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Energy savings calculator and Energy allocation project

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Contents

Key issues

Energy Savings Calculator (ENV055)

- The energy savings calculator was integrated into the energy allocation tool, so that sites only had to enter utility data once
- Given the recent drought and ongoing economic pressure on meat processing sites, payback periods of less than 2 years were generally expected
- Most of the short to medium term savings will result from a combination of
    - Hardware changes – relatively small changes to lighting, steam and hot water systems (insulation, flow restrictors in supply lines, triggers on hoses, efficient nozzles)
    - Software changes – changes to or enforcement of procedures eg ensuring equipment is switched off at breaks/ end of shift, closing doors on chillers
- The program has been simplified to allow for common energy saving projects, such as recovering waste heat from water, reducing water use, changing lighting etc. Given current low electricity prices, changing major capital items, such as refrigeration systems and large motors, is not likely to be economic until the end of the normal life cycle, when a decision can be made to install a more energy efficient item
- The program allows for a cost of carbon to be entered, in the event of future carbon trading
- The program has been designed to be as transparent as possible, so that someone using the program can see where data is coming from and going to, rather than a “black box” approach. It is intended that this can assist with training and awareness of staff. This includes naming cells eg “boiler efficiency” rather than simply using cell references

Energy Allocation (ENV058)

- Although the original scope required only the energy cost of individual products, this report contains information on greenhouse gas “costs” and embodied energy too, and considers the amount of energy consumed by the plant in producing various products. To ensure that best case benchmarks are set, this included assuming that the boiler is a natural gas boiler operating at 85% efficiency (although this can be changed by the site)
- It is strongly advised that sites install submetering to areas they want to be able to allocate energy to, and link this into the computer systems to automate the collection of information. Without an automatic submetering system, a disproportionate use of labour is required to capture and analyse the data, and this can lead to time delays which mean that the data is less useful for management purposes

From the results, the following observations can be made:

- Due to the higher emissions intensity of electricity, it accounts for more of the total t CO_{2-e} than it does the total MJ of energy
- Electricity is also generally more expensive per unit of energy provided that boiler fuel.
- Electricity use in the kill floor varies significantly, mostly due to the level of automation in the process and the physical location of the plant – plants in southern Australia, where temperatures and relative humidity’s are lower, would be expected to have lower values than more northern plant given that refrigeration consumes the majority of electricity on all sites.
- Electricity use in the boning varies significantly, mostly due to the level of automation in the process and the amount of value adding done at the plant, rather than inefficiencies
- Electricity and thermal energy use in the rendering plant do not vary much, due to the more standard nature of equipment and processes in rendering plants. The energy density of rendering products are much higher than the main product, by an order of magnitude

1. Energy Savings Calculator Project (ENV055)

This project involved enhancing the Energy Savings Calculator developed by an AMPC vacation student during the summer vacation of 2006-2007 to include greenhouse savings and payback periods.

The output of this project is incorporated into the Energy Allocation Tool excel spreadsheet. The worksheet is split into electricity and thermal energy savings and the energy saving action items which can be investigated include:

- For electricity:
  - Lighting
  - Motion sensors on lighting system
  - Variable speed drives
  - High efficiency motors
  - Compressed air
- For thermal energy (hot and warm water)
  - Reducing hot and warm water flows
  - Recovering waste heat from water
  - Reducing heat loss from pipes
  - Reducing steam leaks
  - Reducing heat loss from boiler blowdown
- Biogas generation potential
- Space to add information for other audits

The results can then be summarised into a table which is designed to comply with the requirements of the new Federal Energy Efficiencies Opportunities Act (2006).

2. Energy Allocation Project (ENV058)

2.1 Background on project

New Federal Government requirements as part of the Energy Efficiency Opportunities (EEO) Act require corporate groups that consume more than 0.5 PJ per year to take a comprehensive, management system approach to energy and greenhouse management.

