Environment

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Eco-Efficiency Manual for Meat Processing

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Queensland Government
State Development

MEAT & LIVESTOCK AUSTRALIA

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State Development

Foreword

Meat processing is an important manufacturing activity for Queensland. It is one of the largest sectors in Queensland's food and beverage industry. Queensland is Australia's largest producer of meat, with more than 11 million head of cattle, and processing close to 50 per cent of Australia's total.

World demand for safe, healthy meat and processed meat products grows each year, and Queensland is highly regarded for its quality products and consistent supply.

Queensland's meat processing industry faces many challenges in today's competitive international market, with environmental issues being high on the list. The Queensland Government, in partnership with the industry, has identified methods for improved environmental outcomes through the employment of eco-efficient practices.

A key element of the Government's Smart State strategy is to give Queensland a competitive edge by enhancing our traditional industries with 21st century technology.

The achievements of Queensland's meat processing industry is testament to the success of this strategy, where effective environmental management in this industry is viewed proactively as yet another opportunity for Queensland to lead the way.

Information on eco-efficiency has been widely dispersed and this manual provides an up-to-date, comprehensive consolidation of this information.

The Queensland Government will continue to work with meat industry representatives to ensure the continuing profitability and good environmental performance that assures a more livable environment for all Queenslanders.

PBeattie

Peter Beattie MP
Premier of Queensland

TBarton

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Minister for State Development

Eco-Efficiency Manual for Meat Processing

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The authors wish to acknowledge the valuable input provided by the Project Steering Committee, which was made up of representatives from meat processing plants and meat industry research and support groups.

Introduction

The manual explores opportunities to employ eco-efficient practices in the meat industry. Eco-efficiency is a concept being adopted by industries world-wide as a means of improving environmental performance and reducing costs. Its objectives are the more efficient use of resources and the reduction of waste, with the twofold benefits of reduced environmental burdens and reduced costs for resources (water, energy, materials) and waste management.

Traditionally, many industries have relied on end-of-pipe solutions to deal with environmental problems. In contrast, eco-efficiency focuses on reducing or eliminating environmental problems at the source by examining the cause of the problem and coming up with ways to avoid, reduce, reuse or recycle wastes and to use resources more efficiently.

There are many reasons for adopting eco-efficiency. Financial savings are generally the most attractive, but many companies have elected to adopt eco-efficiency for other reasons — stricter environmental standards, greater community expectations, improved image with customers, the expectation of increasing costs for water, energy and waste disposal, or the longer-term sustainability and competitiveness of their businesses.

This manual has been developed to assist meat processors to adopt a more eco-efficient approach to their operations by providing information on how to take the first steps towards eco-efficiency and details of practical eco-efficiency opportunities specific to meat processors.

The manual covers red meat processing (beef, veal, mutton and lamb). Some reference is also made to pig processing, recognising the fact that many plants process multiple species including pigs. Beef processing has a stronger representation due to its dominance in the Australian meat processing sector. Processors of other species (including goat, kangaroo and horse etc.) should still find this manual of considerable use.

Since the early 1990s numerous publications containing aspects of information about eco-efficiency have been prepared by various meat industry research groups. These publications have been the source of much of the information in this manual. The manual represents a consolidation and update of this information relating to eco-efficiency from these earlier publications, supported with practical case studies and cost-benefit information.

Definition of a typical meat plant

Throughout this manual reference is made to a 'typical meat plant', for the purposes of describing resource use and waste generation at meat plants, and for estimating the savings possible from the eco-efficiency opportunities presented in this manual.

A 'typical meat plant' is defined as a plant processing the equivalent of 150 tonnes Hot Standard Carcase Weight (HSCW) per day, which is equivalent to 625 head of cattle per day, based on a conversion rate of 240 kg/head. Production is assumed to take place 5-days per week, 250 days per year, and boning and rendering takes place.

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Part 1

Executive summary

1.1 Profile of meat processing

Meat processing is one of the largest sectors within Australia's food and beverage industry, accounting for around 20% of the economic value and 30% of the employment (see Table 1.1).

Within the meat processing sector, beef and veal products are produced in the highest quantity, representing over 50% of total meat production (including poultry) in Australia. A large proportion of Australia's meat production (close to 50%) is exported (see Table 1.2).

Queensland is Australia's largest processor of meat, processing close to 50% of the national total (see Table 1.3).

Meat processing plants can range from small, family owned businesses processing less than five tonnes of carcase per day through to large corporately-owned firms processing over 600 tonnes of carcase per day.

Like many other agri-based industries in Australia, the meat industry is facing many challenges. It operates in highly competitive domestic and international markets and the last decade has seen a considerable number of plant closures and a trend towards consolidation.

For example, from the late 1980s to the late 1990s, the number of accredited abattoirs in Queensland reduced from 39 to 29 and the number of slaughterhouses from 115 to 83 mainly due to financial reasons (Ooi et al).

Table 1.1 Australian processed food industry (1999-2000)

	Sales turnover		**Employment**	
	million $	% share	'000	% share
Meat	10,958	21.8%	48	29.4%
Dairy	8,348	16.6%	17	10.4%
Fruit and vegetable	3,632	7.2%	11	6.7%
Flour and cereals	3,561	7.1%	8	4.9%
Bakery products	3,440	6.8%	25	15.3%
Other foods	10,477	20.8%	35	21.5%
Beverages and malt	8,972	17.8%	18	11.0%
Oils and fats	934	1.9%	1	0.6%
Total	**50,321**		**163**	

Source: ABARE, 2002

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Table 1.2 Production figures for Australia's meat processing industry (2000-2001)

	Production		Exports	
	'000 kt/yr	% of industry total	'000 kt/yr	% exported
Beef and veal	2,071	54.4%	959	46.3%
Mutton	348	9.1%	180	51.7%
Lamb	367	9.6%	115	31.3%
Pig meat	365	9.6%	26	7.1%
Poultry	657	17.3%	21	3.2%
Total	**3,808**		**1,301**	

Source: ABARE, 2002

Table 1.3 Relative contribution of different states to red meat processing

	Sales turnover (million $)	% of national total
Queensland	3,203	45.5%
New South Wales	1,707	24.3%
Victoria	1,042	14.8%
Western Australia	521	7.4%
South Australia	379	5.4%
Tasmania	181	2.6%
Total	**7,033**	

Source: ABARE, 2002

Resource consumption and waste disposal are relatively small costs compared with the major production costs of livestock and labour. As depicted in Figure 1.1, the cost of services (water supply and energy) accounts for only about five percent of production costs and consumables (packaging, chemicals etc.) account for 12%. Wastewater and solid waste disposal charges, which fall under the category of government charges, would account for less than seven percent (MRC, 1995).

Despite the relatively small costs, resource use and waste generation are areas where direct savings can be made relatively easily. Considering that plant managers may have little control over the factors that most influence their plant’s profitability (livestock prices and labour costs), the ability to reduce resource use and waste generation can be an important means of improving a plant’s profits, particularly at a time when, for most plants, profit margins are low.

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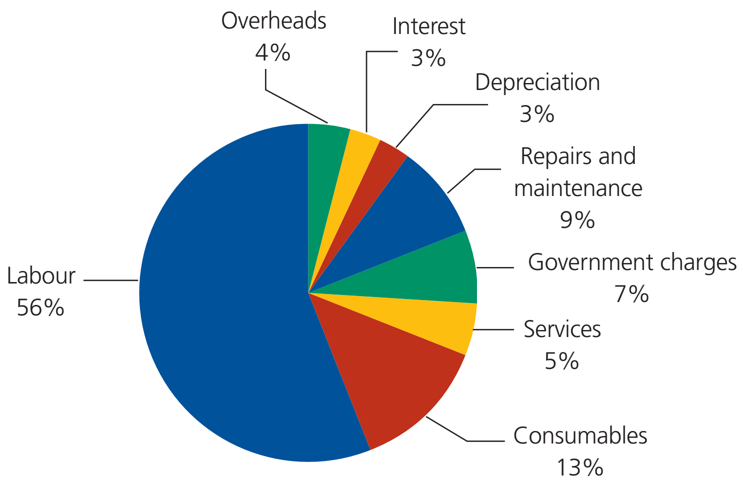
Table 1.4 shows the main resources consumed and wastes generated at a meat plant and the approximate quantities for a typical plant.

The main resource inputs are water, energy, chemicals and packaging materials. These are typical of many food processing sectors. However meat processing plants use very large quantities of water and energy. This is due to the highly perishable nature of the product, the need for high levels of sanitation and the need to keep the product cool.

The main waste streams are wastewater and some solid waste. Meat plant wastewater is characterised as having high organic, fat and nutrient loading. Much of the solid waste produced is organic and is suitable for land based disposal. Quantities of solid waste disposed to landfill are relatively small.

Figure 1.1 **Breakdown of production costs for beef plants (1992 data not including livestock costs)**



Source MRC, 1995

Table 1.4 Resource use and waste generation data for a typical meat plant

Resources use		**Daily quantity**	**Per unit of production**
Water		1,000 kL/day	7 kL/tHSCW
Energy	Coal	8 t/day	53 kg/tHSCW
	LPG	113 m^3/day	0.8 m^3/tHSCW
	Electricity	60,000 kWh/day	400 kWh/tHSCW
Chemicals	Cleaning chemicals	200 L/day	1.3 L/tHSCW
	Wastewater treatment chemicals	30 kg/day	0.2 kg/tHSCW
	Oils and lubricants	30 L/day	0.2 L/tHSCW
Packaging	Cardboard	5 t/day	31 kg/tHSCW
	Plastic	150 kg/day	1 kg/tHSCW
	Strapping tape	105 kg/day	0.7 kg/tHSCW
Waste generation		**Daily quantity**	**Per unit of production**
Wastewater	Volume	850 kL/day	6 kL/tHSCW
	Pollutant load		
	Organic matter (COD)	5,700 kg/day	38 kg/tHSCW
	Suspended solids	2,055 kg/day	13.7 kg/tHSCW
	Nitrogen	255 kg/day	1.7 kg/tHSCW
	Phosphorous	90 kg/day	0.6 kg/tHSCW
Solid waste	Paunch and yard manure	7 t/day	47 kg/tHSCW
	Sludges and floats	6 t/day	40 kg/tHSCW
	Boiler ash	0.7 t/day	5 kg/tHSCW
	Cardboard	95 kg/day	0.6 kg/tHSCW
	Plastic	10 kg/day	0.07 kg/tHSCW
	Strapping tape	2 kg/day	0.01 kg/tHSCW

Source: UNEP Working Group for Cleaner Production

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1.2 Environmental challenges

The meat industry has to deal with a number of environmental challenges as part of the day-to-day running of meat plants. These include:

- potential for odour and noise nuisance for neighbouring communities;
- the need for responsible wastewater treatment and disposal to prevent the pollution of surface and ground waters; and
- the careful disposal of putrescible organic wastes.

These issues have become important operational considerations and are generally well managed. There are however other emerging environmental challenges that will become more important in the future.

Water and water pricing

Fresh water is one of Queensland's most precious resources, and governments and water authorities have been actively promoting greater water efficiency. Meat processing, being one of the largest users of water in the food manufacturing sector has a responsibility to use water efficiently.

Water pricing has been the main mechanism for encouraging water efficiency. Water authorities have progressively implemented full cost recovery, passing the cost of water supply onto the consumer through a user-pays system of charging. As a result, there has been a trend towards higher water pricing over the last decade, a trend that is expected to continue.

Meat plants using potable town water have seen a steady increase in the cost of water. Costs can be expected to continue to increase in areas where water supplies are stretched, yet may remain stable in areas with abundant water supplies.

For plants using groundwater sources, supply availability rather than cost will be the main consideration. Over-allocation of surface water has lead to water abstraction rates beyond sustainable levels in some catchments, especially in southern Queensland.

Plants may find it increasingly difficult to gain approval for increases in water allocation in some areas due to declining reserves, even as part of expansion programs.

In summary, meat plants will find it increasingly necessary to adopt water efficient practices in the future either due to cost or water availability reasons.

Wastewater discharge limitations and costs

Discharge limitations and costs for wastewater disposal vary widely depending on the disposal route.

Plants discharging treated wastewater to municipal sewerage systems face the greatest limitations and costs. Most water authorities currently charge on the basis of the organic

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loads (BOD/COD) and volumetric loads. However for some catchments, additional charges for nutrient loads (nitrogen and phosphorous) are expected to be introduced in the future.

Unlike for water, full cost recovery charging has not been applied to sewer discharge to date. This has meant that the residential sector may subsidise wastewater treatment for industry. However this situation is changing. Local authorities and water boards, especially those in metropolitan areas, are in the process of formulating charging systems that will progressively increase wastewater discharge fees on a user-pay basis until full cost recovery is achieved. This could result in sewer discharge fees increasing from the current level of around $0.40/kL to as high as $3/kL in the future.

Plants irrigating wastewater do not incur direct charges, and quality standards are controlled through site-specific conditions. As long as plants can continue to demonstrate the sustainability of irrigation then this is unlikely to change.

Plants discharging to waterways do not incur direct charges, and discharge standards are dictated by the water quality objectives of the receiving waterway. Effluent discharge standards are likely to become progressively more stringent as a result of scarcer water resources and increasing population pressures.

In summary, plants most likely to see increases in wastewater discharge costs are those discharging to sewer. Plants most likely to be affected by tightening discharge limits are those discharging to waterways. In both cases, costs for water treatment may increase in order to meet the tighter standards or to reduce discharge costs.

Energy, energy costs and carbon taxes

Society's dependence on fossil fuels is one of the most significant environmental issues world wide. As well as depleting non-renewable reserves of oil and gas, the combustion of fossil fuels produces greenhouse gases, which are believed to be responsible for global warming. Australia is one of the world's largest consumers of energy on a per capita basis and our current rate of energy use is believed to be unsustainable.

A factor inhibiting the adoption of energy efficiency and the use of renewable energy in Australia has been the low cost of energy and the lack of mechanisms to control demand. Historical trends show that energy prices are more susceptible to political and economic factors than issues of resource scarcity or environmental impacts. In fact, recent trends show a reduction in energy costs in Australia rather than an increase, which is in contrast to water trends.

Therefore in the short to medium term, energy pricing is unlikely to be a driving force for greater energy efficiency. Factors that may have a greater influence are greenhouse abatement initiatives such as the Greenhouse Challenge and the possible introduction of carbon taxes. Draft discussion papers on a carbon tax systems in Australia have been produced, however political support is currently weak and therefore progress has been slow.

Despite the lack of pricing incentives, the greenhouse gas agenda appears to be driving some interest in greater energy efficiency. Energy is also an area where easy savings are possible and should be seriously considered by meat plants.

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Packaging

Packaging has been recognised for some time as an important environmental issue, particularly for the food industry. Governments around the world are trying to reduce packaging waste through increasingly stringent regulations. These take many different forms, from mandatory recycling rates to minimum recycled content laws through to complete landfill bans.

Europe has taken the lead in relation to packaging restrictions and many other countries to which Australia exports (including Japan and other Asian countries) are following their lead. Australia is also taking steps. However most actions are being taken voluntarily through the National Packaging Covenant. Packaging initiatives by Australia's meat industry will likely be driven by the legislative requirements of export customers rather than by regulation imposed in Australia.

For the meat industry, the message is that packaging must be designed to minimise waste (less packaging) and enable recycling, reuse or recovery (incineration with energy recovery). Also the use of PVC and other chlorine containing plastics may need to be restricted.

Co-product utilisation

The profitability of the meat industry depends to a large extent on the revenue generated from co-products. Australia is fortunate to have a high level of freedom from exotic diseases such as Bovine Spongiform Encephalitis (BSE) and Foot-and-mouth Disease (FMD). But restriction on the use of co-products as a result of disease outbreaks such as BSE could have serious economic consequences, as well as environmental implications. If co-products from the slaughtering process can not be utilised in the current manner and no alternatives are available, then disposal to the environment (landfilling) is inevitable. The identification of alternative uses or conversion processes for co-products should be a priority for the industry while disease outbreak remains a threat.

Legislation

Legislative controls at meat plants are administered through environmental licences, typically covering wastewater discharge, odour and noise nuisance, stack emissions from boilers, stormwater management and waste management. From time to time, due to environmental pressures in water catchments or airsheds, authorities introduce stricter conditions.

It is difficult to predict trends in specific legislative requirements since it varies from state to state and from region to region depending on the particular environmental sensitivities and political priorities at the time. Some of the possible areas of change are as follows:

- a move towards industry self-regulation. To this end, environmental authorities are encouraging industries to adopt self-regulatory tools such as industry codes of practice and Environmental Management Systems (EMS).

- stricter wastewater discharge standards may come into force in catchments experiencing pollution pressures, in particular, nutrients. This may necessitate upgrades to treatment capacity or at source reduction in pollutant loads.
- tighter boiler emissions limits, particularly suspended particulate matter, can and have been introduced from time to time, requiring the upgrade of older boilers, particularly coal boilers. However this is more likely to occur in urban areas with greater air quality pressures.
- waste management is an area that may see the introduction of new requirements in the future. Some states are considering the requirement for licensed manufacturing plants to develop and implement waste minimisation, cleaner production or eco-efficiency plans and to demonstrate reduction in the amount of waste generated. This may be legislated through Environmental Protection Policies (as in Qld) or State Environmental Protection Policies (as in NSW), with site-specific conditions filtering down into licence conditions.

Overseas legislative trends can predict future trends in Australia, however not in all cases due to different environmental sensitivities and community perceptions and expectations. Some of the overseas legislation issues that have been identified as potential challenges for the Australian industry are:

- green taxes;
- restrictions on the disposal of waste organic solids due to BSE concerns;
- concerns in relation to endocrine disruptor substances (thought to come from industrial detergents and plastic manufacture);
- the requirement to disinfect wastewater prior to discharge;
- increasing emphasis on eco-efficiency.

Stricter environmental requirements for suppliers to overseas markets

In some markets, particularly Europe, increasing consumer awareness is being reflected in requirement for manufacturers to demonstrate sound environmental performance. This can include the requirement for producers of goods to have an Environmental Management System (EMS) in place that is certified to the International Standard ISO 14001.

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1.3 Environmental opportunities

The environmental challenges faced by the meat industry are not passing fads. They are here to stay and will only become more important as populations grow and demand for limited resources increases.

Over the longer term it will be more beneficial to view environmental considerations as opportunities rather than challenges by taking a pro-active rather than reactive approach. Below are some of the ways that meat plants can take advantages of environmental opportunities.

Financial savings from eco-efficiency

Financial savings are probably the most convincing reason for businesses to adopt a more environmental approach. Reducing resource use and waste generation provides the dual benefits of financial savings and improved environmental performance, and is the appeal of eco-efficiency.

The first category of savings is that of direct savings from reduced water and energy costs.

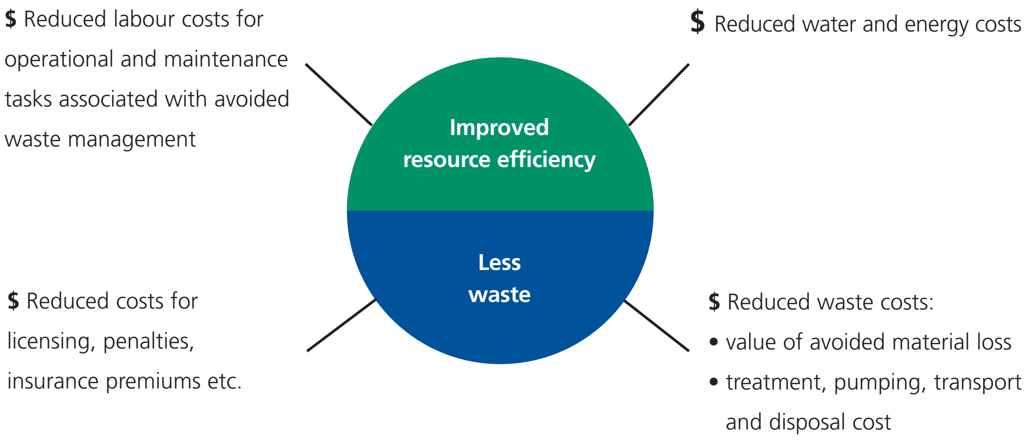
The second category relates to savings from reduced waste generation, which includes the value of the materials lost to the waste stream, as well as the costs of treating, pumping, conveying, transporting and disposing of waste.

The third category of savings is reduced labour costs of operational and maintenance tasks associated with avoided waste collection, handling, treatment and disposal.

The fourth category is indirect savings associated with reduced exposure to liability and community concerns. These could include reduced licensing costs, reduced risk of penalties, reduced community and regulator interaction and possibly reduced insurance premiums.

More details about financial savings are provided in Section 1.6

Figure 1.2: Scope of financial savings from eco-efficiency



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Developing and maintaining a 'Green' image

Environmental image is a growing challenge for the food industry but it can also be a marketing opportunity as consumers become increasingly aware of the environmental issues associated with food production.

Australian food already has a good environmental image, particularly in overseas markets. The industry is in a very good position to build on this further by demonstrating that it maintains high environmental standards throughout the production process, both in primary production and in processing.

In the domestic market, retailers are starting to use environmental credentials to distinguish their product from the competition, particularly for products where price differentials are low.

Eco-labeling is not well established at this stage, however it is expected to become an important tool for marketing the environmental credentials of products within the decade. An international standard for eco-labeling exists and some meat processors are already planning for certification against this standard. Eco-efficiency is an important first step towards implementing eco-labeling.

Improved relations with regulators

The trend towards self regulation means that regulators are very supportive of industries that take a pro-active approach towards environmental management.

The voluntary adoption of eco-efficiency by a meat plant would be evidence to the regulators that the managers were taking positive steps towards further improving their environmental performance. This could quite likely lead to improved relations with regulators and less regulatory scrutiny.

Product diversification

The conversion of what were traditionally wastes into saleable products reduces environmental burdens, by diverting wastes away from landfills, but also provides the opportunity for product diversification and greater profitability through improved resource use efficiency.

The meat industry has become very skilled at converting wastes into products, as evidenced by the wide range of products produced from inedible materials in by-product plants. These co-products have come to be extremely important for the profitability of meat plants.

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This could be expanded further to help address environmental issues, while providing further opportunities for product diversification. Some possible examples are:

- production of compost products from paunch and yard manure;
- the production and use of biogas (methane) from the anaerobic digestion of wastewater and organic solids;
- the use of treated wastewater to support crop production or forestry;
- the operation of aquaculture operations utilising the nutrients contained in treated effluent; and
- the sale of treated wastewater to a third party.

1.4 Why eco-efficiency?

Eco-efficiency is a concept being adopted by industries world-wide as a means of improving environmental performance and reducing costs. The concept has been strongly promoted by the World Business Council for Sustainable Development. Its objectives are the more efficient use of resources and the reduction of waste, with the two-fold benefits of reduced environmental burdens and reduced costs for resources and waste management.

The previous sections described some of the environmental challenges and opportunities for the meat industry. Eco-efficiency can play a role in tackling these challenges and taking advantage of the opportunities.

Table 1.5 is a checklist of reasons for adopting eco-efficiency. Do any of these apply to your plant? If so, you may wish to read through the rest of this manual and consider eco-efficiency for your plant.

The basic principles of eco-efficiency

Eco-efficiency is about reducing the inefficient use of resources and the reduction of waste at source, rather than relying on end-of-pipe solutions.

It involves rethinking conventional practices to come up with smarter solutions by following the hierarchy depicted in Figure 1.3.

Figure 1.3 **Eco-efficiency hierarchy**

Eco-efficiency solutions can range from simple housekeeping improvements and minor process refinements through to major process changes or product redesign. Experience from other industries has shown that the most significant eco-efficiency savings commonly result from low cost options.

Part 2 contains more information about the practical aspect of implementing eco-efficiency at a meat plant.

Table 1.5 Checklist of possible reasons for adopting eco-efficiency

	Yes	No
Are you interested in reducing your plant's operating costs and improving profitability?		
Does your plant incur high costs for water?		
Is your plant faced with future restriction in water allocations?		
Does your plant incur high costs for wastewater treatment and/or disposal?		
Is your plant facing tighter wastewater discharge limits in the future?		
Is your plant facing the introduction of additional wastewater discharge fees (nutrients)?		
Does your plant incur high costs for energy (fuel, electricity)?		
Has your plant signed up or is planning to sign up to the Greenhouse Challenge?		
Does your plant incur high costs for solid waste disposal (packaging, paunch manure etc.)?		
Is your plant facing stricter air emission standards?		
Is your plant required to develop a waste management or waste minimisation plan?		
Can your plant gain any advantage in the market place from an improved environmental image?		
Would you like to improve relations with environmental regulators?		
Are you interested in product diversification?		

