final report

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Options for insulating sites from potential electricity price increases

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Executive Summary

Electricity prices are expected to rise by 1.5 to 3 times their current price in the next ten years as a result of aging infrastructure, growing peak demand and the inclusion of a carbon cost. Electricity at an average plant accounts for about 1/3 of the site energy use, but about 2/3 of the energy costs.

Network charges can contribute up to 50% or more of a sites electricity bill. The disproportionate growth in the electricity supply network of peak usage compared to baseload consumption means that future bills will pay more attention to consumption and demand during the peak supply period for the electricity network (summer afternoons). For many meat processing plants, this coincides with their site peak usage. The installation of interval metering and the direct load control which it enables will change the nature of the electricity market in the residential and commercial sectors, and with it changing expectations of industrial electricity users like meat processing.

Sites can work to reduce their exposure to future electricity price increases by adopting a number of strategies such as:

- **Energy efficiency** – ensuring most efficient equipment is installed (variable speed drives, high efficiency motors, correctly sized motors and fans), ensuring most efficient option selected when equipment replaced or refurbished, ensuring equipment is operated as designed and maintained;
- **Fuel switching** – changing electrical users to another fuel source (such as steam);
- **Load shifting** – scheduling non-essential tasks out of peak periods (eg pumping, pond aeration), improved control of refrigeration and HVAC systems (precooling, co-ordinate with breaks), management of startup after breaks, short (30min-2hour) shutdown of refrigeration system;
- **Load shedding** – not doing some tasks (controlling outdoor lighting during daytime), changing from cold to hot boning, lighting controls (link lights to chiller modes), management of equipment during breaks;
- **Distributed generation** – cogeneration, trigeneration(heating and cooling), emergency backup/ standby generators to cover critical loads
- **Power factor correction** – as close to 1 as economic

There are a few sites in the industry that have already implemented electricity controls to manage costs, such as The Herd Group at Geelong and Camilleri Stockfeeds at Maroota NSW (which has the lowest processing costs in the rendering industry). Trials in other food industries, such as dairy, have indicated that load shifting is possible without compromising food safety requirements.

1. Site electricity and supply side characteristics

1.1 Usage in plant

The amount of electricity used at a plant depends on what processes occur at that plant. Meat and Livestock Australia have published information for a "typical" plant processing the equivalent of 150 tonnes of hot standard carcase weight (tHSCW) per day, which is the equivalent of about 625 head of cattle per day. Production at the typical plant occurs 5 days per week, 50 weeks of the year, and site operations include kill floor, boning room and rendering.

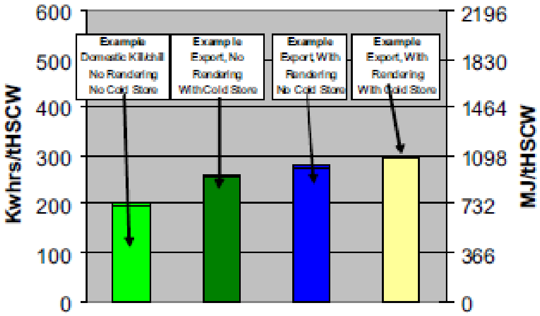
For this plant, Table 1 provides a breakdown of where the electricity is used in the plant. This equates to about 980 MJ/tHSCW in total, compared to the 2003 industry average of 3,389 MJ/tHSCW for electricity and boiler fuel.

Table 1: Breakdown of electricity use at a typical meat processing plant

Area of use	kWh/day	kWh/t HSCW	% of total	MJ
Refrigeration	22,222	148	54	79,999
Motors (pumps, fans, conveyors	15,000	100	37	54,000
Air compression	2,778	19	7	10,000
Lighting	833	6	2	300
Total	**40,833**	**272**	**100**	**146,999**

Even though electricity only accounts for about 30% of the total energy used onsite, it generally costs nearly two thirds of the total utility bill. The usage tends to vary during the day, and between seasons. For example, in summer the electricity use in refrigeration would tend to be slightly higher, as the ambient temperatures and relative humidity are higher, meaning that the refrigeration system has to work harder to achieve the same final product temperature. In winter, the electricity use in refrigeration would tend to be slightly lower.

Figure 1: Electricity consumption at different plants



Source: MLA Environmental Best Practice Guidelines for the Red Meat Processing Industry, 2007, Energy Section

As indicated in Figure 1, the amount of electricity consumed varies depending on what process operations occur at the site. The consumption ranges from 200 kWh/tHSCW at a domestic kill and chill operation to 300 kWh/ tHSCW at an export plant with rendering and cold stores.

The Red Meat Processing Industry Energy Efficiency Manual (MLA, 2009) provided an even wider range, from 43 kWh/tHSCW to 623 kWh/tHSCW.

1.2 Peak vs average usage

There is a clear idea of the amount of electricity used by each type of equipment on an average day, but when is this equipment on? As can be seen in Figure 2 and Figure 3, the peak consumption for a single shift plant generally occurs in the early afternoon before the shift ends, with the summer peak being higher than the winter peak by about 10-15%.

Figure 2: Summer daily electricity load profile, typical plant (one shift, rendering)

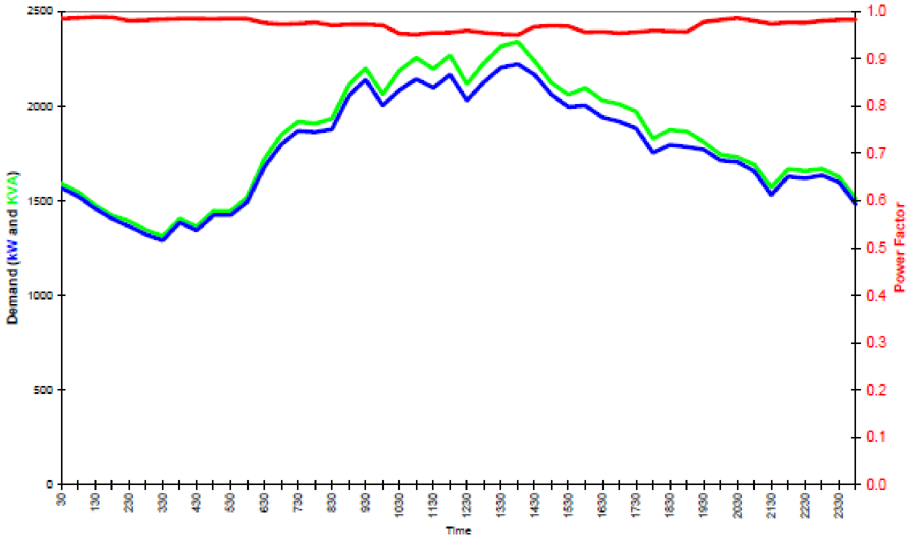
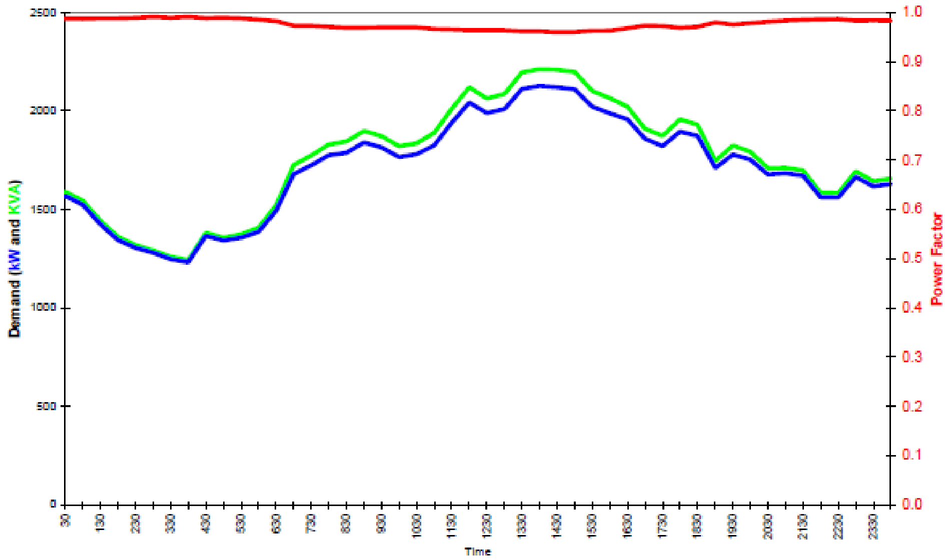


Figure 3: Winter daily electricity load profile, typical plant (one shift, rendering)



The gap between kW usage and kVA results in a dip in the power factor and occurs mostly during shift working hours from 6.30am – 8.30pm. The overnight power factor is much closer to 1, indicating that equipment is operating more continuously. The drops in consumption are most likely to be caused by production breaks, both scheduled and unscheduled.

Individual load characteristics are presented in

Table 2, and provide an indication of why the load and power factor varies during a day.

Table 2: Individual electrical consumption load characteristics

Load	Power factor	Load cycle	Size
Refrigeration	Mainly induction machines: 0.7-0.8	Peaks during shift hours, very variable	Varies from W to hundreds of kW
Ventilation/ Air conditioning	Mainly induction machines for fans and compressors: 0.7-0.8	Peaks during shift hours, variable	Varies from W to hundreds of kW
Motor loads (including air compression)	Mainly induction machines for hand tools, saws, hoists, water pumps and presses: 0.7-0.8	Peaks during shift hours, very variable	Varies from W to hundreds of kW
Lighting	Electrodeless: 0.98 Fluorescent: 0.4 – 0.9 High pressure mercury: 0.44-0.67 HID tube: 0.4-0.9 High pressure sodium: 0.44 Metal halide: 0.6-0.9	Constant during shift, lower during cleaning	At least 16-20 W/m^2, depending on application and luminaire

Source: MLA Energy Management Folder, "Efficient Use of Electrical Power", 1997 with updates for lighting

The largest loads, such as refrigeration and motor loads, have lower power factors and more variable consumption, so will contribute more significantly to the variation in kWh consumption and power factor during main shift times. Consumption can also depend on how the plant is operated – for example, if larger equipment items are shut down during breaks, what impact does this have on peak demand when the break finishes?

