AUSTRALIAN MANUFACTURING GAS EFFICIENCY GUIDE

AiGROUP

energy efficiency COUNCIL

CEFC
CLEAN ENERGY FINANCE CORP

Acknowledgments

The Clean Energy Finance Corporation (CEFC) gratefully acknowledges the contributions of the following organisations

- Alan Pears
- Mars Australia
- BlueScope Australia and New Zealand
- Spirax Sarco
- CSR Limited

Contents

Our commitment to manufacturing

The Australian Industry Group, the Clean Energy Finance Corporation and the Energy Efficiency Council are pleased to present a new resource for gas-intensive manufacturers: *Australian Manufacturing Gas Efficiency Guide*.

All our organisations have a strong commitment to helping Australia's energy intensive manufacturing industry reduce operating costs and carbon emissions. This guide will assist the sector to remain cost competitive in a global economy that is moving fast towards lower emissions and cleaner energy.

Australia's manufacturing sector has confounded doubters in recent years by expanding strongly. The sector has the potential for even greater growth amidst a new industrial revolution that is transforming industry yet again. However, energy costs loom as one of the most significant headwinds to seizing this opportunity.

Recent high gas prices and unfavourable contracting conditions have put pressure on tight operating margins for many manufacturers. Industry has been at the forefront of efforts to ease prices with market reforms and the Australian Domestic Gas Security Mechanism. The extreme prices of 2017 – including some industrial offers above $20 per gigajoule – have thankfully abated. But prices remain two to three times their historic average. It is unlikely they will ever return to the low levels on which industry used to rely, given the transformation of the gas market by export demand, international price pressure and rising production costs.

High gas prices could be a persistent challenge to industry. However, recent analysis has revealed an untapped opportunity to reduce industry reliance on gas by at least 25 per cent in Australia, resulting in estimated emissions savings in the region of 10Mt CO_2e.

This guide examines the energy needs of a wide range of manufacturers, from food processors to building materials producers and identifies areas of opportunity in terms of performance, cost and paybacks.

Whether it is through maintenance improvement, replacing old equipment, smart redesigns of industrial processes or shifting from gas to lower intensity energy sources, this guide is aimed at providing useful insights into technologies and equipment that can make long-term differences.

Furthermore, the benefits of gas efficiency can go well beyond cost and emissions savings; they include reducing maintenance costs, improving the life expectancy of equipment, reducing water consumption and improving site conditions.

The opportunities are significant, however determining whether an approach will work for an individual business involves disciplined research and measurement to identify the opportunities that are affordable and feasible.

This guide is intended to help with the identification of possible initiatives at the earliest stages of planning, before moving on to project-specific advice from industry specialists. We hope it provides inspiration to those in the sector who have been meaning to take the first steps to achieving better gas efficiency, but weren't sure where to start.

Ian Learmonth

CEO, Clean Energy Finance Corporation

Luke Menzel

CEO, Energy Efficiency Council

Innes Willox

CEO, Australian Industry Group

Australian Manufacturing

TAKING CONTROL OF **THE ENERGY CHALLENGE**

LESS GAS **MORE BENEFITS**

81 PROVEN TECHNOLOGIES

25% LESS GAS

5 YEAR PAYBACK

10Mt CARBON SAVINGS

AUSTRALIAN **INDUSTRY**

$100B GDP

900K JOBS

NATIONAL FOOTPRINT

ENERGY INTENSIVE

WHERE TO ACT

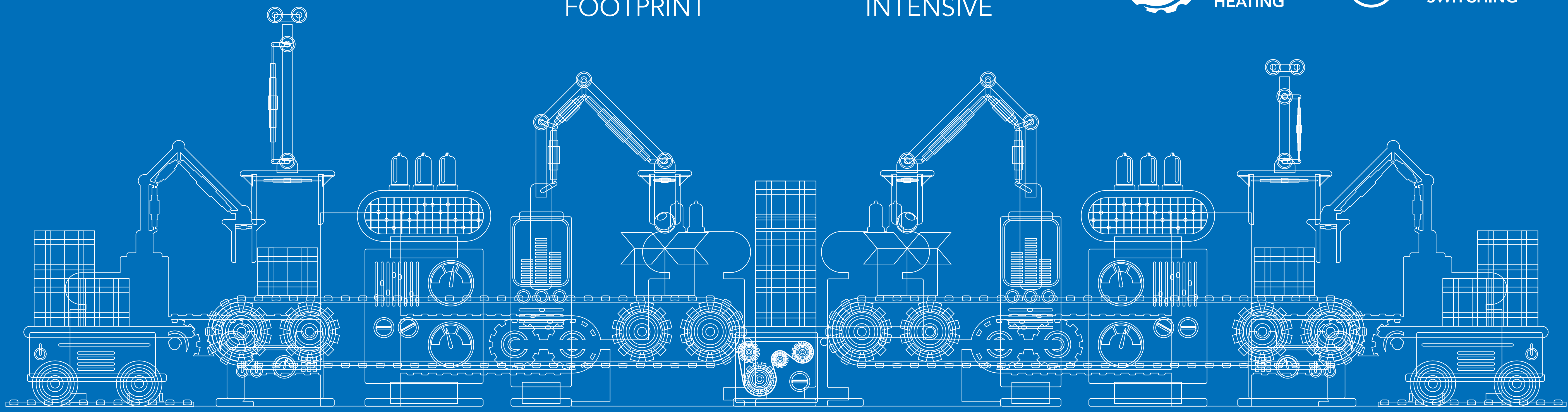
SIGNIFICANT OPPORTUNITIES

STEAM

HOT WATER

PROCESS HEATING

FUEL SWITCHING



1 Taking control of the energy challenge

The Australian manufacturing industry includes businesses engaged in the physical or chemical transformation of materials into new products[1]. Manufacturing is vital to the Australian economy, contributing around $100 billion (6.2 per cent) to Gross Domestic Product annually and supporting nearly 900,000 jobs, or 7.4 per cent of total employment.[2]

Australia's manufacturers are the most energy intensive in the OECD[3] and are also large users of natural gas. In 2014-15 Australian manufacturing was responsible for around 40 per cent of total natural gas consumption[4].

This reliance on gas has been driven by twin forces. Historically, eastern Australia has benefitted from lower gas prices more than most other areas of the developed world because of the relatively plentiful availability of low cost, conventional gas supplies. At the same time our geographical isolation has meant there has been a lack of competition for Australian gas from international customers, limiting demand-driven price increases.

However, the east coast gas market is experiencing a mismatch between domestic supply and demand, driven by rapid growth in the liquid natural gas (LNG) export market[5] and exacerbated by regulatory uncertainty and exploration moratoria limiting the potential for new gas supply[6].

As a result, Australian manufacturers are grappling with high gas prices and unfavourable contracting conditions, increasing margin pressures and challenging the long-term viability[7] of this important sector.

The Western Australia market is separate and somewhat insulated from the circumstances present on the east coast. Based on Australian Energy Market Operator (AEMO) data, the Australian Competition and Consumer Commission (ACCC) expects WA to be well supplied with gas in the short to medium term[8].

With little prospect of major new sources of supply in the southern states in the near-term[9], future prices will almost certainly continue to be influenced by international LNG prices[10] and domestic demand. In this context, Australia's manufacturers must anticipate and adapt to prices much higher than the historical average, as well as the potential for increasing price volatility.

These factors mean it is increasingly important that manufacturers move now to unlock significant untapped opportunities to reduce their reliance on gas through a more rigorous approach to energy efficiency and switching to alternative cleaner energy sources. Quick action tailored to particular business needs can deliver much needed energy cost savings, improve productivity and competitiveness, and help meet Australia's targets for lower greenhouse gas emissions[11].