Specifically, the corporate group must assess all sites with over 0.5 PJ use and 80% of their corporate groups total energy consumption in the first five years EEO cycle. This requires companies to complete a mass and energy balance for 80% of a sites usage to within 5% accuracy based on 24 months of data.

The aim of this project is to generate an energy survey proforma tool permitting the energy cost of individual meat products: particularly meat (as HSCW), tallow and meat meal to be determined accurately from facility data and to identify this cost of Australian industry.

This report supplements the energy survey proforma tool (as excel spreadsheet). Ultimately, plants will be able to allocate energy and greenhouse emissions to various products, in response to emerging consumer demands for greenhouse information.

2.2 Energy usage at meat processing plants with rendering

In preparation for the site visits, an analysis of existing industry data was completed to identify indicative key performance indicators. The key users of energy in the plant are also identified as the EEO Act requires that 80% of the sites energy users re investigated in the first five year round.

The 3 key areas of energy usage at a “typical”1 meat processing plant, which includes rendering, are:

Table 1: Energy use and corrected input into meat processing plant

	% of total energy use[2]	Corrected % of site **energy use**[3]	Corrected % of site **energy input**
Steam	51	59	63
Electricity	28	33	30
Hot water	21	8	7

The corrected % of site **energy use** makes allowance for the heat recovered from the rendering process and used in hot water generation, which basically allows for a 60GJ or 14% "credit". This increases the relative significance of steam and electricity use compared to hot water use.

These numbers look principally at energy used in the process, rather than the energy consumed in the process overall (ie the **energy input**). This is appropriate for electricity but for boiler fuel use, the efficiency of converting the fuel to steam can vary depending on factors such as fuel type, boiler maintenance, boiler operation (constant vs varying loading, operating capacity vs installed capacity) and so on. The energy use figures actually underestimate the contribution of steam to the overall energy use onsite, as they look at the demand rather than the energy required to produce this demand (to allow for the efficiency of the boiler). To ensure that best practice is promoted and a more thorough and consistent approach to allocating energy use, this report assumes a boiler efficiency of 85%, which is best practice for a natural gas fired boiler. The calculated figures allow for losses in the system, that is, between the boiler where the steam/hot water is produced, through the reticulation/supply system to the end user. Once again, this increases the significance of the boiler system in the total site energy system relative to electricity and hot water use. This is fortunate, as sites directly control their boilers.

[1] A typical meat processing plant is defined as processing the equivalent of 150 t HSCW/ day, which is equivalent to 625 head of cattle, 5 days per week, 50 weeks per year, and boning and rendering of all t HSCW takes place onsite

[2] MLA, Eco-Efficiency Manual for Meat Processing Manual, 2002

[3] Calculated using MLA Eco-Efficiency Manual for Meat Processing Manual 2002 Figures

[4] Taken from various confidential industry sources

A more detailed breakdown is taken from Table 3.1 (MLA, 2002) and provided in the following tables, corrected for the "credit" for heat recovery from rendering (corrected energy use) and boiler efficiency (energy input).

Table 2: Detailed breakdown of steam use in meat processing plant

	% of steam use[2]	% of total energy use[3]	Corrected % of **energy use**[3]	Corrected % of **energy input**[3]
Rendering	70	36	42	44
Hot water production	13	7	8	8
Blood processing	9	5	6	6
Losses from pipes	5	2	3	3
Tallow processing	2	1	1	1

Table 3: Detailed breakdown of electricity use in meat processing plant

	% of electricity use	% of site energy use	Corrected % of **energy use**	Corrected % of **energy input**
Refrigeration	68	19	22	20
Motors	21	6	7	6
Air compression	8	2	3	3
Lighting	3	1	1	1