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1.5 Indicators of eco-efficiency performance

Indicators of eco-efficiency performance represent the quantities of resources consumed and quantities of waste generated per unit of production. Examples of indicators that have been developed to date are shown in Table 1.6. There is very little comprehensive data on eco-efficiency indicators available for the meat industry. The figures contained in Table 1.6 are based on data collected from a survey of a limited number of plants in the late 1990s. It is felt that the industry has made considerable performance improvements since this time, and the average industry performance may be better than that represented in the table.

Comparison with industry figures can be useful for identifying areas where there is scope for improvement at your plant. For example you may identify that your plant performs well above average for energy use, but significantly below average for water use. This could indicate that water use is an area where improvements are possible.

Table 1.6: Eco-efficiency indicators for the Australian meat industry

Eco-efficiency indicators	Unit	Range	Average
Water consumption [1]	kL/tHSCW	6 - 15	11.8
Energy consumption [1]	MJ/tHSCW	1,200 - 4,800	3,400
Solid waste to landfill [1]	kg/tHSCW	2 - 17	6
Wastewater pollutant load [1]	kg/tHSCW		
BOD		6 - 70	30
COD		15 - 100	38
Nitrogen		1 - 4.6	1.7
Phosphorous		0.1 - 1.5	0.6
Packaging waste generation [2]	kg/tHSCW		
carboard		-	0.65
plastic		-	0.072
strapping tape		-	0.014

Sources:

[1] MLA, 1998b

[2] MLA, 1996c

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The development of industry benchmarks or ‘best in class’ figures would be very useful for promoting continuous improvement in the industry. However the development of benchmarks has been relatively limited in the Australian meat industry to date for various reasons.

Past studies and reviews have shown that industry figures can be highly variable (Johns, 1993), due to variations in the types of operation undertaken, the species killed, the age of the plants, whether plants service the export or domestic markets and different environmental constraints. Ideally, benchmarks should be set to reflect these variables, so that like operations are compared with like, for example, different benchmarks for older plants and modern plants and for different species plants.

Plants should consider setting internal performance targets for their own operations to encourage improvements in performance within the constraints of the plant. Targets can also be set for individual cost centres or departments within the plant. This has been found to spur on competitiveness within work areas which promotes improvement.

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1.6 Financial savings from eco-efficiency

Saving from reduced water consumption

For every 1 kL/tHSCW of water that is saved, the financial savings for a typical plant could be between $22,000/yr and $75,000/yr, depending on the costs of water (see Table 1.7).

If all the costs associated with water use are taken into consideration (purchase cost and the cost for treating and disposing of the resulting wastewater as well as other costs such pumping); it is assumed that the full cost of water can range from $0.60/kL to $1.95/kL.

Remember you pay for water three times—to buy it, treat it and dispose of it!

For example, if a plant currently using 10kL/tHSCW reduced its water use by 20% to 8kL/tHSCW (a 2kL/tHSCW saving), then the total savings could be between $45,000/yr to $145,000/yr.

Table 1.7 Potential financial savings from reducing water consumption for a typical plant

		Scenario 1	Scenario 2	Scenario 3
Cost of water	$/kL	$ 0.60	$ 1.55	$ 1.95
Savings from every 1 kL/tHSCW reduction in water use	$/tHSCW	$0.60	$1.55	$1.95
	$/head	$0.14	$0.37	$0.47
	$/year	**$22,500**	**$58,125**	**$73,125**

Assumptions:

Definition of a typical plant is stated in the introduction of this manual (page iii)

The costs of water includes the cost of purchase, pumping and treatment and disposal of the resulting wastewater (see Table 2.3 for details)

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Saving from reduced energy consumption

Table 1.8 shows the financial savings possible from reducing electricity and fuel use. For example:

If a plant currently using 300 kWh/tHSCW of electricity, reduced its power consumption by 20% to 240kWh/tHSCW (a 60 kWh/tHSCW saving), the savings would be approximately $112,000/yr.

If a plant currently using 2 GJ/tHSCW of fuel, reducing fuel use by 20% to 1.6 GJ/tHSCW (a 0.4 GJ/tHSCW saving), the savings could range from $27,000/yr (for coal) to $140,000/yr (for natural gas or fuel oil).

Table 1.8 **Potential financial savings from reducing energy consumption for a typical plant**

		Electricity		**Coal**	**Natural gas**	**Fuel oil**
Cost		$0.05/kWL		$1.80/GJ	$9.50/GJ	$9.90/GJ
Savings from every				**Savings from every**		
10 kWh/tHSCW	$/tHSCW	$0.50	**0.1 GJ/tHSCW**	$0.18	$0.95	$0.99
reduction in	$/head	$0.12	**reduction in**	$ 0.04	$ 0.23	$ 0.24
electricity use	**$/year**	**$18,750**	**fuel use**	**$6,750**	**$35,625**	**$37,125**

Assumptions:

Definition of a typical plant is stated in the introduction of this manual (page iii)

The costs of electricity and fuel are based on average costs paid by industry (see Table 3.2 for details)

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1.7 Eco-efficiency report card

The Eco-Efficiency Report Card below is a summary of the things that need to be done if your company is serious about eco-efficiency.

Use the checklist to:

- assess your plant's current eco-efficiency status;
- plan an eco-efficiency project; and
- review the progress of an eco-efficiency project.

Table 1.9 Eco-efficiency report card

Information Collection	**YES**	**NO**
Do we have good data for water and energy consumption, including a breakdown of use for the different process areas or cost centres?		
Do we know which process areas or activities use the most water and energy?		
Do we have an inventory of chemical use, and a clear understanding of the function of the chemicals used?		
Do we have good data for solid waste generation, including the sources and reasons for waste generation?		
Do we have good data for wastewater generation (volumes and pollutant loads), including the sources and reasons for pollutant loads?		
Do we know which process areas or activities contribute the most to wastewater pollutant loads?		
Indicators of Performance	**YES**	**NO**
Do we have a set of performance indicators for resource use and waste generation for our plant?		
Do we regularly report our performance against these indicators?		
Have we compared our performance against industry figures?		

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Opportunities for Improvement	**YES**	**NO**
Have we identified any priority areas for greater resource efficiency or waste reduction?		
Have we undertaken an assessment to identify opportunities for:		
- reducing water use?		
- reusing relatively clean water for other applications?		
- reducing the demand for steam?		
- recovering heat?		
- reducing electricity use?		
- alternative source of energy?		
- reducing loss of material (blood, manure, fat and meat tissue) to wastewater?		
- recovering lost materials from wastewater?		
- converting wastes into co-products?		
- beneficially utilising wastewater?		
Have we undertaken brainstorming sessions or consulted with staff and colleagues about opportunities for improvement?		
Implementation Plan	**YES**	**NO**
Have we determined the most viable eco-efficiency opportunities and developed an implementation plan?		
Do we monitor our progress and report on performance improvements?		

1.8 Frequently asked questions

Is eco-efficiency voluntary or regulatory?

Eco-efficiency is voluntary. Environmental authorities believe that eco-efficiency should be able to sell itself based on the financial savings without the need for regulation.

There has been discussion in some states to include eco-efficiency as a regulatory requirement for industries if deemed necessary, however this requirement has not made it into legislation to date.

Isn't eco-efficiency only applicable to large operations?

No. Eco-efficiency is applicable to businesses of all sizes. Large operations may have a wider scope of opportunities, but even small operations will be able to identify ways to make savings.

Doesn't eco-efficiency involve large capital outlay?

No. Eco-efficiency does not necessarily mean large capital outlay. Some of the best savings can be achieved with little or no capital cost through improved housekeeping, minor process changes or staff training. Once companies have implemented the low cost options, then additional savings can be made through more significant process changes, which require capital outlay.

How does eco-efficiency fit in with other environmental management tools, such as Environmental Management Systems (EMS)?

Eco-efficiency fits in well with Environmental Management Systems (EMS). EMS is about having systems in place to help bring about continuous environmental improvements. Eco-efficiency is one means of achieving this goal. Therefore a company's EMS can be used to drive eco-efficiency by providing the mechanism for ongoing evaluation, setting of targets, implementation, monitoring and review.

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Part 2

Water

2.1 Overview of water use

Water is a very important input for meat processing. The need to maintain strict food safety standards means that it is used in considerable quantities for the washing of livestock and products and the cleaning and sanitising of plant and equipment.

Table 2.1 is an example breakdown of water usage in meat processing, based on the typical plant described on page iii. Water usage can vary considerably from one plant to another, so this should be regarded as an example only.

Table 2.1: Example breakdown of water use at a typical meat plant

			kL/day	**% of total**	
Variable water use	Stockyards	Stock watering	10	1.0%	**25%**
		Stock washing	70	7.0%	
		Stockyard washing	130	13.0%	
		Truck washing	40	4.0%	
	Slaughter and evisceration	Viscera table wash sprays	60	6.0%	**10%**
		Head wash	3	0.3%	
		Carcase wash	40	4.0%	
		Carcase splitting saw	1	0.1%	
	Paunch, gut and offal washing	Paunch dump and rinse	80	8.0%	**20%**
		Tripe / bible washing	30	3.0%	
		Gut washing	60	6.0%	
		Edible offal washing	30	3.0%	
Fixed water use	Rendering	Rendering separators	10	1.0%	**2%**
		Rendering plant washdown	5	0.5%	
	Sterilisers and wash stations	Knife sterilisers	60	6.0%	**10%**
		Equipment sterilisers	20	2.0%	
		Hand wash stations	20	2.0%	
	Amenities	Exit / entry hand, boot and apron wash stations	40	4.0%	**7%**
		Personnel amenities	25	2.5%	
	Plant cleaning	Wash down during shifts	20	2.0%	**22%**
		Cleaning and sanitising at end of shift	170	17.0%	
		Washing tubs, cutting boards and trays	30	3.0%	

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Table 2.1: Example breakdown of water use at a typical meat plant continued

			kL/day	% of total	
Fixed water use	Plant services	Condensers	20	2.0%	**4%**
		Cooling tower makeup	10	1.0%	
		Boiler feed makeup	10	1.0%	
		Refrigeration defrost	3	0.3%	
	Total		**1000**		**100%**
	Per unit of production (kL/tHSCW)		**7**		
	Cold water		687	69%	
	Warm water [1]		85	9%	
	Hot water [2]		225	23%	
	Fixed water use		443	44%	
	Variable water use		554	55%	

Source: Collation of data from MLA, 1995b and internal data of the UNEP Working Group for Cleaner Production

[1] Warm water is used for hand wash stations exit/entry hand, boot and apron wash stations and personnel amenities.

[2] Hot water is used for knife and equipment sterilisers, and for viscera table wash sprays, tripe/bible washing, cleaning at the end of shifts and washing tubs etc.

Some facts about water use

- Meat plants use a variety of sources of water —town water, bore water or dam water.
- Thirty to forty percent of water used is either hot (82°C) or warm (43°C). These temperatures are stipulated by food safety regulations.
- Fifty percent of water use is fixed (i.e. independent of kill rate). This is the water required just to maintain basic plant operations. The other 50% is variable, which means it depends on the production throughput.
- Fifty to seventy percent of water use is dependent on operator practices (e.g. cleaning with hoses, manual washing of livestock and product). Therefore staff awareness and supervisor vigilance has a large bearing on water use.
- Water use at export plants can be higher than domestic plants due to stricter sterilisation requirements.
- Modern plants can be easier to clean due to improved plant layout and equipment design, and therefore can be more water efficient.
- While not obvious from Table 2.1, the slaughter and evisceration area is the largest user of water, being responsible for most of the cleaning and knife and equipment sterilisation. In total this area can account for 40-50% of total water use.

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The cost of water

It is easy to underestimate the true cost of water. In addition to the purchase cost of water, the full cost of water use also includes the cost of pumping (and possibly treating) the incoming water, and the cost of treating and disposing of the resulting wastewater.

You pay for water three times—to buy it, treat it and dispose of it!

Purchase costs for water in Queensland can range from 60c/kL to $1.20/kL (see Table 2.2), with the typical cost being around 75c/kL. Table 2.3 provides examples of the full cost of water under different conditions, taking into account other costs associated with water use. This indicates that water can cost as much as $2/kL.

Plants in urban areas using town water tend to incur high costs for water, particularly if the wastewater is subsequently discharged to sewer. Therefore cost savings can be a considerable incentive for water efficiency for these plants. For plants in rural areas, particularly those using bore water, the availability of sufficient water may be a more important consideration. However bore and dam water supplies can also be quite costly, if the investment and depreciation costs for extraction infrastructure are taken into consideration.

Table 2.2 Range of water supply costs ($/kL)

	Cost ($/kL)
Brisbane	$1.13
Ipswich	$1.50
Toowoomba	$1.05
Stanthorpe	$0.55
Rockhampton	$0.64
Townsville	$1.00
Typical cost	**$0.75**

Source: Water pricing information from water supply authorities (2002)

Water Chlorination tanks

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Table 2.3: Examples of the true cost of water ($/kL)

	Plants in urban areas		**Plants in rural areas**
Source of water:	Town water	Town water	Bore or dam water[1]
Wastewater treatment and disposal:	Wastewater treated to a high standard and discharged to sewer	Wastewater treated to a high standard and discharged to waterway	Wastewater treated to a minimal standard and irrigated
Purchase	$0.75	$0.75	NA
Water pumping	NA	NA	$0.05
Water pre-treatment	NA	NA	$0.30
Wastewater treatment[2]	$0.75	$0.75	$0.20
Wastewater pumping	$0.05	$0.05	$0.05
Wastewater discharge	$0.40	NA	NA
Total	**$1.95**	**$1.55**	**$0.60**

NA - Not applicable

[1] These costs do not include the investment and depreciation cost of infrastructure

[2] Based on the assumption that treatment costs are usually similar to purchase costs

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2.2 Reducing demand for water

Water supply in general

2.2.1 Fitting efficient spray nozzles

Many operations within a meat plant involve the use of hoses, which accounts for around 55% of total water use (derived from the typical breakdown of water consumption in Table 2.1). Therefore the installation of hose fittings that provide an effective yet water-efficient spray can have a significant effect on total water usage. The main factor influencing the choice of fitting is the effectiveness of the spray pattern and the pressure delivered by the nozzle, as this will influence the time taken to do the job and therefore the labour costs.

Spray and jet technologies have improved in recent years and new designs allow for reduced water use without compromising spray effectiveness. Considering the low cost of nozzles, it makes sense to take advantage of the water saving opportunities that the correct selection and maintenance of nozzles provides.

Trigger operated hand guns are commonly used at meat plants for boot and apron washing, as well as carcase, head and offal washing etc. Suppliers of these fittings report that water use for these tasks may be higher than necessary because the appropriate spray tip has not been fitted to the water gun.

The durability and maintenance of nozzles is also important. Water consumption increases with nozzle wear. Table 2.4 shows the increase in flowrate due to wear of nozzles made of different materials. Stainless steel and nylon offer the best durability.

It is good practice to monitor the flowrate of water from nozzles and replace them when the flowrate has increased by about 10% from the design value. Typically, 20% reduction in water use can be achieved by upgrading and maintaining spray nozzles for a given application (March Consulting Group, 1998).

Table 2.4: Comparison of different nozzle materials

	Abrasion resistence ratio	Flow increase from wear after 25 hours use	Flow increase from wear after 50 hours use
Aluminium	1	21%	26%
Brass	1	15%	17%
Stainless steel	4 - 6	4%	4%
Nylon	6 - 8	3%	3%
Hardened stainless steel	10 - 15	1%	1%

Source: http://www.spray.com and http://www.teejet.com/pdf/circ_1192.pdf

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Assumptions used for Cost-Benefits Assessments

The cost-benefit assessments described in this section are based on the following assumptions:

A 'typical' plant is one processing the equivalent of 150 tHSCW/day (625 head beef cattle/day), 250 days/yr.

Water savings are based on a mid-range water cost of $1.55/kL (see Table 2.3).

Table 2.1 is used as the basis for water use for the typical plant.

Heating savings are based on two scenarios:

[1] use of recovered heat from rendering supplemented with steam from a coal boiler—$0.08/kL (see Table 3.4)

[2] direct water heating with gas—$3.90/kL (see Table 3.4)

Costs and Benefits

Assuming that around 55% of total water use is related to hose use, and that a conservative 10% reduction in water use could be achieved from the improved selection and maintenance of spray nozzles, then for a typical plant, this could save around 55kL/ day.

Capital Cost:	~$5,000
Maintenance/Repair Costs:	~$5,000/yr
Water savings:	$21,000/yr
Heating savings:	[1] $200/yr or
	[2] $7,000/yr
Pay Back:	3-4 months

See assumptions above for the basis of these calculations.

2.2.2 Centralised control of water supplies

Water supplies to the production line can be controlled from a central point and switched off by supervisors during breaks when production ceases. This avoids the reliance on supervisors and operators to turn off valves at each individual appliance.

Alternatively sensors could be located strategically on the dressing conveyor line to trigger water supply valves on as the first carcase proceeds along the conveyor, and off as the last carcase clears each station. This avoids any reliance on supervisors and operators to turn off valves when the production line stops.

Centralised control would require the segregation of production line supplies (sterilisers, viscera tables, chute lubrication, trommel washes, head washers etc.) from those not associated with the production line. A successful system requires a continuous circulating ring main feeding back to the hot water tank, with take off points supplying the various applications. This avoids the loss of temperature in the water supply lines when the water supply is shut off for some time.

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For existing plants, water supply segregation could be quite expensive. For sensor control, it would also involve the installation of numerous sensors and interlocking switches and some additional valves (McNeil and Husband, 1995).

Costs and Benefits

If turning off individual water supplies on the production line at breaks is delayed by around five minutes each time, then centralised control of water supply could save up to 30 minutes of water flow in a production day (assuming six breaks per day). This equates to about 5 kL/day (3kL of which would be hot or warm water).

Capital Cost:	~$10,000
Water savings:	$1,700/yr
Heating savings:	[1] $100/yr or
	[2] $2,300/yr
Pay Back:	3-6 years

See assumptions in Section 2.2.1 for the basis of these calculations.

Stock washing

This section mainly relates to the washing of cattle, however many of the principles would also apply to other stock.

The amount of water used for washing stock depends on the type and cleanliness of the stock. Meat plants may have a number of options available to accommodate different levels of cleanliness— preliminary washing or soaking of very dirty stock either manually or with fixed sprays, standard spray washing (possibly using recycled water) and a final wash (using potable water). Water use can vary considerably depending on the washing regime. Table 2.5 provides an indication of typical water use for stock washing.

Table 2.5: Typical water use for stock washing

	Water flowrate (L/min)		**Typical time in use**	**Water use (L/head)**
	Range	Average		Average
Preliminary wash of heavily contaminated cattle				80
Manual pre-slaughter wash	50 - 240	100	0.5 min/head	50
Final spray wash		100	10 min/mob	50

Source: based on data from Wescombe, 1994.

For more information:

Cattle Cleaning—Meat Research Report 3/94. Wescombe, 1994
(available from Food Science Australia—http:// www.meatupdate.csiro.au/)

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2.2.3 Minimising receipt of very dirty stock

Water use for stock washing increases significantly if stock are received in a dirty condition. Feedlots are generally the main source of dirty stock. An extra 80-100 litres/head can be used for the additional washing required for very dirty stock.

Meat plant managers should determine the extra costs incurred to process dirty cattle and communicate this to suppliers and buyers. Some plants impose an extra charge to process dirty cattle or offer a bonus for clean cattle as an incentive (Wescombe, 1994).

Costs and Benefits

If a plant typically pre-washes 30% of the stock received, then reducing this to 10%, could save 10 kL/day.

Capital Cost:	nil
Water savings:	$3,900/yr
Pay Back:	immediate

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.4 Avoiding under-utilisation of spray capacity

Some meat plants have large pens capable of holding 50-100 head (cattle), with floor-mounted and possibly overhead jets covering the entire area. If a small number of stock are washed at a time (say 20- 50), then water is wasted, since stock tend to crowd into the corner and only a portion (50-75%) of the spray capacity is utilised.

Long, narrow pens that can be sub-divided into sections can avoid this problem. For existing large pens, they could be compartmentalised into smaller sections and the water supply segregated to different areas of the pen, so that sprays are only switched on in the section where the stock are located (Wescombe, 1994).

Costs and Benefits

If utilisation of the stock washing area is only 50% on average, then modifying the stock wash area so that utilisation is 100% could halve water use for stock washing (around 35kL/day).

Capital Cost:	$5,000—$10,000
Water savings:	$14,000/yr
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.5 De-dagging to avoid stock washing at domestic meat plants

If stock (cattle) are washed at the feedlot and received and maintained in a clean state at the meat plant, then washing could be avoided. Instead some form of de-dagging could be undertaken to ensure that the opening line is clean.

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De-dagging units, which incorporate a vacuum collection system are available for removing dags from dry cattle. They are not suited to removing dags from wet cattle at this stage and therefore may not be suitable for export plants.

The cost of installing de-dagging unit is estimated to be around $20,000. The labour that would have been used for stock washing could be used for de-dagging, so it is assumed there would be no net increase in labour costs (Wescombe, 1994).

Costs and Benefits

If de-dagging could be successfully employed to virtually eliminate stock washing at domestic plants, then for a typical plant, the reduced water use could be around 95kL/day.

Capital Cost:	$20,000
Maintenance/Repair Costs:	$5,000/yr
Water savings:	$27,000/yr
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

Stockyard washing

According to surveys of water use, water use for stockyard washing can range from 100kL to 300kL/day (MLA, 1995b).

2.2.6 Dry cleaning manure before washing

Dry cleaning is the removal of the bulk of the solid manure from the yards before washing with water. This can potentially reduce the amount of water used by around 20-30% (March Consulting Group, 1998 and Walford et al, 1994). The practicality of dry cleaning will depend on how the stockyards are constructed and may not be possible for some stockyards.

Dry cleaning also enables the manure to be collected dry for sale.

Costs and Benefits

Through dry cleaning water use for stockyard cleaning can be reduced by 20%. For a typical plant, the result in savings of around 25kL/day.

Capital Cost:	minimal
Water savings:	$10,000/yr
Pay Back:	immediate

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.7 Timer controls for stock washing

If hoses or spray systems are left on longer than required, timers can be used. Timer switches are prone to being tampered with and so the effectiveness of this option will depend on operator acceptance. Some form of operator training may need to coincide with the introduction of timer switches.

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2.2.8 Suspended mesh flooring

Suspended mesh flooring is used widely for small stock stockyards, however it has also proven to be effective for cattle, but only those with very hard feet. It is not suitable for cattle from feedlots or cattle that have very soft feet.

For cattle, the mesh is suspended approximately 150mm above the existing concrete floor. For other stock it may be suspended much higher. It is most effective in holding pens and walkways.

The method of manure collection will depend on the height of the suspended floor, but could include manual shoveling, mechanical scraping or use of a bob cat.

As well as helping prevent contamination of stock, suspended mesh flooring also makes the cleaning of stockyards easier, reduces water consumption and can enable manure to be more easily collected dry for sale.

Cost of mesh is about \$100/m^2 plus transport and installation. Labour costs should not change. (Wescombe, 1994)

Elevated lairage

Costs and Benefits

The installation of suspended mesh flooring (if practical) could reduce the amount of water used by 50%. Therefore in a typical plant water use could reduce by around 100kL/day.

Capital Cost:	\$60,000—\$100,000
Water savings:	\$25,000/yr
Pay Back:	2.5—4 years

See assumptions in Section 2.2.1 for the basis of these calculations.

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For more information:

Water and Waste Minimisation, McNeil and Husband, 1995 (available from MLA).

Viscera (and bleed) table wash sprays

The wash sprays on viscera tables are a large user of water in meat plants and an area where good savings can be made. Table 2.6 shows typical water consumption figures.

Some plants may also utilise wash sprays on bleed tables in the bleeding area. The water saving opportunities described here would also apply to bleed tables.