Recent analysis has found that by implementing energy efficiency measures and switching from gas to other clean energy sources, Australian industry can reduce gas consumption by at least 25 per cent on current levels, or 201 petajoules (PJ)/year[12]. This would represent an estimated emissions reduction of 10 $MtCO_2e$/year based on current levels.

These big improvements can be achieved through:

- Equipment maintenance improvements
- Operational optimisation
- Replacement of old equipment with more efficient, newer equipment
- Smart redesign to improve industrial processes
- Fuel shifting from gas to solar thermal, solar PV, bioenergy and low emissions electricity.

Every manufacturing operation is different, and manufacturers need the right information and expert advice to identify the most appropriate energy solution for their activities. The Australian Industry Group, Clean Energy Finance Corporation and the Energy Efficiency Council developed *Australian Manufacturing Gas Efficiency Guide*, a user-friendly resource for decision-makers seeking to reduce their exposure to rising gas costs.

We trust this material provides a useful resource to enable the adoption of a more cost-effective and efficient clean energy solution for this important part of our national economy.

ENERGY EFFICIENCY **BENEFITS TO MANUFACTURING**

Reduced maintenance requirements and costs – reducing the heat load on industrial systems may reduce the maintenance costs on large plant assets such as boilers.

Improved equipment life expectancy – reduced operating hours and reduced thermal stresses may allow plant equipment to last longer before requiring replacement or major overhaul.

Reduced water consumption and water treatment costs – many steam system and heat recovery efficiency initiatives will also result in a reduction in water consumption and less water requiring chemical treatment prior to use.

Improved energy visibility and understanding – installation of sub metering and energy management systems are critical to the longevity of savings and can provide ongoing value and understanding to plant operations.

Improved process control – often energy reduction initiatives utilise automatic controls with smaller error bands than traditional control systems. This can allow for smoother and more automated control of connected systems.

Improved site safety and working conditions – eliminating waste heat can provide a safer work environment where staff are at a reduced risk of exposure to high temperature equipment or uncomfortable work environments.

---

1 *https://www.industry.gov.au/industry/ManufacturingPerformance/Pages/default.aspx*

2 *Department of Industry, Innovation and Science (2015) Manufacturing Data Card - September Quarter 2015: https://www.industry.gov.au/industry/ManufacturingPerformance/Pages/ManufacturingDataCard.aspx*

3 *International Energy Agency (2017) Energy Efficiency Indicators Highlights. IEA/OECD, Paris, France. pp 7.*

4 *Australian Bureau of Statistics (ABS) (2016b) 4660.0 - Energy Use, Electricity Generation and Environmental Management, Australia, 2014-15, Released 12 Jul 2016*

5 *ClimateWorks Australia 2017, Solving the gas crisis - A big problem deserves a big solution. Melbourne, pp 3.*

6 *Mr Rod Sims, Chairman, ACCC - Shining a light: Australia's gas and electricity affordability problem. National Press Club, 20 September 2017: https://www.accc.gov.au/speech/shining-a-light-australia's-gas-and-electricity-affordability-problem*

7 *Ai Group (2017) Energy Shock: No Gas, No Power, No Future? pp 19.*

8 *Australian Competition and Consumer Commission (ACCC) 2017, Gas inquiry 2017-2020: Interim report - September 2017. Canberra, pp 13.*

9 *Australian Competition and Consumer Commission (ACCC) 2017, Gas inquiry 2017-2020: Interim report - September 2017. Canberra, pp 74.*

10 *ClimateWorks Australia 2017, Solving the gas crisis - A big problem deserves a big solution. Melbourne, pp 6.*

11 *Australia's economy-wide target under the United Nations Framework Convention on Climate Change is to reduce emissions by 26-28 per cent on 2005 levels by 2030. By the second half of the century, achieving net zero emissions is likely to be necessary to meet international climate commitments.*

12 *ClimateWorks Australia 2017, Solving the gas crisis - A big problem deserves a big solution. Melbourne, pp 7.*

2 About this guide

Many opportunities to reduce gas consumption – either through energy efficiency measures or fuel switching – have not seen widespread adoption in Australia due to historically low gas prices.

As gas prices rise, decision-makers are becoming more focused on how they can bring down gas costs. This guide brings together expert information and insights into proven and practical initiatives that can help Australia's manufacturers reduce energy costs, boost productivity and cut emissions.

The CEFC and EEC developed this guide with technical input from independent engineering consultants, Out Performers Pty Ltd.

The Out Performers senior engineering team identified a comprehensive list of gas efficiency initiatives applicable to Australia's manufacturing sector. These initiatives where tested with industry advisors and documented and refined for inclusion in this guide.

The initiatives are typically those which:

- Have been demonstrated as technically and commercially feasible to implement on manufacturing sites;
- Can be implemented at the design stage for new projects, or as a retrofit to existing equipment and systems;
- Can be implemented through changes in practices and management.

Please note: this guide provides advice of a very general nature, to aid the identification of possible energy efficiency and fuel switching initiatives. It should not be used as a substitute for specialist project-specific advice from industry professionals.

3 Identifying gas efficiency opportunities

Decades of low gas prices have meant that many manufacturers have not prioritised examination of more efficient operating systems or the use of alternative fuels.

Manufacturers typically use gas as an energy source[13]:

- To produce steam
- To produce hot water; and
- Tor process heating systems.

Many manufacturing sub-sectors use gas for more than one of these functions (Table 1).

The good news is that there is a significant untapped opportunity to reduce reliance on gas by implementing energy efficiency opportunities across all of these functions, with some opportunities benefiting multiple functions.

There are also a number of 'enabling technologies' – including sub metering and analytics platforms – that can play a critically important role in identifying energy efficiency opportunities.

Across manufacturing processes there are also renewable energy options that can reduce or eliminate the need for conventional gas use, increasing energy diversity and minimising the business risk associated with energy costs. These options include bioenergy (biomass, biogas), solar PV, solar thermal and heat pump technology.

TABLE 1: OVERVIEW OF TYPICAL GAS FUNCTION USE IN MANUFACTURING

	Food	Beverage and tobacco products	Textile, leather, clothing and footwear	Wood products	Pulp, paper and converted paper products	Printing	Petroleum and coal products	Basic chemical and chemical products	Polymer and rubber products	Non-metallic mineral products	Primary metal and metal products	Fabricated metal products	Transport equipment	Machinery and equipment	Furniture
Steam generation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hot water generation	✓	✓													
Process heating	✓			✓			✓	✓	✓	✓	✓	✓	✓		

13 Natural gas is utilised in some industries as a feedstock to the process, however this is beyond the scope of this guide.

4 Best practice energy efficiency

The best practice initiatives in this guide are presented on the following pages in a 'dashboard' format. Each initiative includes a detailed description of the possible improvement. Symbols indicate costs, payback period, and market readiness.

MANUFACTURING **ENERGY EFFICIENCY DASHBOARD**

Technology

The initiatives have been grouped according to the relevant technology area:

- Steam systems
- Hot water
- Process heating
- Multiple technology applications
- Fuel switching

Upfront Cost

$ < $15,000

$$ $15,000 - $50,000

$$$ $50,000 - $250,000

$$$$ > $250,000

Indications of upfront cost have been assigned based on typical current costs of implementation of projects.

Payback Period (Years)

< 1 Low hanging fruit

< 2 Short term

< 5 Medium term

< 10 Long term

10+ May never payback

Indications of payback period have been assigned based on implementing the project within an appropriate market sector and technology type suited to the application.

They are an indication only, based on a current average gas price. However, there is significant variation in gas prices as well as unique site issues that will impact actual outcomes.

Only simple economic payback has been considered – different internal rates of return and consequent net present values have not been considered.

Readiness Rating

A Well established technology, widely adopted

B Moderate uptake

C Limited implementations in Australia/emerging technology

D Not commercially implemented in Australia

A large number of variables influence cost, payback periods, suitability and feasibility on any given project, and this indication should not be used as a substitute for project-specific professional advice.