Some users, such as lighting, are on fairly continuously, because after production has ceased cleaning starts. Even within this smaller category of load, there is significant variation between consumption at different plants. Some plants have installed lighting controls so that lower lighting levels are used during cleaning. Some plants have installed timer lighting controls so that when the areas are not occupied (after cleaning and before startup of production) the lights are turned out. More recently, plants have been implementing controls on 250W and 400W mercury vapour lights, as there have been incidents where the ballasts catch on fire when they are left on continuously for long periods of time. Lighting contributes to the air conditioning load, so when calculating energy saving from turning off lighting the saving can be increased by 25% due to a reduction in the air conditioning load.

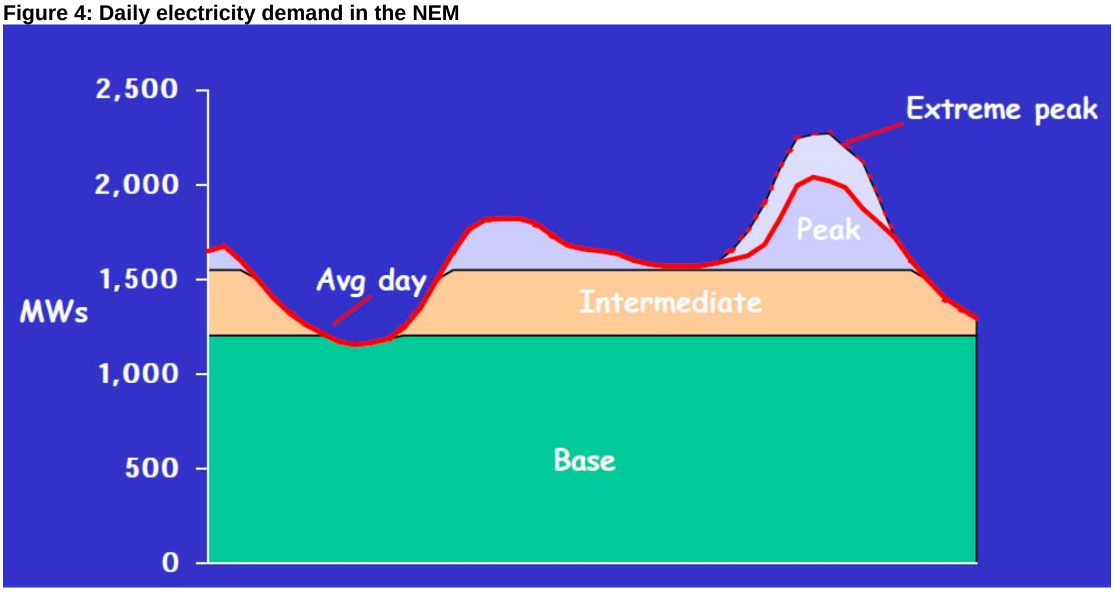
In the 2009 Red Meat Processing Industry Energy Efficiency Manual, it was found that although refrigeration accounted for 55% of the total electricity consumption, and product load was expected to account for up to 80% of the total refrigeration load, in some plants the product heat load was as low as 20% of the installed refrigeration capacity. This means that in some plants **refrigeration capacity is being used for non-product loads, such as air conditioning and the refrigeration plant is sized for the peak capacity (rather than the average).** The capacity issue will mean that the plant is operating at part load rather than full load most of the time, which results in lower efficiencies.

As a result, the load profile and power factor variation during the day for a site can vary depending on what equipment is installed and how it is controlled and operated.

1.3 System peak

The issue relating to peak electricity demand (and therefore higher and increasing prices) is that the electricity supply network peak is during summer. Peaks in the electricity supply system tend to occur on hot summer afternoons (2-8pm), but can occur anywhere from 9.30am – 5.30pm, depending on weather conditions, as indicated in Figure 4. Extreme peaks occur on only a few days each year, but they can have a large impact on the average price of electricity. Figure 4 shows that during peak events, peak power generation equipment is switched on, which is more expensive per unit of power generated.

Figure 4: Daily electricity demand in the NEM



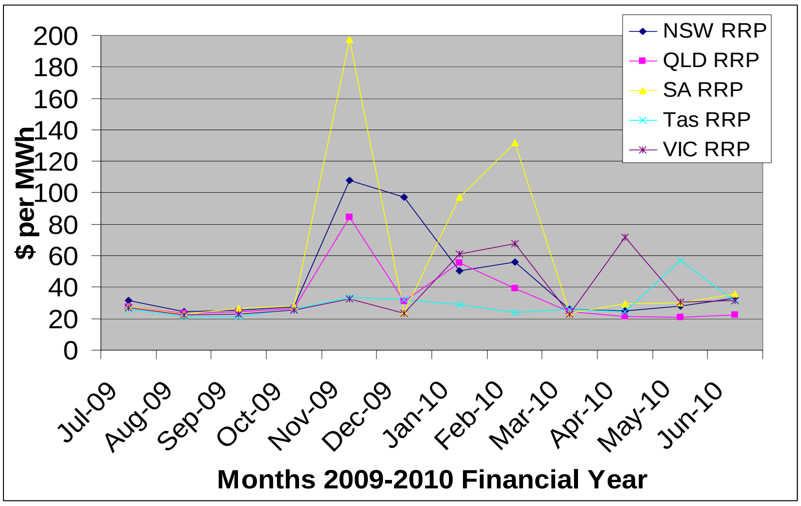
Source: AGL

Every year, the system is becoming peakier due to the ongoing difference on baseload consumption growth and peak load consumption growth. For example, Queensland energy distributors (Ergon Energy and ENERGEX) have forecasted that the total energy consumption in Queensland will increase by **48** per cent between 2008 and 2020, and the peak demand for electricity will increase **74** per cent in the same period. It is estimated that in south-east Queensland it is will cost $1 billion in the next three years to meet the top one per cent of electricity demand. This will end up being recouped through increases in the cost of electricity, particularly peak tariffs and will lead to an increased focus on consumers that contribute to the summer peak load.

As indicated by

Figure 5, summer average costs are higher, largely due to commercial and residential air conditioning loads. The NEM Rules set a maximum spot price, also known as a Market Price Cap, of $12,500 per megawatt hour (MWh), which contributes to the average monthly price depending on how frequently it occurs.

Figure 5: Electricity Average Monthly Prices 2009 – 2010, $/ MWh, AEM



2. Structure and pricing of electricity

2.1 Components of bill

When sites look at their electricity bills, they generally divide the total cost for the month by the total kWh consumed for the month to provide an average cents per kilowatt hour (kWh) value, which can range from 7 – 24c per kWh.

Most electricity bills have three main components

- **Usage charges** based on kWh consumed, usually with different tariff periods for different times of day/ days of the week
- **Demand** based on billed, contract, minimum chargeable or network demand (in kVA or kW), usually with different tariff periods for different times of day/ days of the week and a charge for actual or highest demand (also in kVA or kW). These charges may include fixed charges ($/month)
- **Other** charges such as distribution network charges, distribution non-network charges, regulatory (Australian Energy Market Operator AEMO[1]), renewable energy credit, metering and other charges (such as community ambulance (Qld), smelter tariff (Vic), depending on location). These charges may be fixed charges ($/day or $/month) or usage based charges (c/kWh)

Generally speaking, the **peak usage charge will be twice to three time (or more) the off peak rate** and the rate for both will depend on the location and size of consumption, with larger consumers tending to have lower rates than smaller consumers.

The demand charge can be based on the maximum demand recorded in the current or previous month, a percentage (up to 100%) of the highest demand from the previous 12 month period or the contracted demand. This is quoted as $ per kW or $ per kVA.

The demand tariff periods will line up with the usage tariff periods, and normally there will be another c/kWh charge for each tariff period. This means that the actual cost for peak electricity supply is the combination of the peak usage and peak demand charge and any of the other charges that are based on c/kWh.

Electricity networks need to be able to supply the peak demand of all sites at any time. They use the demand charge to reflect the fact that a site will only use its peak demand for a small period of its operating hours, but the network has to be able to supply that peak amount at any time. This is referred to as the **load factor**, which is a ratio of the average usage to the peak usage.

Power factor is a measure of how efficiently a facility is using electrical energy. A high power factor means that electrical capacity is being used effectively, while a low power factor indicates poor efficiency of electric power use. Power factor involves the relationship between Active Power (measured in kilowatts (kW)) and Reactive Power (measured in kilovolt-amperes-reactive (kVAr)).

Active power is consumed to do actual work, whereas Reactive Power produces an electromagnetic field for inductive loads. Inductive equipment which is lightly-loaded (such as saws, conveyors, compressors or grinders) or has a varying load (such as ventilation and air conditioning systems) will generally have a poor power factor.

Active power and reactive power together make up the Apparent Power, which is measured in kilovolt-amperes (kVA). This is what the electricity supply network "sees" as being the true demand for the site. This is why the site may be charged by kW or kVA, but more likely for kVA if they are a larger user.

[1] The National Electricity Market (NEM) covers all eastern states (TAS, Vic, ACT, NSW, QLD) and South Australia and is managed by the Australian Energy Market Operator

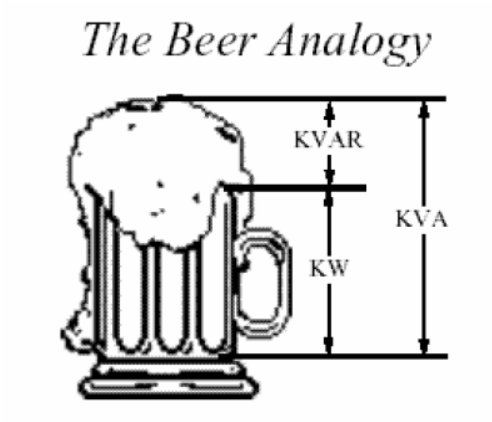
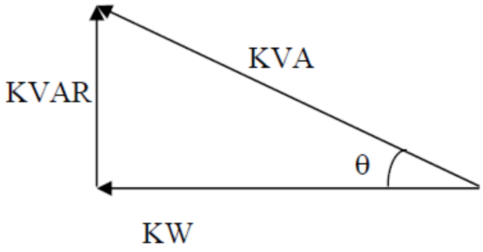


Figure 1

Source:
http://www.powerstudies.com/articles/PowerFactorBasics.pdf

A simplified analogy uses beer, with the actual beer being kW of electricity consumed/ work done, the kVAr being the foam and kVA being height of the glass required to prevent a spill (i.e. the two added together). In reality, it is the vectoral summation of the two, but this provides a simple overview.



If a site has a power factor much below 0.95, the electricity retailer will be penalising them financially in some form or another.