Table 2.6: Typical water use for viscera table washing

	Cold water use (L/minute)		Hot water use (L/minute)		Total water use (L/minute)		
	Range	Average	Range	Average	Range	Average	Ref
Typical flow rates to wash sprays	65 - 220	150	15 - 230	150	80 - 450	300	(1)
Continuous flow		156		156		312	(2)
Intermittent flow		54		54		108	(3)

Sources:

[1] McNeil and Husband, 1995 [2] Walford et al, 1994 [3] Kallu, 1993

2.2.9 Intermittent flow for viscera (bleed) table wash sprays

Some types of modern viscera tables (and bleed tables) incorporate systems that turn wash sprays on only as the table moves forward. However for older style tables water sprays may run continuously. In these situations, it may be possible to install on/off controls linked to sensors or a limiting switch so that the water flows intermittently instead of continuously. It has been reported that intermittent flow can reduce water consumption by more than 50% (Walford, 1994). Since around 50% of the water used is hot water (82°C), there would also be energy savings.

Costs and Benefits

For a plant that has continuous wash sprays on the viscera table, modifications to allow for intermittent flow could reduce water consumption by around 30kL/day, 50% of which would be hot water.

Capital Cost:	\$5,000—\$7,000
Water savings:	\$15,500/yr
Heating savings:	[1] \$300/yr or
	[2] \$10,000/yr
Pay Back:	3-7 months

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

SA Meat Corporation (SAMCOR), South Australia

At the SAMCOR plant, a limit switch and solenoid was installed on the viscera table wash spray system to turn the water supply off when the dressing line stops and during operator breaks. Spray nozzles were also replaced with finer nozzles. The improvement reduced hot water use by 90kL/day.

Total capital cost:	$10,000
Water saving	$19,800/yr
Wastewater treatment cost:	$2,250/yr
Energy savings:	$22,000/yr
Total savings:	$44,050/yr
Payback:	3-4 months

Source: http://www.environment.sa.gov.au/epa/pdfs/cpsamcor.pdf

2.2.10 Setting and maintaining minimum flow rates for viscera (bleed) table wash sprays

For both modern and older style viscera tables, the minimum flow rate required to effectively clean and sterilise the viscera table can by determined by a trial. The water supply can then be set and maintained at this flow rate. Since these units are very high water users, the installation of a flow meter on the inlet water supply may be justified to allow the flow rate to be continuously monitored and controlled. The correct selection and maintenance of nozzles on the wash sprays can also have a bearing on the flow rate, as discussed in Section 2.2.1.

Costs and Benefits

If flow rates of water to viscera table wash sprays are found by trial to be excessive, reducing consumption by 20% will save around 12kL/day.

Capital Cost:	$3,000
Water savings:	$4,500/yr
Heating savings:	[1] <$100/yr or [2] $800
Pay Back:	7 months

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.11 Use of warm water instead of hot water

It has been reported that using 43ºC water to clean viscera tables is as effective as 82ºC and makes little difference to the microbiological count on the trays. The use of warm water is also reported to eliminate the need for washing the trays first with cold water and also reduced the amount of cold water required to cool the trays after being cleaned (Lowry, 1991). There may limitations on taking this approach due to hygiene standards currently in place.

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2.2.12 Use of chlorinated detergents instead of hot water for cleaning viscera tables

Replacing the hot water spray with a spray of chlorinated detergent solution can provide comparable cleaning and disinfection performance. This can provide savings in hot water in those plants where the cost of water or the cost of heating water are high. The net water use will not reduce, since the detergents will still need to be rinsed off with cold water, but the use of hot water will reduce. Chlorinated detergents can be less effective than hot water in removing fatty solids, depending on the detergent used and they can leave detergent residues on the viscera handled on the table. Export regulations require that viscera tables be treated with hot water. Therefore this option may be better suited to domestic plants (Spooncer and Barkley, 1984).

Costs and Benefits

For domestic plants that incur high costs for water heating (i.e. no heat recovery from rendering), the use of chlorinated detergents instead of hot water will eliminate hot water use for viscera table cleaning. This will save 75 kL/day of hot water.

Capital Cost:	minimal
Chemical Costs:	$5,000/yr
Heating savings:	$20,000 /yr
Net savings:	$15,000
Pay Back:	immediate

See assumptions in Section 2.2.1 for the basis of these calculations.

For more information:

Use of chlorinated detergents for continuous cleaning of viscera tables, Spooncer and Barkley, 1984. Available from Food Science Australia—http://www.meatupdate.csiro.au/

Preliminary study on the microbiological effect of washing meat plant equipment with 82°C water, Lowry, 1981 (MIRINZ publication).

Knife and equipment sterilisers

2.2.13 Efficient continuous flow sterilisers

Single-skinned sterilisers have the simplest construction of all continuous flow knife sterilisers. They use a continuous flow of hot water to maintain the water temperature above 82°C and to flush away blood, dirt and hair / wool.

The minimum flow required to maintain temperature is a function of heat loss. Since these units provide no insulation, and generally have poor flow control, they have high water flow rates compared to other systems (see Table 2.7). Water usage can be reduced however through flow restriction and greater control of flow (see 2.2.14). (Walford, 1994)

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Double-skinned sterilisers

Double-skinned sterilisers provide an insulating air gap, which reduces heat loss and therefore water use. Plant surveys indicate that flow rates to double-skinned sterilisers don't necessarily use less water than single-skinned sterilisers (see Table 2.7). This could be due to poor flow control or low supply temperature. Pearson (1981) reports that double-skinned units can use as little as 0.5 L/min (80% less than single skin sterilisers on average) if the supply temperature is 90°C and the drop pipe to the steriliser is well insulated. Flow rates of less than 0.5 L/min are reported to be insufficient to keep the water clean.

The air gap can be filled with insulation to further reduce heat loss. As with single-skinned sterilisers flow can be reduced through better flow restriction but also through temperature-controlled flow (see Section 2.2.14) (Walford, et al, 1994).

Double-skinned sterilisers cost around $600 per unit, therefore replacing existing sterilisers throughout the entire plant could cost somewhere in the order of $20,000.

Water jacket sterilisers

This type uses a hot water jacket to maintain water temperature. After the hot water flows through the jacket, it is returned to the boiler. The hot water flowing through the jacket, used to maintain the temperature, is recovered instead of flowing to drain. The water in the steriliser itself is only required for flushing away blood, dirt and hair/wool. As a result, these units can be very water efficient, using around 70% less than single-skinned sterilisers (see Table 2.7) (Walford, 1994).

Steriliser

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Costs and Benefits

If single-skinned knife sterilisers are replaced with more efficient steriliser systems, reductions in water use of up to 70% are possible. For a typical plant, this would reduce hot water use by around 42kL/day.

Capital Cost:	$10,000—$20,000
Water savings:	$16,000/yr
Heating savings:	[1] $900/yr or
	[2] $28,000/YR
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

For more information:

Measurement and Modelling of Hot and Warm Water Usage in Meat Plants, Walford et al, 1994 (MIRINZ document).

Water Use and Disposal Fact Sheet in Energy Management Advisory Package, MLA, 1997b (available from MLA).

Table 2.7: Comparative water usage for knife sterilisers

	Water flow rate (L/min)			**Activation time**	**Water use**
	Range	Average	Source	(S)	(L/carcase)
Continuous flow sterilisers					
Single-skin sterilisers	1 - 9	4.5	(1)	6.0	See Note 1
	2 - 8	-	(2)		
	2 - 3	2.5	(3)	3.4	See Note 1
Single-skin sterilisers (with flow restriction)	0.6 - 4.5	1.7	(1)	2.3	See Note 1
Double-skinned sterilisers	1 - 4	3.6	(1)	4.8	See Note 1
	1 - 8	4	(2)	5.4	See Note 1
	-	0.5	(3)	0.7	See Note 1
	0.6 - 3.1	1.6	(4)	2.2	See Note 1
Hot water jacket sterilisers	1.1 - 1.5	1.3	(2)	1.7	See Note 1
Intermittent spray sterilisers					
Ring spray	6 - 18	15	(4)	2.5	See Note 2
Rose spray	-	3	(4)	0.5	See Note 2
Sparge pipe spray	-	4.6	(4)	0.8	See Note 2
Alternative sterilisers					
Low temp sterilisers					
Ultrasonic sterilisers					

Sources:

[1] Internal data of Food Science Australia

[2] Walford et al, 1994

[3] Pearson, 1981

[4] Kallu, 1993

Notes:

[1] Based on a daily production of 625 head cattle/day and knife sterilisers flowing for 12 out of 16 hrs/day

[2] Based on 1 actuation per carcase

Table 2.8: **Comparative water usage for equipment sterilisers**

		Water flow rate (L/min)		Activation time	Water use	
	Range	Average	Source	(s)	(L/carcase)	
Hock and horn cutter sterilisers						
foot operated	8.4 - 23	15.8	(1)	2	0.5	See Note 2
	-	15.0	(2)	7	1.8	See Note 2
timer operated	8.4	8.4	(1)	6	0.8	See Note 2
Brisket cutter sterilisers						
with spray nozzles		12	(1)	4	0.8	See Note 2
with drilled sparge pipes		40	(1)	4	2.7	See Note 2
Beef head hook steriliser						
with continuous spray		4.4	(1)		5.4	See Note 1
continuous overflow		3	(2)		3.7	See Note 1
Splitting saw steriliser						
foot operated with spray nozzles		16.8	(1)	6	1.7	See Note 2
timer operated with drilled sparge pipes		83	(1)	10.8	15.0	See Note 2

Sources:	Notes:
[1] Walford et al, 1994	[1] Based on a daily production of 680 head cattle/day and knife sterilisers flowing for 12 out of 16 hrs/day
[2] Kallu, 1993	[2] Based on 1 actuation per carcase

2.2.14 Flow control of continuous flow sterilisers

The most common means of controlling water use at continuous flow sterilisers appears to be the manual adjustment of flow using the ball valve on the water supply to each individual steriliser. This is usually the responsibility of the supervisor, and can be an unreliable, time-consuming and often frustrating means of controlling flow. Flow control measures, such as those described below, can reduce flow by 50-60%.

Setting and fixing a minimum flowrate —The simplest approach is to set the valve at the minimum flowrate required to maintain the temperature and then remove the handle so that it cannot be tampered with. Needle valves are particularly good for this as they provide much finer flow control. However this will only work if the water supply temperature and pressure remain relatively constant. If this is not the case, temperature control valves can be used (see below).

Flow restriction —The aperture of the pipe outlet can be reduced or flow restrictors installed to give a lower flow rate. However this does not necessarily guarantee the flow rate will stay set at the required flow.

Temperature controlled flow —Flow can also be controlled by the temperature in the sterilisers by installing a localised flow controller and temperature probe. This means that hot water is only fed when the temperature falls below a preset value. This could be most beneficial for double-skinned sterilisers to take advantage of the reduced heat loss.

This option may only be applicable for pot sterilisers that do not receive a large amount of solid material (hair, fat, etc.) that floats on the surface and that needs a constant flow to remove it.

Costs and Benefits

If flow restriction devices are installed to continuous flow sterilisers throughout the plant, water use could be reduced by 50%. For a typical plant, this is a water saving of 30kL/day.

Capital Cost:	$5,000
Water savings:	$12,000/yr
Heating savings:	[1] $600/yr or [2] $20,000
Pay Back:	2-5 months

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

Richmond Group, New Zealand

Flow restriction devices were installed on knife sterilisers as well as hand wash stations to standardise the flow rates. Water use at the sterilisers and hand wash stations reduced by 25%, and the energy for heating the water reduced by 38%.

Total capital cost:	$2,735
Total Savings:	$68,340/yr
Payback:	2 weeks

Source: http://www.businesscare.org.nz/material/casestudies/c211_1.html

2.2.15 Spray sterilisers

Spray sterilisers use sprays directed towards the knife or piece of equipment instead of immersion in water. To date they have been more commonly used for equipment sterilisation than for knife sterilisation. The sprays can be foot operated or actuated by a timer switch or sensor.

The water efficiency of spray sterilisers depends on the type of spray, the flow rate and the activation time. Units with properly positioned and sized spray nozzles generally clean and sterilise faster and with less water than those with drilled sparge pipes, because the latter have a much higher flow rates. The activation time has a significant bearing on the water use. If the setting on timer-operated units is too long they can use more water than foot - operated units, which offsets the advantages of automatic operation.

A well-designed spray knife steriliser does not necessarily use less water than a well-designed continuous flow steriliser. This is because spray sterilisers usually have higher instantaneous flow rates and if used frequently, or if activated for too long, can use more water than a properly adjusted continuous flow steriliser. They may be of most benefit in locations where they are used infrequently. (Walford, 1994)

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Case study

Valley Beef, Grantham

Valley Beef are progressively replacing pot-style sterilisers with spray sterilisers. Spray sterilisers cost about the same per unit than conventional pot-style sterilisers, and the company has measured the water use to be less than 0.75 L/operation. The company expects to see a considerable reduction in water use as a result of introducing the spray sterilisers.

Source: Compiler's personal communication with staff of Valley Beef

2.2.16 Other steriliser systems

A number of other alternative steriliser systems are reported to be in use overseas, including low-temperature sterilisers, ultrasonic sterilisers, steam sterilisers, chemical sterilisers and dry air sterilisers. There are no examples of their use in Australia and they may not be appropriate, given the current hygiene standards.

Carcase washing

Some plants have moved away from full carcase washing. Trimming and spot cleaning with steam-vacuum systems may be used instead to remove contaminants from the outer surface of the carcase.

Often the main reason for carcase washing is to remove bone dust generated during carcase splitting. Modern band saws tend to generate less bone dust and so washing of beef carcases may be limited to the backbone, the chest cavity and the fore shank.

In most cases, the preferred technique for carcase cleaning will be dictated by the plant's food hygiene targets rather than water consumption considerations.

(Please refer to Table 2.9 on page 40)

2.2.17 Manual versus automatic carcase washing

It can be difficult to train operators of manual carcase wash systems to turn off the water spray when the side or carcase is clean. There is a tendency for them to continue washing unnecessarily. Automatic carcase wash systems can help avoid this if the system is efficient. However, manual washing may be preferable to automatic cabinets, where water consumption can be unnecessarily high (see Table 2.9). The choice of a manual or automatic carcase wash system will depend on a number of factors and the best option will vary (European Commission, 2002).

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Carcase washing

2.2.18 Sensor control of automatic carcase washing

Sensors can be employed in carcase wash cabinets to detect the presence of a carcase and thereby turn the flow off and on as required. Some spray cabinets are triggered by the motion of the overhead chain. For these systems, sprays may still operate even when carcases are not passing through the cabinet. Sensors that detect the presence of a carcase could help in these situations to avoid unnecessary water use. Sensor control could be expected to reduce water use by 30-50%.

Costs and Benefits

If carcase washing can be reduced by 20%, for a typical plant, the resulting savings would be around 8kL/day.

Capital Cost:	$5,000
Water savings:	$3,000/yr
Pay Back:	1.5 years

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

Valley Beef, Grantham

Sensor controls were installed on an automated carcase wash system at this plant. The carcases are washed as the spray bar moves up and down in a vertical direction. The sensors detect the height of the carcase from the floor and the sprays are started as close as possible to the neck as the spray bar moves upwards. The existing system had a fixed travel distance. The installation of sensors means that the spray bar only travels the length of the carcase and unnecessary water usage is avoided. The company estimates that this saves around 5 L/carcase.

Source: Compiler's personal communication with Valley Beef

Table 2.9: Typical water use for carcase washing

	Water use (L/carcase)	
	Range	Average
Manual systems		
Manual wash of entire carcase		50
Manual wash of backbone and cavity only		20
Automatic systems		
Automatic carcase wash system (both sides) – inefficient design	200-300	250
Automatic carcase wash system (both sides) – efficient design	90-130	110

Source: Green, et al, 1994

Automatic carcase washer

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2.2.19 Water sprays on splitting saws to remove bone dust and reduce carcase washing

A water spray kit can be fitted to splitting saws to remove bone dust during splitting. Approximately 8 L of water are sprayed per carcase. The spray is also effective in cleaning the inside surface of the carcase. The result is that no further internal washing is required and water use in the final carcase wash can be reduced by around 50%. The final carcase wash may even be eliminated at plants that can demonstrate a high standard of sanitary dressing (Green, et al, 1994).

Costs and Benefits

Fitting a water spray kit to a splitting saw would reduce water use for carcase washing by 50% compared with a full carcase wash. Therefore for a typical plant, water use could be reduced by around 20kL/day.

Capital Cost:	$5,000
Maintenance/Repair Costs:	$1,000/yr
Water savings:	$7,700/yr
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

Cooling water on breaking saws

2.2.20 On/off controls for cooling water on breaking saws

Some models of splitting and brisket saws have continual flows of cooling water to the blade. An on/off switch can be installed so that cooling water only flows when the saw is operated. This could reduce water use by 50%.

Costs and Benefits

If water use to breaking saws were reduced by 50% through the installation of an on/off switch, then the savings in water would be around 0.5kL/day.

Capital Cost:	$1,000
Water savings:	$200/yr
Pay Back:	5 years

See assumptions in Section 2.2.1 for the basis of these calculations.

Pig scalding

2.2.21 Alternative scalding systems

Alternatives to the traditional scalding tanks are water circulation spray scalding, steam scalding and condensation scalding. All of these alternatives use less water than scalding tanks.

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For circulation spray scalding a reservoir of hot water is maintained and the water is sprayed onto the pig carcases. Since the amount of water maintained in the reservoir is less than for scald tanks, less water is used overall.

Steam scalding systems involve the injection of steam into the scalding chamber. For condensation scalding the pig carcases pass through a tunnel into which moist air heated to around 60°C is injected. Heat transfer to the carcase occurs through the condensation of the hot moisture on the carcase. Since no reservoir of water is maintained, considerably less water is used for both of these techniques. Table 2.10 shows the comparative water consumptions for these systems. These alternative systems also use less energy.

The high capital costs of converting to a new scalding system would not be justified on the basis of water and energy savings, particularly for plants processing only small number of pigs. It may be worth considering for very large pig only plants in the event of a new plant construction or upgrade. (European Commission, 2002)

Table 2.10: Comparative water use for pig scalding systems

	Average water use (L/pig)
Scalding tanks	17
Circulation spray scalding	11
Steam scalding	4
Condensation scalding	1

Source: European Commission, 2002

Costs and Benefits

For a plant killing 100 pigs per day, changing from a scalding tank system to the alternative scalding system will reduce water consumption by around 1-2 kL/day. It will also reduce energy consumption.

Capital Cost:	Very high
Water savings:	$750/yr
Pay Back:	Never

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.22 Water level control on scald tanks

Unnecessary loss of water to the overflow drain from scald tanks should be avoided by setting the correct water level in the tank. Fairly minor amounts of hot water could be saved by setting the correct water level. (European Commission, 2002)

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Paunch dumping

2.2.23 Dry dumping of paunch contents

The replacement of wet-dump systems with dry-dump systems for emptying paunches has become popular. Dry-dump systems use substantially less water than wet dump systems (see Table 2.11), however the paunch sack cannot be used as an edible product due to contamination with paunch manure. Most plants would aim to recover edible stomach products since it is more profitable than disposing of the emptied or full paunch sacs to rendering (a 12kg paunch sac may return a revenue of about $17 as edible product, but only $1.44 from rendering).

A two-step process involving a dry-dump followed by a spray wash allows the paunch sack to be processed as an edible product, but uses about as much water as an efficient wet-dump system, and no additional water is required to convey the paunch manure or assist effluent pumping (van Oostrom and Muirhead, 1996).

Dry paunch dumping also reduces the loss of phosphorous to wastewater by around 40%.

Table 2.11: Comparative water use for paunch dumping systems

	Water use (L/paunch)	
	Range	Average
Wet dump	145 - 310	220
Dry dump	7 - 20	15
2-step dry dump plus spray rinse		150

Source: van Oostrom and Muirhead, 1996

Dry dumping of sheep paunch contents

Dry dumping of sheep paunches is also possible, however due to the generally high throughput, it is not feasible to open the paunch manually. A machine has been developed by CSIRO to dry dump sheep paunches.

Dry dumping of pig stomach contents

Pig stomach opening equipment is available for the dry dumping of pig stomachs. Stomachs are conveyed over a rotating slitting blade and the contents fall into a chute (McNeil and Husband). The capital cost of this equipment is expensive and pay-back on investment could be around five years. A cost of a new system is around $55,000 and the cost to modify an old stomach machine is $30,000 (European Commission, 2002). This options therefore may only be worth considering for new plants or plants undergoing refurbishment.

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Costs and Benefits

For a typical beef plant, changing from a wet dump system to a 2-step dry dump and spray rinse would reduce water use by 44 kL/day. For plants that incur substantial costs for wastewater treatment, it will also reduce treatment costs due to the reduced COD and phosphorous load.

Capital Cost:	$10,000—$20,000
Water savings:	$17,000/yr
Pay Back:	0.5 - 1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

For more information:

Evaluation of Beef Paunch Contents Handling Practices, van Oostrom and Muirhead, 1996 (MIRINZ report).

Tripe and bible washing

2.2.24 Efficient water use in tripe and bible washing machines

Tripe and bible cleaning machines use large volumes of both hot and cold water. Some brands of machines may be more efficient than others, and should be considered when purchasing a new machine.

Alternatively the flow of water to these machines could be monitored and controlled through the installation of flow meters on both the hot and cold water supply lines.

Costs and Benefits

If water use for tripe / bible washing could be reduced by 25% through better flow control or a more efficient machine, water use could reduce by around 13 kL/day.

Capital Cost:	$5,000
Water savings:	$6,000/yr
Heating savings:	[1] $200 or [2] $4,500/yr
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

Casings washing

2.2.25 Limiting water use in casing washing

There is a tendency in some casings departments to leave water running unnecessarily. To avoid this, water supply can be controlled by interlocking the operation of the machine to a timer switch. Given that casings washing is occurring for 60% of the time that the machine is in operation, this could reduce water use by 40%.

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Reduced water consumption will also result in reduced loss of slimes, mucosa, serosa and other wastes to wastewater; which can contribute significantly to nutrient loading.

Costs and Benefits

Assuming that a typical plant uses around 30 kL/day for casing washing, incorporating an interlocking device could reduce water use by 40%. This is a saving of 12 kL/day.

Capital Cost:	$1,000
Water savings:	$4,600/yr
Pay Back:	3 months

See assumptions in Section 2.2.1 for the basis of these calculations.

Gut washing

2.2.26 Water efficient gut washing systems

Rotating screens tend to use more water than rotary drum washers. Immersion washers use the least amount of water because they are designed to operate with low water usage (see Table 2.12) (Swan et al, 1986).

An alternative gut washing system has been proposed by CSIRO to operate in association with a Brentwood Shredder gut cutter. It is based on a set of high pressure sprays that wash the gut material as it falls out of the Brentwood Shredder. Water use for this system is reported to be high (6,000 L/hr) and the reuse of wastewater from another area is recommended (Hamilton and Aust, 1989).

The other factor that needs to be considered in the selection of a gut washing system is the amount of fat loss. For example, while rotating screens use more water than rotary drum systems, material loss is less due to the much smaller screen gap size. Immersion washers result in the least total fat loss (Swan et al, 1986). Therefore water use needs to be balanced against fat loss. Immersion washers seem to offer a good balance between water efficiency and fat retention. Fat loss considerations are discussed in Section 4.2.12.

Costs and Benefits

If an immersion washer were used instead of a rotating screen or rotary drum washing systems, which are assumed to be 40% more efficient, then water savings would be 24kL/ day.

Capital Cost:	minimal (additional cost)
Water savings:	$9,000/yr
Pay Back:	<1 year

See assumptions in Section 2.2.1 for the basis of these calculations.

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Table 2.12: Typical water use for gut washing systems

	Water use(L/tHSCW)		Ref
	Range	Average	
Contra-Shear systems	-	2260	(1)
Rotary drum systems	500 - 3,300	1,500	(1)
Immersion systems	680 - 1,100	900	(1)
CSIRO modified Brentwood Shredder	6,000 L/hr		(2)

Sources:

[1] Swan et al 1996

[2] Aust, 1989

For more information:

Assessment of four viscera cutting and washing systems, Swan et al 1986 (MIRINZ report).

Evaluation of a system for cutting and washing soft offals, based around a modified Brentwood Shredder, Hamilton and Aust, 1989 (available from Food Science Australia, http:// www.meatupdate.csiro.au/)

Edible offal washing

2.2.27 Water efficient shower roses

In many plants, standard shower roses are used at offal washing stations. More water efficient shower roses or spray nozzles could reduce the amount of water used for offal washing, while still maintaining effective washing. The correct selection and maintenance of nozzles on wash sprays is discussed earlier in this section. Typically, 20% reduction in water use can be achieved by upgrading spray nozzles (March Consulting Group, 1998).