Keep in mind that not all of the initiatives described are compatible with one another – it would not be possible to implement all projects on the same site.

To reiterate – this guide is intended to provide very general advice and guide the selection of initiatives in the earliest stages of design. It should not be used as a substitute for project-specific professional advice.

WHERE TO ACT: **STEAM SYSTEMS**

Opportunity		Description	Cost	Payback	Readiness
1	Maximise condensate return	Once steam has been used, the hot condensate holds a large amount of recoverable energy (up to 25% of the initial steam energy). Returning this energy to the boiler can minimise gas use. Prior to collecting and returning condensate, the quality should be assessed to check it has not been contaminated by product, oil, chemicals or other sources. Maximising the amount of condensate recovered and returned to the boiler will reduce gas consumption costs and reduce water consumption and treatment costs.	$	<1	A
2	Total Dissolved Solids (TDS) control of blowdown	All boilers conduct a 'blowdown' process to clear a build-up of chemicals and minerals dissolved in the water. This blowdown process occurs at a set time interval and may purge the boiler unnecessarily. Installing sensors to measure the level of dissolved minerals can allow the blowdown to be controlled and only occur when necessary. This can save energy by minimising the heat, water and chemicals lost during blowdown.	$	<2	A
3	Maximise feedwater temperature	Most steam systems utilise a small steam line to maintain the feedwater tank at 80-90°C. This hot water is then fed to the boiler and the high temperature helps to minimise gas use from a sudden drop in boiler temperature. Further efficiency gains can be achieved by maintaining a high feedwater temperature using heat sources other than steam injection. Feedwater temperature can be maximised through techniques such as condensate recovery, tank insulation, waste heat recovery, and economisers.	$	<2	B
4	Water treatment to reduce blow down losses	The quality of the water entering the boiler has a direct relationship to the volume of boiler blowdown required to remove excess minerals. The boiler blowdown is a release of hot water and as such is also releasing energy from the system. Water softeners in the boiler make-up water, provide chemical treatment of the water, and can minimise the need to conduct a boiler blowdown. Your water treatment provider can assist with optimising the chemical dosing of boiler make-up water.	$	<5	A
5	Blowdown heat recovery	Hot, pressured water from the boiler blow down contains high levels of minerals and is not suitable for direct use in the boiler system. The heat from the blowdown stream can be used, however, to maintain high feed water temperatures and pre-heat make-up water. This is achieved by capturing blow down water, depressurising it to drive off flash steam which is then injected into the feedwater tank. The still hot water is then passed through a heat exchanger to heat the incoming make-up water.	$$	<5	B

WHERE TO ACT: **STEAM SYSTEMS**

Opportunity		Description	Cost	Payback	Readiness
6	Boiler sequencing and scheduling	Due to variations in plant demand, a steam boiler will not perfectly match the requirements of the plant at all times. Therefore boilers are often operated at partial loads which reduces efficiency. For large systems that operate multiple boilers, it can be difficult to determine which boiler or combination of boilers is most efficient. You may also have multiple boilers operating at partial load. A boiler sequencer can assist with the control of multiple boilers by selecting the most efficient combination to operate. Sequencers can not only improve total efficiency by utilising the most efficient boiler, but will also reduce partial load operation. This can greatly reduce purge cycle and radiant heat losses. Sequencing control may be achieved through existing control panels, site SCADA system or a dedicated controller. Careful consideration should be given to the control logic of a sequencer in order to maximise efficiency. A review of the controls should be conducted if major changes to plant steam demand occur.	$$	<2	A
7	Failed steam traps and steam leaks	Every steam system utilises steam traps in order to hold useful steam in the system, whilst releasing condensate. Steam traps often fail resulting in steam being vented from the system or condensate being held in the system. Both scenarios reduce total system efficiency. Identification of failed traps can reduce operating costs of the steam system. A scheduled maintenance program for steam traps should be implemented on a 6 or 12 monthly cycle. This should include an ultrasonic and temperature bases survey of all traps followed by replacement of failed traps. This is also an opportunity to identify and replace traps that have been incorrectly selected or installed. Hard to access traps can be monitored remotely using a wireless steam trap meter.	$$	<2	A
8	Modulating water level control	As steam is generated within the boiler, the water level changes and cool make-up water is provided to offset the steam demand. For boilers below 3MW, typical on/off water level control mechanisms can adequately maintain boiler operation, but efficiency can be improved through the implementation of a modulating level control system. A modulating level control system provides smoother operation of the boiler and more efficient burner operation.	$$	<2	A
9	Flash steam recovery	Condensate captured from a steam system may be at a high temperature and a high pressure. Reducing the pressure of the condensate allows the residual heat to create flash steam. This flash steam can then be utilised for lower temperature applications or waste heat recovery.	$$$	<2	B

WHERE TO ACT: **STEAM SYSTEMS**

	Opportunity	Description	Cost	Payback	Readiness
10	Steam accumulator	A steam accumulator can be added to a steam system to provide additional storage. If correctly designed, this storage can be used to eliminate or minimise peaks in the steam demand of the plant. This can provide energy savings by allowing one boiler to meet the plant demand and eliminating the operation of a second boiler for the peak load. Steam accumulators should also be considered when designing a new or replacement system as a smaller boiler may be able to be purchased in conjunction with an accumulator.	$$$	<5	C
11	Add/refurbish boiler refractory	The internal lining of a boiler's combustion chamber is commonly lined with refractory material to reflect the heat back into the chamber. This material can become less effective as it ages and covered by soot from combustion. Relining the boiler with new refractory material will assist in localising heat and minimising radiant losses from the surface of the boiler.	$$$	<5	A
12	Pressurised de-aerator	Large boiler systems can benefit from a pressurised de-aerator over the traditional atmospheric de-aeration head. The de-aerator provides a mixing point for make-up water and recovered condensate to assist with oxygen removal from the make-up water. The removed oxygen is then vented to atmosphere with a portion of heat from the system. A pressurised de-aerator allows higher temperatures within the aerator and therefore increases thermal efficiency. This also has the operational benefit of lower oxygen levels and therefore reduced system corrosion.	$$$	<5	A
13	De-superheaters	During steam generation, water is heated to the point where it evaporates to create saturated steam. This steam is at a temperature where a small temperature decrease will result in condensate and the release of a large amount of heat. In some steam systems, particularly where power is generated from steam, the steam is further heated to create superheated steam. Superheated steam has benefits for turbine operation during power generation, but is less thermally efficient for heat transfer applications. In these instances, the installation of a de-superheater to cool the superheated steam back down to saturated steam can be beneficial.	$$$	<5	B

WHERE TO ACT: **HOT WATER**

Opportunity		Description	Cost	Payback	Readiness
1	Reduce hot water temperature	The requirements of a plant may change over time, or the operation of equipment may be changed by operators or service providers. Determining the site's maximum hot water temperature, and decreasing the hot water heater's output to match this can be a simple measure to reduce gas consumption. Care should be taken to ensure that the temperature still meets any appropriate safety requirements.	$	<1	A
2	Hot water use: efficient nozzles	Much of the hot water use within the food manufacturing sector is used for cleaning purposes. Commonly this is through taps and hoses with no nozzles on the outlet. As such, it is common for far more hot water to be consumed than is actually necessary to perform the function. There are a variety of nozzles available which can assist in minimising the amount of hot water used. In addition, trigger control at the point of use can reduce unnecessary use of hot water. Operator training and engagement is often required to ensure the introduction of nozzles and triggers are accepted.	$	<1	B
3	Hot water heater control	Hot water systems can waste energy by the heater responding to heat losses in the pipework and distribution system rather than actual load requirements. Modern control units are available which can measure the supply and return temperatures to determine if the temperature change is due to a load or standing losses and determine if the heater needs to operate.	$$	<2	B
4	Condensing boiler (generator)	Some food manufacturers are operating steam systems as a result of historically available technology when the site may only require hot water. In these cases, steam is used to generate hot water and this consumes much more energy than direct hot water generation, due to the higher temperatures and evaporation process. If your site only requires hot water, consideration should be given to replacing the boiler with a condensing boiler (generator) designed specifically for hot water production.	$$$$	<10	B

