeper understanding of the relationship between energy use and other business variables. For example, the energy use per unit of production may differ at different production volumes. Changes in environmental conditions may impact energy use patterns. Other business contextual information such as organisational changes, growth projects, planned shutdowns, and other business plans could also have a significant impact on energy use and should be taken into account. A rich collection of energy and business contextual data enables a comprehensive understanding of the factors that influence variations in energy use.'

Tutorial Exercise 2: Identify potential data types to inform an energy efficiency assessment
Based on an item from the list in the above overview, i.e. 'Blast furnaces', use the table below to brainstorm possible types of data that would be valuable to an energy efficiency assessment that included this item.[2]

Data Analysis

According to the EEO Handbook 'Analysis of energy data can first be used to calculate an energy baseline that establishes the relationship between energy use and business activity. In its most basic form, the energy baseline relates energy expenditure to business output over a specific time period. Analysis can yield many insights [leading to an] understanding of energy use and the opportunities that may exist within the organisation. The correct selection and use of analysis techniques is critically important, because the information gathered and analysis undertaken will underpin the identification and evaluation of opportunities.'

The EEO Handbook suggests the following main types of data analysis methods:

- Total energy use (*such as fuel type (gas, oil, diesel, other), electricity (imported, generated in-house), heat (steam, waste heat recovery), compressed air, water, or other*)[3]

[2] Refer to http://eeo.govspace.gov.au/files/2012/12/Assessment-Handbook.pdf page 70 for a list of possible background data types to either use as provocation for students or to inform the tutors to assist marking.
[3] Engineers Australia (1997) *Towards Sustainable Engineering Practice: Engineering Frameworks for Sustainability*, Engineers Australia, Canberra, Australia.

- Energy demand over time (*Understanding the reasons behind energy use patterns and changes in energy use in relation to business activities and changing environmental conditions can often yield new insights*.),
- Comparing energy performance to production indicators (*This technique can reveal whether or not there are relationships between energy use and production. It can also highlight if any production thresholds exist where a dramatic change in energy use occurs*.),
- Benchmarking against other sites or processes, and
- An energy-mass balance.

Of particular interest to engineers is the development of an energy-mass balance. The EEO Handbook points out that '*The practice of balancing the energy and materials flows within a site, facility, or individual equipment or machinery can provide a deep understanding of energy and material flow. This modelling can indicate where energy is exiting the process through heat or steam losses, and where opportunities to improve efficiency may exist.*'

Tutorial Exercise 3: Calculating an energy baseline

Choose an industry, such as one shown in Figure 1, then select a data analysis method from the above list and explain the role that an engineer would play in the analysis of energy data and what value the to the company the data analysis results may provide.

Tutorial Exercise 4: Develop a Hypothetical Energy Mass Balance

Informed by the table below and using the hypothetical input data provided in Appendix D of the Energy Efficiency Opportunities Assessment Handbook, students are to create a flow chart to represent the flow of energy and mass as part of the operation of a fictional company (Solution provided in Figure 12 of the EEA Handbook).[4]

Purpose	Where it may be useful	Key questions to ask
Energy-mass balance		
To systematically understand where and how energy is used, wasted and lost throughout a system To assist in development of effective models that help identify and measure energy losses and opportunities As a check to ensure completeness and accuracy of data across the whole process (and to help identify data gaps) To meet an explicit requirement of Energy Efficiency Opportunities	Any process where energy is used to carry out a task before, during and after an assessment. Development of the energy-mass balance is usually iterative, as often there is insufficient data to quantify all required parameters in the first iteration. Understanding of the process may also improve over time. The energy-mass balance could potentially be integrated into a broader environmental mass balance showing energy, material, water and waste flows. To quantify and measure the energy savings possible from an idea	Where is energy used and wasted? What material flows and transformations occur at each point in the process? How much energy is theoretically needed to carry out each stage – and how much is actually used or lost, when and where? Are there opportunities to avoid using energy, or to use energy lost from one part of the process somewhere else? Where are the biggest ares of energy use/ loss/potential efficiency gains? Is a balance achieved? Where do I need improved metering/data? Is there a significant gap in data or a significant imbalance between inflows and outflows? Can I sub meter or undertake additional analysis to fill data gaps to get an improved energy-mass balance?

[4] Refer to http://eeo.govspace.gov.au/files/2012/12/Assessment-Handbook.pdf page 70 for a list of possible background data types to either use as provocation for students or to inform the tutors to assist marking.

4.2 Element 4: Identifying Potential Opportunities

Overview

The intent of Element 4 of the Framework, namely '*Opportunity identification and evaluation*', relevant to the EEERE project is to see that:

- An effective process is undertaken to identify all potential cost-effective energy efficiency opportunities. This process is broad, open-minded and encourages innovation.
- Ideas are filtered to identify a documented list of potential opportunities that can then be analysed to a level sufficient for informed evaluation with a payback period of 4 years or less.

