Energy Management Overview

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AMT
AUSTRALIAN MEAT TECHNOLOGY

The reasons for good energy management in any industry are twofold. Firstly, it can reduce total energy costs to the plant, resulting in a direct saving. Secondly, reduced energy consumption is more 'environmentally friendly', since increased energy use means increased (and usually detrimental) environmental effects through emissions from coal burning used for electricity, or from gas burning used for heat.

It is therefore important, both for the company and for the environment, to effectively and efficiently manage energy production and consumption in the plant. Equally important are monitoring and targeting programs to ensure continuation of correct and effective energy management practices. An energy audit throughout the plant every few years would be an appropriate program which could also be beneficial for isolating any problem areas.

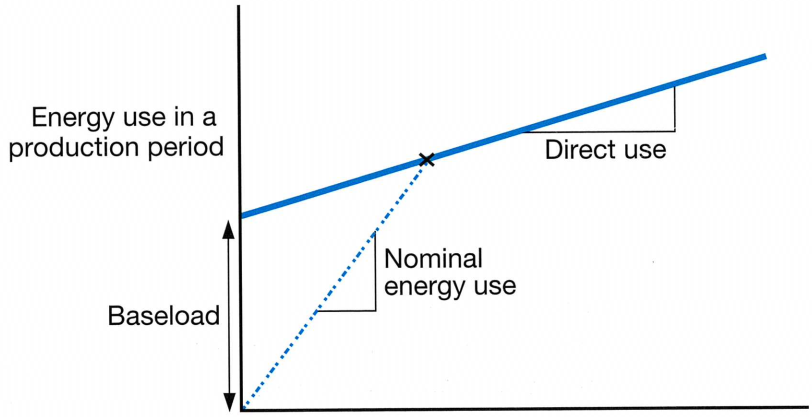
Processing Capacity

The production of an abattoir is rarely constant throughout the year and can vary from one year to the next, depending on climate as well as supply and demand. For example, a plant may operate at 80% production capacity on average, up to 100% capacity in peak periods and down to 30% capacity during slow periods. The energy consumed during each of these three scenarios is not in proportion to production. The reason for this is that plants consume a certain amount of energy just to operate, independent of production. Significant overhead costs exist, as Figure 1 illustrates, in a so-called 'baseload' component which is the energy that would be used if the plant was held perpetually in a state ready for processing but without throughput (Cleland, 1997).

Surveys of New Zealand meat processing plants have been regularly carried out over the past 25 years, and reported on by Fleming and Kemp (1992). In over 13 plants, the baseload contributed between 20% and 60% (mean = 40%) of the fuel use, and for over 22 plants the baseload was responsible for between 30% and 65% (mean = 50%) of the electricity use. Additionally, plants rendering on-site tend to use more fuel per tonne of product processed.

A survey, in which plants were grouped according to whether they had coldstores or not, was performed in Australia. On-site coldstores were found to have a significant baseload factor (Graham, 1979).

FIGURE 1 Baseload, nominal and direct use components of energy use (Cleland, 1997)



Facility Design

Energy management is an important consideration in the design of a new meat processing facility, and in the design of a modification to an existing plant to reduce baseload energy consumption as well as minimise energy consumption during processing. Figures 2(a) to 2(d) show four possible concept diagrams for energy use as a function of product throughput (Cleland, 1997). In all four graphs, greater differences occur between options as production capacity increases.

Basic features, such as choice of lighting (fluorescent over incandescent) as well as construction and building materials, can also have a significant impact on the total energy consumption of an abattoir. One example is in the batch chilling room (Cleland, 1997). If a 100mm thick concrete floor heats to 20°C (as a result of using hot water for cleaning), and recools to 2°C daily for 200 days per year, the annual cost of recooling the floor is about NZ$25/m^2. Added to this cost will be that of the extra refrigeration capacity required to handle the floor-cooling load and the interference of the floor heat load with the task of cooling the air (Cleland, 1997).

This is one of many examples in which heavy building construction, due to materials with poor thermal inertia (poor insulation), raises energy costs. Hence, there is a demand for low-thermal-inertia building materials, and one solution that is commonly used for walls and ceilings is foam panel insulation.