Table 4: Detailed breakdown of hot water use in meat processing plant

	% of hot water use	% of site energy use	Corrected % of **energy use**	Corrected % of **energy input**
Knife / equipment sterilisers	34	7	2.7	2.4
Plant cleaning	28	6	2.2	2.0
Slaughter and evisceration	17	4	1.3	1.2
Hand wash stations	6	1	0.4	0.4
Amenities	6	1	0.4	0.4
Heat loss from hot water pipes	6	1	0.4	0.4

The top 5 areas for energy use/input for a meat processing plant with onsite rendering and heat recovery from rendering for hot water production are therefore

Table 5: Top 5 energy users (over 80% of total) in meat processing plant with rendering

	% of site energy input
Rendering steam use	44
Refrigeration	20
Hot water production	8
Motors (pumps, fans, conveyors etc)	6
Blood processing	6
Total	84

If we assume varying percentages of electricity use in rendering, basic conversions as per Figure 4.1 from the Eco-Efficiency Manual and 85% boiler efficiency, then the following key performance indicators can be derived. This analysis allows a comparison with the results from actual plants visited.

Table 6: KPI for various percentages of electricity use in render plant

	10% electricity used in render	30% electricity used in render	Current benchmarks
kWh/ t HSCW	197	153	400 #
kWh/t boning room product (BRP)*	287	223	
kWh/ t rendering product (RP)	161	484	
MJ stationery energy/ t HSCW	420	420	
MJ stationery energy/ t BRP	613	613	
MJ stationery energy/ t RP	10,613	10,613	
MJ total energy/ t HSCW	1,128	971	3,389 +
MJ total energy/ t BRP	1,645	1,415	
MJ total energy/ t RP	11,194	12,356	

* assumes that all the HSCW is boned onsite + 69% boning room yield
\+ from MLA Industry environmental performance review (2005)
\# from UNEP Working Group for Cleaner Production as quoted in Table 1.4 of Eco-Efficiency Manual

This analysis confirms that the vast majority of the total energy used in an integrated meat processing plant is used in the rendering plant, as the rendering energy use has been removed from the t HSCW figures. Of the energy used in the kill floor/boning room (ie non rendering), slightly over half (57-63%) is electricity use and half is hot water use.

2.3 Energy usage at meat processing plants without rendering

A desktop analysis of the same data was conducted prior to site visits, so that ball park key performance indicators could provide a basis for comparison. The amount of energy used in meat processing plants without rendering depends on the efficiency of the hot water generation and how much we assume has been used in the rendering plant.

Table 7: Plant without rendering – percentages of electricity vs hot water

Efficiency of hot water generation	% electricity used in render	Total site MJ/ day for 150t HSCW/d	% of site MJ used as elect	% of site MJ used as hot water
50	10	458,200	23	77
50	30	434,600	19	81
75	10	262,644	40	60
75	30	239,044	35	65
80	10	243,700	44	56
80	30	220,100	38	62
85	10	227,999	47	53
85	30	204,399	40	60
90	10	214,842	49	51
90	30	191,242	43	57

If we assume varying percentages of electricity use in rendering and varying efficiencies of hot water generation, a similar table to Table 6 can be derived.

Table 8: Electricity KPI for non rendering meat processing plants (assuming various percentages of electricity use in render plant removed from figures)

	10% electricity used in render	30% electricity used in render	Current benchmarks+
kWh/ t HSCW	245	191	
kWh/t boning room product (BRP)*	357	278	

Table 9: Stationery and Total Energy KPI for non rendering meat processing plants assuming 50% hot water generation efficiency

	10% electricity used in render	30% electricity used in render	Current benchmarks+
MJ stationery energy/ t HSCW	1,173	1,173	
MJ stationery energy/ t BRP	1,710	1,710	
MJ total energy/ t HSCW	1,881	1,724	3,389
MJ total energy/ t BRP	2,742	2,513	

Table 10: Stationery and Total Energy KPI for non rendering meat processing plants assuming 90% hot water generation efficiency

	10% electricity used in render	30% electricity used in render	Current benchmarks+
MJ stationery energy/ t HSCW	652	652	
MJ stationery energy/ t BRP	950	950	
MJ total energy/ t HSCW	1,360	1,203	3,389
MJ total energy/ t BRP	1,982	1,753	

2.4 Energy "Costs" & tariff structures

Electricity

The way that electricity retailers structure their contract varies significantly as indicated in Table 11. An electricity retailer would prefer it if each site used the same amount of electricity all the time. Meat processing sites, which have a substantial variation in load throughout a day and the peak load coinciding with the electricity supply system peak, will be charged more than sites which have a constant load.