Depending on the site, the usage charges can account for 50 – 80% of the total bill, with other charges accounting for about 2-5% and demand charges making up the rest (18-48% of total bill). Depending on their location, some sites do not have much of a demand charge at all. The issue for sites to consider is; if the demand component only makes up 20% of my bill, what will the cost impact be if it increases to 50% of my total bill? Often sites will not be aware that significant price increases are likely until they attempt to renegotiate their electricity supply contract.

2.2 Distribution and Transmission Loss Factors

Distribution and transmission[2] loss factors are determined by the physical location of the site, so that sites which are at the end of an electricity supply network will have higher losses than sites that are closer to generators. Red meat plants are generally supplied from the distribution system; it is generally only very large users, such as aluminium smelters, that are supplied directly from the transmission system.

CSIRO undertook the Maine's Power Project, at Castlemaine in Victoria. The transmission loss factor at Castlemaine was 7.27% for the 2008/2009 year, and the distribution loss factor (DLF) was 6.59% for the 22kV, 11kV or 6.6kV system (or 9.25% for the 240/415V system).

The total transmission losses are calculated using the following formula and in this instance were found to be 15% for the higher volume and 17% for the lower voltage.

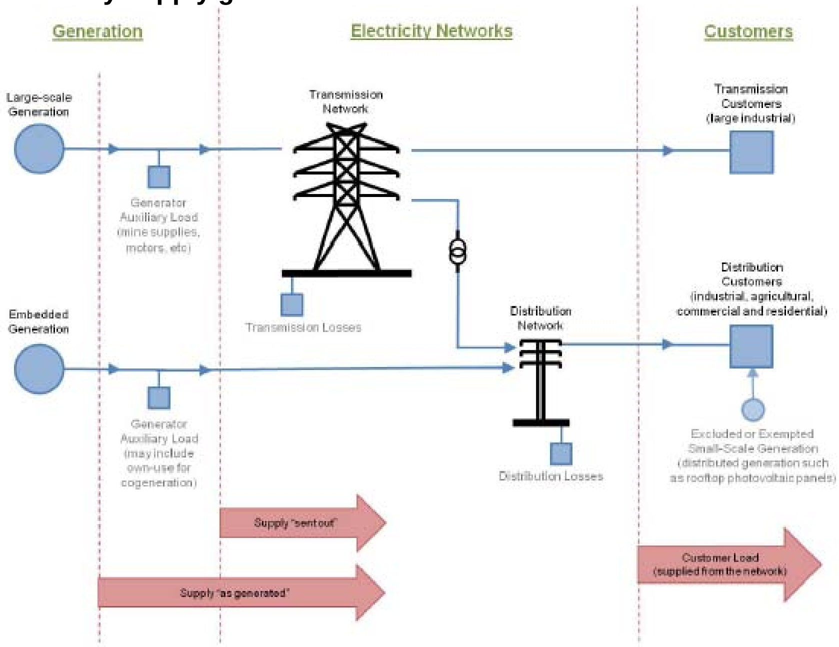
$$TLF = \left[\left(\left(1+\frac{MLF}{100}\right)\times\left(1+\frac{DLF}{100}\right)\right)-1\right]\times 100$$

What this effectively means is that, by the time the power arrives at the site, it is 15 – 17% more greenhouse intensive than when it left the generator.

Although it is not something that an individual site can control, it will have to pay for the fact that 15-17% extra power needs to be sent out from the generation assets to meet its actual consumption requirements. Losses are to be expected, as the NEM is the largest interconnected power system in the world.

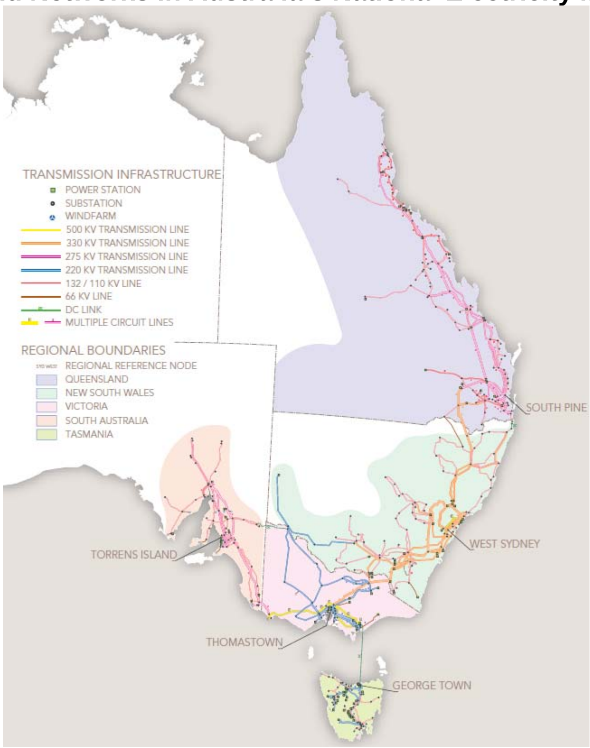
2 Average transmission loss factors are also referred to as marginal loss factors or MLF, and covers the transmission system

Figure 6: Electricity supply grid



Source: AEMO 2010 Statement of Opportunity

Figure 7: Regions and Networks in Australia's National Electricity Market (NEM)



Source: AEMO "Introduction to the NEM"

At the moment, the NEM is an energy only market (ie MWh), with no capacity market (MW). The NEM is a compulsory wholesale pool which generators sell their electricity into. The main customers are retailers, who buy electricity to resell to commercial, industrial and residential customers. End-use customer can buy directly from the NEM but few choose this option other than very large users such as aluminium smelters. There are currently 26 licensed retailers in the NEM.

Figure 8: Western Australian Electricity Supply System

The Western Australian (WA) electricity supply system is shown in Figure 8. This is a stand-alone market which is known as the Wholesale Electricity Market (WEM) and it operates in the South-West Interconnected System (SWIS). The WA market is an energy market (MWh) and a capacity market (MW).

Another small network, the North West Interconnected System (NWIS), forms part of the Horizon Power area. Horizon Power is a government owned entity that manages the NWIS and 29 other islanded systems in regional WA.

In the WA market, Verve Energy is the major generator, Western Power is the network owner (transmission and distribution systems) and Synergy is the dominant retailer. All of these entities are government owned.

The SWIS has the same problem as the NEM – namely that the top 15% of electricity demand only occurs for less than 2% of the year.

2.3 Tariff periods

The actual timing of the peak period will vary depending on the site, but tends to be from 7 – 7.30am until 7 - 11pm on weekdays (12-16 hours per day, 60-80 hours per week).

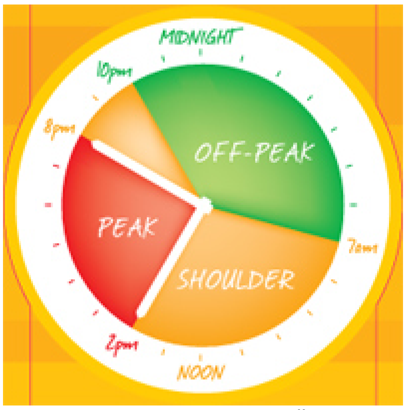
Offpeak tend to be “at all other times” ie 11pm Friday until 7am Monday and 11pm until 7am weekdays (8-12 hours per day, 88-108 hours per week).

Some small and medium sized businesses, particularly those close to metropolitan areas, have shoulder periods which can run from 7am-2pm and then 8 – 10pm weekdays (45 hours per week), which means that the peak usage runs from 2 – 8pm weekdays (30 hours per week), with offpeak all other times (93 hours per week). In these instances, peak tariff would be in the order of two and a half to three times offpeak and the shoulder tariff twice the offpeak rate.

Some retailers (such as EnergyAustralia) have recently introduced peak, offpeak and shoulder for, as indicated in

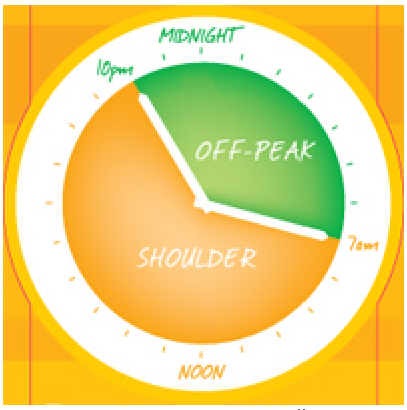
Figure 9 and Figure 10. This provides a focus on 2 – 8pm on weekday afternoons, but also extends the shoulder period to weekend between 7am until 2pm and 8pm until 10pm.

Figure 9: Weekday Time of Use Tariff Periods



Source: EnergyAustralia

Figure 10: Weekend Time of Use Tariff Periods



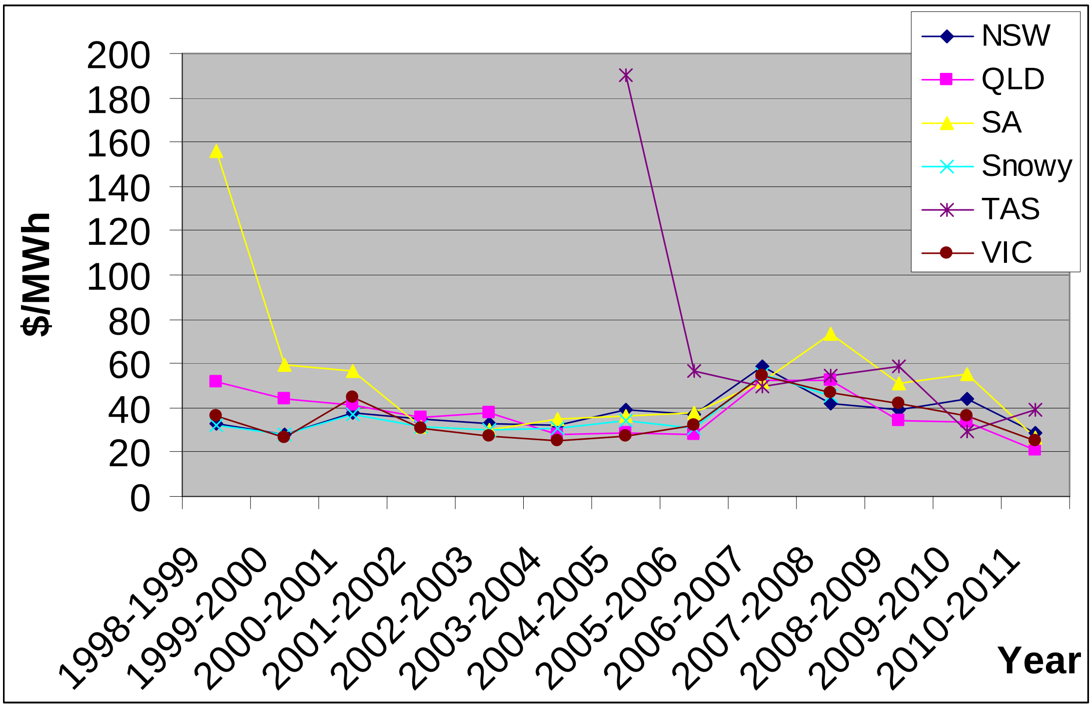
Source: EnergyAustralia

This has been enabled by the widespread installation of interval meters in small and medium sized businesses, which can be smart meters. Larger industrial and commercial electricity purchasers will have had interval meters for some time, but they are now being rolled out across the NEM to all consumers. Smart meters allow communication between the meter and the supply network, which could be used in future for such applications as direct load control (DLC) of air conditioning.