FIGURE 2(a) Effect of capital cost on energy usage

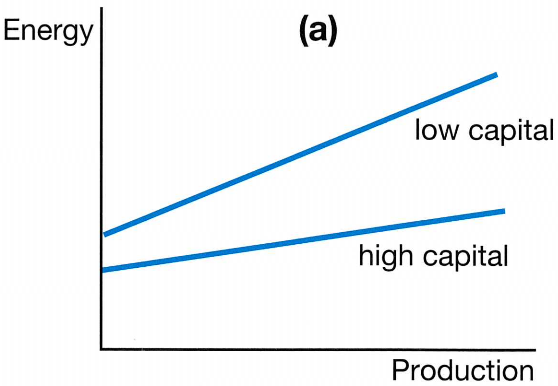


FIGURE 2(b) Effect of automation on energy usage

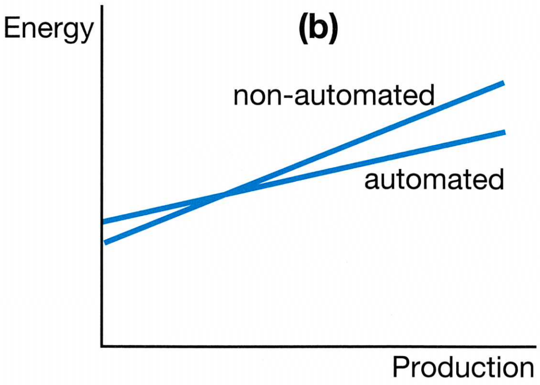


FIGURE 2(c) Effect of plant age on energy usage

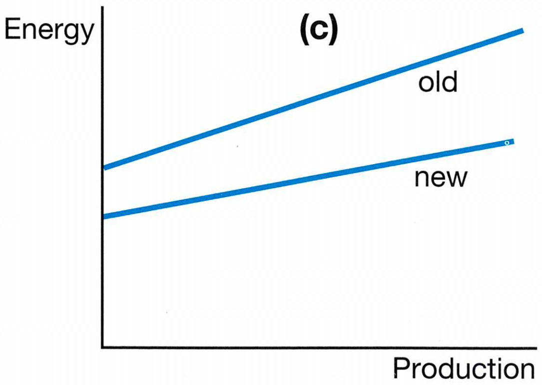
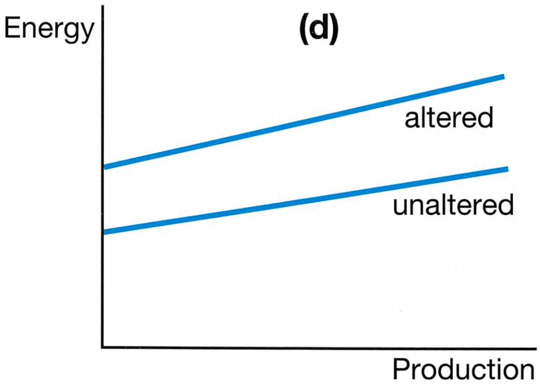


FIGURE 2(d) Effect of building alterations and process add-ons on energy usage. This does not include process technology replacement for an existing process



Greenhouse Gas Emissions

Table 1 lists the major greenhouse gas emissions that can be generated in meat plants. Many other greenhouse gases are produced, but to a lesser extent. For example, H_2S and volatile fatty acids are produced in biological treatment systems during anaerobic digestion, although these emissions are not the result of energy management within the production areas of the abattoir itself. In addition, rendering systems, particularly dry rendering cookers, generate greenhouse gases during the material heating phase; however, most of the gases produced are combined with the condensed vapours and enter the wastewater treatment system, with moderate levels of volatilisation to the atmosphere.

TABLE 1 Sources of greenhouse gases in an abattoir with the major greenhouse gas emissions in relation to energy management

Source	Emissions
Coal-fired Boiler	CO_2 CO CH_4
Gas-fired Boiler	CO_2 CO
Rendering	CO_2 NH_3

The primary reason for greenhouse gas emissions from on-site heating processes such as boilers is the inefficient burning of the fuel used to generate the heat. Gas, although more expensive than coal for a given energy output, is a cleaner fuel since other pollutant gases including sulphur dioxide and nitrogen oxides are not released. Moreover, coal burning will generate more carbon dioxide than gas for a similar energy output because of its higher carbon content. Therefore, more efficient burning of fuels will reduce the output of greenhouse gases from a plant. Some gases, including the methane (CH_4) generated during anaerobic digestion, may be collected and used as a fuel to save on total fuel costs.