2.2.28 On/off control of flow

It is common for offal washing stations to be left to run continuously during production periods. Continuous flow of water may not be necessary. Manually operated on/off controls could significantly reduce water use. Possible options are a knee-, thigh- or foot - operated valve in the water line or a sensor switch triggered by the presence of the operators hands under the shower rose.

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Costs and Benefits

If through the use of more efficient shower roses and/or an on/off flow control device, water for edible offal washing could be reduced by 20%, then water savings would be 6 kL/ day.

Capital Cost:	$2,000
Water savings:	$2,300/yr
Pay Back:	10 months

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.29 Automatic spray washers

Automatic spray washers for offal washing can reduce water use for offal washing by around 50%. They are tumblers with a perforated bowl, which act much like a washing machine.

Costs and Benefits

If water use for offal washing could be reduced by 50% through the use of an automatic offal washing system, then water savings would be 15 kL/ day.

Capital Cost:	$40,000
Water savings:	$6,000/yr
Pay Back:	7 years

See assumptions in Section 2.2.1 for the basis of these calculations.

Plant cleaning

Plant cleaning takes place both during and at the end of production, but most of the cleaning effort occurs at the end of a production day. Table 2.13 provides an indication of the volumes of water used for plant cleaning, based on New Zealand data. Plant cleaning is not related to production throughput but to the surface area requiring cleaning. Therefore water use for cleaning is best expressed per square metre of floor and wall area.

Table 2.13: Typical water use for plant cleaning

	Hot water use		**Cold/warm water use**		**Total water use**	
	(L)	(L/m^2)	(L)	(L/m^2)	(L/m^2)	Source
Cleaning during production						
Morning rinse	1,500	1.9	0	0.0	1.9	(1)
Morning tea clean up	0	0.0	1,212	1.6	1.6	(1)
Lunch clean up	0	0.0	1,260	1.6	1.6	(1)
Cleaning at end of production						
Slaughter floor	2,600 - 2,980	2.1 - 3.9	3,900 - 10,800	5.9 - 7.6	9.7 - 9.8	(1)
					11.8	(2)
Boning room	9,520	15.1	0	0	15.1	(1)
					12.9	(2)

Sources: [1] Walford et al, 1994 [2] Kallu, 1993

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2.2.30 Improved dry cleaning prior to wash down

Dry cleaning of plant and equipment prior to wash down is practiced widely in the industry, however there may still be room for improvement at various times. Operator training is a key factor in achieving good dry cleaning, however making the dry cleaning process easier for operators may help maintain good performance. Industrial vacuum cleaners for easier collection of solids and transfer to rendering may be worth considering.

Typically water use for cleaning can be reduced by 20—30% by using good dry cleaning practices (March Consulting Group, 1998 and Walford et al, 1994). Dry cleaning also reduces product loss and pollutant load of the wastewater.

Costs and Benefits

For plants where dry cleaning practices are poor, improved dry cleaning could conservatively reduce plant cleaning water use by 20%. For a typical plant, this would be a saving of around 30kL/day.

For plants with substantial wastewater treatment costs there would also be reduced treatment costs from the reduced COD load.

Capital Cost:	minimal
Water savings:	$13,000
Pay Back:	immediate

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

Danish cattle abattoir

A Danish cattle abattoir uses a vacuum cleaner in its slaughter floor to routinely remove blood and floor waste during production and prior to washdowns.

Water consumption for cleaning reduced by about ten percent and the COD of the effluent reduced by seven percent. Source: March Consulting Group, 1998.

For more information:

Automated plant cleaning, MLA, 1995c (Available from MLA).

Measurement and monitoring of hot and warm water usage in meat plants.
Walford et al, 1994 (MIRINZ report)

Reducing the cost of cleaning in the food and drink industry, March Consulting Group, 1998. (Downloadable from http:// www.envirowise.gov.uk). Publication code GG154.

Reducing water and effluent costs in red meat abattoirs, WS Atkins Environment, 2000. (Downloadable from http:// www.envirowise.gov.uk). Publication code GG243.

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2.2.31 High pressure water ring main for cleaning

High pressure water, supplied by a pressurised ring main can reduce water use for cleaning. Higher pressure systems use less water and chemicals due to the mechanical cleaning action of the water jet. This advantage needs to be weighed against the risk of aerosol. Table 2.14 shows the difference in water flow rates for high pressure and low pressure systems. High pressure cleaning can reduce water consumption by 60% (March Consulting Group, 1998).

If the capital cost of a high pressure ring main is prohibitive, mobile pressure washers may be worth considering. However these can be awkward to use. It may be tempting for operators to use mains hoses rather than set up the mobile washer. Pressurised ring mains are always available for use and therefore the benefits can be maximised.

Table 2.14: Typical flow rates for low and high pressure cleaning

	Water flow rate (L/min)	
	Range	Average
Low pressure cleaning hose	30 - 90	50
High pressure cleaning system	11 - 25	17

Source: Walford et al, 1994

Costs and Benefits

Assuming that pressurised water could be used for 75% of end-of-day plant cleaning with a conservative reduction in water use of 40%, then for a typical plant the water savings would be 50 kL/day. There would also be savings in energy since about 40% of the water used for cleaning is hot.

Capital Cost: (for pressurised ring main)	$50,000
Water savings:	$20,000/yr
Heating savings:	[1] $4,000/yr or [2] $13,500/yr
Pay Back:	1.5-2.5 year

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

Danish pig abattoir

A trial undertaken at a small Danish pig abattoir reported that water use for plant cleaning reduced from 750 to 500 L/tonne carcase when high pressure water was used. In this case the pressure was increased to eight bar. Source: European Commission, 2002.

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2.2.32 Automatic washers for tubs, cutting boards and trays

Mechanical washers for tubs, cutting boards and trays are designed to soak, pre -wash, wash, rinse, disinfect and possibly dry. They can save water, detergent, energy and labour for this task. Such units have been reported to use less than five percent of the water used for manual cleaning (March Consulting Group, 1998). The capital cost could range from $25,000—$50,000 (MLA, 1995c) and may therefore only be viable for washing a large number of items.

Costs and Benefits

If an automatic washing machine was used for washing tubs, cutting boards and trays, water use could be reduced by 95%. The water savings for a typical plant could be around 30 kL/day.

Capital Cost:	$25,000
Water savings:	$11,000/yr
Pay Back:	2 years

See assumptions in Section 2.2.1 for the basis of these calculations.

2.2.33 Floor cleaning machines for large areas

Floor cleaning machines may be an option for cleaning large flat areas such as boning rooms, chillers and carcase holding areas. They can be used for wet or dry cleaning and are available as hand-push or ride-on models. Their use in areas such as chillers will reduce water use for cleaning in these areas and also chemical usage, labour and chiller downtime. The capital cost for small units is about $10,000 - $20,000 (MLA, 1995c).

Costs and Benefits

If a floor cleaning machine was used to clean large areas such as chillers or freezers, the water savings would probably be less than about 10 kL/ day.

Capital Cost:	$10,000
Water savings:	$4,000/yr
Pay Back:	3 years

See assumptions in Section 2.2.1 for the basis of these calculations.

Case study

Richmond Group, New Zealand

The Richmond plant has four chillers, which are cleaned to remove the protein that builds up on the floors. The purchase of a small mechanical scrubber reduced water use, chemical usage, labour and chiller down time.

Capital Cost:	$2,155
Total savings:	$5,858/yr
Payback:	5 months

Source: http://www.businesscare.org.nz/material/casestudies/c211_1.html

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2.2.34 Timers on water taps

For some cleaning jobs, water may be wasted because hoses or taps are left on unnecessarily. Careful observation of cleaning practices will identify where this is occurring, and then timers can be installed to stop the flow of water after a set period of time. This removes the onus on the operator to remember to turn the tap off. The water savings may be small, but the capital cost is also very low and therefore an easy way to make some savings.

Amenities

Amenities refers to areas such as toilets, changerooms and hand, apron and boot wash areas. Amenities are located at entrances to clean areas where staff wash before entering and exiting. Hand wash stations are also located throughout process areas, often next to knife sterilisers. This section provides a comparison of the different options for controlling the use of water at these areas.

Thigh– and pedal– operated switches are the conventional means of controlling water supply for amenities. The operator operates a pedal switch or 'knee wand', which directly opens the water supply valve to the tap. These systems can be efficient, however they are susceptible to being tampered with by operators so that water runs continuously.

2.2.35 Automatic controls for hand washing

Increasingly, electrical sensors are being used to control water supply. They overcome the problem of tap tampering, but are also susceptible to damage from high-pressure water during cleaning. The need for an electrical supply to the sensors may also pose some hazards in process areas. Use of sensors can reduce water use by up to 90% (see Table 2.15).

Pneumatically operated valves can be operated by a foot pedal or 'knee wand', but switch off after a set period of time. These systems provide control of water flow, like the electrical sensors, but are not as prone to damage and avoid the need for an electrical supply.

Table 2.15: Typical water use for hand wash stations

	Water use (L/carcase)	
	Range	Average
Knee-operated units	0.03-2.97	0.7
Sensor-operated units	0.04-0.04	0.04

Source: MLA, 1997(b)

Costs and Benefits

If sensors or pneumatically-operated switches with timers were installed at hand wash stations, for a typical plant water use for hand washing could conservatively be reduced by 60%. This is a saving of 12 kL/day. There would also be an energy saving from the reduction in warm water use.

Capital Cost:	$10,000
Water savings:	$4,500/yr
Heating savings:	[1] $100/yr or
	[2] $4,000/yr
Pay Back:	1-2 year

See assumptions in Section 2.2.1 for the basis of these calculations.

Plant services

2.2.36 Maximising condensate recovery

Water can be lost from the boiler system in the form of steam condensate. If condensate is not recovered, additional boiler make-up water must then be added to compensate for the lost condensate.

Maximising condensate recovery reduces the amount of water used as boiler feed, but also reduces chemicals use due to the reduced amount of boiler feed water requiring pre-treatment.

Energy is also saved since it avoids heating the make-up water that it displaces. The energy content of the condensate can be 20% of the energy content of the steam.

Costs and Benefits

If a typical plant currently recovers only 50% of condensate, increasing this to 90% will save around 20kL/ day, but also a significant portion of the heat content of the steam.

Capital Cost:	$5,000
Water savings:	$7,700/yr
Heating savings:	~$10,000/yr
Pay Back:	4 months

See assumptions in Section 2.2.1 for the basis of these calculations.

For more information:

Energy Management Advisory Package, MLA, 1997b (Available from MLA).

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Case study

Churchill Abattoir

Churchill Abattoir did not have a condensate return line from its continuous cooker back to the boiler. Instead the condensate was discharged to wastewater.

At a cost of $4,000, a return line was installed to divert the condensate to the existing condensate return tank and heat exchanger. This resulted in the recovery of 21-63 kL/day of condensate and a reduction of at least 15% in steam generation costs.

Capital Cost:	$4,000
Savings in steam generating costs:	$12-15,000/yr
Water savings:	$24-36,000/yr
Total Savings:	$36-50,000/yr
Payback:	immediate

Source: Compiler's personal communication with Churchill Abattoir

2.2.37 Conductivity controlled blowdown on cooling towers

Many cooling water towers have timed automatic blowdown controls that release water for a few minutes each hour or which release water continuously, or blowdown may be a manual operation. In these situations, blowdown may be higher than really necessary, resulting in the use of more cooling water makeup than necessary .

The alternative is for blowdown to be controlled by a conductivity probe that initiates blowdown when the conductivity level in the cooling water exceeds a set value (US DoE, 1995).

Costs and Benefits

For a typical plant that has continuous blowdown, cooling water makeup could be reduced by around 50% by installing automatic blowdown controls, which is a saving of around 5kL/day.

Capital Cost:	$5,000
Water savings:	$2,000/yr
Pay Back:	2 years

See assumptions in Section 2.2.1 for the basis of these calculations.

2.3 Water reuse

This section deals with opportunities for reusing water within the plant. The beneficial reuse of the main treated wastewater stream is discussed in Section 6.5.

2.3.1 Reuse of clean wastewater streams

Some wastewater streams are relatively clean and may be used elsewhere in the plant for activities that do not require high quality water. The key to water reuse is the ability to segregate suitable wastewater streams from the main wastewater drainage system. Some wastewater streams could drain directly to the reuse application, however others may need to be fed to a storage tank for reuse as required.

Segregation of wastewater lines may be difficult, if not impossible, for existing plants. The best time to install segregated wastewater lines is when the plant is being upgraded or refurbished.

Figure 2.1 lists those wastewater streams that may be suitable for reuse and those areas where water could be reused. Hygiene standards do not allow the reuse of water on edible product or in a process where the water could come into contact with edible product. Therefore water reuse opportunities are relatively limited, and this is more so for export plants than for domestic plants.

To determine the best opportunities for water reuse, estimate the quantities and the quality of water available for each reuse stream and match this up with the quantities required for each potential application, as shown in Figure 2.1.

If water reuse is limited to relatively clean wastewater streams, then pre-treatment should not be required. However if plants are interested in reusing wastewater stream with some level of contamination, then some form of treatment will be required.

Costs and Benefits

If reuse opportunities were maximised, up to 400 kL/yr of relatively clean wastewater could be reused in the plant for non-critical applications at a typical plant. This would require considerable capital expense, particularly if some of the steam need pre-screening.

Capital Cost:	\$100,000—\$200,000
Water savings:	\$155,000/yr
Pay Back:	0.5—1.5 years

See assumptions in Section 2.2.1 for the basis of these calculations.

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Figure 2.1: Examples of water reuse opportunities

Potential sources of water for reuse	Available volume (kL/day)	Potential area of reuse	Volume required (kL/day)
Freezer defrost	5	Cooling tower makeup	45
Knife and equipment sterilisers	120	Pig scald tanks Stock washing (initial rinse only for some plants)	20 100
Cooling water from pig singeing oven	20	Pig dehairing, scraping and brushing	20
Handwash basins	75	Rendering material conveyance chutes Sprays on trommel screens	5 60
Carcase wash Viscera and bleed table wash Edible offal wash water	60 75 30	Rendering plant washdown Odour scrubbers Stockyard washing Truck washing	8 5 75 5
Head wash	5	Gut washing	60
Total	390	Total	403

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2.4 Alternative Sources of Water

2.4.1 Rainwater harvesting

For those plants in urban areas that purchase municipal treated water from local councils or water boards, some savings can be made by supplementing water supplies with rainwater collected from roof surfaces. Most meat plants have large roof areas from which to collect rainwater. However the amount that can be collected in South East Queensland could be less than five percent of total water consumption. Plants located in the wetter northern regions may be able to collect more. Collection of rainwater off hard surfaces around the plant would generated larger quantities of water, however the quality would likely be poor.

Rainwater collection trials undertaken in inner-city Sydney have demonstrated that rainwater collected off roof surfaces is of good quality and suitable for potable use. If quality concerns are an issue, the water could be used for non-process applications such as cooling water or for stockyard washing, etc.

Costs and Benefits

If rainwater is collected from a roof surface area of around 10,000m^2 in an area with a rainfall of around 1,200 mm/yr, then 12,000kL/yr of water could be collected and displace the use of town water supply.

Capital Cost:	$10,000—$20,000
Water savings:	$12,500/yr
Pay Back:	1-2 years

See assumptions in Section 2.2.1 for the basis of these calculations.

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Part 3

Energy

3.1 Overview of energy use

Energy is an important input for meat processing. The perishable nature of meat products means that they need to be chilled or frozen or cooked in order to preserve them. This involves the use of electricity for refrigeration and heat for cooking (at plants that process by-products). The need to maintain strict food hygiene standards also necessitates the use of hot water for sterilisation of plant and equipment.

Table 3.1 is an example of the breakdown of energy use in meat processing, based on the typical plant described on page (iii). The plant in the example uses coal for steam raising and produces hot water using heat recovered from the rendering plant.

Energy use patterns can vary considerably from one plant to the next, so this should be regarded as an example only.

Some facts about energy use

- Steam is used by plants that render by-products. Steam is generated in on-site steam boilers fuelled by coal, fuel oil, natural gas or LPG (with coal the most commonly used fuel since it is the cheapest).
- Around 30-40% of water used at meat plants is warm (43°C) or hot (82°C). For plants with rendering, water is commonly heated using heat recovered from the cooker, with some supplementary steam heating. Plants with no rendering heat water directly, usually with gas.
- Refrigeration is the largest user of electricity at meat plants, accounting for 40-50% of total use. The other large area of use is the multitude of motors that drive pumps, fans, conveyors and hydraulic systems.

Table 3.1 Example breakdown of energy use at a typical meat plant

Hot water

Areas of hot water use	MJ/day	**Hot water production**		
Knife and equipment sterilisers	30,000	Hot water demand	88,000	MJ/day
Hand wash stations	5,000	Recovered heat	60,000	MJ/day
Slaughter and evisceration	15,000	Supplementary steam heating	28,000	MJ/day
Plant cleaning	25,000			
Amenities	5,000			
Tripe / bible washing	2,000			
Hook wash tanks	1,000			
Heat loss from hot water pipes	5,000			
Total	**88,000**			

Continued next page

Table 3.1 Example breakdown of energy use at a typical meat plant (continued)

Steam

Areas of steam use	t steam/day	MJ/day	**Steam raising**		
Rendering	54	150,000	Steam demand	213,000	MJ/day
Hot water production	10	28,000	Energy consumption in boiler	236,667	MJ/day
Blood processing	7	20,000	Coal consumption in boiler	8	t/day
Tallow processing	2	5,000			
Heat loss from steam pipes	4	10,000			
Total	**77**	**213,000**			

Electricity

Areas of electricity use	kWh/day	MJ/day
Refrigeration	22,222	80,000
Motors (pumps, fans, conveyors etc.)	15,000	25,000
Lighting	833	3,000
Air compression	2,778	10,000
Total	**40,833**	**118,000**

Total energy use

Coal	8 t/day	51 kg/tHSCW	236,667	MJ/day	1.6	GJ/tHSCW
Electricity	40,833 kWh/day	272 kWh/tHSCW	118,000	MJ/day	0.8	GJ/tHSCW
Total energy input			**354,667**	**MJ/day**	**2.4**	**GJ/tHSCW**

Source: Internal data, UNEP Working Group for Cleaner Production

The cost of energy

Table 3.2 shows typical costs for the energy sources commonly used at meat plants. It should be noted that there is considerable variation in the price paid for fuels and electricity within the industry, depending on the supplier and the negotiating power of the business.

Table 3.3 shows typical fuel costs for steam production in coal, natural gas and oil boilers. These costs do not include the operating costs of chemicals, labour, maintenance and ash disposal etc. The fuel costs for producing steam from coal is considerably lower than for gas and for fuel oil, and hence coal is the most commonly used fuel in the industry.

Table 3.4 shows typical fuel costs for water heating. The cost of hot water production for plants with rendering can be very low, since the majority of the heat is provided by heat recovered from rendering cookers. For plants without rendering, hot water heating is considerably more costly.

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Units of energy

Because different types of energy are used within the meat plants, with different units of measurement (tonnes coal, kWh electricity, m^3 gas, etc.), it is convenient to convert them to a common unit, such as megajoules (MJ). Use the following calorific values and conversion factors to do this:

Coal = 30.7 MJ/kg
Natural gas = 39.5 MJ/m^3
Fuel oil = 43.1 MJ/kg
Electricity = 3.6 MJ/kWh
Steam = 2.8 MJ/kg steam

Table 3.2 Typical costs for primary energy sources

		Typical fuel cost	
Fuel costs	**Calorific value**	($/quantity of fuel)	($/GJ)
Coal	30.7 MJ/kg	$55/t	$1.79
Fuel oil	43.1 MJ/kg	$425/t	$9.86
Natural gas	39.5 MJ/m^3	$0.38/m^3	$9.50
Electricity	3.6 MJ/kWh	$0.05/kWh	$13.89

Table 3.3 Typical fuel costs for steam production[1]

	Coal boiler	Natural gas boiler	Fuel oil boiler
	(85% efficiency)	(95% efficiency)	(90% efficiency)
Energy content of steam	2.8 GJ/t steam	2.8 GJ/t steam	2.8 GJ/t steam
Fuel energy input	3.3 GJ/t steam	2.9 GJ/t steam	3.1 GJ/t steam
Quantity of fuel	107 kg coal/t steam	74 m^{3}gas/t steam	72 kg oil/t steam
Cost	**$5.87/t steam**	**$27.84/t steam**	**$30.50/t steam**

[1] Based on a steam system producing steam at 11 bar and 184ºC, with a steam enthalpy of 2.8GJ/kg steam

Table 3.4 Typical fuel costs for heating water to 84ºC

	Heating with recovered heat from rendering cooker [1]		Direct water heating	
	with supplementary steam heating from coal boiler	with supplementary steam heating from natural gas boiler	Electricity	Gas
Heat input required (MJ)	40 MJ/kL	40 MJ/kL	282 MJ/kL	282 MJ/kL
Quantity of fuel / power	14 kg steam/kL	14 kg steam/kL	78.2 kWh/kL	7.1 m^{3}gas/kL
Cost	**$0.08/kL**	**$0.40/kL**	**$3.91/kL**	**$2.68/kL**

[1] Assumes that water is heated to 75ºC with recovered heat and then to 84ºC with steam

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3.2 Reducing demand for steam

3.2.1 Reducing water entrainment in rendering materials

The more water that is entrained in the rendering materials, the greater the steam consumption required to drive off the water. Therefore reducing the amount of water added to the rendering material is the easiest means of reducing steam consumption at the rendering plant.

The main mechanisms for water entrainment in the rendering material is the washing of materials before being transferred to rendering (gut washing) and the addition of water as a lubricant in conveyance systems.

The best means for reducing entrainment water in rendering materials is to prevent the addition of water in the first place. As a guide, the condensate generated from dry rendering systems should be 46-50% of raw material intake (McNeil and Husband, 1995).

Assumptions used for Cost-Benefits Assessments

The cost-benefit assessments described in this section are based on the following assumptions:

A ‘typical’ plant is one processing the equivalent of 150 tHSCW/day (625 head beef cattle/day), 250 days/yr.

Table 3.1 is used as the basis for energy use for the typical plant.

Steam savings are based on an average cost for steam production of $5.90/t steam (see Table 3.3).

Electricity savings are based on an average price for electricity of $0.05/kWh (see Table 3.2).

Fuel savings are based on the average fuel prices in Table 3.2.

Costs and Benefits

If steam consumption for rendering could be reduced by 10% by reducing entrainment of water, then steam consumption would reduce by 5 t/day.

Capital Cost:	minimal
Steam savings:	$8,000/yr
Pay Back:	immediate

See preceding assumptions for the basis of these calculations.

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3.2.2 Automatic diversion valves in bleed area to avoid dilution of blood

The dilution of blood with water leads to higher steam consumption in blood processing to drive off the excess water. It also results in poor coagulation during blood processing and potentially reduced blood solids yields.

Automatic two-way diversion valves in the bleed area that prevent water flowing to the blood pit can help reduce blood dilution. With good diversion, the final solids concentration of the collected blood should not fall below about 15%, which is a 25% dilution with water (MLA, 1997d). Good diversion systems also reduce blood loss.

Blood recovery drain

Costs and Benefits

With reduced blood dilution, from 35% to 25%, steam consumption for blood processing could be reduced by 10%, saving of around 1 t steam/day. There would also be an increase in blood product yield.

Capital Cost:	$10,000
Steam savings:	$1,000/yr

See assumptions in Section 3.2.1 for the basis of these calculations.

3.2.3 Reducing hot and warm water use

For those plants that heat water using steam, reducing the use of hot and warm water will reduce steam use. Opportunities for reducing hot and warm water use are discussed extensively in Section 2 (Water).