Table 11: Variations in electricity contract arrangements[4]

Time period	Peak 1400 – 2000 hours weekdays Shoulder 0700 – 1400 and 2000-2200 weekdays Offpeak all other times
Usage Rates	Peak $0.05 – 0.10 per kWh Shoulder $0.05 – 0.09 per kWh Offpeak $0.03 – 0.06 per kWh
Demand charge	Ranged from $1.41 – $8.94 per kVA per month

It is interesting to note that with the sites investigated as part of this project:

- Peak and shoulder periods were merged into the one tariff time period
- Demand charge was at the higher end but usage rates were at the lower end. This reflects the poor daily load profile of meat processing plants

Companies with all plants located in the National Electricity Market (NEM), which covers the eastern states (SA, QLD, NSW, Vic, Tas, ACT), can negotiate with an electricity retailer for supply to all their sites. This practice is used by large companies such as Coles, Woolworths, Telstra etc and can lead to substantial savings.

As most electricity bills already have or soon will have a demand (kVA) component, this has been included in the KPI section.

Boiler fuel

The program only considered the energy costs of the boiler system, not the operating and maintenance costs. The latter can be quite significant for solid fuel systems when compared to gas or liquid fuel systems, so that even thought the unit cost of coal is low, the total effective price can actually be higher and more comparable to other fuels.

2.5 Site investigations

Four sites were investigated to determine if the above figures were representative. Two sites did have onsite rendering and two did not, so are reflective of the range of plants operating in the meat industry. Two plants were integrated beef/cattle plants and the other two were sheep plants.

The sites were provided with a partly completed program and then asked to use it. Sites were also provided with a summary of the findings and observations from the site visits once the program was finalised. Due to the lack of inhouse metering, estimates were often required to complete the energy and water balances, but these can be checked by more detailed audits at a later stage.

2.6 Assumptions

A number of simplifying assumptions were made to minimise the amount of data that sites needed to enter into the program. These are listed in the excel spreadsheet as comments, but are also included here:

- Hot and warm water energy use was corrected for boiler efficiency and system losses to ensure that the actual energy used in not understated
- The amount of electricity and thermal energy used in each area was calculated from the site audit proforma, and then the electricity and thermal energy used in non process areas was allocated according to
  - For electricity use
    - Refrigeration and loadout consumption was allocated on the basis of the change in temperature of the product, which is an indication of the amount of “work” the refrigeration system has to do in each area. This is a relatively simple method, which avoids problems with allocating electricity usage between the high and low stage refrigeration plant but instead focuses on the process loads
    - Administration and amenities were allocated on the basis of the corrected percentage of staff in each main area
    - Outside usage, including wastewater treatment, was allocated on the basis of volume of water used in each area
    - Boiler/ Utilities usage was allocated on the basis of the thermal content of the water used in each area
  - For thermal energy use
    - Refrigeration and loadout consumption was allocated on the same basis as electricity
    - Administration and amenities were allocated on the same basis as electricity
    - Outside usage, including wastewater treatment, was allocated on the same basis as electricity
- Heat recovery has a significant impact on the overall efficiency of plants, which means that integrated plants have an advantage over. For plants with rendering, heat recovered from the rendering plant was entered as a negative energy value in the balance, to ensure that only the actual energy consumed in the rendering plant was allocated to rendering. This allows for a more balanced comparison between integrated and non-integrated plants to allow for the “credit” for co-locating rendering.
- If condensate, hot or warm water were returned from a process area, this was entered as a negative value in the spreadsheet, effectively giving a “credit” to the process area to ensure that actual energy embodied in the product from that area was not overstated