3. Potential changes in electricity bills

The average electricity price in the National Electricity Market (NEM) varies considerably by year and state, but the general trend is upwards. Some states have more expensive average prices, such as South Australia and New South Wales, despite the fact that they are part of a NEM. As indicated in Figure 11, the wholesale prices can vary between years.

Figure 11: Electricity Average wholesale annual prices (per financial year), NEM, $/MWh

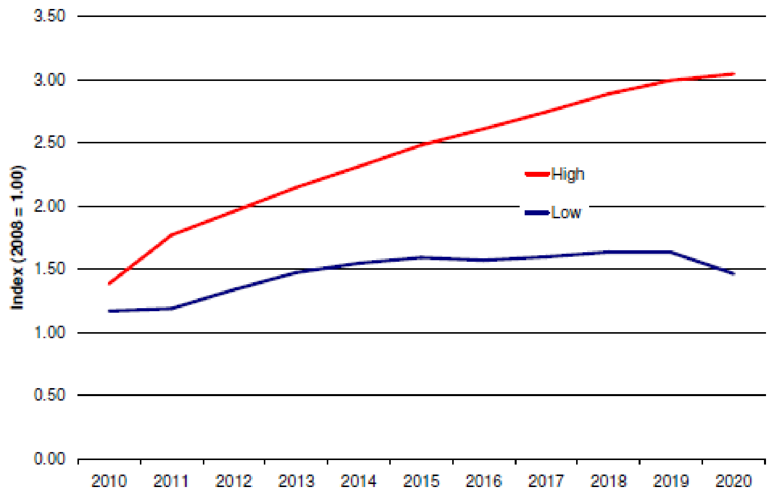


Source: AEMO * please note that 2010-2011 year is for July – September only ie winter months, which are lower cost. Full year figures for 2010-2011 may be higher than 2009-2010, depending on what sort of summer weather occurs.

The prediction is that electricity prices will increase in the next 10 years to somewhere between 1.5 times to current price, to up to three times the current price, as indicated in Figure 12 (CSIRO, 2008).

The low estimate includes a carbon price of $20/tonne while the higher price indicates the most stringent carbon price scenario (a stringent emission reduction target to 2020, no cap on carbon permit prices (carbon prices reach around $130/tCO2e by 2020 in real terms) and ‘free auction’ of permits to some polluters which increases the cost of GHG abatement to the economy).

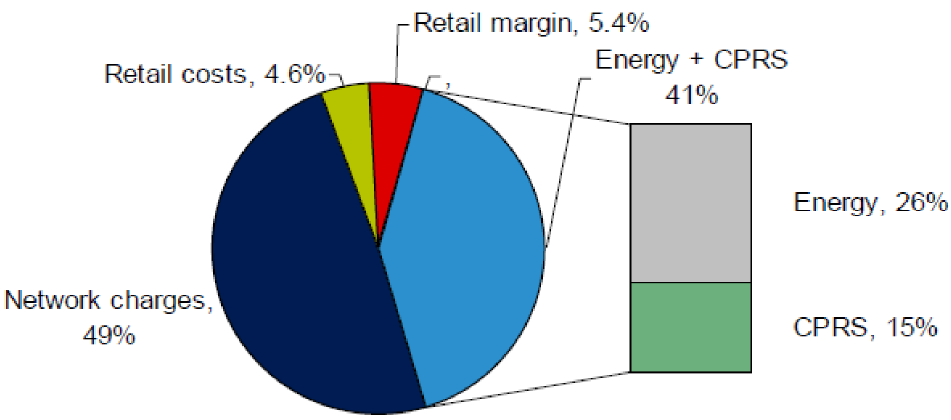
Figure 12: Retail electricity price projections, 2010 – 2020



Source: Maine's Power Project, Stage 2 Report: Options Development, CSIRO, Oct08

When investigating potential price increases, it is valuable to look at what current costs are made up of. Figure 13 provides an indication of the typical composition of a retail bill for customers who have not entered into contracts in NSW. The situation will be slightly different for sites like meat processing sites that have entered into contracts but basically it shows that most of the bill is made up of network charges and energy. The retail costs and margins comprise only 10% of the total bill. The network component of the bill is regulated by the Australia Energy Regulator and is effectively not negotiable. The retail component accounts for less than half of the bill and is made up of wholesale energy costs (26%, in grey), retail operating costs and the retail margin.

Figure 13: Composition of a typical retail bill, 2012/2013



Source: IPART Fact Sheet, Retail Tariffs 1Jul2010 – 30Jun2013, draft report, Dec09 (NSW only)

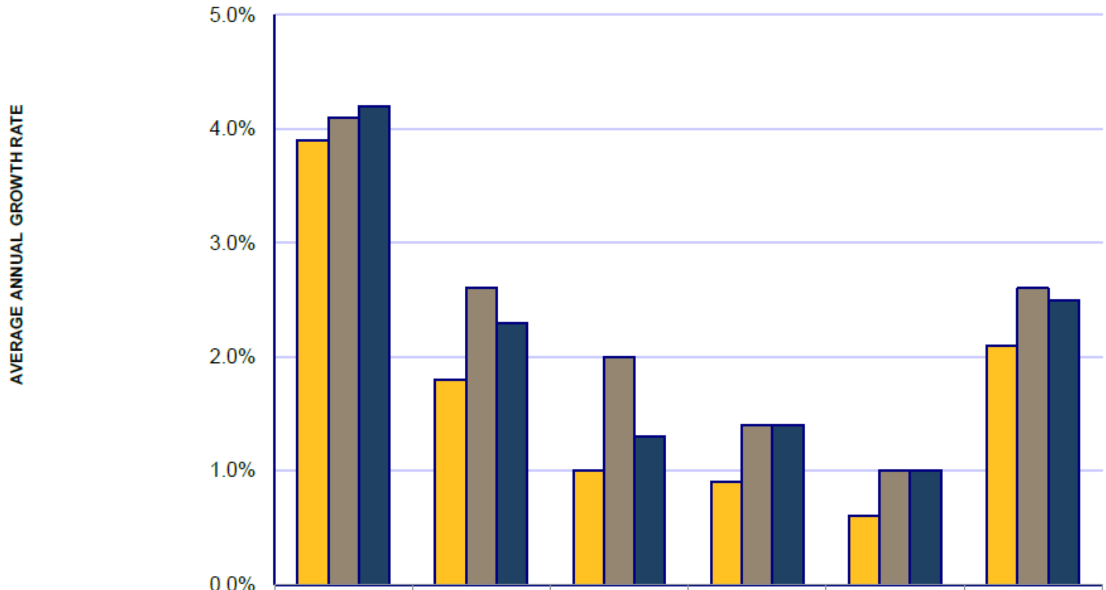
The network charges were expected to increase significantly over the next 3 years, to improve network security and reliability. Overall, prices in NSW were expected to increase between 44 – 58% over the 2010-2013 periods, with 16-35% due to increased network charges and 21-25% due to Carbon Pollution Reduction Scheme (CPRS) costs. Regardless of whether the CPRS or equivalent carbon tax is implemented, costs will increase 16-35% in the next 3 years in NSW due to network expenditure. Other states in the NEM are likely to be facing similar price escalations.

The issue driving this increased network expenditure is the **growth in baseload vs peak electricity consumption** as indicated in Figure 14. This shows that the maximum demand is growing at a higher rate that the overall energy consumption, in some areas (eg Victoria) by as much as a factor of 2. This means that more generation, transmission and distribution capacity will need to be installed and it will be used for only a fraction of the total time. These costs will have to be recouped by increasing tariffs, particularly for peak periods. Since 2004, the average annual summer peak demand growth for the entire NEM has been 3.5%, whereas the average baseload energy consumption growth has been 1.2%.

This increase is being created largely by commercial and residential air-conditioning, but it means that electricity supply companies are becoming increasingly interested in managing system peak demand. Demand Side Management programs have involved direct load control and demand responses, such as load shedding, switching on standby generation and customer responses to higher price signals.

Higher price signals can include seasonal time of use tariffs, where, for example, the summer peak tariff is higher than the non-summer peak tariff. It can take the form of real time pricing or critical peak pricing, where Time of Use Pricing is in effect with the exception of certain peak days, during which electric prices may reflect a value closer to the actual costs of generating and/or purchasing electricity at the wholesale level (up to $12,500 per MWh). Under the current contracts system, retailers protect customers from price volatility in the NEM wholesale spot market.