As with Element 3 above, each of these intentions will involve engineers, in particular as part of the estimation of potential energy savings, with the EEO Framework suggesting that such evaluations can be undertaken using a number of different methods, including:

a) If a change has previously been made at another similar site, the savings may have been metered and documented,

b) Engineering calculations or modelling of the savings may be carried out based on metered data,

c) A trial or pilot may be implemented, metered and measured, or

d) Information may be provided by equipment suppliers and designers (this information should be validated).

Identification of Opportunities

According to the EEO Handbook, 'The process of opportunity identification ideally uses the data which has been analysed [along with information from equipment suppliers, results of performance trials, and papers on similar investigations] to identify areas where energy saving opportunities may exist. Providing the results of this energy analysis to a broad range of people throughout the organisation can often result in further ideas and insights.' The EEO Handbook suggests that brainstorming can be used to encourage exploration of energy efficiency opportunities, and encourages participants to explore opportunities from a 'whole business opportunity' perspective when answering the following questions.

1. Are there specific production bottlenecks?
2. Is there equipment that is difficult or costly to maintain or control?
3. Can staff comfort be improved by reducing waste heat or cooling?
4. Are there other business benefits (e.g. water savings, productivity, product quality, 'licence to operate')?
5. What information is needed to identify opportunities or improve the management of energy? How can that information be provided?
6. Are there organisational solutions or barriers (e.g. change contracts, price signals, organisational systems)?
7. What equipment is due for replacement or upgrade? Soon or in the foreseeable future? Is equipment redundant?

8. Are there things we can do now? schedule into future plans? and/or conduct more research on or pilot test, in order to learn more?

Tutorial Exercise 5: Explore Areas for Potential Energy Efficiency Improvement
Based on the energy-mass balance created in Tutorial Exercise 3, or based on Figure 12 of the EEO Handbook, as well as your understanding of typical organisational structures, students are to brainstorm answers to the question 'Are there other business benefits (e.g. water savings, productivity, product quality, 'licence to operate')'?

The 1997 Engineers Australia report on '*Engineering Frameworks for Sustainability*' included a list of potential energy efficiency opportunities that may be common across a number of engineering designs, such as:[5]

- *Pressure reduction followed by recompression,*
- *Heat loss from a hot stream while a cold stream is heated by additional heat source,*
- *Batch processes that may be able to be modified to semicontinuous/continuous,*
- *Replace equipment with newer, more efficient, lower maintenance options,*
- *Oversized equipment that can be replaced with smaller equipment,*
- *Loss of energy through uninsulated or poorly insulated surfaces and interfaces,*
- *Utilise waste products as fuel, such as solvent recovery from drying operations,*
- *Use of variable speed drives to match loads.*
- *Poorly tuned and maintained equipment,*
- *Leaks/loss of containment of fuels, fluids, steam etc,*
- *Over-design of safety lighting, air-conditioning, and ventilation systems, and*
- *Standby/redundant equipment on idle rather than shutdown.*

Tutorial Exercise 6: Identify examples of energy efficiency opportunities in particular engineering disciplines
(Linked to Section 4 of the Discipline Specific Flat-Packs)
Considering the list of potential areas for energy efficiency opportunities above students are to select an area of relevance to their engineering discipline and identify and describe 3 industry examples of where consideration of this area has led to energy savings in practice. The EEERE project has developed a flat-pack for each discipline that will contain such opportunities and students are to be encouraged to search further.

Tutorial Exercise 7: Review industry case studies for areas of energy efficiency opportunities
(As part of Discipline Specific Flat-pack Tutorial)
Considering the list of potential areas for energy efficiency opportunities above students are to review the case studies presented in the discipline flat-pack as part of the EEERE Project to identify areas where energy efficiency opportunities were identified. Students are encouraged to identify areas as listed above in the case studies and to also create new categories based on the material presented in the case studies.

[5] Engineers Australia (1997) *Towards Sustainable Engineering Practice: Engineering Frameworks for Sustainability*, Engineers Australia, Canberra, Australia.

4.3 Element 5: Detailed Investigation

Overview

According to the EEO Handbook 'The detailed investigation phase determines the feasibility of each opportunity, and provides decision-makers with the information they need to make a final investment decision. A 'whole of business' approach which extends beyond cost and energy impacts to include strategic, labour, health & safety and other concerns or benefits, improves the understanding of the overall costs and benefits of energy efficiency opportunities. Project risks also need to be understood and addressed.

Other factors which may be considered in this analysis are:

- Shutdowns or downtime required to implement the change,
- Changes in production output,
- Changes in other process inputs, such as water or raw materials,
- Changes in maintenance costs,
- Hardware changes that make spare parts inventories obsolete,
- Business plans or forecasts that affect the lifetime or throughput of the process that is being changed, and
- Costs of training or new skills that might be required.'

In 2013 the Australian Government released an '*Energy Saving Measurement Guide*' to complement the EEO Handbook and support the estimation, evaluation, and tracking of energy efficiency opportunities. The guide includes three methods for estimating energy savings as outlined below.[6] A number of methods can be used to estimate energy savings from a potential energy efficiency opportunity. The guide presents three common methods, namely calculated savings, pilot study or bench test, and modelling/simulation. In this flat-pack we will focus on the first method, that of calculated savings, with the following method presented in the energy savings measurement guide.