3 Results

3.1 Site visits – general findings

General findings from site visits are summarised in the table below:

Table 12: General findings from site visits

Issue	Finding
Boiler fuel supply	• Most sites had access to natural gas for boiler fuel, even though it may not have been used as it was more costly than the alternative (coal)
Electricity tariffs	• Most sites only had peak and offpeak tariffs, with no shoulder period. Peak period tending to cover what is normally covered by the shoulder period at a lower tariff. In one instance, the peak period covered the whole of Saturday • sites had a usage and a demand component to their bill and the demand component was usually about 50% of the total bill amount • tariffs (c/kWh and kVA) were within the ranges provided, so do not appear excessive
Metering	• most sites only had the meter coming into the plant, without much in the way of submetering within the plant
Equipment Lists	• most plants had a list of equipment installed at the plant, some plants also had a sublisting of motors which included number, kW rating and type (DOL, Star/ Delta etc) • Most plants had redundancy in key equipment, such as boiler pumps, air compressors, blood pumps, hot and warm water pumps, some wastewater pumps • Most plants had over capacity in key equipment such as refrigeration capacity, to ensure that peak requirements could be met despite equipment outages
Backup electricity supply	• No plant had a backup power supply, meaning a loss of grid power for an extended period would probably lead to a loss of product

3.2 Key Performance Indicators & Energy/Greenhouse Costs

The key performance indicators for the sites investigated are indicated below.

Table 13:KPI’s for Products – Energy Allocation and Greenhouse

Key Performance Indicator				Values	Factor
Electricity	kWh per tonne of product		t HSCW t boning room product t meal + tallow	48-207 125-510 144-208	4.3 4 1.4
		cost per tonne of product	t HSCW t boning room product t meal + tallow	$5.07-16.54 $13.21-40.84 ~$10	3.3 -
		t CO_{2-e} per tonne of product	t HSCW t boning room product t meal + tallow	0.05 – 0.23 0.13 – 0.53 0.15 – 0.22	4.6 4 1.5
Thermal energy	MJ per tonne of product		t HSCW t boning room product t meal + tallow	489 – 1,000 694 – 2,181 3,025 – 5,051	2 3 1.7
		cost per tonne of product	t HSCW t boning room product t meal + tallow	$1.16 - $4.42 $3.01 - $9.28 ~$8	3.8 3.1 -
		t CO_{2-e} per tonne of product	t HSCW t boning room product t meal + tallow	0.03 – 0.09 0.04 – 0.19 0.39 – 0.47	3 4.8 1.2
Total energy use	MJ per tonne of product		t HSCW t boning room product t meal + tallow	661- 1,451 1,142 – 3,685 3,774 – 5,569	2.2 3.2 1.5
		cost per tonne of product	t HSCW t boning room product t meal + tallow	$9.50 - $17.69 $19.49 - $43.85 ~$20	1.9 2.2 -
		t CO_{2-e} per tonne of product	t HSCW t boning room product t meal + tallow	0.08 – 0.28 0.17 – 0.71 0.61 – 0.62	3.5 4.2 1

Observations about the above information include:

- Due to the higher emissions intensity of electricity, it accounts for more of the total t CO_{2-e} than it does the total MJ of energy
- Electricity is also generally more expensive per unit of energy provided that boiler fuel.
- Electricity use in the kill floor varies significantly, mostly due to the level of automation in the process and the physical location of the plant – plants in southern Australia, where temperatures and relative humidity’s are lower, would be expected to have lower values than more northern plant given that refrigeration consumes the majority of electricity on all sites.
- Electricity use in the boning varies significantly, mostly due to the level of automation in the process and the amount of value adding done at the plant, rather than inefficiencies