Figure 14: Average Annual Growth Rate in Electricity consumption, 2010

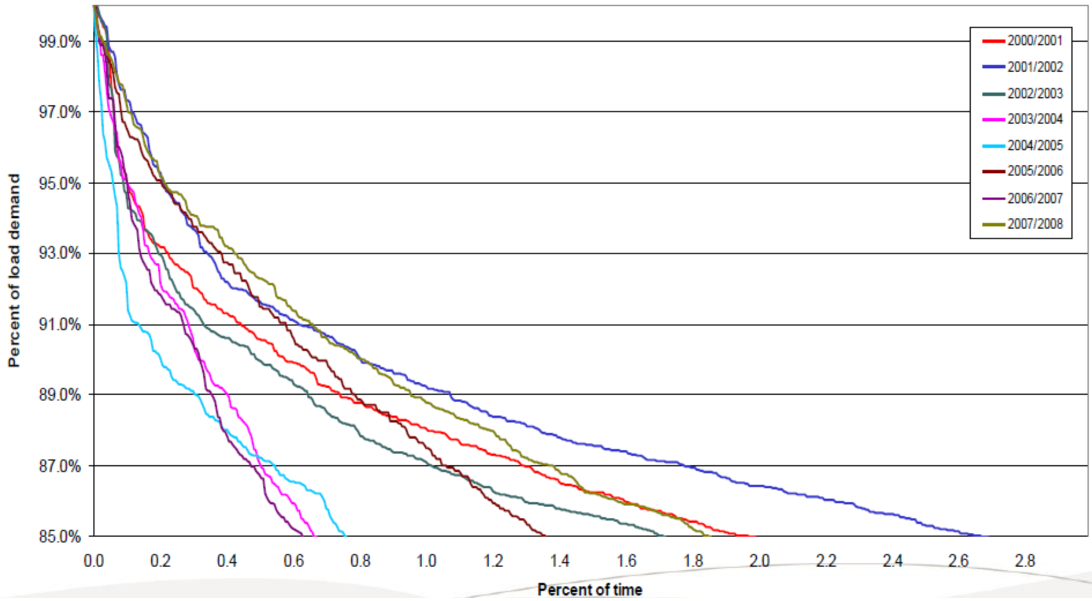


	QLD	NSW	VIC	SA	TAS	NEM
Energy consumption	3.9%	1.8%	1.0%	0.9%	0.6%	2.1%
Summer maximum demand	4.1%	2.6%	2.0%	1.4%	1.0%	2.6%
Winter maximum demand	4.2%	2.3%	1.3%	1.4%	1.0%	2.5%

Source: AEMO 2010 Statement of Opportunities

This has lead to analysis such as Figure 15 for Western Australia, where the top 1% of electricity demand is required for less than 0.2% of the time, but there still needs to be all the poles and wires to supply this peak demand. The NEM covering the eastern and southern states has a similar problem.

Figure 15: WA Market – peak electricity demand vs % of time required



Source: Western Power (Peter Martino) presentation, MINTRAC Environmental Managers Network Meeting, 12March09

It is likely that both the demand and usage components of the bill will increase due to network constraints, as the electricity supply industry tried to control the peak demand on the system. Underlying cost of generation is most likely to be impacted by a carbon tax although increasing pressure on coal exports will put pressure on coal costs in NSW and Queensland. Coal fired generators have long term supply contracts with mines so the impact is likely to be more gradual than a carbon tax. Despite the delay of the Carbon Pollution Reduction Scheme under the Rudd-Gillard Labor Government during 2009-2010, it is likely that a carbon tax of some sort will be part of the short to medium term outlook in Australia.

Much of the peaking power generation is provided by natural gas peaking plants, such as gas turbines or combined cycle turbine plants. This is currently more expensive than baseload or intermediate generators, and is likely to become more expensive due to upward pressure on natural gas supply in certain states due to supply constraints.

4. Potential impact of interval metering on pricing

Red meat processing plants have probably had interval meters installed for some time and suppliers can generally provide sites with a daily load profile of electricity consumption at half hourly intervals. Now that residential, commercial and smaller business sectors of the electricity market will also have interval meters installed, there will be increasing awareness of issues relating to peak demand. In particular, if these market segments are put under increasing cost pressure, the focus will inevitably turn to larger industrial consumers, to ensure that they are “doing their bit” to assist with peak demand management.

Examples from the residential sector of direct load control linked to cheaper tariff rates includes:

- Off peak hot water heating
- Swimming pool filters and pumps
- Water bed heaters
- Freezers
- Irrigation pumping equipment

However, not many red meat processing sites have a meter that they have access to internally that can tell them what their current total site demand is and trend it over a day. Rather, they rely on information provided by their electricity retailer at the end of the month or they may have a local readout in their switchgear rooms. While interesting, this is not useful to assist with managing consumption on a day to day basis, and particularly not at finding what is contributing to peak consumption events.

It would be worthwhile a site investigating when the peak demand occurred in the last 12 month period and determining what contributed to this. Factors could include a hot, humid day and break in production, followed by restart of all equipment simultaneously, rather than a sequenced startup.

Many red meat processing plants do not have any metering of electricity inside the plant, and linking of the meter back to a SCADA or equivalent system to enable analysis of the data on which area is using the most electricity. **Sites can only manage what they measure**. Installing submetering on the electricity system can be cost effective, but very small electricity saving may be required to pay off meters given the large size of most monthly electricity bills.

The potential for interval meters to provide more detailed and useful information to sites must be considered in conjunction with the trend towards **smart grids**, which is occurring in Australia and overseas. Aging electricity supply infrastructure means that alternatives to traditional centralised generation and dispatch could be more responsive to demand and more cost effective. It enables the convergence of 3 markets – energy, communications and information technology, through the use of technologies such as power line communications and advanced metering infrastructure.

Increasingly, the market will offer contracts which provide incentives for demand side management through **real time pricing tariffs**, such as **critical peak pricing**. The issue for red meat processing plants is how to best take advantage of this emerging opportunity, while insulating themselves from price increases. There will be increasing interest in demand side alternatives to network augmentation.

Figure 16: Western Powers vision of future electricity supply network

Country Energy implemented a Critical Peak Pricing (CPP) trial in Queanbeyan for residential consumers. The tariffs were: The tariff levels are as follows: critical peak 37.74 c/kWh, peak 18.87c/kWh, shoulder 12.7c/kWh and offpeak 7c/kWh. It covered a summer cooling peak period (2-8pm) and winter heating peak (7 am to 9 am and 5 pm to 8 pm). This was the first time CPP has been used in the NEM.

In line with changes occurring in the residential and commercial sectors (time of use tariffs, direct load control, CPP) some countries have implemented critical peak pricing. California has implemented critical peak pricing (CPP) for large industrial consumers, because of the impact they have on the system. The tariff means increased prices during 6 or 7 hours of up to 12 Critical Peak Pricing Days each year and a commensurate reduction in prices during non-critical-peak periods. A CPP event can only be activated during summer. There are actually two levels of critical peak pricing – for example, the highest peak is five to ten times the offpeak and the moderate peak is twice to four times the offpeak tariff rate. Spain, which has a summer cooling peak like Australia and a winter heating peak, has a number of programs relating to Interruptibility of load for industrial users.

Murray Goulburn Co-operative Company Limited was involved in a study of Demand Side Response in the National Electricity Market - Case Studies End-Use Customer Awareness Program which was conducted by the Energy Users Association of Australia in 2005. This looked specifically at refrigeration, cold storage and On-site generation. It identified that at least two of the rural manufacturing sites and the logistics complex had significant potential to provide fast response and reliable Demand Side Response with no reduction in site health and safety, no impact on production volumes or timeframes, and no additional impact on the local environment. The study looked at a value of $1,000/MWh for the Demand Side Response load reduction, which is only likely to be paid if the load can be reduced at short notice and is highly reliable. Other investigations have found that there are significant demand management options available for $500 per kVA or less (Next Energy, 2004).

It is likely that a range of changes will occur in the National Electricity Market to increase the amount of demand management occurring, including such options as (Next Energy, 2004):

- clearer standard network connection provisions to facilitate small generators;
- development of a market platform for real time Demand Management;
- improved price signals, including trials of localised congestion pricing ie CPP;
- ongoing assistance to governments in reviewing the roll-out of interval meters and associated pricing issues;

- clarifying the treatment of avoided transmission use of system and distribution use of system charges; and
- clarify the regulatory treatment and recovery of spending by network service providers on Demand Management.

5. Desktop review of options

The most cost effective option for a site will depend on its current tariff regime, including the difference usage tariffs (peak vs offpeak kWh) and the demand component of the bill.

5.1 Energy efficiency

Energy efficiency involves producing the same amount of product but consuming less electricity and hopefully at a better power factor and lower peak demand. Energy efficiency can provide a permanent form of electricity demand reduction, particularly when it arises from a technology upgrade or control improvements. Improvements to energy efficiency arising from changes in procedures, training or awareness are generally less certain than those arising from technology, as long as the technology can not be tampered with and is operated as designed.

There have been a number of Meat and Livestock reports relating to potential energy efficiency improvements at red meat processing plants. The most recent will be summarised here and the less recent (Eco-Efficiency Manual from 1997) will be included in an appendix. Examples from the US Department of Energy Industrial Technologies Audit program are also provided in an appendix.

Table 3: Summary of energy saving opportunities

System	Potential saving measure	Sites
Thermal Energy	Boiler burner tuning	12 out of 12
	Flash steam recovery	9 out of 12
	Boiler drum TDS level	8 out of 12
	Blowdown heat recovery	5 out of 12
	Boiler Economiser	11 out of 12
	Cooker waste heat recovery	9 out of 12
	Increased condensate recovery	9 out of 12
	Sterilisers/ waste heat recovery	10 out of 12
	Improved boiler part load performance	12 out of 12
	Reduction in hot water use	12 out of 12
Refrigeration	Sub metering (monitoring & targeting)	12 out of 12
	Reducing refrigeration lift	12 out of 12
	Review boning room fresh air intake	12 out of 12
	Use of Plate freezers	9 out of 12
	Use of dehumidifiers in freezers	12 out of 12
	Automated refrigeration system control	12 out of 12
	Floating heat condenser control	12 out of 12
	Evaporative/chilled water spray pre-cooling	12 out of 12
	VSD on trim screw compressors	12 out of 12
	VSD’s on evaporator fans	12 out of 12
Other opportunities	Eliminate compressed air leaks	12 out of 12
	VSD on screw air compressors	12 out of 12
	Optimise sequence of air compressors	12 out of 12
	Power Factor Correction	7 out of 12
	Purchase energy efficient motors	12 out of 12
	Improve lighting control	12 out of 12
	Biogas capture and use	9 out of 12
	Cogeneration	12 out of 12

Source: Red Meat Processing Industry Energy Efficiency Manual, MLA, 2009

It has been estimated that the potential energy savings for manufacturing in Australia may range from 22-45% (COAG Ministerial Council for Energy, 2003).

A report on energy efficiency improvement potential case studies was completed in 2004 as part of the National Framework for Energy Efficiency. For meat processing, it outlined the following potential opportunities, ranked by payback period.