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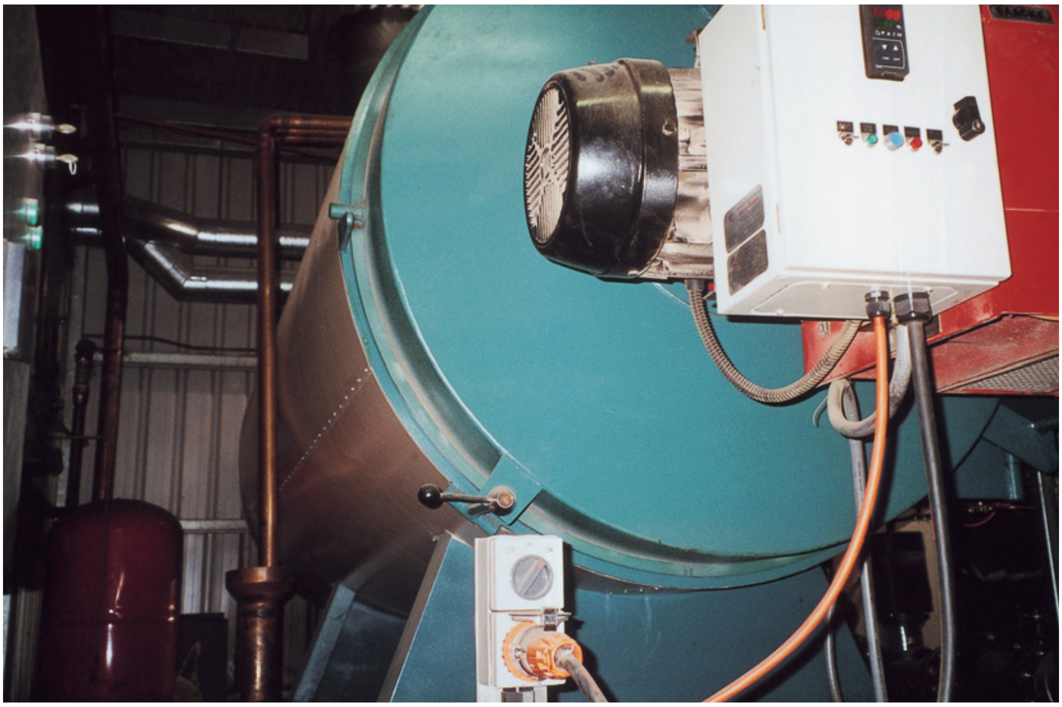
3.3 Efficient steam raising

3.3.1 Rationalisation of boiler use

At many plants, steam is used to produce hot water as well supplying the rendering and the blood processing plants. On some occasions the boiler may be operated outside production hours, possibly at reduced capacity, to heat water required for cleaning or hot water supply to amenities. In such situations, it may be more economical to install a dedicated hot water system to produce hot water rather than operating the boiler inefficiently at reduced capacity.



Energy boiler

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Case study

Richmond Group, New Zealand

On Saturdays, product is loaded out of the chillers during which time a steriliser and apron wash facility must be available. Historically the boiler was operated to heat a small amount of water. A small electrical point-of-use hot water system was installed to avoid this.

Capital Cost:	$400
Total Savings:	$8,000/yr
Payback:	3 weeks

Source: http://www.businesscare.org.nz/material/casestudies/c211_1.html

3.3.2 Matching steam supply with demand

Often steam supply capacity at the boiler house is too high compared to the plant's steam demand and this results in unnecessary fuel wastage. A plant's steam demand is variable over a production day and over different months. Boilers must be run in a flexible manner to meet variable steam load. More metering instrumentation will help do this.

3.3.3 Rectification of steam leaks

Steam leaks allow steam to be wasted, so that more boiler feedwater and more fuel is used to heat the additional water feed and more chemicals to treat the extra water. Elimination of such leaks can save up to two percent of steam production costs (CADDETT, 2001).

Costs and Benefits

Assuming that rectification of steam leaks at a typical plant reduces total steam production by two percent, then this is a steam saving of two t steam/ day.

Capital Cost:	minimal
Steam savings:	$2,000/yr
Pay Back:	immediate

See assumptions in Section 3.2.1 for the basis of these calculations.

3.3.4 Insulation of steam lines

Uninsulated steam and condensate return lines are a source of wasted heat energy. Insulation can help reduce heat loss by as much as 90%, as shown in Table 3.5. Any surface over 50°C should be insulated, including boiler surfaces, steam and condensate return piping and fittings. It is also important that sources of moisture are eliminated to prevent insulation from deteriorating and insulation that is damaged should be repaired.

Table 3.5 **Heat loss from steam lines**

	Heat loss [1]	
	MJ/m/h	kg steam/m/h
Uninsulated	2.83	1.0
Insulated with mineral fibre	0.138	0.05
Insulated with polystyrene	0.096	0.03

Source: US DoE, 2002

[1] Based on 125mm steel pipe at 150ºC

Costs and Benefits

Assuming that a typical plant has 200m of steam pipes, only 50% of which are insulated, increasing insulation to 95% will save 1.4 t steam/day.

Capital Cost:	$1,000
Steam savings:	$2,100/yr
Pay Back:	6 months

See assumptions in Section 3.2.1 for the basis of these calculations.

3.3.5 Rationalisation of steam lines

For some plants, particularly older plants that have progressively expanded over the years, steam supply lines may not take the most direct route from the boiler to the point of use. This results in a greater length of steam pipe work than is really required and consequently greater opportunity for heat loss and leaks. Based on the heat loss information in Table 3.5, every metre of unnecessary steam pipework will lose 0.05 kg steam/h if it is insulated and 1 kg steam/h if it is not insulated.

Costs and Benefits

Reducing the length of steam pipework from 200m to 150m through rationalisation would save around 0.8 tonnes steam/day.

Capital Cost:	$5,000
Steam savings:	$1,200/yr
Pay Back:	4 years

See assumptions in Section 3.2.1 for the basis of these calculations.

Case Study

UK Meat Processor

A UK plant rationalised steam and hot water lines by removing 80m of steam and 80m of hot water pipes. This reduced heat loss from the steam and hot water supply system and resulted in an energy saving of 474 GJ/yr, equivalent to 13 tonnes coal.

Capital Cost:	$3,300
Total Savings:	$2,950
Payback:	1.1 years

Source: European Commission, 2002

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For more information:

Energy Management Advisory Package, MLA, 1997b (Available from MLA).

Saving Energy with Steam Production and Distribution, CADETT, 2001.
http://www.caddet.org/

Energy Tip Sheets—US DoE, 2002. http://www.oit.doe.gov/bestpractices/

3.3.6 Fine tuning of boiler operation

Regular flue gas analysis can help determine the operating efficiency of the boiler. Optimal percentages of oxygen (O_2), carbon dioxide (CO_2) and excess air in exhaust gases are shown in Table 3.6. The boiler air/fuel ratio can be adjusted to obtain the optimum mix of flue gases.

A high flue gas temperature can mean there are deposits and fouling on boiler tubes, which reduces boiler efficiency. A one percent efficiency loss occurs with every 5°C increase in stack temperature. A major variation in stack gas temperature indicates a drop in efficiency and the need for air-fuel ratio adjustment or boiler tube cleaning.

Table 3.6 Optimum flue gas composition

	O_2	CO_2	Excess Air
Natural gas	2.2%	10.5%	10%
Coal	4.5%	14.5%	25%
Liquid petroleum fuel	4.0%	12.5%	20%

Source: Muller et al, 2001

Costs and Benefits

If coal boiler efficiency could be improved from 80% to 85% through regular flue gas analysis and fine tuning, the amount of fuel combusted for a typical plant would be reduced by 0.7 tonne coal/day.

Capital Cost:	$1,000
Monitoring Costs:	$3,000/yr
Steam savings:	$10,000/yr
Pay Back:	2 months

See assumptions in Section 3.2.1 for the basis of these calculations.

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Case study

Australia Meat Holdings

AMH identified low coal combustion efficiencies for a number of its boilers. It undertook in-house training for its boiler operators in more efficient boiler operation and initiated monitoring. This led to an immediate improvement in boiler performance and a decrease in the percentage of uncombusted coal from 25% to 2% at one site and from 13% to 4% at another site.

Capital Cost:	$nil
Monitoring costs:	$3,000/yr
Total Savings:	$62,000/yr
Payback:	immediate

Source: http://www.emcentre.com/unepweb/tec_case/food_15/process/p18.htm

3.3.7 High efficiency boilers

Boiler efficiency can be improved by installing heat recovery equipment such as economisers or recuperators.

An economiser is an air-to-liquid heat exchanger that recovers heat from flue gases to pre -heat boiler feed-water. Fuel consumption can be reduced by approximately one percent for each 4.5°C reduction in flue gas temperature

Recuperators are air-to-air heat exchangers that are used to recover heat from flue gases to pre-heat combustion air. Combustion air can be pre-heated to as high as 540°C with inlet flue gases entering at 1,000°C and exiting at 700°C (Muller et al 2001).

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3.4 Alternative sources of energy for steam raising

3.4.1 Conversion to cleaner boiler fuel

Most Queensland meat plants burn coal for steam raising. However there are still a significant number of plants using fuel oil and a number of plants have changed to natural gas.

Natural gas is a cleaner burning fuel compared with coal or fuel oils and there has been some promotion by governments for the use of natural gas over coal and oil due to the reduced emissions of greenhouse gas and other air pollutants.

Many plants would not consider converting to natural gas because of the higher fuel cost. However in some situations, natural gas may be more economical overall due to lower labour, maintenance costs and avoided ash disposal costs.

The conversion from coal or fuel oil to natural gas would require the installation of a new boiler or substantial changes to the burner and fuel delivery system. Therefore the capital cost of this would make the conversion prohibitive for many plants. However it may be worth considering for any planned upgrades.

3.4.2 Tallow burning

Tallow burning may be an option for plants that operate oil, gas or LPG-fired boilers. It would be viable when the selling price of tallow is lower than the cost of oil or gas. The market value of tallow has trended downwards since 1998, such that it is now significantly lower than the cost of fuel oil (See Figure 3.1). Currently tallow competes favourably with fuel oil and LPG, but not with coal or gas.

Tallow as a fuel falls into the heavy fuel oil category (grade 5 or 6) because of its high density (0.9 kg/L) and pour point (30°C). The levels of impurities are quite low for a heavy fuel oil, and it has a calorific value slightly lower than that of fuel oils.

Oil-fired boilers can quite easily be converted to operate on tallow. The main modification needed is the provision for the boiler to start up and shut down on fuel oil or diesel to preheat the fuel lines to prevent solidification of the tallow. Alternatively diesel could be mixed with the tallow at about 10% to lower the melting point.

Gas-fired boilers would require the additional expense of an atomising oil burner as well as the pre-heating provisions mentioned above.

Tallow does not contain sulphur, therefore the problem of formation of corrosive acids from condensation in the stack does not exist. Flue temperature can be less than the 150°C normally required for fuel oils, therefore there would be a net increase in boiler efficiency.

The slightly lower calorific value results in a slightly higher combustion air requirement. Tallow also has a higher flash point, meaning that the minimum furnace temperature would be around 300°C. This would not normally be a problem for burners that have a refractory lined combustion chamber (Downey and McDonald, 1984).

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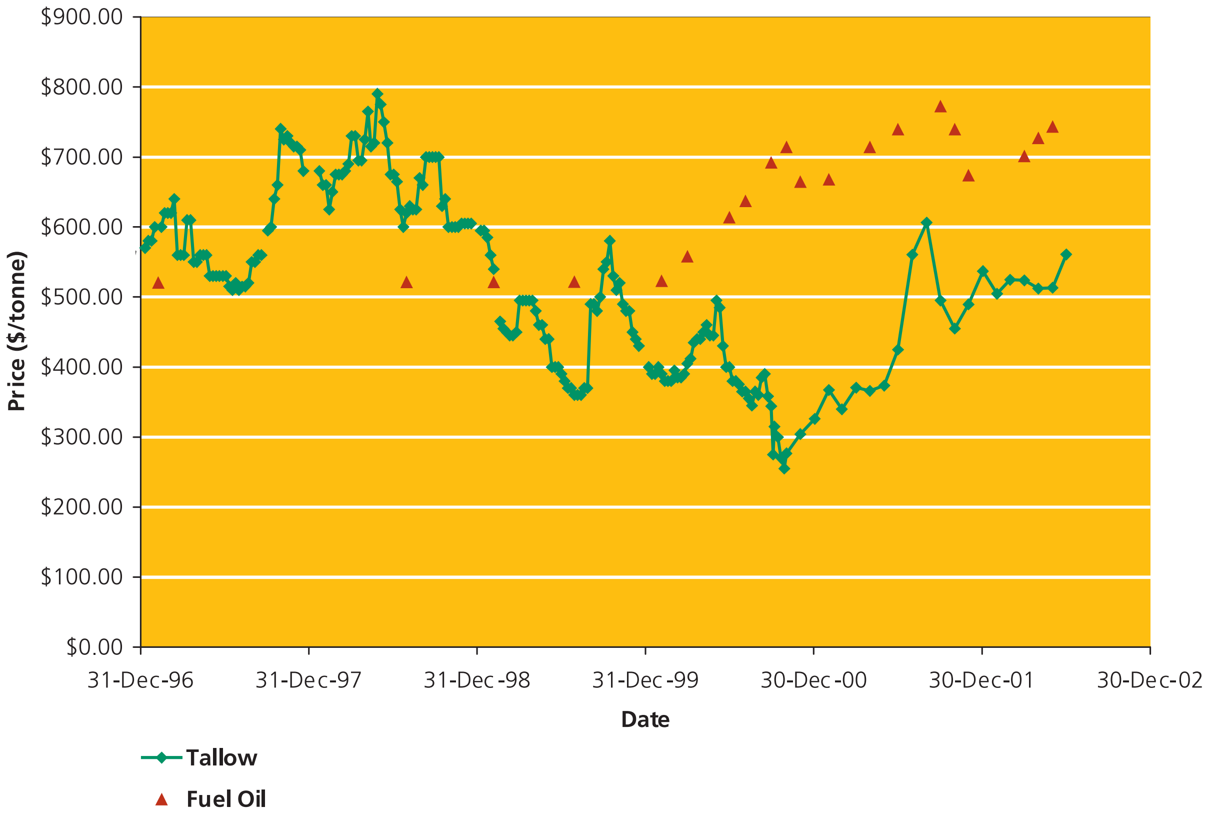
Figure 3.1 Tallow and Fuel Oil Prices



Source: McPhail, 2001

For more information:

Raw tallow as a fuel oil substitute, Downey and McDonald, 1984. (MIRINZ report).

Case study

Conversion of a 150kW boiler from LPG to tallow

An abattoir at Roma, Qld, operated its 150kW LPG boiler on tallow for a period of time. The boiler required only minimum modifications. The boiler already had the required fuel pre-heater, however the fuel filtration system was upgraded to 50 µm.

The main problem to be overcome was maintaining optimum ignition and temperature of the tallow. This was achieved by heating the tallow in tanks to keep the tallow liquid (30°C). The optimum injection temperature varied but the boiler was run with ambient temperatures ranging from –3°C to 40°C. Over 6 months of operation, tallow proved to be a cleaner burning fuel, showing less wear than with hydrocarbon fuels.

The boiler consumed 2-2.5 t/production week (5 days of 10 hour shifts). At the time, LPG costed $500/t and the value of tallow was $200/t. Therefore it provided considerable cost savings.

Total capital cost:	Nil
Total Savings:	not reported
Payback:	immediate

Source: http://www.caddet.org/

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3.4.3 Biogas as a supplementary heating fuel

Biogas is the methane-rich gas produced from the anaerobic digestion of organic material. Meat plants that use anaerobic lagoons for wastewater treatment will already be producing biogas. Biogas contains predominantly methane, carbon dioxide and other components such as hydrogen sulphide (H_2S) and moisture (see Table 3.7). Methane concentrations in biogas can range from 52-95% (v/v), however 60- 80% is more common (Wheatley, 1990).

Digestion of wastewater is the most obvious and viable means of generating biogas, however yard and paunch manure are also good feedstocks for digestion.

Biogas with a typical methane content of 65% has a heating value of 22.4 MJ/m^3, compared with pure methane (natural gas), with a heating value of around 40 MJ/m^3. The H_2S content is generally between 0.001—2%, but it can be as high as five percent, depending on the feedstock. The moisture and H_2S content of biogas can lead to corrosion in boilers, however this can be alleviated in a number of ways. Moisture can be removed using a condensate trap and H_2S can be removed by passing the biogas through a scrubber containing iron filings. Alternatively, warming the boiler to operating temperature before introducing the biogas may avoid the need to scrub the gas to remove H_2S.

A series of feasibility studies on biogas utilisation (UNEP Working Group for Cleaner Production, 1999) found that the energy available from biogas from the digestion of food processing wastewaters typically provide 10-20% of a plant’s thermal energy requirements. Table 3.8 shows the methane and energy recoverable from biogas produced from the anaerobic digestion of wastewater as well as yard and paunch manure.

Example capital costs required to generate, collect and use biogas are shown in Table 3.9. For wastewater, lagoon digesters are the most practical, since they are already widely used, the technology is well known to the industry, and they are simple and cheap to operate. The digestion of manure solids can be undertaken using plug flow digesters, a technology widely used as farm digesters at piggeries and dairy farms in Europe.

The economic viability of generating and using biogas is quite site specific. A reasonable return on investment (2-4 years) may be possible under the following situations:

- where the infrastructure for utilising the biogas is already in place, i.e. an existing gas boiler, hot water system or gas generator;
- where a high cost is paid for heating fuel (eg. LPG); and
- where the company can benefit from reduced costs of effluent disposal (eg. sewer discharge) by augmenting wastewater treatment capacity with an anaerobic digestion process.

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Table 3.7 **Composition of biogas**

	Content% (v/v)
Methane	52-95
Carbon dioxide	10-50
Hydrogen sulphide	0.001-2
Hydrogen	0.01-2
Nitrogen	0.1-4
Oxygen	0.02-6.5
Argon	0.001
Carbon monoxide	0.001-2
Ammonia	trace
Organics	trace

Source: Wheatley, 1990

Costs and Benefits

If biogas was collected from the anaerobic lagoons at a typical plant, and used in a gas boiler to displace 15% of fuel, it would save 56 GJ/day of fuel energy.

Capital Cost:	$350,000
Gas savings:	$84,000/yr
Pay Back:	4 years

See assumptions in Section 3.2.1 for the basis of these calculations.

For more information:

Energy Recovery from Wet Waste in NSW, UNEP Working Group for Cleaner Production, 1999 (Available from NSW Sustainable Energy Development Agency).

Methane Capture and Use—Waste Management Workbook. Aquatech, 1997. Downloadable at http:// www.greenhouse.gov.au/pubs/methane/

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Table 3:8 Methane and energy yields from biogas digestion

	Digestion of wastewater	Solids digestion of yard and paunch/manure
Material available for digestion	1,000 kL wastewater/day	2,040 kg manure (dry)/day[1]
Organic load available for digestion	5,700 kg COD/day [2]	1,632 kg VS/day [3]
Methane conversion rate[2]	0.352 m^3/kg COD removed[4]	0.4 m^3/kg VS added[5]
Organic load removal rate	85%	NA
Methane yield	1,705 m^3 CH_4/day	653 m^3 CH_4/day
Energy yield	61,055 MJ/day	23,370 MJ/day
Percentage of thermal energy requirement[6]	18%	7%

Source: UNEP Working Group for Cleaner Production, 1999

[1] Based on 3 kg yard and paunch manure (dry)/head and 680 head/day

[2] Based on an average COD load of 38 kg/tHSCW and a typical meat plant of 150 tHSCW/day

[3] Based on volatile solids as 85% of total solids (Stewart et al, 1984)

[4] Eckenfelder, 1989

[5] Safley and Westerman, 1992

[6] Based on a typical thermal energy consumption of 237,000 MJ/day

Table 3.9 Infrastructure requirements for biogas digestion

	Lagoon digestion of wastewater	High-rate digestion of wastewater (UASB)	Solids digestion of yard and paunch manure
Digestion			
Lagoon construction	$50,000		
Lagoon cover (installed)	$50,000		
High-rate digester (UASB)		$1,500,000	
Manure digester (plug flow)			$50,000
Gas collection and treatment			
Condensate trap	$4,000	$4,000	$4,000
Flare	$60,000	$60,000	$60,000
Gas pipe ($100/m)	$10,000	$10,000	$10,000
Gas blower and regulator	$15,000	$15,000	$15,000
Gas storage (optional)	$10,000	$10,000	$10,000
Boiler modifications	$115,000	$115,000	$115,000
Gas heater			
Second gas train			
Gas booster			
Control system			
Design costs	$30,000	$170,000	$26,400
TOTAL	**$344,000**	**$1,884,000**	**$290,400**

Source: UNEP Working Group for Cleaner Production, 1999

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Case Study

NSW Meat Plant

A feasibility study was undertaken to determine the economic viability of collecting biogas from a meat plant's existing anaerobic lagoon and using the gas in the boiler. It was estimated that the biogas would replace 20% of the LPG used in the boiler. For this site, the relatively high cost of LPG used in the boiler meant that the potential return on investment was good.

Total capital cost:	$230,000
Total Savings:	$88,000/yr
Payback:	2-3 years

Source: Energy Recovery from Wet Wastes in NSW, 1999

3.4.4 Solar pre-heating of boiler feed water

Solar hot water heating has been used successfully in the residential sector, but its use in the industrial sector has been limited to date. There are however a few examples of solar heating being used to pre-heat boiler feed water in steam boilers and power stations.

This type of application could be worth considering for boilers at meat plants. Boiler feed make-up water could be heated in solar panels up to 80°C before being fed to the boiler. Queensland's climate is particularly suited to solar hot water heating.

A standard panel is 2m^2 and produces 5kW of heating energy per day (based on yearly averages). The approximate capital cost is about $1,000 per panel installed.

If a meat plant typically has a boiler feed of 15kL/day, 20 panels could potentially provide enough energy to heat the feed water from 20°C to 80°C (3,762 MJ/day or 1,045kWh).

Installation of solar systems into new buildings is usually more favourable than retrofitting an existing building because the cost of retrofitting in framing and plumbing may be as much as the cost of the collectors.

Costs and Benefits

If 20 solar panels were installed to pre-heat boiler feed water, for a typical plant this would save 3.8 GJ/day of boiler fuel.

Capital Cost:	$20,000
Fuel savings:	$1700/yr (coal)
	$9,000/yr (gas)
Pay Back:	12 years (coal)
	2 years (gas)

See assumptions in Section 3.2.1 for the basis of these calculations.

Case study

Hong Kong Abattoir

A new abattoir in rural area of Hong Kong installed solar panels to pre -heat boiler feed water. The system comprises 450 solar panels

Source: Hui, 2000

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3.5 Heat recovery

3.5.1 Optimising heat recovery from rendering

Many plants already recover heat from the rendering plant to produce hot water. Optimising heat recovery to achieve an outlet temperature as high as possible (ideally 80ºC) will reduce the amount of additional energy required to bring the hot water temperature up to 85ºC, and will prevent the unnecessary waste of excess hot water. A 70ºC outlet temperature will produce an additional 20% hot water and a 60ºC outlet temperature an additional 50% hot water compared with an outlet temperature of 80ºC (McNeil and Husband, 1995). This is generally because the flow of water through the heat exchangers is higher, reducing the amount of heat exchanged and increasing the volume produced.

It is not uncommon for excess hot water to be generated by rendering heat recovery and this provides little incentive to improve the efficiency of hot water use in the plant. If excess hot water production cannot be avoided, the excess heating capacity could be used for other applications such as pre-heating boiler feed water, running an absorption refrigeration system for corridor and boning room air conditioning or pre-heating raw material in low-temperature rendering vessels (Amos, 1997).

3.5.2 Heat recovery from sources other than rendering

In addition to the recovery of heat from the rendering process, there are a number of other waste heat sources from which useful heat can be recovered. Figure 3.2 lists potential sources of waste heat and those applications where the recovered heat could be used.

To identify any viable opportunities for heat recovery, estimate the amount of energy (MJ) available for each waste heat source (See Table 3.10) and match this up with the quantities required for each potential application. This is a very crude technique for identifying heat recovery opportunities. For a more detailed and accurate heat recovery assessment, a technique called ‘pinch analysis’ should be used. An energy management specialist can be engaged to undertake this.

The practicality of recovering heat is most commonly limited by the distance between the heat source and the potential application. Generally, if the separation distance is greater than about 30m, then heat recovery may not be practical.

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It is also possible to recover heat from wastewater streams, such as knife and equipment steriliser water and discharged hot water from tripe / bible washers. However they tend to have a low heat density and heat recovery can be complicated by the presence of contaminants in the wastewater which can block heat exchangers. For these reasons it is not considered to be a viable option.

For more information:

Energy Management Advisory Package, MLA, 1997b. (Available from MLA).