WHERE TO ACT: **PROCESS HEATING**

Opportunity		Description	Cost	Payback	Readiness
1	Oxygen enrichment	Combustion air fed to process heating applications contains approximately 21% oxygen due to the makeup of the atmosphere. Supplementing combustion air with oxygen provides an oxygen enriched environment which can assist with combustion efficiency. Since using oxygen avoids heating up almost five times as much air, it can be worthwhile, especially for high temperature processes. Due to advancements in technology, this is becoming a viable approach, particularly in the metals processing sector.	$	<5	C
2	Process temperature	Many process heating applications have been in operation for a number of years without consideration given to the required operating temperature. Changes in raw material and final product specification may present an opportunity to reduce the operating temperature of the process without detrimental effects on the quality of the product. These process improvements can provide significant savings, however they may require detailed investigation to confirm viability.	$	<1	B
3	Air infiltration and seals	Many process heating applications utilise ovens and furnaces to localise the heat of combustion for specific applications. These ovens and furnaces are often long, with multiple burners and are enclosed with multiple access hatches and doorways. These access ways are often a source of heat loss due to lack of, or poor seals around the hatches. Thermal imaging along with insulation and seal specialists can assist with identification, costing and implementation of air infiltration initiatives.	$	<5	A
4	Recirculation fans	Recirculation fans can assist with providing an even heat distribution within process heating applications such as ovens and furnaces. The small addition of electrical energy for fans can often decrease the gas requirements as heat becomes less localised around the burners and a greater thermal efficiency can be achieved.	$$	<5	B
5	Product pre-heating	Pre-heating of products or material prior to entering process heating application can assist in reducing gas consumption. Exhaust gases may be able to be used in a waste heat recovery process to pre-heat materials. This is particularly effective where the materials are in liquid form as this allows for good heat transfer with waste heat.	$$	<2	B
6	Process heat ancillary controls	Many process heating applications operate a number of associated fans and pumps which can save electrical energy if controls are linked to the combustion process. This may allow recirculation fans and pumps to operate on Variable Speed Drives (VSDs) and reduce consumption as the combustion load decreases. Installation of newer motors, fans and pumps can also result in additional electrical energy savings. Whilst the focus here is gas savings, electrical energy savings can assist in reducing project payback.	$$	<2	A

WHERE TO ACT: **PROCESS HEATING**

Opportunity		Description	Cost	Payback	Readiness
7	Advanced materials	Many high temperature process heating applications require cooling of components to minimise thermal stress and damage. Due to advancements in materials development, conventional materials may be able to be replaced with advanced materials which are able to withstand higher temperatures with less thermal damage. As a result, the heat load on the system is often reduced. The advanced materials often result in a lower mass of components and this provides a further efficiency improvement.	$$$	<10	D
8	Material handling improvements	Many opportunities exist to reduce thermal/gas requirements through changes in the material handling processes. This does not utilise a specific technology to achieve efficiency but utilises improved process flow and/or controls to minimise heat requirements. An example of these improvements may include reduction of product holding times between casting and further processing in metal manufacturing plants. This allows the product to be received into downstream processes at higher temperatures and reduces the overall thermal energy requirements. Another example is the application of product sensors and controls to switch off (or idle) thermal equipment if product is not detected.	$$$	<10	B

WHERE TO ACT: **MULTIPLE TECHNOLOGY APPLICATIONS**

	Opportunity	Description	Cost	Payback	Technology Area	Readiness
1	Plant scheduling	Plants operating less than 24 hours a day, or 7 days per week, may benefit from aligning boiler operation with production requirements. Many such plants start up the boiler prior to production, resulting in an additional 1-2 hours of boiler operation per day. Improving plant scheduling may involve determining the actual start-up time of the boiler and operator training or practice changes to ensure the boiler is turned on a short time before the first production process that requires steam. This can be a very low cost housekeeping opportunity and can minimise gas consumption through a reduction in purge losses and radiant heat losses.	$	<1	Steam Systems Process Heating Hot Water	A
2	Maximise heat transfer	Within steam boilers, hot water systems and process heating, the efficiency objective is to transfer the maximum amount of heat from combustion into the water or process fluid. Therefore it is important to maintain clean heat transfer surfaces within the combustion chamber. This can be achieved through a combination of water treatment to minimise scaling, combustion analysis and control to minimise soot, and periodic cleaning of heat transfer surfaces.	$	<2	Steam Systems Process Heating Hot Water	A
3	Combustion analysis and tuning	Combustion of gas should be periodically monitored to ensure that control systems are working properly and identify if there are improvements that can be made. Many existing combustion systems rely upon mechanical linkages between the gas inlet and combustion air control which wear with time and therefore require periodic adjustment to maintain efficiency. Combustion analysis is already being conducted by your service provider for safety reasons but should also be incorporated into scheduled maintenance for efficiency checks. Combustion service providers can typically tune the system whilst conducting the analysis.	$	<1	Steam Systems Process Heating Hot Water	A
4	Isolate unused steam lines	Old, unused steam and hot water lines provide a location for steam and water to collect and cool. This can potentially reduce the temperature of steam and water nearby and reduce overall efficiency of the system. Unused lines should be isolated from the system to minimise losses.	$	<2	Steam Systems Hot Water	A

WHERE TO ACT: **MULTIPLE TECHNOLOGY APPLICATIONS**

	Opportunity	Description	Cost	Payback	Technology Area	Readiness
5	Sensor selection and placement	Sensor selection, positioning and maintenance can have a large impact on the energy consumption of a system. If a sensor is not accurate or is incorrectly positioned, the control system may be receiving the wrong information to be able to efficiently control the system.	$	<1	Steam Systems Process Heating	A
6	Process control	The controllers for many thermal applications contain pre-programmed logic to define how the system will operate and respond to temperature changes. The algorithms within these controllers may be basic and allow the system to overshoot the temperature target and then drift back to the required level. This can waste significant gas and can be avoided through the implementation of modern control algorithms with tighter control bands.	$$	<2	Steam Systems Process Heating	A
7	Flue gas shut off dampers	When the burner is not operating in a combustion chamber, hot flue gases may be escaping from the system. This can be reduced by installing dampers to close off the flue. This initiative can contribute small savings (1%) to the boiler, particularly in applications where the boiler may cycle off for extended periods of time. These dampers do not provide any benefit for systems when the burner is operating.	$$	<2	Steam Systems Process Heating Hot Water	B
8	Cleaning In Place (CIP) optimisation	A large heat user from steam and hot water systems is the CIP processes on food manufacturing plants. Often the CIP utilises a number of rinse cycles and heated chemicals. Process optimisation of CIP may involve insulation of heated chemical tanks, and capturing secondary or final rinse cycles and storing them to become the initial rinse cycle in the next CIP run.	$$	<5	Steam Systems Hot Water	B
9	Pipe and valve insulation	When steam, hot water and thermal fluids are generated at the source (such as a boiler), the hot fluid must then be transferred to the actual point of use on the plant. Whilst travelling through the pipework, a significant portion of the heat can be lost. Insulation and pipe lagging can greatly reduce the heat lost from piping. Permanent insulation should be installed on all hot pipe work. Thermal imaging can be used to identify areas where additional insulation is necessary and assist with quantifying the energy loss for business case development. Regular maintenance surveys of insulation should be conducted to ensure it is in place, in good condition and effective.	$$	<2	Steam Systems Process Heating Hot Water	A