- Electricity and thermal energy use in the rendering plant do not vary much, due to the more standard nature of equipment and processes in rendering plants. The energy density of rendering products are much higher than the main product, by an order of magnitude

3.3 Energy Savings Calculator Trial

Results from the plant trials of the calculator are summarised below:

- It was difficult for site personnel to find blocks of time to obtain the data required to populate the databases, given their many other responsibilities
- On the thermal energy balance, it would be useful to include cost estimations for each line item, as is provided in the electricity balance
- It would be useful to have graphs to represent the information from the summary page
- Some sites had very stringent security protocols for accessing the internet, problems with software compatibility or problems with internet access/ reliability (given their regional location), so it was though prudent to provide all information in a stand-alone hard copy version
- This project would be ideal to allocate to someone, such as a summer student or trainee/apprentice, who could focus solely on this project for 2+ months. This would enable the site to undertake readings for process areas to obtain a more accurate balance, given that most plants do not have submeters.

3.4 Future trends

These results represent a snap shot of the industry at a point in time. It is important to consider that there are a number of impacts which are likely to change these figures in future, most of which point to these benchmarks increasing over time due to factors which are largely outside the control of meat processing sites.

Table 14: Factors likely to influence key performance indicators

Energy type	Factor	Change	Likely impact on usage	Controlled by site?
Electricity	Level of automation	Likely to increase due to o increasingly stringent OH&S and Quality requirements o increasing labour costs and constraints on labour availability	Electricity consumption will increase per unit of production as tasks which are currently done manually are in future done by machines	Partly
	Refrigeration load due to climate change	Likely to increase due to o increase in average ambient temperatures o increase in humidity, particularly in northern half of Australia	Electricity consumption will increase per unit of production	No
	Power quality and reliability	Likely to decrease due to o increasing frequency and severity of storms due to climate change o increasing peak demand due to growth in residential HVAC o peak demand for meat processing sites coincides with peak electricity network demand (ie hot summer afternoons)	Electricity consumption may increase due to increased frequency of brownouts/ blackouts, requiring plant restarts, particularly for sensitive electronic equipment eg boning room	No, unless onsite power generation installed
	Inclusion of carbon cost	Likely to increase price of electricity	Increases pressure to reduce usage	No
	Retailer contracts and billing ie cost	Likely to increase due to • inclusion of demand component of bill (if not already present) or increase in effective “penalty” for poorer load factors and peak usage occurring at some time as system peak • possible inclusion of summer peak power demand charges	Increases pressure to reduce usage through • permanent demand reduction ie energy efficiency • load shedding or load shifting to offpeak periods • embedded generation eg cogeneration to reduce site peak load • power factor correction	Retail contracts
Boiler fuel	Food safety & quality requirements	Likely to become more stringent and limit the amount of recycling and reuse options available, particularly for export plants	Likely to increase hot and warm water use, which will in turn increase boiler fuel consumption due to • additional clean down • additional separation of byproducts/wastes	No

	Inclusion of carbon cost	Likely to increase price of electricity	Increases pressure to reduce usage	No

4 Recommendations

1. Sites could investigate installing additional metering to process areas which produce products they want to be able to allocate energy/greenhouse too. These meters would ideally be integrated into an automated monitoring system, such as SITEC, so that readings are taken automatically to minimise the amount of data handling required (and the potential for error)

2. Plants can use the results from the audit proforma to identify the most costly items of equipment to operate (in terms of cost and energy). Sites with rendering focus on minimising heat use (ie steam) in rendering and look for opportunities to recover waste heat from water streams. Plants without rendering should focus on the largest hot water users

3. The tool could be used by Victorian sites who have new legal requirements and has been developed to be consistent with Energy Efficiency Opportunity requirements.

5 References

Meat and Livestock Australia (MLA) 2002, “Eco-Efficiency Manual for Meat Processing”, Meat and Livestock Australia, Sydney

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