Saving Energy with Steam Production and Distribution, CADETT, 2001.
http://www.caddet.org/

Using Pinch Analysis to Identify Opportunities to Reduce Meat Plant Utility Costs, Chadderton, 1995. (MIRINZ Report)

Hot water tank steriliser vat

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Table 3.10: Example calculation of heat recovery potential

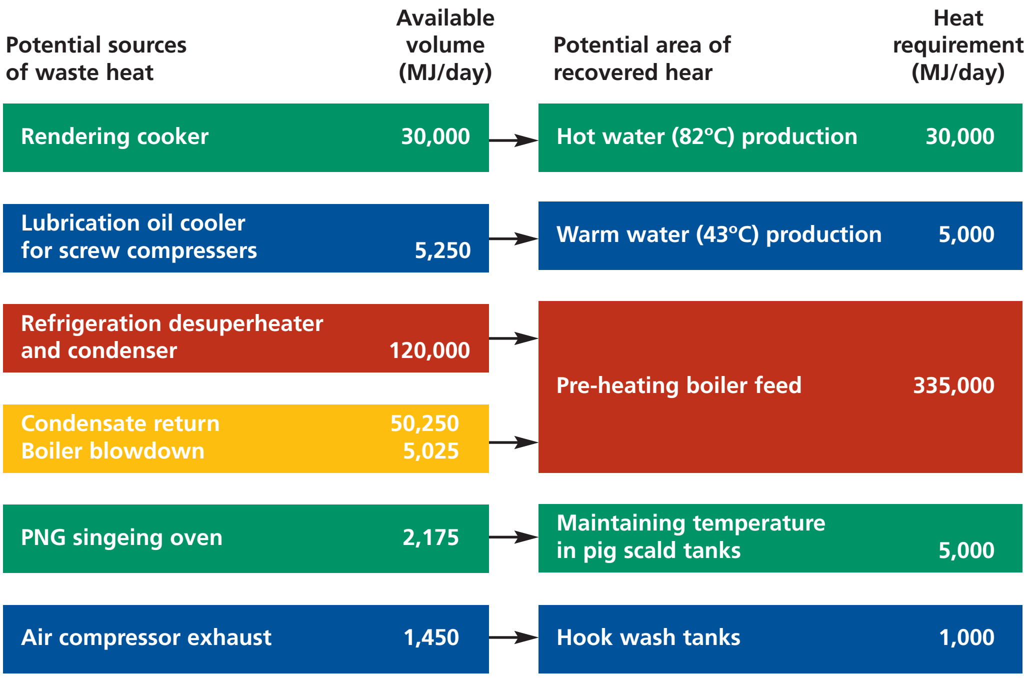
	Energy input (MJ/day)	Percentage waste heat	Theoretical recoverable heat (MJ/day)	Heat recovery efficiency[1]	Actual recoverable heat (MJ/day)	Temperature of recovered steam
Rendering cooker	200,000	20%	40,000	75%	30,000	80ºC
Refrigerant desuperheater and condenser	80,000	20%	16,000	75%	12,000	30ºC
Lubricating oil cooler for screw compresser			7,000	75%	5,250	35ºC
Steam boiler condensate return[2]	335,000	20%	67,000	75%	50,250	90ºC
Boiler blowdown	335,000	2%	6,700	75%	5,025	90ºC
Pig singeing oven	5,000	58% [3]	2,900	75%	2,175	
Air compressor	3,000	60%	1,800	75%	1,450	60ºC

[1] Includes the efficiency of the heat exchanger plus distribution losses

[2] Assumes 90% condensate return

[3] European Commission, 2001

Figure 3.2: Examples of heat recovery opportunities



Case Study

New Zealand Beef Processing Plant

A pinch analysis was undertaken for a 300 head/day beef plant to determine opportunities for heat recovery. The plant does not undertake byproducts processing so the opportunity to recover hot water from the rendering plant did not exist.

The assessment found that all process water for sterilising and washing could be heated to 40°C using heat recovered from desuperheating and condensing the refrigerant using heat exchangers. By doing so fuel consumption is reduced by 43% and cooling water requirements reduced by 15%.

Total capital cost:	$20,000
Fuel savings:	$21,700
Cooling water savings:	$5,900
Total Savings:	$27,600
Payback:	1 year

Source: Chadderton, 1995

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3.6 Reducing demand for electricity

Refrigeration

3.6.1 Reducing heat ingress to refrigerated areas

Up to 10% of power consumed in refrigeration plants can be due to heat ingress through doorways and from lighting being left on.

Many plants rely on good operator practice to keep doors closed and switch lights off. If this is not effective, automatic door closure and light switches or alarm systems should be considered. Plastic curtains at the entrances to frequently opened areas is another means of reducing heat ingress while doors are open. MIRINZ has reported an instance where improved door discipline on a 4,000 tonne capacity cold store with two doors led to an annual saving in electricity of $14,000 (Wee and Kemp, 1992).

For batch chillers that are cleaned after each batch, the use of hot water for cleaning can add considerably to the heat load when the chiller operates. The thick concrete floor absorbs the heat from the hot water, increasing the temperature up to 20°C or so. The concrete slab then needs to be re-cooled back down to 2°C during chilling. Over a full year of heating and re-cooling the slab, the accumulated additional energy costs can be considerable (Cleland, 1997). This could be avoided by using sanitising agents instead of hot water.

Costs and Benefits

If heat ingress to refrigerated areas at a typical plant were reduced by 50%, through automatic door closure mechanisms and light switches, then the savings in electricity could be around 1,000 kWh/day.

Capital Cost:	$10,000
Electricity savings:	$14,000 /yr
Pay Back:	8 months

See assumptions in Section 3.2.1 for the basis of these calculations.

Case study

UK meat processor

At a UK meat plant, doors to chillers and external loading areas were frequently left open leading to considerable power wastage. Three alarms were installed and programmed to sound when the doors were left open for more than a permitted period. This encouraged personnel to keep the doors closed. The savings in electricity was estimated to be 226 GJ/yr.

Total capital cost:	$9,500
Total savings:	$7,000/yr
Payback:	1.4 years

Source: European Commission, 2001

3.6.2 Improving efficiency of refrigeration compressors

The greatest improvements in the energy efficiency of refrigeration plants can be achieved by ensuring that sufficient condenser capacity is available, either by adding additional condensers or by regularly servicing and maintaining condensers in good working order. Greater condenser capacity ensures the head pressure on the system is as low as possible.

For example, at a head pressure of 1,100 kPa a refrigeration plant has a capacity of 1,829kW and draws 192 kW. At a head pressure of 1,200 kPa, the plant's capacity is reduced to 804 kW and the power it draws increases to 204 kW. The optimum head pressure is considered to be about 900 kPa.

Costs and Benefits

If the efficiency of the refrigeration compressors can be improved by 5%, by increasing the capacity of the condensers, this will be a saving of 1,000 kWh/day.

Capital Cost:	$5,000
Electricity savings:	$14,000 /yr
Pay Back:	4 months

See assumptions in Section 3.2.1 for the basis of these calculations.

3.6.3 Evaporative cooling of carcases

Evaporative cooling of animal carcases is an energy-efficient alternative to conventional chilling systems. Carcases are firstly moistened with a fine spray of water and transported through a cooling tunnel, where they are brought into contact with cold, dry air. The moisture on the surface evaporates, drawing heat from the carcase. This process is repeated until the required cooling has been achieved, after which they are moved to a cold storage room to complete the chilling.

Energy is saved because a portion of the cooling is driven by the heat content of the carcases evaporating the water. Therefore air temperature and air flow in the chiller do not have to be as high as for conventional chillers. Additional savings result from reduced weight loss. In conventional cooling systems, weight loss is around 1.1% compared with 0.9% for an evaporative cooling system.

Costs and Benefits

If at the time of upgrade an evaporative cooling system was installed instead of a conventional chiller system, electricity for chilling could be reduced by around 50%. For a typical plant, this is a saving of 12.5 MWh/day.

Capital Cost:	$1,000,000
Electricity savings:	$140,000/yr
Pay Back:	7 years

See assumptions in Section 3.2.1 for the basis of these calculations.

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Case study

Salland by Abattoir, Olst, the Netherlands

This abattoir installed an evaporative cooling tunnel for chilling pig carcases. They noted an electricity consumption of 1.5 kWh/carcase compared with the conventional chilling system that used around 3.3 kWh/carcase. For their plant processing one million pigs/yr there was a reduction of 1,800 MWh/yr. Based on energy savings alone, the pay-back is seven years. However if reduced weight loss of the product is also considered, then the pay-back reduces to around 2.5 years.

Total capital cost:	$1.4 million
Energy savings:	$195,000/yr
Reduced weight loss:	$344,000/yr
Total savings:	$540,000/yr
Payback:	7 years (energy alone) 2.5 years (energy and product weight loss)

Source: http://www.etis.net/caddet/

3.6.4 Turning off refrigeration at night

Refrigeration plants are designed to handle the peak loads present during the first 2-3 hours after carcases and product are loaded into chillers and freezers. Once the required temperature is achieved the refrigeration plant operates at low load, and consequently lower efficiency. The operation of the refrigeration system at low load over weekend periods can be an inefficient use of power.

It has been suggested that refrigeration plants be switched off during the nights on non-production days (weekends). For modern refrigeration systems temperatures increase only slowly when refrigeration is turned off and it could be off for up to 15 hours without compromising the temperatures allowed in regulations. The down side is that the plant will have to work harder initially to draw the temperature back down after the shut-off period. This will negate some of the savings. Electricity consumption for refrigeration could be reduced by around 50% for the non-production periods (weekends) by turning the system off at night (Cain, 1986).

Costs and Benefits

Turning off refrigeration systems at night during the weekends (24 hrs out of 168 hrs per week), will reduce electricity by around 10%. This will save 550 MWh/yr.

Capital Cost:	nil
Electricity savings:	$28,000 /yr
Pay Back:	immediate

See assumptions in Section 3.2.1 for the basis of these calculations.

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3.6.5 Energy-efficient freezing systems

Plate freezers used for the freezing of cartoned meat have a number of advantages over conventional air blast tunnel freezers. The major advantage is greater energy efficiency (plate freezers use 45-65% less power than air blast freezers).

In some situations, the installation of a plate freezer can be justified— for a new 'green field' site and where the addition of extra freezing capacity is required in a system which has insufficient or no low side refrigeration capacity. Plate freezers however have a higher capital cost than an equivalent air blast freezer (Graham, 1996).

Table 3.11 shows the comparative cost of small-scale plate and airblast freezers. For this example the additional $20,000 in capital cost would be paid back in just over 1 year due to the lower electricity consumption.

Costs and Benefits

Table 3.11: Costs and benefits of small-capacity plate and air blast freezers

		Plate freezer	Air blast freezer
System power	kW	39.1	58.8
Hours run/week	hr	116	152
Energy used/week	kWh	4535.6	8937.6
Weekly production	t	57.12	57.12
Energy used / tonne	kWh/t	79.4	156.5
Annual production	t	2,700	2,700
Annual energy use	kWh	214,420	422,525
Annual energy cost [1]		**$16,926**	**$29,236**
Capital cost of freezing equipment		$145,000	$80,000
Capital cost of refrigeration system		$147,000	$195,000
Total capital cost		**$292,000**	**$275,000**

Source: Graham, 1996

[1] Electricity cost based on 3.78c/kWh and a maximum demand charge of $18.80/month for each kW of maximum demand

For more information:

Energy Management Advisory Package. MLA, 1997b. (Available from MLA).

Refrigeration Advisory Package MLA, 1997a. (Available from MLA).

CADDET, Saving Energy with HVAC Systems in Commercial Buildings. CADETT, 1997b. http://www.caddet.org/

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Compressed air

Compressed air is a major user of energy by Australian industry, representing around 10% of industrial electricity use. Compressors are by nature inefficient, with up to 80% of the electricity lost as heat at the compressor. An air compressor typically uses its purchase price in electricity every year (Dept Industry, Science & Research, 2001).

3.6.6 Improving efficiency of air compression

Leaks in a compressed air system can contribute as much as 30% of total air consumption. Two simple methods can be used to determine the extent of air leaks. This is best carried out when the plant is shut down and the background noise is minimal.

Method 1: While no equipment is in use, measure the proportion of the time in which the compressor is loading over a cycle.

$$\text{Leakage} = \text{compressor capacity} \times \frac{\text{time loaded}}{(\text{time loaded} + \text{time unloaded})}$$

For example, for a compressed air system with a capacity of 100 L/s, which is loaded for 10 minutes and unloaded for 30 minutes within a cycle, the air loss is:

$$\text{Leakage} = 100\text{ L/s} \times \frac{600\text{ s}}{(600\text{ s} + 1{,}800\text{ s})}$$

$$= 25\text{ L/s}$$

Method 2: Measuring how quickly the pressure drops when the compressor is off. The leakage is calculated as:

$$\text{Leakage} = \text{pressure drop} \times \frac{\text{total volume of distribution}}{\text{system elapsed time}}$$

(CADDET, 1997a)

Air compressors run most efficiently when the inlet air is cold as less energy is required to compress the air. Every 10°C increase in inlet temperature increases electricity consumption by three percent (SEDA, 2002). Plant rooms should be well ventilated with waste heat ducted away, and air intakes should bring in the coolest possible air.

Air pressure should be kept as low as possible. Generally, every 50 kPa increase in pressure increases energy use by four percent (SEDA, 2002). Often the minimum air pressure is determined by only one item of equipment in the plant. Redesign of this item may allow the whole plant to run at a lower compressed air pressure.

Costs and Benefits

Improving the efficiency of air compression by eliminating leaks, reducing the air inlet temperature etc. could reduce electricity consumption by around 30%, which for a typical plant is 800 kWh/day.

Capital Cost:	minimal
Electricity savings:	$10,000 /yr
Pay Back:	immediate

See assumptions in Section 3.2.1 for the basis of these calculations.

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For more information:

Saving energy with industrial motors and drives. CADDET, 1997a.
http://www.caddet.org/

Compressed Air Calculator. SEDA , 2002.
www.seda.nsw.gov.au/inbus_calc_nav.asp

3.6.7 High-efficiency air compressors

High-efficiency air compressors incorporating variable speed drives and automatic timing systems are available. While they come at a higher capital cost, the savings in electricity consumption can be worth the additional expense.

Costs and Benefits

When an air compressor is due to be replaced, installing a high-efficiency compressor can save around 40% in operating costs, saving 1,000 kWh/ day.

Capital Cost:	$30,000 (additional cost)
Electricity savings:	$14,000 /yr
Pay Back:	2 years

See assumptions in Section 3.2.1 for the basis of these calculations.

Case Study

Valley Beef

Valley Beef recently installed a high-efficiency air compressor that incorporates variable speed drives and an automatic system that turns the unit on and off according to programmed times. The compressor therefore only runs when required and consumes less power. The unit cost $30,000 more than a conventional compressor, however it has reduced power consumption by about 43%.

Additional capital cost:	$30,000
Total savings:	$29,000/yr
Payback:	1 year

Source: Compiler's personal communication with Valley Beef

Motors

On average, electric motors use 4-10 times their purchase price in electricity costs every year (Centre for Advanced Engineering, 1996). It is therefore not prudent to select a motor based on purchase price alone. It is cheaper over the life of the motor to purchase a motor with a higher upfront cost but lower operating cost.

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3.6.8 Avoiding over–capacity motors

It is important that motors are correctly sized for the function. Installing an oversized motor can lead to unnecessary energy use. However, an oversized motor should not be replaced without making an accurate assessment on energy savings. An oversized motor could actually be just as efficient as a smaller sized motor. The load on the motor, full load speeds (rpm) and operating efficiencies should be considered before deciding the appropriate size. Software is available to help calculate the most appropriate sized motor for the task (see "For More Information"). Table 3.12 shows some examples of the possible savings by replacing an oversized motor with a correctly sized motor.

Costs and Benefits

Table 3.12 Operating cost comparison for oversized motors

	Small motor operating 2,500h/yr		Large motor operating 6,000h/yr	
	7.5 kW (40% loaded)	3.7 kW (78% loaded)	110 kW (Oversized by 15%)	75 kW (sized to match flow)
Annual energy use (kWh)	17,813	8,788	627,000	427,500
Annual energy cost @ $0.05/kWh	$891	$439	$31,350	$21,375
Annual energy saving		**$451**		**$9,975**

Source: US DoE, 2002 and US DoE, 2002a

For more information:

Motor Solutions Online, Dept. Industry, Science and Research, 2001. www.isr.gov.au/motors.

Motor Selector Software – from US Office of Industrial Technologies Energy Efficiency and Renewable Energy, http://www.oit.doe.gov/bestpractices/software_tools.shtml

3.6.9 Variable speed drives

Variable speed drives (VSD) modulate motor speed to continually match the load on the device (pump, fan etc.). The power consumed by fans and pumps is proportional to the cube root of motor speed. Therefore, if motor speed is reduced by 10%, power consumption is reduced by 27%. If speed is reduced by 20%, power is reduced by 49%. Therefore for devices that operate at variable loads or that are oversized to cater for high contingent loads, being able to modulate motor speed using VSD can provide significant savings, as shown in Table 3.13. On average a 20% reduction could be expected.

Basic VSD cost about the same as the motors they drive and the relative cost per kW decreases with increased motor size. Costs for basic drives start at around $1,000 per kW for 1-4kW drives and drop to around $320 per kW for 8-20 kW drives.

At meat plants, variable speed drives could be useful on water pumping equipment, on fans and pumps that circulate air and refrigerant and on refrigeration compressor motors.

Table 3.13 **Operating cost comparison with and without variable speed drive**

	Operating cost for 75kW motor operating 2,000h/yr	
	Flow controlled by throttling	Flow control with VSD
Annual energy use (kWh)	380,000	282,000
Annual energy cost @ $0.05/kWh	$19,000	$14,100
Annual energy saving		**$4,900**

Source: US DoE, 2002a

Costs and Benefits

At the time of upgrading pumps and motors, the installation of variable speed drives for one or a couple of the larger (>75kW) and highly utilised motors on the plant, could save about 100,000 kWh/yr for each motor.

Capital Cost:	$20,000 (additional cost)
Electricity savings:	$5,000 /yr
Pay Back:	4 years

See assumptions in Section 3.2.1 for the basis of these calculations.

Case Study

UK Poultry Processor

After identifying that the amount of water used for cleaning was excessive, a UK poultry processor, Buxted Chicken Ltd, fitted a speed control on the main water pumps. This allowed the water pressure to be controlled better, thus reducing water consumption by about 10%.

Total capital cost:	$8,000
Total Savings:	$800/week
Payback:	10 weeks

Source: March Consulting Group, 1998

3.6.10 Optimising piping layout to reduce pumping load

Flow paths for pumping fluids should be as direct as possible. Elbows and bends in pipes should be avoided as they add to friction, which increases the energy required for pumping. Poorly designed piping systems can also create air pockets, which can impede flow. Pipes should also be optimally sized based on the flow-rate and type of liquid being pumped. Removing the buildup of grit, scale or other contaminants will also reduce pipe friction and minimise pumping costs.

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Lighting

3.6.11 Energy efficient lighting

Different types of lights are available with different efficiencies. The following describes the different lighting types and their use, from most to least energy efficient.

Low pressure sodium—These are the most efficient lamp type. They are most suited to exterior lighting and emit a yellow light. Colour is not discernible using these lights.

High pressure sodium—These are not as energy efficient as low pressure sodium lights. They are suitable for internal and external use, where colour rendition is not important.

Metal halide and mercury vapour—These are commonly used for high bay factory lighting and emit a bluish white light. Metal halide lighting is 25% more efficient than mercury vapour lighting. Two types of metal halide lighting are available – standard and pulse start. Pulse start lights are more efficient and start more quickly.

Fluorescent—These are the most efficient type for lighting small areas with low ceilings or for task level lighting. High efficiency triphosphor fluorescent lamps are available which are 20% more efficient. Fluorescent lights are available as a standard long lamp or in a compact style, which can be used as a direct replacement for incandescent lamps. The initial cost is higher, but the lamps use one fifth the electricity and last up to ten times longer.

Miniature dichroic down lights—These are often used in reception areas. Their energy efficiency is inferior to fluorescent lights and they should be avoided if energy consumption is a priority.

Incandescent lamps—These are the least efficient style of lamp and although have a low purchase cost will end up costing more in the long run because of higher operating costs and lower product life.

Task-level lighting

The design of lighting can also save energy. For example, task level directs light where it is required instead of lighting up a large area. Having segregated light switches allows for certain banks of lights to be turned off when not in use, without affecting other areas.

Costs and Benefits

If electricity use for lighting can be reduced by 10% through the use of energy efficiency fittings and efficient design, this is a saving of around 80kWh/day.

Capital Cost:	$1,000
Electricity savings:	$1,000 /yr
Pay Back:	1 year

See assumptions in Section 3.2.1 for the basis of these calculations.

For more information:

Energy efficiency best practice program. Industry Science and Resources,
http:// www.isr.gov.au/energybestpractice/techno/lighting.html

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3.7 Alternative Sources of Electricity

3.7.1 Cogeneration of heat and electricity

Cogeneration or combined heat and power (CHP) systems use a single source of fuel to produce both electrical and thermal energy.

The main advantage of a cogeneration system is the overall system efficiency. The efficiency of a cogeneration plant can be as high as 80%, because energy is being extracted from the system in the form of both heat and power. Whereas at a conventional power station, producing only power, the conversion efficiency is only 30%, with the remaining 70% being lost as un-recovered heat.

For this reason cogeneration is seen to provide good environmental outcomes because less fossil fuel is consumed, resulting in the conservation of fossil fuel resources and reduced greenhouse gas emissions.

Types of Cogeneration

There are three (3) main types of cogeneration:

Steam turbines require a source of high-pressure steam and are mostly used when electricity demand is greater than 1MW.

Gas turbines are suitable for applications where high-pressure steam is required and can be used for smaller capacity systems (from a fraction of a MW) and provide the flexibility of intermittent operation.

Reciprocating engines can be operated as cogeneration systems by recovering the heat from the engine exhaust and jacket coolant. Approximately 70-80% of fuel energy input is converted to heat that can be recovered to produce hot water up to around 100°C or low pressure steam.

Examples of Cogeneration in the meat industry to date have used the last of these—reciprocating engines with heat recovery (see case studies over page). No rendering is undertaken at these case study sites and therefore steam is not required and the recovered heat from the reciprocating engine is used to produce hot water.

Applicability of cogeneration to the meat industry

It appears that currently Cogeneration would be most applicable for plants that are unable to heat water cheaply, i.e. no major sources of waste heat, and that pay a relatively high price for electricity. In these instances smaller scale reciprocating engines, with heat recovery would be viable.

For larger-scale Cogeneration based on steam or gas turbines, the current low cost of energy (coal and electricity) would prohibit the viability of such projects in most instances. This may change in the future if the cost of energy, particularly electricity, increases significantly.

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A major down-side for the application of Cogeneration at meat plants is the very high maintenance and labour costs associated with their operation and up-keep. For this reason, it would be preferable to go into partnership with a power company to own and operate the system.

Under what circumstances is cogeneration viable?

Cogeneration may be viable for plants that meet the following criteria:

- a steady demand for steam and power throughout the year;
- a higher demand for thermal energy than for electrical energy;
- a thermal fuel consumption of more than 2,000 GJ/yr;
- a maximum electricity demand of more than 100 kW;
- long annual operating hours (more than 3,000 h/yr);
- operations taking place during peak electricity charging periods; and
- a high price paid for electricity.

Case Study

1MW cogeneration plant at Rockdale Beef, Yanco, NSW

Rockdale Beef installed a reciprocating gas engine that drives a 920 kW generator to produce electricity and hot water. The system initially supplied 90% of the plant's power demand, but this has been reduced to 50% due to plant expansions. Heat from the engine supplies about 80% of the plant's hot water requirements. The average annual energy outputs are 4,335 MWh of thermal and 4,488 MWh of electrical energy.

Total capital cost:	$1,000,000
Total Savings:	$300,000/yr
Payback:	3-4 years

Source: http://www.caddet.org/

Case Study

0.1 MW cogeneration plant at Westside Meat Works, Vic, and Normanville Meat Works, SA.

At both of these sites, two 50 kW reciprocating gas engines were installed to generate power and heat for hot water. The units produce 100 kW of electricity and 150 kW of heat and run on LPG.