Table 4: Energy Efficiency Improvement opportunities in the Meat and Meat Products Industry

Fuel	Process Equipment	EEI Opportunity	Simple Payback
Electricity	Process Equipment (Rendering, Dressing, Boning, Pumps, etc)	Improve operating practices to minimise energy waste (e.g. breaks, out-of-hours	0.00 Years
Electricity	Packaging	Improve operating practices to minimise energy waste (e.g. breaks, out-of-hours)	0.00 Years
Electricity	Refrigeration & Freezing	Switch off equipment / cold stores / freezers when not used or where operations are seasonal	0.00 Years
Electricity	Refrigeration & Freezing	Maintain cold room and tunnel freezers fully sealed when not required	0.50 Years
Fuel	Hot Water	Reduce hot water usage using efficient nozzles, trigger action hoses	0.50 Years
Fuel	Process Equipment (Rendering, Singeing, Scalding, etc)	Maximise loading of render plant cookers, and rotate to even steam demand	0.50 Years
Electricity	Services (Lighting, A/C, Boiler)	Implement lighting controls (e.g. in vacant areas, offices, carcass stores)	2.00 Years
Electricity	Services (Lighting, A/C, Boiler)	Optimise heating, air conditioning controls and setpoints	2.00 Years
Fuel	Hot Water	Maintain hot tank / wall and line insulation, repair leaks	2.00 Years
Electricity	Services (Lighting, A/C, Boiler)	VSD control of boiler fans	2.50 Years
Fuel	Steam System Losses	Maintain steam traps, optimise condensate return, insulate all valves, flanges, lines, remove dead legs, repair all leaks	2.50 Years
Electricity	Process Equipment (Rendering, Dressing, Boning, Pumps, etc)	VSD control and automation of pumps (e.g. carcass washwater, wastewater pumps)	3.00 Years
Electricity	Refrigeration & Freezing	Automate chiller temperature profile control and implement fan speed controls	3.00 Years
Electricity	Refrigeration & Freezing	Optimise condenser operation (e.g. pressure reduction using fan speed control, purging operation)	3.00 Years
Electricity	Refrigeration & Freezing	Optimise ancillary equipment (e.g. VSD for cooling tower fans, cooling and chilled water, refrigerant pumps)	3.00 Years
Fuel	Boiler Losses	Install oxygen trim control	3.00 Years
Electricity	All Electricity	High efficiency motors	3.00 Years
Electricity	Refrigeration & Freezing	Optimise compressor performance (e.g. Staging controls, VSD control, electronic expansion control)	4.00 Years
Fuel	Boiler Losses	Automate blowdown on TDS and recover heat to boiler feedwater tank	4.00 Years
Fuel	Process Equipment (Rendering, Singeing, Scalding, etc)	Cover surface, insulate and recover heat from scalding tank water	4.00 Years
Electricity	All Electricity	Energy monitoring and control	4.00 Years
Fuel	All Fuel	Energy monitoring and control	4.00 Years
Electricity	Services (Lighting, A/C, Boiler)	Best practice lighting technology	5.00 Years
Electricity	Refrigeration & Freezing	Use conventional refrigeration rather than cryogenic freezing where feasible	5.00 Years
Fuel	Hot Water	Heat recovery from refrigeration superheat to pre-heat hot water	5.00 Years
Fuel	Boiler Losses	Install economiser on boiler flue gas	5.00 Years
Fuel	Process Equipment (Rendering, Singeing, Scalding, etc)	Heat recovery from render plant cooker exhaust	6.00 Years
Electricity	Refrigeration & Freezing	Optimise design of blast tunnel fans	6.00 Years
Fuel	Boiler Losses	Upgrade to a high efficiency modulating burner with low turn down ratio	7.00 Years
Electricity	Refrigeration & Freezing	Upgrade to high efficiency, multiple stage refrigeration plant	10.00 Years

Source: NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector, March 2004, Energetics

It is important to keep a few key points in mind when considering energy efficiency opportunities:

- Savings in lighting also benefit the refrigeration/ air-conditioning system;
- Saving water saves electricity in pumping, as water is pumped 2-4 times around the plant, so electricity costs may be more significant that water supply cost savings;
- Largest electricity savings are likely to come from high efficiency motors (replacing existing motors before end of life), variable speed drives and pumps and motors that are sized and managed correctly[3];
- Largest step change is likely to come from cogeneration or trigeneration, but the economics are very location and site specific; and
- **Choosing the more energy efficient option when equipment is being refurbished or replaced can achieve large savings**.

The Herd Group at Geelong are a leader in electricity price control. They have installed VSD's on all their hot and cold water supply pumps, and they are controlled based on pressure feedback from the system. Herds have installed high bay and low bay LED lights, which have reduced the electricity consumption by 80% and although they are twice the capital costs of the mercury vapour and metal halide luminaires, the payback was estimated to be 18 months or less. Since they have installed automated rapid roller doors (which close in 3 seconds), there has been a noticeable decrease in condensation inside the chillers and freezers.

[3] Online Motor Solutions website at http://www.climatechange.gov.au/en/what-you-need-to-know/appliances-and-equipment/electric-motors.aspx contains an extensive guide to motor selection, operation and maintenance

5.2 Fuel switching

Fuel switching involves using an alternative energy source instead of electricity. Typically, electricity would be replaced by gas, either natural gas or biogas generated onsite.

Table 5: Fuel switching options

Option	Details
Gas cooling ie absorption refrigeration	• Replace some of electrical chillers with absorption chillers, driven by either waste heat or direct gas use
Electrical heating changed to steam	• Tallow tank heaters changed to steam • Boiler preheating tank deaerator coils changed to steam • Air heaters for cryovac machines[4], change to steam
Electric hot water heating	• Replace with gas heating

[4] Pers Comm, Brian Kelly

5.3 Load shifting/scheduling

Load shifting involves moving when a task is undertaken from peak to shoulder or offpeak periods. The same amount of electricity is used, but it will be in a cheaper tariff period. It may involve doing the same task but at a slower rate, so that the load is shifted over a longer time period at a lower consumption rate. This is indicated in

Figure 17. Loads can either be advanced (ie done earlier) or deferred (done later).

Figure 17: Loading shifting

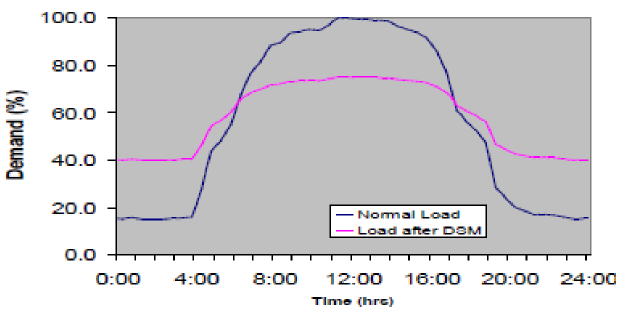


Table 6: Load shifting/scheduling options

Option	Details
Shift scheduling	• Reorganise shifts so that they occur out of summer peak periods ie summer only – operate night shift rather than day shift – either advance or defer eg kill floor in morning, boning room in afternoon
Water pumping	• Schedule pumping outside of peak periods ie run down water levels in wastewater pits prior to peak periods, ensure supply tanks are full. Requires proper sizing of holding tanks.
Refrigeration system	• Ensure system operation has been optimised eg set points, controls • Install advanced control system to optimise system operation • Ensure control system closely matches AQIS refrigeration index requirements, not exceeds them by a large margin eg meet target temperature with 1 hour to spare, not 5 hours • Shut down cold stores and freezers for short periods (15 minutes[5] to 2 hours), chillers likely to be more difficult depending on production schedule / refrigeration index
Air conditioning/ Precooling of rooms	• Precooling - run room temperatures down to below required temperature outside of peak period, allow to climb back up • Note that air conditioning can be as much as 80% of the total heat load/ refrigeration capacity (not product cooling or freezing)[6] • Increase rate of air conditioning during breaks when other equipment is turned off • Review fresh air intake/ air exchange rate • Closely monitor condensation inside rooms – look at people using hoses, do proper dry out before room loaded
Final product freezing	• Consider holding in chillers and loading outside of peak periods, will depend on plant configuration, scheduling and AQIS requirements

[5] The Herd Group at Geelong have found that 15 minutes shutdowns do not adversely impact room temperatures
[6] From MLA Red Meat Processing Industry Energy Efficiency Manual, 2009

Option	Details
Breaks	• Sequence startup after breaks to manage peak demand
Irrigation	• Manage pumping of wastewater system so that it occurs mostly overnight or out of peak period. May require additional storage tanks or buffering in system
Water supply / treatment	• Schedule water treatment/ pumping to occur outside of peak period, so tanks are full at start of shift and run down towards end, with possibly top up during cleaning (normally partly out of peak period). May require additional storage tanks • Schedule pond aeration outside of peak period
Outside electricity use eg yards	• Install daylight sensors or timers on outside lighting • Manage water flows to and from yards to minimise peak use eg troughs, hoses, pits
Forklift charging	• Install timer switches to ensure only charge during off peak periods, may require spare battery packs
Rendering	• Defer production until outside peak period where possible (will depend on tallow and meal quality constraints), such as presses, meal dryers, centrifuges, bagging plant. May require additional holding vessels for intermediate products

The Herd Group at Geelong have an automated system, whereby they load shed based on set points. The site maximum demand is 1575 kW and the alarm is set at 1500. When electricity demand gets close to the set point, the SITEC system sends the site engineering manager's mobile an SMS alert and then automatically turns off a motor in the refrigeration engine room for a 15 minute block (say, a 100kW motor). Experience has shown that this short term shutdown on the cold stores and freezers does not adversely impact room temperatures greatly in the short term. The Herd Group have found that they can save $20-40K per year by controlling their maximum demand in this way.

From the Murray Goulburn case study as part of the EUAA project, the plant found that it could shut down the electric refrigeration plants (refrigeration compressors and pumps) for the cool stores for a short time (30 minutes to up to 2 hours). This would provide a 10% reduction (600kW) in their site demand at each of the Cobram (6.2MW peak demand) and Leongatha sites and a 35% reduction (320kW) in site demand at the Laverton North site (EUAA, 2005). The site could provide additional load reduction at the Cobram site by shutting down a drying process (drier and exhaust fans), but this would be disruptive to whey production and so would require a much higher price per MWh as compensation.

Camilleri Stockfeed Pty Ltd at Maroota in NSW are the lower costs renderer in Australia. They use load shifting, such as running aerators and pumps in wastewater system during offpeak periods, to keep their electricity prices down.