Process Integration and Pinch Analysis

Process integration and pinch analysis can be used to optimise energy usage and heat recovery from plants as a whole (Linnhoff *et al*., 1994). Hot and cold streams in the plant are identified, followed by the use of a systematic method to determine the process 'pinch', which represents the bottle-neck for heat recovery. Once the pinch is found, heat exchange networks and waste heat recovery techniques can be designed.

Table 2 lists the results of applying pinch analysis to different processes, either for new facilities or modifications to existing plants.

Only some of the processes in Table 2 were in operation at the time of the analysis (1994), and are all in the U.K. where pinch technology was developed and commercialised. It was used in New Zealand in the late 1980s and has now been applied by a wide range of industries, including those in the food and drink sector and the meat industry, mainly to analyse energy use at existing sites (Cleland and Kallu, 1997).

Pinch analysis is easiest to apply in plants with time-constant heating and cooling demands, e.g. petrochemical plants. Meat plants typically have time-varying heating and cooling demands, making it more difficult to apply pinch analysis without the use of computer prediction tools. Chadderton (1995), however, applied pinch analysis to case study beef and lamb plants and showed it to be a useful tool for optimising heat exchange networks between heating and cooling processes.

TABLE 2 Results of applying pinch analysis to projects (Linnhoff *et al.*, 1994)

Process	Facility*	Energy savings available $/yr	Capital cost expenditure or savings $
Organic bulk chemical	New	800 000	Same
Specialty chemical	New	1 600 000	Saving
Crude unit	Mod	1 200 000	Saving
Inorganic bulk chemical	New	320 000	Saving
Specialty chemical	Mod	200 000	160 000
	New	200 000	Saving
General bulk chemical	New	2 600 000	Unclear
Inorganic bulk chemical	New	200 000 to 360 000	Unclear
Future plant	New	30 to 40%	30% saving
Specialty chemical	New	100 000	150 000
Unspecified	Mod	300 000	1 000 000
	New	300 000	Saving

Strategies for Saving Energy

The following list outlines some of the strategies for reducing energy usage [Meat Industry Research Institute of New Zealand (MIRINZ), 1992]. Some *low-cost* ones are:

- Choose the best power tariff that best suits the electricity load profiles in the plant.
- Reduce peak electricity loads by rescheduling processes so that they do not coincide with peak times.
- Select appropriate refrigeration evaporating temperatures and maintain the condensing pressure at the lowest achievable.
- Ensure good door discipline in cold rooms. Keep doors on coldstores, chillers and freezers shut when not in use for loading.
- 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 are not leaking, are being used only when needed, and are in good condition.
- 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.
- Shed peak heat loads. Operate the minimum number of boilers needed 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.
- 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.

Medium-cost strategies for energy savings are available, although may require significant modifications to equipment and/or operations. Examples of these strategies include:

- Modulate freezer fan speeds by setting to the minimum speed required to achieve the freezing specifications.
- Recover waste heat. Significant amounts of waste heat can be recovered from processes which use large amounts of heat such as rendering processes.

Longer term strategies for energy savings will involve a tiered approach, which begins with appointing a person as an 'Energy Management Officer'. This person could be an existing staff member who has a good general knowledge of the plant workings or a new employee knowledgeable in meat plants and energy management.

Following the selection and appointment of an appropriate Energy Management Officer, a plant-wide audit on energy consumption should be carried out to provide a current 'base-case' scenario. This base-case can then be used to produce a new (or an improvement on an existing) energy management program for reduced energy consumption.

Staff training should be carried out. Strategies will only be successful if staff are more closely involved in the energy management program.

On-going monitoring and targeting programs should be adopted to ensure that the plant-wide energy management strategies are carried out effectively, and to provide potential improvements on the energy management program.

A number of computer software packages from MIRINZ are available to help with the decision-making processes during production of an energy management program. These software packages have been developed for modelling and analysing energy and product-related issues in meat plants (MIRINZ, 1992).

References

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7. MIRINZ Information Bulletin No. 20, 'Energy Use and Conservation', November 1992, Meat Industry Research Institute of New Zealand.

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