Total capital cost:	$150,000
Total Savings:	not reported
Payback:	not reported

Source: Who's Who in Australian Cogeneration, http://www.ecogeneration.com.au

For more information:

Australian Eco-Generation Association. www.ecogeneration.com.au.
This website includes downloadable Cogeneration Ready Reckoner software.
Sinclair Knight Merz, 1997.

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Part 4

Livestock Utilisation and Product Yield

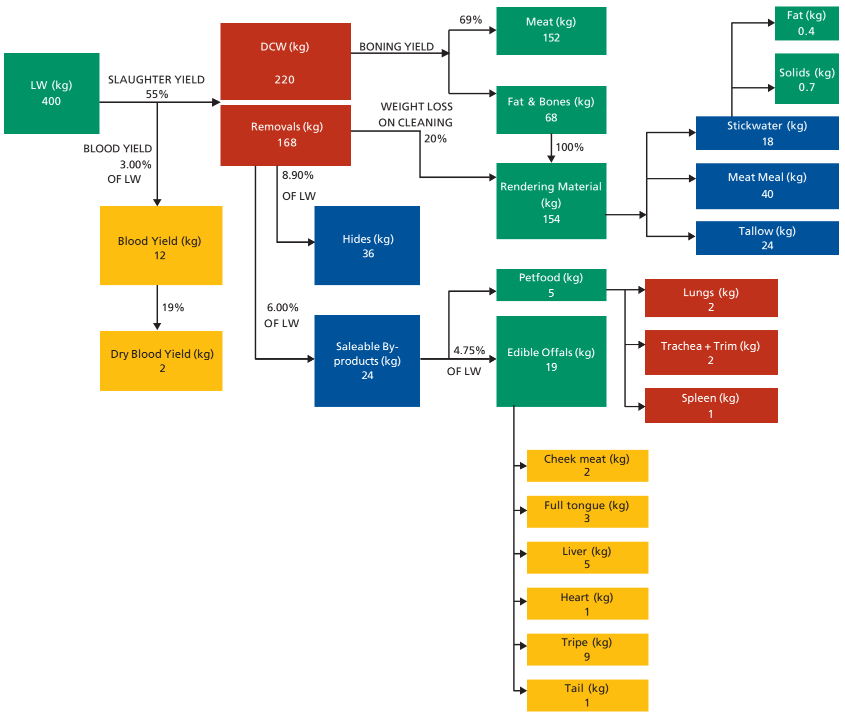
4.1 Overview of Livestock Utilisation and Product Yield

Livestock utilisation and product yield is a very important aspect of eco-efficiency. Materials (meat tissue, blood, fat, manure, etc.) can be lost from the process, generally ending up in the wastewater stream. These losses represent a waste of resources that could otherwise be recovered as products or co-products. They also contribute to the pollutant load of the wastewater stream, resulting in increased treatment and disposal costs.

Figure 4.1 is an example material balance for the processing of beef cattle, showing the flow of materials through the plant. Depicting theoretical product yields in this way and comparing it to actual product yields helps identify areas where product and revenue is being lost as waste.

This section discusses opportunities for reducing the loss of materials and therefore improving the recovery of coproducts (manure, blood and rendering materials). All of these initiatives will lead to the multiple benefits of reduced pollutant loads in wastewater as well as increased yields of saleable co-products.

Figure 4.1 **Example material balance for a beef processing plant (source: MLA)**



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4.2 Product yield improvements and alternative value-adding opportunities

4.2.1 Dry collection of yard manure

In Sections 2.2.6 and 2.2.8 the dry collection of yard manure prior to cleaning of stockyards was discussed. As well as reducing water use for cleaning, it also allows for the dry collection and possible use of yard manure. The collection of the material in a dry form maximises the amount of material that can be potentially processed into a value-added product, and avoids cost associated with pumping, screening and dewatering. It also allows for the manure to be stockpiled if necessary.

The ease of manure collection may vary considerable from one site to the next and for some sites, it may be quite difficult due to the design of the floor. Collection techniques could include manual shovelling, mechanical scraping or use of a bobcat.

The collected manure could be sold as is or combined with other materials (paunch manure, abattoir wastes, etc) in a composting process. The subsequent utilisation of yard manure is discussed later in this section.

4.2.2 Dry dumping of paunch contents

In Section 2.2.23 the dry dumping of paunch contents was discussed. As well as reducing water use, dry dumping enables greater recovery of paunch solids and reduces loss of pollutants to the wastewater stream. Trials comparing wet dump and dry dump systems report that solids retention of dry dump systems is 25% higher than for wet dump system with subsequent screening.

The concentration of plant nutrients retained in dry dumped material is also higher. For wet dump systems 77- 88% of total nutrients are washed into the effluent, compared with 13-46% from dry dump systems. Maximising the recovery of paunch solids and the associated nutrients will be particularly important for sites considering the on-sale of manure products (van Oostrom and Muirhead, 1996).

4.2.3 Dewatering paunch manure using a screw press

Screw presses have proven to be a convenient means of dewatering paunch manure. This unit is a screw press of which there are several designs and manufacturers. They perform a similar function dewater to varying degrees. They can be used to separate paunch solids from paunch washings from wet dump systems, or to dewater paunch from dry dump systems.

Screw presses squeeze liquid out of the solids to produce a cake with a relatively low moisture content. The dewater solids can then be easily transported or composted etc. The reduced moisture content of the paunch solids means that transport costs for haulage of the material can be significantly reduced.

An advantage of screw presses is their low energy consumption. A standard sized unit uses a motor of only around 5kW (http://www.fan-separator.com/PSS01.htm).

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Case Study

Churchill Abattoir

Churchill Abattoir has installed a fan separator to separate and dewater paunch solids from a wet dump paunch system. The company has reported three benefits:

- easier handling of the paunch solids including a significant reduction in odour;
- easier transportation of paunch solids off site— reduced odour, no dripping of wastewater and easier utilisation in land rehabilitation and worm farming; and
- significant improvements in the quality of wastewater entering the pond system—30-50% solids reduction and at least a 20% phosphorous reduction. This has avoided the need to construct an additional pond ($50,000).

Total capital cost:	$70,000
Savings:	difficult to quantify

Source: Compiler's personnal communication with Churchill Abattoir

4.2.4 Direct utilisation of manure

Animal manures contain phosphorous, nitrogen, and also organic carbon. While the nitrogen and phosphorus value of manure is well recognised, its carbon value has been overlooked by the agricultural sector to date. The comparative inorganic fertiliser value of the nitrogen and phosphorus in cattle manure for example is $30-$40/t. However the price paid at the gate is generally $3-10/t.

4.2.5 Composting of manure

The composting of manure makes it microbiologically stable and less odorous, as the heat generated during the composting process kills seeds and pathogens. It also enables the incorporation of other materials (sawdust, green waste etc.) to produce a product with specific characteristics. Therefore as an agricultural, horticultural or gardening product, it is valued more highly than raw manure. It also enables the co-composting of other waste streams (paunch manure and no commercial value skins (NCV)) to assist with their disposal.

Composting systems can vary greatly in complexity, sophistication and capital cost. Composting techniques, in order of complexity are turned windrow systems, aerated piles and in-vessel composting. Windrow composting requires the lowest capital investment and the lowest cost of production, estimated to be \$10-\$25/m^3 (MLA 1995a). The quantities of compost that can be produced are shown in Table 4.1.

Compost from abattoir manure generally meets the Grade A environmental protection requirements for contaminants, which means it is suitable for agriculture, landscaping, home lawns and gardens.

Indicative market prices for compost products are shown in Table 4.2. While there appears to be a good market for compost product, it is likely that the revenue from selling compost would be less than the cost of production.

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Table 4.1 **Compost production rates**

	Production (m^3)
Per 1,000 cattle	17
Per 1,000 calves and pigs	8.5
Per 1,000 sheep and lambs	5

Source: MLA 1995(a)

Table 4.2 **Market prices for compost**

	Market price ($\$/m^3$)
Packaged compost and potting mix	\$100 - \$180
Bulk growing medium	\$35 - \$60
Mulch	\$0 - \$20
Bulk abattoir compost	\$5 - \$12
Vermicompost	\$180 - \$250

Source: MLA 1995(a)

4.2.6 Vermicomposting

Vermicomposting uses specific species of earthworms to decompose and stabilise organic wastes. The process has attracted much interest in recent years for processing yard and paunch manure and numerous vermicomposting operations have been established in association with meat plants.

The advantage of vermicomposting over conventional composting is that it produces a product (vermicast) that is more concentrated in nutrients and therefore more valuable. The vermicomposting operations that have been established to date in the meat industry have generally been operated on-site by independent vermicomposting companies in association with the meat plant.

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4.2.7 Anaerobic digestion of manure solids

Animal manures have been successfully digested to produce methane for centuries. It is particularly common in Asia and India, where it forms an important part of small-scale integrated farming and animal husbandry systems. There are examples of biogas produced from farms being reticulated as a cooking gas to villages. It is also commonly used in the cooler climates of Europe, North and South America, particularly at dairies and piggeries, where the gas is used to heat animal housings.

The technology employed for digesting manure solids can range from the very simple farm digesters traditionally used in Asia, through to large-scale fully automated digesters such as those used in central digestion facilities in Europe. Somewhere in the middle are the Continuous Stirred Tank Reactors (CSTR) and Plug-Flow Digesters, commonly used on farms in Europe. See Section 3.4.3 for more details on anaerobic digestion.

Blood

4.2.8 Avoiding blood loss in the bleed area

The bleed area of the slaughter floor is the main source of blood loss and also blood dilution. The blood collection area generally has two drains, one to the blood tank and the other to the effluent system. For systems that rely on the manual change over of plugs in the drain, accidental loss of blood to the drain or ingress of water to the blood pit can occur due to operator error. This could be prevented by installing a two-way diversion valve that is interlocked to the water supply in the blood collection area, so that water can only be used if the valve is directed to the effluent.

A good blood diversion system will also help reduce the dilution of collected blood with water, which has implications for energy yield during blood processing. This is discussed further in Section 3.2.2.

4.2.9 Electrical stimulation

Electrical stimulation of the carcase after sticking increases the weight of blood discharged from the carcase during bleeding by around five to seven percent (MLA, 1997d and Graham and Husband, 1976). As well as increasing blood yield, it also reduces blood loss further down the process, which would otherwise be lost to wastewater.

4.2.10 Blood loss for different blood processing systems

Blood loss during processing depends on the type of blood processing system used. Losses are greatest when blood is centrifuged following coagulation (continuous coagulation), less when blood is drained after coagulation (batch coagulation), and least for direct drying in a batch dryer without prior coagulation (see Table 4.3).

However blood loss needs to be weighed against energy use. Whilst systems that involve pre-coagulation may incur some blood loss, they use much less energy than direct drying. For most plants, the energy savings would far outweigh the cost of blood loss.

An option for achieving good efficiency, while still reducing blood loss is to capture the decanted stream after coagulation and treat the stream to recover the lost blood.

Table 4.3 Typical blood loss from different blood processing systems

	Coagulation and centrifugation (to 40% solids) [1]	Coagulation and decanting (to 22% solids) [1]	Batch drying
% blood solids loss	5%	3%	0%

Source: MLA 1997d

[1] This assumes a starting blood solids content in raw blood of 15% and 1.0% solids in the drained liquid

4.2.11 Monitoring blood yields

Blood yields should be routinely monitored to check the efficiency of blood collection and processing. Table 4.4 shows the theoretical yields of raw and dried blood from different livestock.

An overall blood solids loss of four percent is about the minimum possible, representing the non-coagulable fraction of raw blood. In practice, an overall loss of less than 10% would be considered satisfactory (i.e. 90% recovery of the theoretical dried blood yield).

Frequent checks on the solids content of the incoming whole blood, the coagulated solids and the blood stick water (effluent) will indicate potential problems in the blood collection and processing methods (MLA, 1997d).

Table 4.4 Theoretical maximum yields of raw and dry blood

	Raw blood % of dressed carcase weight	Dry blood % of dressed carcase weight
Cattle <200 kg	6.3%	1.2%
Cattle 200-300 kg	5.3%	1.0%
Cattle >300 kg	4.2%	0.8%
Bobby calves	7.4%	1.4%
Pigs	4.0%	0.75%
Sheep	7.4%	1.4%
Lamb	6.9%	1.3%

Source: McNeil and Husband, 1995

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Rendering material

4.2.12 Reducing material loss during gut cutting and washing

Fat loss from gut cutting and washing ranges from 2-10 kg/tHSCW, depending on the system used. The least fat is lost when using cutters with sharp or slow-moving blades, compared with hoggers, which have blunt fast moving blades. The reduction in fat loss between these two types of systems can be 30%-70% (Swan et al, 1986) and up to 75% (MLA, 1997d).

Less material is lost when washing in a Contra-Shear system than in rotary drum washers, probably because the Contra-Shear screen gap size is much smaller. Total fat loss tends to be lowest for immersion washers, irrespective of the type of cutter used (Swan et al, 1986).

The proportion of fat that is floatable is highest for rotary washers, intermediate for immersion washers and lowest for rotating screen systems, indicating that much of the fat can be recovered if the washing action is gentle (immersion washers) or if a screen with a fine mesh is used (rotating screens) (Swan et al, 1986).

The reduced fat loss of rotating screen systems needs to be balanced against the higher water use (see Section 2.2.26). Immersion washers appear to offer a good balance between water efficiency and relatively good fat retention.

4.2.13 Dry cleaning prior to wash down

Section 2.2.30 described dry cleaning prior to wash down as a means of reducing water consumption. Dry cleaning also reduces the amount of material lost and the pollutant load of the wastewater. The amount of material recovered from improved dry cleaning practices can be significant.

For more information:

Assessment of four viscera cutting and washing systems. Swan, et al, 1986.
(MIRINZ report).

4.2.14 In-drain screens

It is common practice during cleaning for operators to remove drain grates and screens and flush solids directly down the drain. The reason for this may be that the screens are not designed for easy cleaning when they get blocked, or that operators believe that the downstream screens will trap the solids. The turbulence, pumping and mechanical screening that these scraps encounter breaks down the meat, increasing the COD of the effluent and releasing fats and finer solids that are more difficult to remove in downstream treatment processes.

Good design of in-drain screens in conjunction with operator training should help increase the amount of material recovered.

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4.2.15 Centrifuge tallow refining rather than tallow washing

Fat loss in centrifugal tallow refining is negligible (0.02—0.25%). In comparison, up to 10% of tallow can be lost by manual tallow washing (MLA, 1997d).

4.2.16 Material loss for different rendering systems

Materials losses during rendering depends on the type of rendering system used. Theoretically there are no losses of material during dry rendering. For wet rendering on the other hand losses can be between 0.06% and 0.6% of raw material depending on the amount of water ingress (MLA, 1997d). The ingress of water leads to greater volumes of wastewater which will take greater quantities of material with it, when it is decanted.

4.2.17 Aquaculture feeds (high protein meal)

Research has demonstrated that there is an opportunity for incorporating meat meal into aquaculture feeds to assist the expansion of aquaculture operations in Australia. Fishmeal is the main protein in most aquaculture feeds and fishmeal production is not expected to increase. Therefore there will be an increasing demand to use materials from the livestock industries.

Up to two thirds of the diets of silver perch and giant tiger prawns can be substituted with meat meal and complete substitution is possible for barramundi. This will require the rendering operation to consistently produce to a tight specification and to prepare at least two products of vastly different composition. This can be achieved through pre-selection and segregation of raw materials for specific products or fractionation of finished meal into separate streams based on their physical properties. If the national value of meat meal to the aquaculture feed industry is realised, then it is possible that the entire Australian meat-meal production of some 450,000 tonnes/yr could be used for this purpose (MLA, 2001).

For every tonne of high-protein meal produced from aquaculture feeds, half a tonne of low protein meal is made available. This low protein meal could be marketed as an organic fertiliser.

4.2.18 Anaerobic digestion of non-manure and paunch (NMP) waste

Anaerobic digestion is an option for the treatment and disposal of solid NMP waste. While the anaerobic digestion of wastewater and manure solids from meat plants is a mature technology, digestion of organic solid wastes is still under development.

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NMP wastes contain high levels of protein and fat that degrade to produce ammonia and long-chain fatty acids, which inhibit the digestion process. To alleviate this problem, NMP wastes are best co-digested with wastewater or with other low-fat and low-nitrogen substrates, such as yard and paunch manure and the organic fraction of household waste.

Experience with this technology to date in Germany, New Zealand and Denmark indicates that digestion of NMP waste at meat plant premises many not be viable due to limited co-substrate availability. Co-digestion with the organic fraction of municipal solid waste at centralised digestion facilities servicing plants close to urban areas would be more viable (MLA, 1996b).

4.2.19 Composting of NCV skins

It has been demonstrated that skins of no-commercial value (NCV skins) can be effectively composted along with yard and paunch manure. As well as being preferable to burial as a means of disposal, it also adds some value, since the resulting compost product can be sold.

Composting effectiveness is improved if the NCV skins are shredded prior to composting. The composting process should also be well managed to ensure that the skins are effectively broken down and that odours are minimised (MLA, 1999).

4.2.20 Tallow burning

The use of tallow as a boiler fuel has been discussed in Section 3.4.2. Its use as a fuel may be an option if its current predominant use as a food or cosmetic ingredient is limited due to concerns over diseases transmitted through the food chain.

4.2.21 Biodiesel from tallow

There has been interest recently in the production of biodiesel from tallow as a substitute transport fuel. The production of biodiesel from tallow is a simple chemical process called transesterification, involving the addition of sodium hydroxide or potassium hydroxide as a catalyst and ethanol or methanol, which reacts with the fats in the tallow to produce the ethyl ester (biodiesel) and glycerin.

Diesel vehicles can run very effectively on biodiesel and the exhaust emissions are much lower than petroleum- based diesel. Governments have been supporting the development of a biodiesel industry because of the greenhouse gas benefits.

With relatively small investment, meat plants could easily produce biodiesel for their own use, if they operate a fleet of vehicles or company cars. Simple ‘how to’ guides are available with step by step instructions (see “For more information”). Producing biodiesel for retail sale could be more complicated due to the quality control and regulatory aspects.

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Alternatively, energy retailers have expressed an interest in purchasing tallow from meat plants for biodiesel production (Burbidge, 2001). At present, energy retailers are actively exploring opportunities for generating renewable energy in order to meet the target under the Renewable Energy Agreement for two percent of energy from renewable sources.

For more information:

Anaerobic Solids Review, MLA, 1996b (available from MLA).

Novel Co-products from the Meat Industry, MLA, 2001 (available from MLA).

Australian Biodiesel Association, http://www.biodiesel.org.au/.

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Part 5

Other Material Inputs

5.1 Overview of other material inputs

Material inputs used at meat plants include packaging and a wide variety of chemicals, oils and lubricants. The two major material inputs discussed here are packaging and chemicals.

Packaging

Cardboard is the largest packaging input (82% of total packaging use) and the largest packaging waste stream (67% of the total packaging waste stream). Overall, three percent of packaging materials consumed by the industry is lost as waste (MLA, 1996c).

The other important packaging material is plastic, which is used for vacuum pack bags, plastic sheeting and strapping.

Table 5.1 shows the types and quantities of packaging used and wasted by the Australian meat industry. In relation to the type of packaging used, meat plants are generally constrained by customer specification, particularly in export markets. Plants do however have control over the wastage of packaging materials.

Table 5.1 Consumption of packaging materials by the Australian meat industry

	Consumption (t/yr)				**Waste (t/yr)**	
	Total	Domestic products	Export products	Rendering	Quantity	% of use
Cardboard	43,744	14,191	28,568		985	2%
Vacuum bags	3,608	1,607	1,681		320	9%
Polyethylene plastic	2,950	232	2,471	106	141	5%
Polypropylene plastic	130			130	nd	nd
Strapping	1,179	375	781		23	2%
Paper	1,298			1,298	nd	nd
Other plastic materials	87	12	64		11	13%
Stockinette	510	0	510	nd	nd	nd
Hessian	567	567	0	nd	nd	nd
Total	**54,073**	**16,984**	**34,075**	**1,534**	**1,480**	

Source: MLA, 1996c

Note: Other packaging materials include PVC trays, drip keepers and boneguards

nd: no data

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Chemicals

Chemicals are used at most plants for cleaning, sanitising, hook cleaning, and in some cases water and wastewater treatment.

In all categories, there is a wide range of products available and marketing by suppliers can be very persuasive. Operators may find it difficult to make informed choices due to lack of objective information about different chemical products. They may also find themselves stocking and using a large range of different chemicals, some of which may not really be required.

As well as putting together an inventory of all the different chemicals used on site, operators should try to understand the chemical composition and function of these chemicals, so that they can make more informed purchasing decisions, that could lead to a reduced inventory and reduced costs.

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5.2 Chemicals

5.2.1 Rationalising use of cleaning and sanitising agents

Due to the wide range of chemical products available on the market and the persuasive marketing of chemical companies, meat plants may find themselves stocking a wide range of different chemical agents for different applications. This can lead to operator confusion over dosing procedures, possibly resulting in inefficient use of chemicals. It may be possible to reduce the number of cleaning agents down to a handful of basic chemicals which suit a number of applications.

5.2.2 Dosing systems for dispensing cleaning and sanitising agents

Many large meat plants use dosing systems, which automatically dispense the correct amount of cleaning agents. These systems provide greater control over the use of cleaning agents. Small plants however may find it difficult to justify the capital cost of dosing system and opt for manual dosing. However, there is evidence to suggest that manual dosing results in the overuse of chemicals (March Consulting Group, 1998). Therefore the cost of a dosing system may be justified even for smaller plants if cleaning and sanitising chemicals are being used excessively.

Based on a typical usage rate of 100 L/day and an average cost of $2.00/L, if chemical use were reduced by 20% (20 L/day) through the use of a dosing system, then the chemical savings could be around $10,000/yr, which would likely justify the cost of a dosing system.

5.2.3 Environmentally friendly cleaning and sanitising agents

Increasingly, environmentally friendly cleaning and sanitising agents are becoming available on the market. These alternatives are proven to be as effective as conventional cleaning chemicals, but are generally less hazardous to the receiving environment and to staff.

Biotechnology-based cleaning agents contain naturally occurring enzymes or microorganisms. They are supposedly less harmful to the environment, can be used at lower temperatures than conventional chemicals and are non-corrosive.

Ozone is an extremely powerful and effective natural disinfecting agent. It can be generated with an ozone generator that converts oxygen from the air into ozone using electricity and UV light. Ozone avoids the use of sanitising chemicals that end up in the wastewater stream, and any unused ozone naturally decays back to oxygen in a few hours.

Plant-based cleaning compounds contain naturally occurring plant-based substances such as ester alcohols, that cause organic soils to be repelled from the surface. They are readily biodegradable and non-toxic and therefore very compatible with biological wastewater treatment systems.

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Case Study

UK poultry processor

A major UK poultry processor had an area soiled with faeces, blood, urine, grease, fat and feathers, which was proving difficult to clean even with sodium hydroxide, a corrosive substance. The company now uses a biotechnological product, which removes organic matter more effectively. Cleaning of this area now takes less time, is safer and uses less energy because hot water is not required.

Source: March Consulting Group, 1998

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5.3 Packaging

The ideas in this section are related to reducing the amount of packaging used and wasted at meat plants for existing packaging systems.

5.3.1 Lighter weight cardboard

Lighter weight E-flute cardboard (1.5mm) allows meat to freeze in around 15-20% less time than the thicker B-flute (3mm) cardboard, with significant energy savings (MLA, 1996c and MLA, 1997c).

5.3.2 Recycled content of packaging materials

Cardboard from different suppliers can have different levels of recycled content. A higher recycled content may not lead to reduced costs, but it could provide environmental benefits.

5.3.3 Automated carton construction

Automated carton construction generates 50% less packaging waste than manual carton construction due to reduced rejects. The packaging materials used in automated systems are also lighter and cheaper resulting in inward freight savings. The high capital cost of automated carton construction means that it may not be viable for all plants (MLA, 1996c).

5.3.4 Vacuum pack tubing for reduced off-cut waste

About 18-20% of the plastic bag material used in conventional vacuum packing processes is lost as off-cut waste. The plastic is supplied as individual pre-cut bags and excess is cut from the bags during packaging. Equipment for making bags from plastic tubing is becoming available. This equipment allows the processor to make the size of bags needed each day. Rolls of tubing are fed into the machine and cut to the required length.
So instead of keeping 30-40 different bag sizes, only 4-5 different roll widths need to be kept in stock and this avoids obsolescence and potential waste. Overall cost reductions are in the order of 25-30% and the capital cost is around $50,000 per machine installed (1-4 machines per plant).(MLA, 1996c).