WHERE TO ACT: **MULTIPLE TECHNOLOGY APPLICATIONS**

	Opportunity	Description	Cost	Payback	Technology Area	Readiness
10	Combustion air pre-heat	Air is needed for the combustion of gas to release useful heat. As large volumes of combustion air are typically provided at ambient temperatures, this air is much cooler than the combustion chamber, and more gas is used to bring the combustion products (flame) up to the required temperature. Combustion air pre-heating increases air temperature before injection into the combustion chamber and can reduce gas consumption. Combustion air is typically pre-heated with waste heat from other sources on site, or the stack/exhaust from the oven/furnace.	$$$	<5	Steam Systems Process Heating Hot Water	B
11	Boiler insulation	Boilers for both steam and hot water lose waste heat through exhaust gases and radiant and convective losses. Radiant losses are related to the surface area, material and temperature of the boiler. Covering exposed, high temperature surfaces of the boiler with insulation can reduce radiant and convective heat losses. Thermal imaging can be helpful in identifying the hottest parts of the boiler and all areas that need insulation.	$$$ (Depends on the m^2 insulated)	<5	Steam Systems Hot Water	A
12	Burner upgrade	The burner is a crucial piece of equipment in gas systems as it is the point of mixing for fuel and air, and is the actual point of combustion. Upgrading existing burners to modern technology can assist with air to fuel mixing, and heat distribution which contribute to efficiency gains. In addition, modern burners are typically able to achieve a greater turn-down ratio, meaning that the boiler is able to operate more efficiently under low load conditions. This can drive significant savings through a reduction in boiler purge cycles.	$$$	<5	Steam Systems Process Heating Hot Water	A
13	Digital combustion control	Many existing combustion systems rely on a mechanical linkage between the gas inlet and combustion air control. These linkages are subject to incorrect tuning, wear and have limitations in how closely they can control the fuel to air ratio. Modern digital combustion control systems (also commonly known as oxygen trim or air to fuel ratio controllers) can provide energy savings through a tighter control capability, independent operation of gas and air controls and more consistent control with time. Many of these controllers can be connected to the site's SCADA system to provide monitoring and reporting of the boilers.	$$$	<5	Steam Systems Process Heating Hot Water	A

WHERE TO ACT: **MULTIPLE TECHNOLOGY APPLICATIONS**

Opportunity		Description	Cost	Payback	Technology Area	Readiness
14	Variable Speed Drive (VSD) on combustion air fan	In order to achieve good combustion of the gas injected into a boiler, water heater or process heater, air is also injected by a combustion air fan. These fans often operate at fixed speed with an inefficient damper to control air flow. Implementing a Variable Speed Drive (VSD) on the fan and removing the damper can result in a reduction of electrical energy consumed by the fan and provide more accurate control of combustion air delivered. This control improvement improves the ratio of gas to combustion air providing savings by minimising unburnt gas in the flue and minimising excess heat removed by providing too much combustion air. Combustion air fan control is often incorporated with digital combustion control projects and combustion air pre-heat projects to maximise energy savings.	$$$	<5	Steam Systems Process Heating Hot Water	A
15	Condensing and non-condensing economisers	From the combustion process in steam boilers and hot water heaters, a large amount of heat is lost in the exhaust gases vented via the flue. Heat from the exhaust gas can be recovered through the use of an economiser. The economiser is installed in the flue and feed water is passed through the economiser allowing the water to be heated. There are condensing and non-condensing economisers. Condensing economisers will recover a larger amount of heat, however, water vapour in the exhaust will condense which is corrosive and special care with material selection must be taken when considering this type of economiser.	$$$	<5	Steam Systems Hot Water	B
16	Waste heat recovery	Many industrial applications will require thermal energy which is derived from steam or a heat source. Often the remaining steam, condensate or heat source still has a significant amount of thermal energy available but at lower temperatures. This presents the site with an opportunity to recover the lower grade heat and use it in a different area of the plant. This can offset gas consumption in other heating processes or at the boilers. Potential areas for heat recovery include waste condensate, boiler blowdown, flue gases, combustion air preheating and process streams that require heating or cooling. Heat recovery can also come from tertiary systems (such as compressed air and refrigeration) to provide heat for pre-heating or low grade hot water.	$$$	<5	Steam Systems Process Heating Hot Water	B

WHERE TO ACT: **MULTIPLE TECHNOLOGY APPLICATIONS**

Opportunity		Description	Cost	Payback	Technology Area	Readiness
17	Cascading heat use	Cascading heat use aims to maximise drying processes by utilising the highest temperature heat source at the end of the drying process where moisture removal is most difficult. After the initial use of heat, the heat source is then utilised for multiple passes earlier in the drying process. This is common in the paper industry where steam is used at the final stage of the paper drying process. Excess heat from the steam and flash steam is then used in the previous drying stage and so on, back to the beginning of the drying process. This method of control can maximise heat extraction from the source and maximise drying efficiency through the greatest temperature driver.	$$$	<5	Steam Systems Process Heating	B
18	Sub metering systems	Sub metering systems use a number of carefully placed energy meters (such as gas, steam or thermal meters) to pinpoint how different parts of the site are using thermal energy. This allows energy wastage to be identified, and helps in managing improvement. Connecting sub meters to an energy management platform can automatically record data in one place, and provide meaningful analysis of the data. Emerging data analytics techniques can increasingly reduce the need for sub metering and improve feedback on operation. While most focus has been on electricity analysis, it can also be applied to gas.	$$$	10+	Steam Systems Process Heating Hot Water	B
19	Boiler sizing and low load boiler	Plants that do not operate 7 days per week, or have a highly variable steam or hot water demand, may benefit from a low load boiler. This allows the large boiler to meet the plant demand during normal operation and the smaller boiler to operate during weekends or low load periods. This initiative can greatly minimise the inefficiencies associated with purge cycles and radiant losses of an oversized boiler. This approach may also apply to situations where there are small steam loads connected to a large steam system but distributed over a large physical area. In these cases, it can be viable to operate separate steam/heat systems to offset losses from large piping runs.	$$$$	<10	Steam Systems Hot Water	A

WHERE TO ACT: **FUEL SWITCHING**

Opportunity		Description	Cost	Payback	Readiness
1	Heat pumps	Where electricity is available in abundance or at low cost, heat pumps can be utilised for thermal energy, in the range of 65-150°C, to offset gas consumption. Heat pumps utilise a refrigeration cycle process to transfer heat from one stream to another whilst increasing the heat through an electric pump. Where traditional heat recovery is not possible due to a lack of temperature difference, heat pumps can be used to take the heat from a warm stream and transfer it into a hotter stream. Heat pumps are most efficient in systems where heating and cooling is required as one stream can be cooled whilst another is heated. They are especially good when the waste stream is humid, as they can recover the latent heat.	$$$	<5	D
2	Solar hot water	Solar hot water systems can be used to eliminate or offset the hot water generation through steam or instantaneous systems. Solar hot water systems collect heat from direct sunlight in either a flat plate or evacuated tube system. Evacuated tube systems are more thermally efficient particularly in cold weather. Usually solar hot water systems are fitted with a gas or electric heating booster to achieve the correct temperature when natural conditions are inadequate. Solar hot water systems may also be used as a preheating source for boilers.	$$$	<5	B
3	Condensing and non- condensing turbines	Many steam systems are designed to produce steam at a higher pressure than actually required on the plant, as this allows the pipework to be smaller with a lower capital cost. As a result, steam systems often incorporate a pressure reduction valve (PRV) to lower the pressure to the plant's needs. During the pressure reduction, pressure energy is lost. This PRV can be replaced with a steam turbine to generate electricity through the process of reducing steam pressure. No gas savings are achieved but the electricity generated can offset site electricity costs. These turbines work best in applications where steam demand is continuous. Effectively this is a form of cogeneration and the electricity is mostly produced from reduced energy waste.	$$$$	<5	C
4	Alternate process heating technology	Thermal energy has traditionally been provided by gas systems, however there are a number of process heating applications such as heating, drying, melting and forming that may be conducted through electric-based thermal energy. There is potential to switch from gas based systems to electric based systems such as arc furnaces, infrared, induction, laser and microwave systems. Whilst switching to alternate heating methods, implementation of other efficiency measures are often included to minimise energy requirements. This type of switching to alternate technologies is highly dependent upon the price and availability of electrical energy and relative capital costs.	$$$$	<10	C