Calculated savings is the most common method used to estimate energy savings and engineering calculations can be used to estimate post-implementation energy consumption levels, with a worked example provided below. This method is valuable when there is a high degree of process or equipment knowledge available. Applying the calculated savings approach to an energy efficiency opportunity typically involves the following steps:

1. *Analyse the opportunity and its interactions with other processes. This ensures the full energy changes are being assessed. An energy-mass balance can be used to determine energy relationships between processes.*
2. *Forecast the post-implementation energy consumption. Use engineering principles and calculations.*
3. *Estimate energy savings. This involves comparing the post-implementation energy consumption forecast to the forecast energy baseline if the opportunity was not implemented.*

[6] Department of Resources, Energy and Tourism (2013) *Energy Saving Measurement Guide: How to Estimate, Evaluate and Track Energy Efficiency Opportunities – Version 2.0*, Department of Resources, Energy and Tourism, 2013, Canberra.

Although this method appears simple, forecasting the post-implementation energy consumption in Step 2 and the 'business as usual' baseline can be complex, and input from site engineering teams, specialist consultants or equipment manufacturers and suppliers may be required.'

Tutorial Exercise 8: Identify technologies or processes with the potential to deliver energy efficiency improvement

Students are to identify a specific technology or process that stands to deliver energy savings in their field/discipline of engineering. Students are to identify the standard energy consumption of such a technology or process and then identity options for improvement. The potential post-implementation energy consumption for the option is to then be forecast, with all assumptions made noted. Students are to identify the opportunity and present a case for its consideration as an alternative to current technologies or processes anticipated to be used in their fields by estimating energy savings.

A Worked Example

A plant currently heats water to 80°C using steam. An opportunity has been identified which would preheat the water to 45°C to reduce the steam required. The following table calculates the current energy baseline. The operating hours of the system vary significantly, so the steam consumption is expressed in t/h. The heating required is calculated using the engineering equation $Q=mC_p\Delta T$, with the variables tabulated below.

	Value	Units	Calculation
Inlet water temperature	18	°C	
Target water temperature	80	°C	
Temperature change (ΔT)	62	°C	
Water flow (m)	12,000	kg/h	
Specific heat of water (C_p)	4.18	kJ/kg °C	
Heating required (Q)	3.11	GJ/h	= $mC_p\Delta T$
Steam enthalpy	2400	kJ/kg	
Steam required	1.296	t/h	= 3.11 GJ/h ÷ (2400 kJ/kg × 1000 kg/t ÷ 1000000 kJ/GJ)

Step 1 - Analyse the opportunity

It is assumed that there will be no changes to this system other than the opportunity implementation. In the absence of external influences on energy use, this becomes the forecast energy baseline.

Step 2 - Forecast the post-implementation energy consumption

The next step is to estimate the steam requirement post implementation. This is essentially the same calculation that was used to establish the energy baseline, but using the post-implementation inlet water temperature of 45°C.

	Value	Units
Inlet water temperature (forecast)	45	°C
Target water temperature	80	°C
Temperature change (ΔT)	35	°C
Water flow (m)	12	m^3/h
Specific heat water (C_p)	4.18	kJ/kg °C
Heating required (Q)	1.76	GJ/h
Steam enthalpy	2400	kJ/kg
Steam required	0.733	t/h

Step 3 - Estimate energy savings

The forecast energy consumption post-implementation is 0.733 t/h. To estimate the energy savings, calculate the difference between the baseline steam use and this forecast of post-implementation steam use.

	Value	Units
Baseline steam required	1.296	t/h
Forecast steam required	0.733	t/h
Estimated steam saving	0.563	t/h
Estimated energy saving	1.35	GJ/h

[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.

[2] Australian Government (2013) Energy Efficiency Opportunities Program, The First Five Years: 2006–2011, Overview, Commonwealth of Australia.

[3] Australian Government (2013) Energy Efficiency Opportunities Program, The First Five Years: 2006–2011, Overview, Commonwealth of Australia.

[4] Desha, C., Hargroves, K. and El Baghdadi, O. (2012) 'Review of Postgraduate Energy Efficiency Course Content and Recommendations for Use of Existing Course: Vocational Graduate Certificate in Building Energy Analysis (Non-Residential)', Report to the National Framework for Energy Efficiency, The Natural Edge Project (TNEP), Australia

[5] Commonwealth of Australia (2013) Australian Government Request for Quote (RFQ) for The Development of Resources and Supporting Materials to Facilitate the Delivery of Energy Efficiency Content in Undergraduate Engineering Courses, Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE), and the Department of Resources, Energy and Tourism (DRET), Canberra, Australia.

[6] Australian Government (2011) *Energy Efficiency Opportunities Assessment Handbook*, Department of resources, Energy and Tourism, Australian Government

[7] Australian Government (2011) *Energy Efficiency Opportunities Assessment Handbook*, Department of resources, Energy and Tourism, Australian Government