5.4 Load shedding/ Interruptibility

Load shedding involves not doing a task at all, meaning that a lesser amount of electricity is used during the peak period. This usually involves equipment which is left idling and could be switched off, or equipment that is on when it doesn't need to be such as lighting in stockyards. This can be done either through demand response (manual response, where the site is notified and opts to reduce load) or through direct load control (automated, based on signal from network). This can be overlap between this type of demand response and load shifting.

Several trials have been done (SA and NSW) to determine the feasibility of direct load control (DLC) of residential air conditioning, which involved cycling the unit off for a certain number of minutes every hour or half hour, and it was found that user amenity was not adversely impacted.

Similar programs, which are part of a wider category of Demand Side management (DSM) programs, have been used in other countries with the commercial and industrial sector. In the USA, direct load control has been used in industrial applications for industrial HVAC, interruptible loads and standby generators. They can be referred to as Emergency Load Response programs or Economic Load Response programs, and the sites are paid a premium to reduce loads during periods of peak supply constraints or given a discount on their electricity bills. These normally only occur for short time periods (2-4 hours) and the forward notice of the constraint ranges from days to a few hours. Generally, the shorter the notice, the shorter the time period the reduction is required for.

There is normally a limit on the number of times a “call” to reduce load can be made eg one call per day up to a maximum of 6 hours, maximum of 10-20 calls per year.

Table 7: Load shedding options

Area of usage	Options
Refrigeration	• Use control system and refrigeration index to manage refrigeration load, don’t overcool • Use evaporative precooling of carcasses • Ensure good procedures so that chillers are fully loaded as quickly as possible and then doors shut and left shut • Lights out when chiller doors closed • Install rapid closing doors to reduce condensation[7]
Refrigeration - boning	• Change from cold boning to hot boning
Air conditioning	• Better control of air conditioning to meet QA requirements without overcooling
Lighting	• Daylight sensor to turn off lights during day • Skylights where practical • Timer switch to periodically turn off 250 W and 400W lights (rather than leaving on all the time) eg link to chiller controls, once chiller fully loaded and doors shut, lights go out automatically • Motion sensors in stairwells, store rooms, meeting rooms ie spaces often not occupied
Breaks or shutdowns	• Turn equipment off or into hibernation mode during breaks eg conveyors, main chain • Ensure startup is sequenced to minimise peak consumption
Idling or part load equipment	• Check operation, where required install timer switches to turn off so that all units not running at part load eg compressors, pumps, fans
Outside users	• Can account for 10-15% of total electricity use, ensure that if they can be switched off during peak periods

Load shedding was used by Integral Energy as part of their Seven Hills Demand Management program, where a $1.7 million network augmentation project was deferred from 1998 to 2005. Under the program, a large industrial customer is given 24 hours notice to shed load between 1pm and 5pm the following day. The customer achieved this by speeding up production prior to the event and then slowing it down from its average rate during the peak, which saved between 3.5 and 4.5 MVA. The majority of the cost of the program has been the

[7] Pers Comm, Trevor Egan, The Herd Group

payments made to the participating customer. Integral Energy has used load shedding by large industrial consumers in other areas, such as Wetherill Park (Western Sydney).

5.5 Distributed generation

Distributed generation include cogeneration, trigeneration and standby generation (or emergency backup). Standby generation is generally only licensed to operate a certain number of hours per year (less than 200 hours for NSW Environment Protection Agency) and it is advisable to regularly test units to ensure that they will work when required.

Distributed generation often produces the largest amount of reduction in electricity demand from the grid. Depending on the local electricity supply network, there may be network support payments available for installing major reductions to grid demand, such as cogeneration, trigeneration or standby generation. Alternatively, it may be part of a demand side management contract, which provides payments for demand reduction.

Table 8: Distributed generation options

Option	Details
Cogeneration/ Trigeneration	• Install cogeneration or trigeneration, which backs up major equipment items such as refrigeration and lighting
Emergency backup/ standby generators	• Install backup power supply, so that in the event of grid failure or electricity supply constraints, site can still operate • Often has blackstart capability, so can start without electricity supply available

From the Murray Goulburn case study as part of the EUAA project, the plant found that it could switch load to the onsite Distributed Generators. This could be done with a short notification period (30 minutes) with high reliability. The Cobram and Leongatha sites would each be capable of providing 340kW, while the Laverton North site would be capable of providing 1.2MW, including export to the grid.

Most meat processing plants do not currently have any emergency backup power generation or cogeneration/trigeneration capability.

5.6 Power Factor Correction

This option involves the potential to increase the power factor to closer to unity (1) at the site by installing power factor correction equipment, thereby achieving a reduction in electricity demand. The electricity consumption (kWh) may remain the same, but the demand charge (kVA) will decrease.

Power Factor Correction is often the main category of cost effective demand side reduction found when local network constraints are investigated (Charles River Associates, 2003).

6. Summary - options to respond to electricity price changes

The options available to sites for managing increases in electricity prices are

- As covered in detail in Section 5:
  - energy efficiency – ensuring the most efficient equipment is installed, equipment used as design, maintained and only on when required;
  - load shedding - control of refrigeration and HVAC, lighting control systems, management of breaks and shutdowns;
  - load shifting/Interruptibility – non-essential loads moved to off-peak periods eg water pumping and aerators, refrigeration management (comply with but not exceed AQIS requirements by large margin);
  - distributed generation – cogeneration, trigeneration and emergency backup power supply;
  - power factor correction – target for 0.95 or above;
  - fuel switching – switching electrical users to another energy source such as steam.
- Getting a better deal on tariffs – likely to be fairly limited, given that retail margins make up less than 10% of the total bill, but still worthwhile taking advantage of full retail competition
- If critical peak pricing comes into play, consider changing shift patterns to night shift rather than day shift and some weekend work rather than all week days

There are over twenty electricity retailers operating in the National Electricity Market as full retail competition is now in place. When renegotiating contracts, particularly for multiple sites, it may be worthwhile negotiating on a group basis for all sites. In addition, some retailers sell electricity and natural gas, and can bundle the contracts together.

Retailers in the NEM include such companies as AGL, Aurora Energy, Australian Power and Gas, Country Energy, Diamond Energy EnergyAustralia, Integral Energy, Lumo Energy, Momentum Energy, Origin Energy, Powerdirect, Red Energy, Simply Energy and TRUEnergy. Electricity retailers in the WA Market include Synergy, Alinta, Wesfarmers Premier Power Sales and TransAlta Energy (Australia).

7. References

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Appendix 1. Eco-Efficiency Manual Information

Possible energy efficiency opportunities with indicative paybacks (0-2 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Water	Stock washing	Minimise receipt of very dirty stock through contract clauses (section 2.2.3, pg 28)	0
Water	Stockyard washing	Dry cleaning manure before washing (section 2.2.6, pg 29)	0
Water	Viscera (and bleed) table wash sprays	Use of chlorinated detergents instead of hot water for cleaning viscera tables (section 2.2.12, pg 33)	0
Water	Plant cleaning	Improved dry cleaning prior to wash down (section 2.2.30, pg48)	0
Steam	Reduce steam demand	Reduce water entrainment in rendering materials (section 3.2.1, pg60)	0
Steam	Efficient steam raising	Fix steam leaks (section 3.3.3, pg 63)	0
Steam	Alternative fuel sources	Convert LPG boiler to tallow (section 3.4.2, pg 67-68)	0
Electricity	Refrigeration	Turn off refrigeration at night (section 3.6.4, pg 79)	0
Electricity	Compressed air	Improving efficiency of air compression by fixing leaks (section 3.6.6, pg 81-82)	0
Electricity	Process Equipment	Improve operating practices to minimise energy waste (eg breaks, out of hours)	0
Electricity	Packaging	Improve operating practices to minimise energy waste (eg breaks, out of hours)	0
Electricity	Refrigeration & Freezing	Switch off equipment/ cold stores/ freezers when not used or where operations are seasonal	0
Steam	Efficient steam raising	Rationalisation of boiler use (section 3.3.1, pg62-63)	0.1
Water	Alternative sources	Rainwater harvesting for cooling water or stockyard washing (section 2.4.1, pg56)	0.1
Steam	Efficient steam raising	Fine tune boiler operation (section 3.3.6, pg 65)	0.2
Water	Casings washing	Limiting water use in casing washing by interlocking the operation of the machine to a timer switch (section 2.2.25, pg44-45)	0.3
Water	Water sprays	Fit efficient spray nozzles (section 2.2.1, pg 25-26)	0.3
Water	Knife and equipment sterilisers	Flow control of continuous flow sterilisers (section 2.2.14, pg 36-37)	0.3
Water	Plant services - boiler	Maximise condensate recovery (section 2.2.36, pg52-53)	0.3
Electricity	Refrigeration	Improve efficiency of refrigeration compressors (section 3.6.2, pg 78)	0.3

Possible energy efficiency opportunities with indicative paybacks (0-2 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Water	Water supplies	Centralise control of water supplies, to supervisor can switch off during breaks (section 2.2.2, pg 26-27)	0.4
Water	Viscera (and bleed) table wash sprays	Intermittent flow for viscera (bleed) table wash sprays, only when table moves forward (section 2.2.9, pg 31)	0.4
Steam	Efficient steam raising	Insulate steam lines (section 3.3.4, pg 63-64)	0.5
Electricity	Refrigeration & Freezing	Maintain cold room and tunnel freezers fully sealed when not required	0.5
Fuel	Hot Water	Reduce hot water usage using efficient nozzles, trigger action hoses	0.5
Fuel	Process Equipment	Maximise loading of render plant cookers, and rotate to even steam demand	0.5
Water	Viscera (and bleed) table wash sprays	Setting and maintaining minimum flow rates for viscera (bleed) table wash sprays (section 2.2.10, pg 32)	0.6
Water	Paunch dumping (beef)	Dry dumping of paunch contents (section 2.2.23, pg43-44)	0.8
Water	Edible offal washing	On/off control of flow (section 2.2.28, pg46-47)	0.8
Water	Stock washing	Avoid under-utilisation of spray capacity (section 2.2.4, pg 28)	1
Water	Stock washing	De-dagging at feedlot to avoid stock washing at domestic plants (section 2.2.5 , pg 28-29)	1
Water	Knife and equipment sterilisers	Efficient continuous flow sterilisers (double skinned, water jacket etc) (section 2.2.13, pg 33)	1
Water	Carcase washing	Water sprays on splitting saws to remove bone dust and reduce carcase washing (section 2.2.19, pg41)	1
Water	Tripe and bible washing	Efficient water use in tripe and bible washing machines (section 2.2.24, pg44)	1
Water	Gut washing	Water efficient gut washing systems (immersion washer) (section 2.2.26 , pg 45)	1
Water	Water reuse	Reuse of clean wastewater streams (section 2.3.1, pg54)	1
Steam	Heat recovery	Optimise heat recovery from rendering, recover heat to produce hot water (section 3.5, pg 73-76)	1
Electricity	Lighting	Energy efficient lighting (section 3.6.11, pg 85)	1
Electricity	Refrigeration	Reduce heat ingress to refrigerated areas (section 3.6.1, pg 77)	1.1
Water	Carcase washing	Sensor control of automatic carcase washing (section 2.2.18, pg 39-40)	1.5
Water	Amenities	Automatic controls for hand washing (section 2.2.35, pg 51-52)	1.5