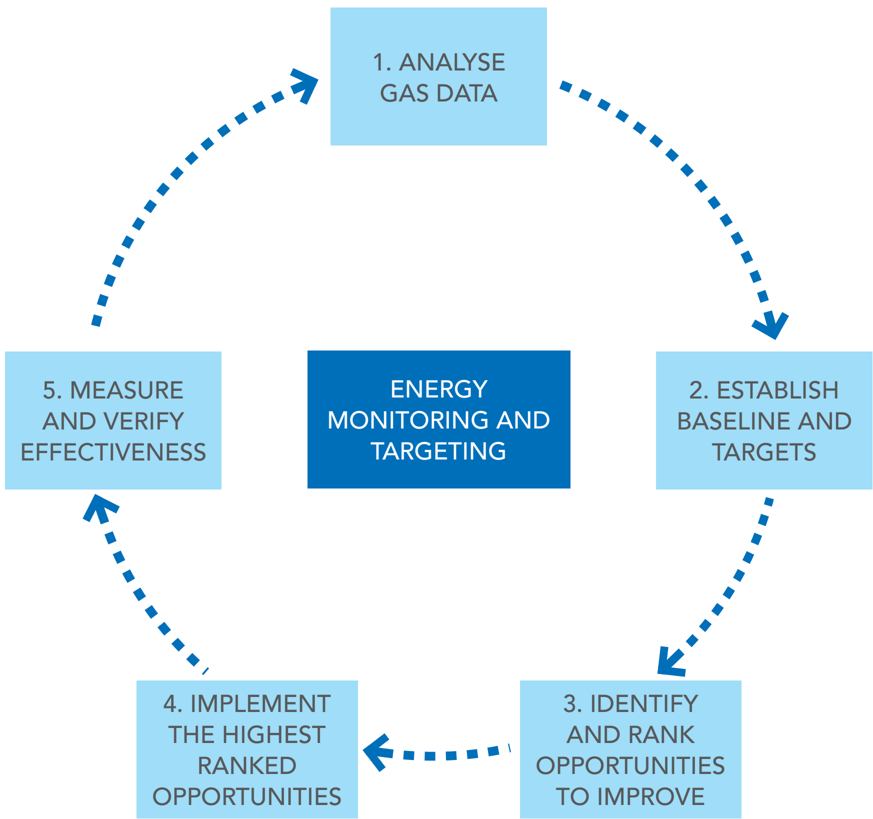
WHERE TO ACT: **FUEL SWITCHING**

Opportunity		Description	Cost	Payback	Readiness
5	Bio fuels and alternative fuels	Bio-fuels and production by-products can form an alternative to natural gas and may include sawdust, captured methane (from effluent treatment) and oven gases from metal manufacturing. Many boilers and combustion systems (such as cogeneration) can be modified to make use of multiple fuels to offset purchased natural gas. Sources of alternative fuels may be available on site or may be purchased.	$$$$	<10	C
6	Cogeneration and trigeneration	Cogeneration (also known as Combined Heating and Power (CHP)) systems generate electricity from combustion (typically natural gas but biogas is also possible), and use the waste heat to provide hot water or steam. 'Trigeneration' refers to the same process but waste heat is also used by an absorption chiller to create chilled water. The electricity produced by these systems is cleaner and more reliable than grid electricity in some locations, but becomes less financially viable if gas prices rise faster than electricity prices. Maintenance requirements also need to be considered in the financial assessment.	$$$$	<10	B
7	Solar thermal	Solar thermal systems can use a variety of technologies to concentrate solar energy to heat a fluid such as molten salt, thermal oil or water. The thermal fluid can then be used for process heating, steam generation or electricity generation, and can be stored for 8-10 hours to provide a thermal energy source when sunlight is unavailable. This is currently an emerging technology with a large potential to reduce or eliminate gas consumption. A large area is required to implement a solar thermal system with a very high capital cost.	$$$$	10+	D

5 How to assess energy intensity

Understanding and changing the energy-intensity of any manufacturing process is complex. Experience points to a clear five-step process to continuous improvement of energy use.

FIVE STEPS TO CONTINUOUS IMPROVEMENT



1. Measurement and analysis of gas consumption data

Energy losses associated with gas consumption are often not immediately obvious, as the losses are invisible: heat is dissipated, transparent gas is leaked or efficiency within closed pipelines is poor.

That is why quantifying and monitoring energy use is so important, so your business can effectively manage its consumption and cost on an ongoing basis.

It's important to look at the overall consumption of the system, the individual consumption of each unit operation, and the interaction of the unit operations. This 'systems approach' establishes an understanding of the material and energy flows within the system.

In an era of high gas prices, a good sub metering system and reporting is an essential management tool for businesses with a high exposure to gas.

Businesses should aim to have individual gas sub meters for each major appliance of the plant, allowing the distribution of gas load to be established. If steam is utilised onsite, total steam generation and major steam applications should also be sub metered. All gas and steam meters should take into account temperature and pressure to give a true indication of the energy content of the stream.

2. Establish baseline and targets

Measurement of energy content alone is not adequate to manage the gas system. Where possible, secondary factors should be measured to allow the energy to be converted into a key performance indicator (KPI).

For example, gas energy into a boiler can be measured in relation to steam energy out of the boiler to establish the boiler's energy efficiency. Or gas consumption for a process heating application can be measured and related to units produced to create a meaningful KPI (GJ/1000 production units). These straightforward KPIs can provide businesses with real visibility into how productive you are being with the energy you are using, and the information you need to improve that productivity over time. Effective sub metering is essential to establishing KPIs of this kind.

3. Identify and rank opportunities

Once this base level of information is established, unit operations should be ranked based upon:

1. Size of energy consumption
2. Quality of data available
3. Possibility for energy efficiency improvements.

At this point, detailed analysis of the unit operations that consume the most energy should be undertaken to fully understand the unit's operation and develop a list of potential energy efficiency initiatives. This may involve engaging a specialist to provide systems/equipment specific review and more detailed measurements. Internal business cases can then be developed for project approval.

4. Implement opportunities

An iterative approach to conducting upgrades is often effective – that is, implementing an upgrade on unit operations that consume the most energy, assessing the energy impact and how the upgrade has interacted with other units, then reassessing the next largest energy consumer and potential savings.

5. Ongoing measurement and verification of effectiveness

Following the implementation of an initiative, it is important to conduct measurement and verification with comparison to the baseline to ensure the initiative is successful and achieving the objective established in the business case. This presents an opportunity to make adjustments to energy initiatives until the energy objectives are achieved.

Ongoing monitoring is also crucial after you've undertaken an energy saving project; initially to establish that the targeted savings have been achieved, and then to ensure they are maintained. A range of energy management systems are available from different technology providers that can provide managers with an easy to interpret summary of their energy use and performance against KPIs.

6 Essential skills for energy efficiency projects

A successful gas efficiency or fuel switching project needs a multi-disciplinary team with a 'can-do' attitude, and strong management and leadership to ensure that the different technical disciplines work together in an integrated way to deliver the best possible outcome. Integration is the key to excellent long-term outcomes.

Projects with access to the skills and expertise below have proven to be more successful.

A high level of skill and deep expertise in all of these areas may not be found in one individual. Rather comprehensive projects are most commonly undertaken by a team under expert and experienced leadership.

Confirm that these following skills and expertise are present in the project team by reference to previous project work, reports and outcomes.
A starting point for identifying potential service providers is available on the Energy Efficiency Council member database: www.eec.org.au/membership/overview#/members.

ESSENTIAL SKILLS FOR **ENERGY EFFICIENCY PROJECTS: TOP 10**

1. Leadership and project management - ability to effectively lead and manage a gas efficiency or fuel switching project in its entirety, from scoping through to completion.

2. Energy consumption, assessments and analysis - understanding of energy consumption, collection, billing, modelling and analysis, and ability to oversee energy assessments and audits.

3. Measurement and verification of energy savings - ability to oversee a robust process for measurement and verification of energy savings.

4. Business case development and project justification - ability to undertake cost benefit analysis and develop business cases.

5. Client procurement options - ability to advise clients on the procurement models available, and the most appropriate model for a given project.

6. Interdependencies between systems and processes and managing operational impacts - ability to ensure integration between systems and processes whilst managing the operational impact of a gas efficiency or fuel switching project.

7. Energy efficiency, fuel switching and generation technologies - understanding of energy efficiency, fuel switching and generation technologies, systems and processes.

8. Commissioning and tuning - ability to ensure equipment is appropriately commissioned and tuned.

9. Risk management - ability to effectively manage the risks associated with a gas efficiency or fuel switching project.

10. Stakeholder engagement - ability to effectively manage the stakeholders associated with a gas efficiency or fuel switching project.

7 Financing gas efficiency and fuel switching projects

1. Financial Considerations

COSTS

- What is the upfront capital expense (CAPEX) cost?
- Are there any ongoing maintenance, fuel or electricity operating costs relating to the investment?
- Can cost uncertainty be removed by fixing-in these future operating costs?

REVENUES OR AVOIDED COSTS

- What are the cost savings from the project?
  - This can be measured in absolute $/GJ of gas or $/kWh of electricity or in $ per unit output, i.e. fuel or electricity savings over the lifetime of the equipment.
  - While some investments in energy efficiency can contribute to revenue, most improve profit margins and project viability by reducing or avoiding operating costs.
- How are the avoided fuel or electricity costs expected to change over the project lifetime?
- Are there any other savings that can be attributed to the project, such as savings from changes in associated processes, i.e. reduced product handling or transport costs from process redesign?

PAYBACKS

Understanding the value of a project can be as unique as your business itself, with investments in energy often providing advantages beyond just cutting bills. However, there are several easy methods to begin to understand the financial benefits in the long term. These include:

SIMPLE PAYBACK or RETURN ON INVESTMENT

A simple payback is the period of time required to recoup the cost of the investment, or to reach the break-even point.

It can be calculated as follows:

$$\frac{\text{Initial CAPEX}}{\text{Projected Annual Savings (Avoided Costs – Operating Costs)}} = \text{Simple Payback (in years)}$$

For example, an investment of $40,000 on equipment, which avoids the need to spend $12,000 of ongoing gas costs and requires $2,000 of annual, ongoing maintenance operating costs, the payback would be 4 years.

$$\frac{\$40,000}{\$10,000 \; (\$12,000 - \$2,000)} = \text{4 year Simple Payback}$$

It is also worth considering, what are the gains once the investment has paid for itself? If an investment provides further value or efficiency to the company, it may be justified to accept a longer payback period.

NET PRESENT VALUE

An alternative or complimentary approach when considering the payback of an investment can be to determine the Net Present Value (NPV).

NPV is used to calculate the present value of an investment by the discounted sum of all cash flows received from the project, providing an estimate of how profitable the project or investment will be.

This calculation demonstrates the value of all future cash flows (positive and negative) over the entire life of an investment, discounted to the present, with the initial investment a negative cash flow showing that money is going out as opposed to coming in.

To consider the NPV of the investment, speak to your bookkeeper, accountant or financial advisor for further details.

2. Financing Options

	Finance Option	Description	Advantages	Disadvantages
TRADITIONAL FINANCING OPTIONS	Self-funded	From balance sheet / cashflows.	• Suitable if the investment is smaller, or cashflows are sufficient to support the expenditure, as may be simpler to organise. • Suitable if the investment doesn't fit into existing debt arrangements. • No ongoing repayment costs directly related to the project.	• Less capital available for investment in core business activities.
	Asset / equipment loan (e.g. chattel mortgage, commercial loan, equipment loan)	A financier provides capital to a borrower to finance a specific project or piece of equipment. Repayment profiles can be tailored to suit the borrower's cashflow, such as interest-only with balloon (lump sum) repayment, credit finance (equal payments per period), or other tailored repayment profiles.	• Reduced or no upfront costs for the project. • Loans are generally secured against the equipment. • Repayments are generally fixed and known in advance and can be tailored to cashflows. • There are loans specifically designed for energy efficiency projects, which generally have lower interest rates and longer finance periods.	• Interest rates for loans secured against the equipment can be higher than general business lending interest rates.
	Asset / equipment lease (e.g. finance lease, Hire purchase, operating lease)	The equipment is owned by the financier and the borrower obtains the sole right to use it. The borrower pays regular payments to the financier. Ownership may transfer to the borrower at the end of the lease period.	• Reduced or no upfront costs for the project. Interest charges can have tax advantages. • Leases are generally secured against the equipment. • Repayments are generally fixed and known in advance, and can be tailored to cashflows.	• Interest rates for leases secured against the equipment can be higher than general business lending interest rates.

	Finance Option	Description	Advantages	Disadvantages
OTHER FINANCING OPTIONS	Environmental / Building Upgrade Agreement (EUA)	Finance to make environmental upgrades to existing premises that improve energy, water or waste efficiency or increase renewable energy. Different from traditional financing options, an EUA is secured and tied to the property rather than an owner.	• No upfront costs for the project. • Loan repayments made through a local council charge on the land (paid via Council Rates). • Allows owners to use energy savings to pay back project costs or reduce energy bills for tenants. • No mortgage security required.	• Currently available in selected local council regions across New South Wales, Victoria and South Australia. • Limited to existing, non-residential/commercial buildings only.
	Energy Services Agreement (ESA)	An Energy Services Agreement (ESA) provider will offer a 'turn-key' solution. The provider designs, constructs, owns and often maintains equipment.	• Reduced or no upfront costs for the project. • Interest charges can have tax advantages. • Implementation and operating risks are borne by the ESA provider.	• Can be a higher cost than using other finance options in isolation, due to transfer of risks to ESA provider.

3. Accessing finance

Businesses looking for ways of financing energy efficient equipment have several CEFC options available to them. By teaming with major Australian banks and specialist finance providers, it is easier for businesses and consumers to secure discounted interest rate loans to make clean energy improvements and upgrades. These programs are targeted to the clean energy needs of smaller-businesses, manufacturers and the agricultural sector, as well as smaller-scale commercial property.

For information about CEFC co-finance arrangements, please visit cefc.com.au

4. Government support and Energy Savings Schemes

The Federal government, along with multiple State and local governments provide incentives for gas energy efficiency and fuel switching projects via grants and Energy Savings Schemes. For up-to-date information on available incentives please visit the Energy Efficiency Council website: www.eec.org.au.

8 Case studies

ABATTOIR AND MEAT PROCESSOR

A large modern abattoir and rendering plant is a supplier of sheep meat, skins, wool, co-products, cotton, grain and pulses to the global market. The site is a large energy user, relying heavily on substantial volumes of natural gas to produce steam for further processing and hot water production.

The abattoir has invested in energy efficiency measures for the plant in the past, however recent gas price escalations highlighted a pressing need to further reduce site energy consumption. At the same time, the managing director was eager to take advantage of the New South Wales Government's Gas Efficiency Program and Energy Savings Scheme. Run by the Office of Environment and Heritage (OEH), the scheme offers subsidies to offset the size of any energy saving investments, and ultimately improve returns.

Opportunities implemented

The site team responded pro-actively to the price shocks by embarking on a program of significant energy upgrades across its facility. Project opportunities in the boiler house and steam system were identified as the fastest path to cutting gas consumption.