Possible energy efficiency opportunities with indicative paybacks (0-2 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Electricity	Compressed air	High-efficiency air compressors (section 3.6.7, pg 82)	1.5
Water	Plant cleaning	High pressure water ring main for cleaning (section 2.2.31, pg49)	2
Water	Plant cleaning	Automatic washers for tubs, cutting boards and trays (section 2.2.32, pg 50)	2
Water	Plant services – cooling tower	Conductivity controlled blowdown on cooling towers (section 2.2.37, pg53)	2
Electricity	Motors	Variable speed drives (section 3.6.9, pg 83-84)	2
Electricity	Services	Implement lighting controls eg in vacant areas, offices, carcass storage	2
Electricity	Services	Optimise heating, air conditioning controls and setpoints	2
Fuel	Hot water	Maintain hot tank/well and line insulation, repair leaks	2

Possible energy efficiency opportunities with indicative paybacks (2 - 4 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Electricity	Services	Variable Speed Drive control of boiler fans	2.5
Fuel	Steam system losses	Maintain steam traps, optimise condensate return, insulate valves, flanges and lines, remove dead legs, repair all leaks	2.5
Steam	Efficient steam raising	Rationalise steam lines (section 3.3.5, pg 64)	2.6
Water	Plant cleaning	Floor cleaning machines for large areas (section 2.2.33, pg 50)	3
Electricity	Process Equipment	Variable Speed Drive control and automation of pumps (eg carcass washwater, wastewater pumps)	3
Electricity	Refrigeration & freezing	Automate chiller temperature profile control and implement fan speed controls	3
Electricity	Refrigeration & freezing	Optimise condenser operations eg pressure reduction using fan speed control, purging operations	3
Electricity	Refrigeration & freezing	Optimise ancillary equipment eg Variable speed drive for cooling tower fans, cooling and chilled water, refrigerant pumps	3
Fuel	Boiler losses	Install oxygen trim control	3
Electricity	All electricity	High efficiency motors	3
Water	Stockyard washing	Suspended mesh flooring (sheep + non-feedlot cattle) (section 2.2.8, pg 30)	3.3
Electricity	Alternative Sources	Cogeneration (section 3.7, pg 86-87)	3.5
Steam	Alternative fuel sources	Biogas from anaerobic ponds (section 3.4.3, pg 69)	4
Electricity	Refrigeration & freezing	Optimise compressor performance eg staging controls, variable speed drive controls, electronic expansion control	4
Fuel	Boiler losses	Automate blowdown on TDS and recover heat to boiler feedwater tank	4
Fuel	Process Equipment	Cover surface, insulate and recover heat from scalding tank water	4
Electricity	All electricity	Energy monitoring and control	4

Possible energy efficiency opportunities with indicative paybacks (over 4 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Electricity	Refrigeration	Evaporative cooling of carcases (section 3.6.3, pg 78)	4.8
Water	Cooling water on breaking saws	On/off controls for cooling water on breaking saws (section 2.2.20, pg 41)	5
Electricity	Services (lighting)	Best practice lighting technology	5
Electricity	Refrigeration & Freezing	Use conventional refrigeration rather than cryogenic freezing where feasible	5
Fuel	Hot water	Heat recovery from refrigeration superheat to pre-heat hot water	5
Fuel	Boiler Losses	Install economiser on boiler flue gas	5
Fuel	Process Equipment	Heat recovery from render plant cooker exhaust	5
Electricity	Refrigeration & Freezing	Optimise design of blast tunnel fans	6
Fuel	Boiler Losses	Upgrade to a high efficiency modulating burner with low turn down ratio	7
Steam	Reduce steam demand	Automatic diversion valves in bleed area to avoid dilution of blood (section 3.2.2, pg61)	10
Electricity	Refrigeration & Freezing	Upgrade to high efficiency, multiple stage refrigeration plant	10
Water	Pig scalding	Alternative scalding systems – water circulation spray scalding, steam scalding and condensation scalding (section 2.2.21, pg 41-42)	when replacing equip
Steam	Alternative fuel sources	Solar pre-heating of coal fired boiler feedwater (section 3.4.4, pg 72)	12
Steam	Alternative fuel sources	Solar pre-heating of gas fired boiler feedwater (section 3.4.4, pg 72)	2
Electricity	Refrigeration	Energy-efficient freezing systems (plate freezers rather than blast tunnel freezers (section 3.6.5, pg 80)	when replacing equip
Water	Stock washing	Timer controls for stock washing (section 2.2.7, pg 29) - prone to tampering?	
Water	Viscera (and bleed) table wash sprays	Use of warm water instead of hot water (section 2.2.11, pg 32) - hygiene limitations?	
Water	Knife and equipment sterilisers	Spray sterilisers for knife or equipment cleaning (section 2.2.14, pg 36-37) - can use same amount of water as well-designed continuous flow steriliser??	
Electricity	Motors	Avoid over-capacity motors (section 3.6.8, pg 83)	

Possible energy efficiency opportunities with indicative paybacks (over 4 years)			
Utility	**Process Equipment**	**Opportunity** (note - section and page numbers refer to Eco-Efficiency Manual)	**Payback (yrs)**
Electricity	Motors	Optimising piping layout to reduce pumping load (section 3.6.10, pg 84)	

Appendix 2. MIRINZ 1992 Information

Possible energy efficiency opportunities with indicative paybacks from MIRINZ 1992			
Utility	**Process Equipment**	**Opportunity**	**Cost**
Electricity	All	Reduce peak electricity loads by rescheduling processes so that they do not coincide with peak times	Low
Electricity	Refrigeration	Select appropriate refrigeration evaporating temperatures and maintain condensing pressure at lowest achievable	Low
Electricity	Refrigeration	Ensure good door discipline in cold rooms - keep doors on coldstores, chillers and freezers shut when not in use for loading	Low
Electricity	All	• Turn off lights, heaters, conveyors and other electrical equipment when not in use. • Put time switches on lighting and heating. • Check that compressed air utilities not leaking, are being used only when needed and are in good condition	Low
Steam	Piping	• Reduce heat losses, lag all steam and hot water pipes, • Avoid long pipe runs, • Fix steam and hot water leaks as soon as they are discovered	Low
Steam	All	• Shed peak heat loads • Operate the minimum number of boilers and reschedule heat loads so that the capacity of those boilers is not exceeded. • Use insulated tanks to store hot water when demand is low and then release it when demand is high	Low
Steam/ water	All	• Use water and steam efficiently. • Use water at the lowest temperature required for the job. • Use efficient wash-down techniques. • Fix leaking hot water taps and hoses quickly	Low
Electricity	Refrigeration	Modulate freezer fan speeds by setting to the minimum speed required to achieve the freezing specification	Medium

Appendix 3. US Department of Energy Information

Possible energy efficiency opportunities from U.S. Department of Energy - Energy Efficiency and Renewable Energy, Industrial Technologies Program		
Utility	**Opportunity**	**Average payback (yr)**
	0 – 1 year payback	
Electricity	Reduce the pressure of the compressed air system to the minimum required	0
Electricity	Use synthetic lubricants	0.1
Waste	Lease/purchase baler; sell cardboard to recycler	0.1
Electricity	Reduce illumination to minimum necessary levels	0.1
Electricity	Eliminate leaks in inert gas and compressed air lines/ valves	0.2
Boiler	Minimise water usage	0.2
Boiler	Repair leaks in steam lines and valves	0.4
Boiler	Install turbolators (into boiler tubes or heat exchangers to break up laminar flow)	0.4
All	Turn off equipment when not in use	0.4
Electricity	Reduce infiltration to refrigerated areas/ isolate hot equipment from refrigerated areas	0.5
Electricity	Install times and/or thermostats	0.5
Boiler	Insulate steam/hot water lines	0.7
Boiler	Direct warmest air to combustion intake	0.8
Boiler	Analyse flue gas for proper air/fuel ratio	0.9
Boiler	Insulate bare equipment	0.9
	1 – 2 year payback	
Boiler	Install/Repair insulation on condensate lines	1.1
Electricity	Install compressor air intakes in coolest locations	1.1
Boiler	Use Waste Heat from hot flue gases to preheat combustion air	1.1
Electricity	Use demand controller or load shedder	0.2
Electricity	Use more efficient equipment at its maximum capacity and less efficient equipment only when necessary	1.3
Electricity	Modify refrigeration system to operate at a lower pressure	1.3
Boiler	Use flue gas heat to preheat boiler feedwater (ie install economiser)	1.4
Electricity	Use more efficient light source	1.6
Electricity	Install occupancy sensors	1.6

Possible energy efficiency opportunities from U.S. Department of Energy - Energy Efficiency and Renewable Energy, Industrial Technologies Program		
Utility	**Opportunity**	**Average payback (yr)**
Electricity	Utilise high efficient lamps and/or ballasts	1.6
Electricity	Optimise plant power factor	1.8
Over 2 year payback		
Electricity	Recover and reuse cooling water	2.3
Electricity	Use Power Factor controllers	2.4
Boiler	Recover heat from refrigeration condensers	2.4
Electricity	Use multiple speed motors of AFD for variable pump, blower and compressor loads	2.7
Electricity	Use most efficient type of electric motor	8.5

* from 1982 – 2010, free audit program run by US Government from 26 centres at 31 Universities, details at http://iac.rutgers.edu/database/index.php