The project team focused on the following key opportunities:

- Automated temperature control of tallow tanks
- Flash steam and condensate recovery to provide hot water
- Steam pressure set point adjustment allowing one of the boilers to be decommissioned
- Installation of a new boiler feed tank with de-aerator and recirculation system quenching the flash steam (old tank was poorly insulated and had no de-aerator)
- Replacement of a steam strap with a condensate pump to redirect condensate from the drain back to the feedwater tank
- Blowdown heat recovery systems were also installed to recover heat lost to boiler blowdowns:
  - Installation of a TDS sensor based blowdown system
  - Installation of a blowdown flash steam heat recovery system
  - Installation of a blowdown residual heat exchanger
- Installation of two heat recovery systems on flash steam that was previously vented to atmosphere.

Outcomes

The implementation of these initiatives was able to:

- Reduce gas consumption by 21% (24,817 GJ/yr)
- Monthly gas savings of $45,000 per month
- Reduction in boiler water consumption of 8ML per annum
- Reduced chemical use of $10-$15K per annum

With a total investment cost of $443,000, the project was able to provide a payback in under 10 months.

BEVERAGE MANUFACTURER

A manufacturing and distribution site for non-alcoholic soft drink products. The site operation is 24 hours per day 365 days per year with one primary steam boiler rated at 6MW.

The steam produced from the boiler feeds production process including bottle warming and process cleaning, with a small portion used for hot water generation to supply the kitchen and toilet facilities.

Opportunities implemented

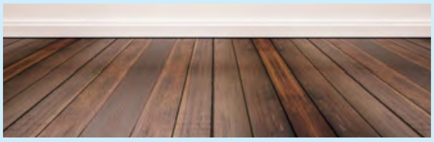
Installation of a combustion analysis control system on the steam boiler.

Outcomes

The implementation of this initiative was able to:

- Reduce gas consumption by 9.5% (2,004 GJ/yr)
- Gas savings of $14,800 per year

With a total investment cost of $11,850, the project was able to provide a payback in under 10 months.



BUILDING PRODUCTS MANUFACTURER

A building products manufacturing plant producing various types of fibre cement products for the building industry such as weatherboard, flooring, eaves and soffits and internal wall linings.

Opportunities implemented

A new control system was installed on its 8MW boiler at this plant. The control system includes various features to improve combustion and reduce emissions:

- High precision control of air and gas valves and dampers using servo motors
- VSD on the combustion fan
- Water level control
- Pressure and temperature set-point control
- 3 Parameter trim (fuel/air ratio) based on exhaust gas O2, CO2, and CO
- TDS control with top and bottom blowdown
- Installation of steam flow meter

Outcomes

The implementation of this initiative was able to:

- Reduce gas consumption by 5.6% (5,444 GJ/yr)
- Gas savings of $42,000 per year

With a total investment cost of $119,600, the project was able to provide a payback in under 3 years.

FOOD MANUFACTURER

This site manufactures a wide range of small food products & utilises a small (2.5MW) steam boiler to support the production processes.

Opportunities implemented

The boiler previously utilised an injection nozzle style burner. This nozzle was replaced with a Weishaupt burner with an integrated VSD to supply combustion air and an oxygen trim control system.

Outcomes

The implementation of these initiatives was able to:

- Reduce gas consumption by 6.9% (797 GJ/yr)
- Gas savings of $9,500 per year

With a total investment cost of $59,400, the project was able to provide a payback of 6.2 years.

9 Glossary

Term	Definition
Boiler blowdown	Boiler blowdown refers to the periodic release of hot water from a boiler to purge the build-up of Total Dissolved Solids (TDS). This prevents the build-up of minerals within the boiler that can foul the heat transfer surface and reduce efficiency of the boiler.
Clean In Place (CIP)	Clean In Place (CIP) is a common term for the industrial cleaning of process lines and equipment which remain in a fixed location on the site. This often involves a number of rinse cycles with hot water and various chemical solutions.
Condensate	This is the liquid formed once heat is removed from steam. As heat is removed from the steam, it changes from a gas to a liquid (a process known as condensation).
De-aerator	A de-aerator is a device used in steam systems to assist with the removal of oxygen and other gases from the incoming water stream. The de-aerator is often part of the feed water tank.
De-superheater	A device which reduces the temperature of superheated steam (back to being saturated steam) so that it can then be used effectively for heat transfer applications.
Flash steam	Flash steam is produced from hot condensate at a high pressure experiencing a rapid decrease in pressure. This results in some of the condensate's heat energy converting the water to steam (a process known as evaporation).
Purge cycle	Purge cycle refers to the venting of air and gases within a combustion chamber during the ignition or start-up phase. This is a necessary safety measure to eliminate a build-up of combustible gases.
Pressure Reduction Valve (PRV)	A device commonly installed on steam systems to reduce the pressure of the steam in a pipe down to the desired pressure for use in a particular application.
Saturated steam	Saturated steam is the hot vapour that forms from the evaporation of water.

Term	Definition
Supervisory Control And Data Acquisition (SCADA)	Supervisory Control And Data Acquisition (SCADA) systems are commonly present on industrial sites and are a control system utilising computers and networks to connect to equipment and devices.
Super-heated steam	Super-heated steam is saturated steam that has been further heated to increase its temperature.
Radiant losses	Radiant losses refer to the undesirable heat transfer from a hot surface to the surrounding material or medium. For example, a hot pipe will have radiant heat losses into the surrounding cooler air.
Refractory	Refractory material or refractory bricks refers to a material that is resistant to heat. It is commonly used as a lining within boilers, furnaces and high temperature applications to contain the heat of combustion.
Thermal energy	Thermal energy is the internal energy of a substance as a result of its temperature. For example, water at 90°C has more thermal energy than water at 25°C.
Total Dissolved Solids (TDS)	This is a measure of the quantity of dissolved mineral and salt components within water. The higher the TDS content, the more likely scaling is to occur within the boiler, reducing efficiency.
Thermal imaging	Also known as Infrared Thermography. This is a method for visualising heat losses by converting heat radiating from a surface into a coloured temperature scale.
Variable Speed Drive (VSD)	A device fitted to an electric motor that regulates the speed of the motor through manipulation of the electrical energy.
Water softener	A water softener is a device installed on the boiler make-up water. It contains resin beads with salt to remove hard water mineral components, such as calcium and magnesium. These minerals would otherwise readily precipitate within the boiler, creating scale which reduces the boiler's efficiency.

Clean Energy Finance Corporation

The CEFC is responsible for investing $10 billion in clean energy projects on behalf of the Australian Government. Our goal is to help lower Australia's carbon emissions by investing in renewable energy, energy efficiency and low emissions technologies. We also support innovative start-up companies through the Clean Energy Innovation Fund. Across our portfolio, we deliver a positive return to taxpayers.

cefc.com.au

Energy Efficiency Council

The Energy Efficiency Council is Australia's peak body energy efficiency, energy management and demand response. The Council is a not-for-profit membership association focused on making sensible, cost-effective energy efficiency measures standard practice across the Australian economy. The Council works to promote stable government policy, provide clear information to businesses and householders and drive the quality of energy efficiency products and services.

eec.org.au

Ai Group

Ai Group has been a leading industry association in Australia for over 140 years. Our membership includes thousands of businesses across key sectors of the economy such as manufacturing, construction, labour hire, defence, ICT, food, pharmaceuticals and confectionery.

We intrinsically understand the challenges facing industry and remain at the cutting edge of policy debate and legislative change – and strategic business management. We work to provide our members with the practical information, advice and assistance they need to run their businesses more effectively, and provide a powerful representative voice at all levels of government through our policy leadership and influence.

aigroup.com

CEFC
CLEAN ENERGY FINANCE CORP

energy efficiency
COUNCIL

AiGROUP