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5.3.5 Using glue instead of stretch wrap

Stretch wrap can be eliminated by using a special glue that holds cartons together on a pallet but easily comes apart when the product is unloaded. It is most applicable to chilled meat, because the cartons are strong and retain their shape, but problematic for frozen cartons that expand during freezing.

For more information:

Trends and future regulatory issues concerning packaging material use in the Australian meat industry, MLA, 1996c. (available from MLA).

Packaging Advisory Package, MLA, 1997c. (available from MLA).

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Part 6

Wastewater

6.1 Overview of wastewater generation

Two aspects of wastewater need to be considered – volume and the pollutant load. Volume is important because it can affect the hydraulic loading of down-stream wastewater treatment and hence the treatment efficiency. The volume of wastewater generated is typically about 85% of fresh water intake.

The load of pollutants in the wastewater is important because it can cause detrimental effects when discharged to the receiving environment.

During processing, blood, fat, manure, urine and meat tissue can be lost to the wastewater stream. As well as contributing to the pollutant load of the wastewater, these losses also represent a loss of resources. Table 6.1 shows the materials that contribute to the pollutant load in meat plant wastewater and Table 6.2 is an example breakdown of pollutant loading. Every plant's breakdown will be different depending on the types of processes undertaken.

Table 6.1 Materials that contribute to pollutant load in meat plant wastewater

Sources of pollutants	COD	N	P	Na	TSS	oil & grease
Fat	●				●	●
Yard manure	●		●		●	
Panch manure	●		●		●	
Blood	●	●	●			
Meat tissue		●				
Urine		●		●		
Fresh water supplies				●		
Recycled effluent				●		
Pickling brine				●		

Source: MLA, 1995c

Table 6.2 **Example breakdown of wastewater pollutant loads**

Sources of pollutants	Organic (COD)	Nitrogen (N)	Phosphorus (P)	Sodium (Na)	Total Suspended solids (TSS)	Oil and grease
			(kg/tHSCW)			
Stockyards	1.20	0.18	0.04	0.03	0.50	–
Slaughter and evisceration	3.75	0.54	0.04	0.75	0.95	0.35
Offal processing	3.95	0.30	0.05	0.16	0.75	0.55
Boning rooms and chillers	0.30	0.10	0.00	0.01	0.40	0.05
Paunch dumping	8.20	0.40	0.19	0.87	1.55	2.45
Gut washing	0.50	0.18	0.03	0.40	0.50	0.04
Raw material bin draining	6.00	0.43	0.05	0.10	0.95	7.50
Blood processing	3.13	0.22	0.08	0.13	0.54	0.10
Tallow processing	18.00	0.11	0.03	0.08	7.50	10.00
Cooker condensate	0.94	0.11	0.01	0.05	0.05	0.03
TOTAL	**46.0**	**2.5**	**0.5**	**2.6**	**13.7**	**21.1**

Source: MLA, 1995b

Note: Shaded areas indicate the sources that contribute the most for each pollutant

The cost of wastewater

The cost of wastewater treatment and disposal varies from one plant to the next, as shown in Table 6.3. For plants in rural areas that have land available for lagoon-based digestion and irrigation of the treated effluent, treatment and disposal costs will generally be lower than urban plants that may require high rate treatment systems and that discharge to sewer.

The full cost of wastewater treatment and disposal can include:

- electricity cost for equipment operation, aeration and mixing during treatment etc;
- chemical costs for pH balancing, flocculation etc;
- oxygen injection in some instances where the treatment system is overloaded;
- electricity for pumping raw and treated wastewater; and
- sewer discharge fees.

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These costs are related to the volume of wastewater treated through the system and some costs are related to the pollutant load of the wastewater. Therefore treatment costs will reduce with reduced volumetric load and reduced pollutant load. There are also fixed costs, such as equipment depreciation, maintenance and labour, which do not vary with the load on the system.

If plants have not already done so, it can be a very useful exercise to calculate the full costs of wastewater treatment and disposal, highlighting those costs that vary with the volumetric and pollutant load on the system, so that managers have an appreciation of the benefits of reducing the load on the system.

Table 6.3 **Typical costs for wastewater treatment and disposal**

	Treatment scenario 1 - Typical system for rural plants		**Treatment scenario 2 - Typical system for urban plants**	
	Annual cost	Cost per kilolitre[2]	Annual cost	Cost per kilolitre[2]
Primary treatment				
Screening	$40,000	$0.11	$40,000	$0.11
DAF	$150,000	$0.40	$150,000	$0.40
Secondary treatment				
Anaerobic lagoon	$10,000	$0.03		
Aerated lagoon	$80,000	$0.21		
Sequencing batch reactor			$125,000	$0.33
Wastewater discharge		NA		$0.40
Total		**$0.75**		**$1.24**

[1] Taken from MLA, 1998a

[2] Based on 1,000kL/day

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6.2 Recovery of resources from wastewater

6.2.1 Screening of individual wastewater streams to recover lost product

In some areas it is difficult to avoid the loss of materials to wastewater. It may be possible to recover lost solids directly downsteam from the process and transfer the collected solids to rendering. This way the quality of the recovered material remains high. For example:

- passing offal washing water over a static wedge wire screen or corrugated plate separator; and
- pre-screening wastewater from tripe/bible washer over static wedge wire screen.

6.2.2 Segregation of hot water streams to improve fat recovery

The recovery of fat from the wastewater stream in Savealls and DAF systems can be reduced if the temperature of the wastewater is too hot (>38°C). If this is the case, segregating hot wastewater streams from the main wastewater can help reduce the temperature. If the segregated hot water stream is only slightly contaminated (eg. water from knife and equipment sterilisers), it could be diverted directly to the main wastewater plant, by-passing the Saveall or DAF . If the segregated stream is heavily contaminated, requiring primary treatment (tripe / bible wash water or plant cleaning water), it could be held in a buffer tank to cool before being sent to the Saveall or DAF. The increase in fat recovery from reducing wastewater temperature from 40°C to 30°C is estimated to be up to 50% of recoverable fat.

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6.2.3 Recovery of stickwater solids using evaporation

Low temperature rendering (wet rendering) produces stickwater, which contains high concentrations of contaminants. For sites that undertake rendering, stickwater represents the single largest source of wastewater contaminants (MLA, 1995d). As well as placing a significant load on the wastewater treatment system, these contaminants also represent a loss of materials, which could be recovered to increase the yield of rendered products. An effective means of evaporating stickwater is to use a Double Effect Evaporator (DEE). This involves heating the liquid with steam, while the liquid is under vacuum. Approximately 2kg of water is evaporated per kilogram of steam.

Evaporation can be an alternative to treatment and disposal of the stickwater. It concentrates both organic pollutants and nutrients, effectively removing 99.5% of the organic and nutrient load. If evaporation is compared with a wastewater treatment system with equivalent treatment capacity (activated sludge incorporating biological nutrient removal), then the economics can work out marginally better. However if an existing dryer in the rendering plant can be utilised, then the economics are much more favourable. (MLA 1996d).

6.2.4 Recovery of stickwater solids using ultrafiltration

Another means of recovering the materials from stickwater is ultrafiltration. Ultrafiltration concentrates liquid streams by passing them through selective membranes. Ultrafiltration trials undertaken by MIRINZ successfully concentrated stickwater from less than 5% total solids to 25% total solids, making the concentrate suitable for subsequent drying back in the rendering plant. Typically 99% of fat, up to 90% of COD and 70% of nitrogen were recovered. For a typical plant, this recovery would translate to a 20%, 14% and 12% reduction in the fat, COD and nitrogen loads in meat plant effluent (Brown et al 1993).

The capital cost of ultrafiltration systems are expected to range from $150,000—$300,000 and pay back periods can range from 1-5 years. The most favourable pay backs are expected to be for sites that can recover large amounts of material from high volumes of stickwater (Brown et al 1993).

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6.3 Wastewater treatment

Even if efforts are taken to reduce pollutant loads at source and recover lost resources from wastewater, there will still be a need for meat plants to treat wastewater. A wide range of treatment techniques are utilised by the meat industry (see Table 6.4). The most appropriate system will depend on a number of factors:

- required effluent quality, which will depend on the disposal route;
- land availability;
- community amenity considerations (odour); and
- capital and operating costs.

If an eco-efficiency approach is taken, the choice of wastewater treatment system should also consider the resources consumed (electricity, chemicals, oxygen, etc.) and the resource recovery opportunities. For example biological systems, which mimic natural processes, generally require minimal energy or chemical inputs and can also recover useful products (biogas, stabilised organic material). However land availability is a pre-requisite for this to occur. If small-footprint treatment systems are required, then they generally require energy and chemical consumption to speed up natural processes.

For more information:

Best practice wastewater treatment, MLA, 1998 (available from MLA).

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Table 6.4 Overview of wastewater treatment options

	Treatment efficiency				Operational inputs		Annual	Capital
	BOD/COD	SS	Oil & grease	Nitrogen	Electricity	Chemicals	Operating cost	Cost
Primary treatment								
Screen (static)	20-50%	30-80%	20-90%	-	Nil	Nil	$10,000	$35,000
Screen (vibrating)	20-50%	30-80%	20-90%	-	Medium	Nil	$25,000	$55,000
Screen (rotating)	20-50%	70-80%	20-90%	-	Medium	Nil	$40,000	$90,000
Saveall	20-30%	40-50%	50-85%	-	Low	Coagulant	$55,000	$150,000
Dissolved air flotation (DAF)	15-30%	30-60%	60-90%	-	Medium	Nil	$150,000	$550,000
Induced air flotation (IAF)	70%	80%	95%	-	Low	Nil	$150,000	$400,000
Vortex clarification	40-75%	60-95%	70-98%	30-70%	Low	Coagulant	$175,000	$500,000
Stickwater evaporation	90%	99%	90%		Low-medium	Nil	$125,000	$800,000
Secondary treatment								
Anaerobic lagoon (uncovered)	60-97%	60-90%	70-90%	-	Low	Nil	$10,000	$250,000
Anaerobic lagoon (covered)	60-97%	60-90%	70-90%	-	Low	Nil	$30,000	$1,000,000
High-rate anaerobic	70-95%	60-90%	85-98%	-	Low	Nutrients pH control	$90,000	$2,250,000
Hybrid anaerobic	70-95%	60-90%	85-98%	-	Low	Nil	$90,000	$2,250,000
Aerated lagoon	50-80%	-	-	0-10%	High	Nil	$80,000	$800,000
Facultative lagoon	60-90%	-	-	10-20%	Nil	Nil	$80,000	$800,000
Continuous activated sludge	85-97%	95-98%	-	0-50%	High	Oxygen	$125,000	$3,000,000
Biological nutrient removal	85-97%	95-98%	-	70-90%	High	Nil	$150,000	$6,000,000
Sequencing batch reactor	90%	95%	100%	50-90%	High	Nil	$125,000	$2,500,000
Trickling filtration	30-60%	50-80%	40-60%	15-30%	Low	Nil	$40,000	$500,000
Tertiary treatment								
Wetlands	80-90%	60-95%	-	30%	Low	Nil	$50,000	$600,000
Ultrafiltration	90%	100%	-	75%	Medium	Cleaning agents	$350,000	$4,000,000
Maturation lagoon	40-70%	0-80%	-	-	Nil	Nil	Negligible	$300,000
Chlorination	-	-	-	-	Nil	Chlorine Sulfur dioxide	$25,000	$30,000
Ultraviolet irradiation	-	-	-	-	Medium	Cleaning agents	$40,000	$150,000

Source: MLA, 1998

6.4 Beneficial utilisation of wastewater

The nutrients contained in treated wastewater (some organic matter, nitrogen and phosphorus) can either be a problem or a useful resource depending on the wastewater disposal options available to the plant. For plants discharging wastewater to municipal sewerage systems or to local waterways, nutrients can be a problem, either for environmental reasons or because of charges imposed by local authorities. For those plants that are not limited to these disposal options, the nutrients contained in the wastewater could be beneficially used. Options for the beneficial utilisation of treated wastewater could include crop production, forestry, land rehabilitation or even aquaculture.

Crop production

Crop production using treated effluent is already being undertaken by the meat industry, particularly by those plants located in rural or semi-rural areas with sufficient land to support cropping. Examples of crops being cultivated using treated wastewater include grains (corn, sorghum, etc) as well as fast-growing grass varieties for hay production. The managed and careful use of treated wastewater for crop production is a sustainable means of utilising the nutrients contained in the wastewater, resulting in the net export of nutrients from the operation, when the crop is harvested. Guidelines for sustainable effluent irrigation are available from MLA (see "For More Information"). Cropping operations can be undertaken by the meat plant itself of leased out to someone else.

Forestry and land rehabilitation

Use of treated wastewater for forestry operations or land rehabilitation has not been undertaken by the meat industry to date however there are examples from other industries. Forestry is similar in nature to the crop production operations described above, but is a longer-term commitment. The principles of matching the nutrient needs of the forest crop with the nutrients available from the wastewater would still apply, and guidelines applicable to effluent irrigation for cropping would also apply for forestry.

Tree crops are suited to secondary treated wastewater reuse. The experience of a number of experimental effluent plantations in Victoria has shown that some species of eucalypt and conifer can have very fast growth rates when irrigated with treated wastewater and appear to have some prospects as commercial wood crops (Stackpole, 2001).

Aquaculture

Aquaculture is another options for the beneficial utilisation of the nutrients contained in treated wastewater. The nutrients act as a food supply for algae and fast growing aquatic plant species (such as duck weed), which in turn are a food supply for the cultivation of freshwater fish (mullet, perch, etc.) or shellfish (freshwater crayfish such as red claw). While this concept has not be explored to any extent in Australia, it is commonly utilised in integrated agricultural operations in Asia.

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For more information:

Effluent Irrigation Manual, MLA, 1996. (available from MLA).

Productive reuse of effluent on tree plantations. Stackpole, 2001

Sustainable Effluent Irrigated Plantations: An Australian Guideline. CSIRO, 1999.

Recently built Anaerobic Pond

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Part 7

Eco-efficiency self-assessment guide

How to use this section

The following steps in this section describe how to plan and implement an eco-efficency project

1. Identify and record all the inputs and outputs of your process.
2. Collect data for all areas of resource use and waste generation.
3. Establish performance indicators and set targets for improvement.
4. Identify eco-efficiency opportunities that will help achieve your targets.

Introduction

This self-assessment guide takes the reader step-by-step through the process of implementing eco-efficiency at a meat plant.

It is a tool to help managers and staff to start thinking about eco-efficiency in a strategic way by assessing the current status of resource use and waste generation, determining if there's room for improvement, identifying ways to make improvements and then progressively implementing the changes.

The guide contains worksheets that can be used for recording information and checklists for assessing opportunities relevant to your plant.

Step 1: Identify inputs and outputs

Prepare a flow chart showing all the inputs and outputs of the process.

Understanding the inputs and outputs of the process is an important first step in an eco-efficiency project. Figure 7.1 is a generalised flow chart showing inputs and outputs for a typical meat plant. Developing a chart such as this can help identify where and how resources are consumed and where wastes are generated. When developing such a chart don't forget to include plant services and ancillary activities as well as the basic meat processing steps.

Inputs are the resources (materials and energy) that are consumed in a process.
For meat plants the main inputs are livestock, water, energy, packaging, chemicals, LPG, lubricating oils etc.

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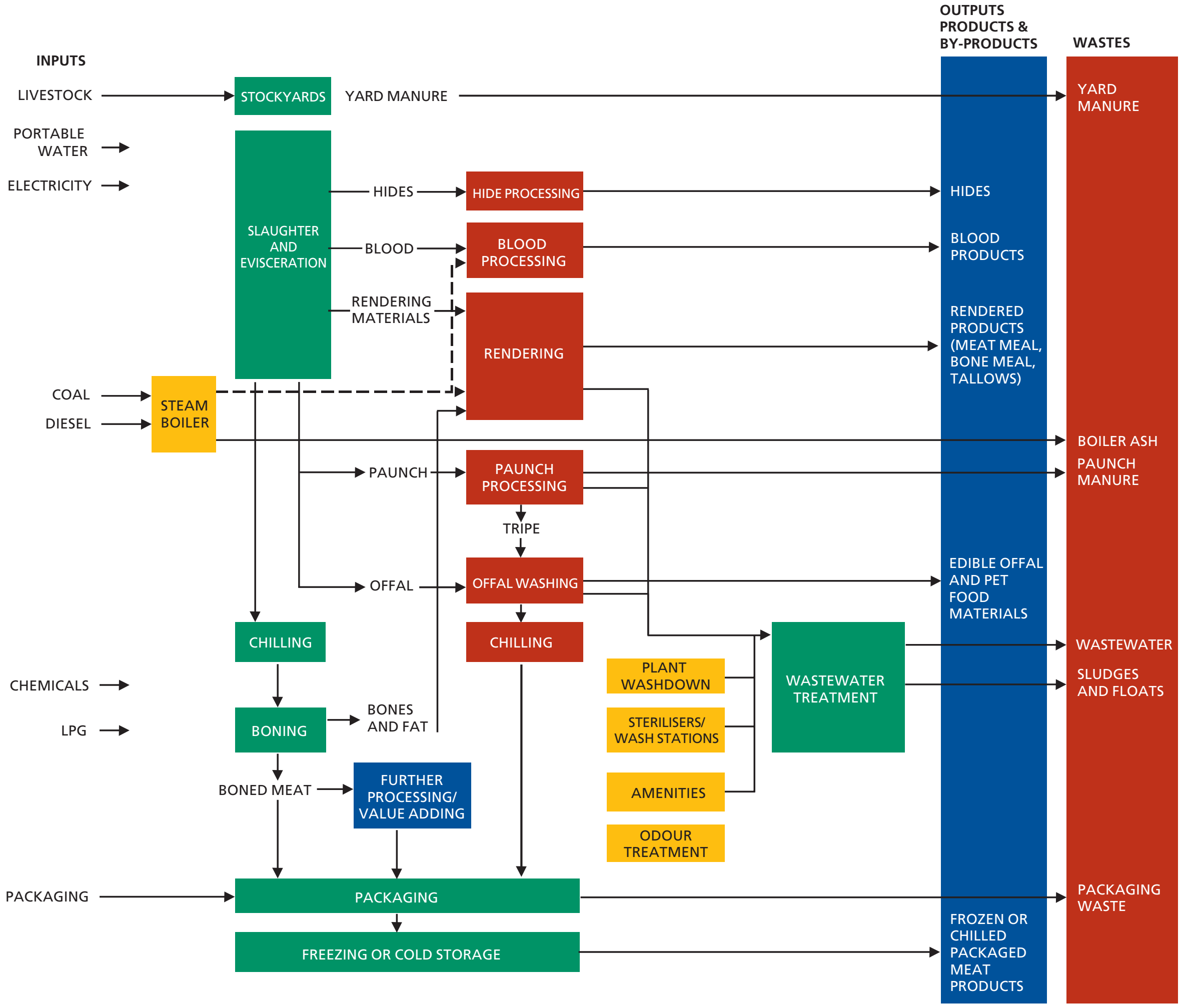
Outputs are the products, co-products and wastes generated from a process. The main products from meat plants are chilled or frozen meat and edible offal. The outputs referred to as co-products are rendered products (meat meal, bone meal and tallow), hides, pet food ingredient and blood products. The outputs regarded as wastes are commonly yard and paunch manure, wastewater, sludge and floats, boiler ash and packaging waste.

The distinction between co-products and wastes can be hazy. A co-product is a secondary product that has some value, whereas a waste is an unwanted material that has no value or is a cost to the generator. A waste for one site may be a co-product for another.

Figure 7.1: Process flow chart for a typical meat plant showing inputs and outputs



Step 2: Collect Data

Compile all existing resource use and waste generation information

Compile information related to resource use and waste generation at your plant. Use Tables 7.1 and 7.2 as a guide. Most plants should be able to compile this information from existing records and accounts.

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Table 7.1: Resource use data

Resource Use		Quantity (per day/week/year)				Total (per day/week/year)	
Water	Town water				kL		kL
	Dam water				kL		
	Bore water				kL		
Energy		**Quantity**		**Energy value**			GJ
	Coal		t		GJ		
	Natural gas		m^3		GJ		
	Fuel oil		t		GJ		
	LPG		m^3		GJ		
	Electricity		kWh		GJ		
	Other				GJ		
Chemicals	Cleaning chemicals				kg		kg
	Wastewater treatment chemicals				kg		
	Oils and lubricants				kg		
	Other				kg		
Packaging	Cardboard				kg		kg
	Plastic				kg		
	Other				kg		

Table 7.2 Waste generation data

Waste generation		Quantity (per day/week/year)	
Water	Volume		kL
	Pollutant load		
	Organic matter (COD)		kg
	Suspended solids		kg
	Nitrogen		kg
	Phosphorous		kg
	Oil and grease		kg
	Other		kg
Solid waste (disposed to landfill)	Paunch and yard manure		t
	Sludges and floats		t
	Boiler ash		t
	Cardboard waste		t
	Plastic waste		t
	Other		t

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Step 3: Establish performance indicators

Performance indicators commonly represent resource use and waste generation per unit of production (per tonne HSCW). Tables 7.3 and 7.4 provide examples of performance indicators that could be used for meat processing. Use these tables to record your plant's current eco-efficiency performance, based on the information collected in Tables 7.1 and 7.2 and the production throughput of your plant. You may wish to add additional performance indicators for other aspects.

Compare your plant's current performance with industry figures in Section 1 (Table 1.6). You may wish to improve your plant's performance in some areas. If so record your target performance in Tables 7.3 and 7.4.

Table 7.3 Performance indicators for resource use

Resource Use	**Current performance (per tonne HSCW)**		**Target performance (per tonne HSCW)**	
Water		kL/tHSCW		kL/tHSCW
Energy		GJ/tHSCW		GJ/tHSCW
Chemicals		kg/tHSCW		kg/tHSCW
Packaging		kg/tHSCW		kg/tHSCW
Other				

Table 7.4 Performance indicators for waste generation

Waste Generation	**Current performance (per tonne HSCW)**		**Target performance (per tonne HSCW)**	
Wastewater volume		kL/tHSCW		kL/tHSCW
Wastewater pollutant load				
Organic matter (COD)		kg/tHSCW		kg/tHSCW
Suspended solids		kg/tHSCW		kg/tHSCW
Nitrogen		kg/tHSCW		kg/tHSCW
Phosphorous		kg/tHSCW		kg/tHSCW
Oil and grease		kg/tHSCW		kg/tHSCW
Other		kg/tHSCW		kg/tHSCW
Solid waste (disposed to landfill)		kg/tHSCW		kg/tHSCW
Other		kg/tHSCW		kg/tHSCW

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Units of production

The meat industry has historically used many different units of production—head, live weight, dressed weight, hot standard carcase weight etc. Hot Standard Carcase Weight (HSCW) is being used more commonly as a standard unit and has been adopted here.

HSCW describes the weight of animal carcases after slaughter, dressing and evisceration and prior to chilling and boning. For beef it is generally 55% of live weight. This unit is useful because it takes into account the variations in live weight between different species and different plants.

Step 4: Identify eco-efficiency opportunities

Review the checklist of eco-efficiency opportunities and identify opportunities applicable to your plant.

Table 7.5 is a checklist of generic questions you can ask to help identify eco-efficiency opportunities and the checklists over page outline specific opportunities applicable to meat processing. Use these checklists to brainstorm possible opportunities that may be applicable to your plant.

Table 7.5 **Checklist of generic questions for identifying eco-efficiency opportunities at meat plants**

Reducing water use:		**Check if appropriate**
1.	Can we avoid or reduce the use of water for any of operations at our plant?	
2.	Can we reuse relatively clean water in other applications?	
3.	Can we use any alternative sources of water to reduce our reliance on potable water?	
Reducing energy use:		
1.	Can we reduce the demand for steam in the by-product plant?	
2.	Can we reduce the use of hot water?	
3.	Can we reduce our electricity demand?	
4.	Can we recover waste heat for use in another application?	
5.	Are there any opportunities for using alternative sources of energy?	
Reducing waste:		
1.	Can we reduce the loss of materials (blood, fat, manure, meat tissue etc.) to wastewater?	
2.	Can we recover lost materials (manure, protein and fat) from wastewater?	
3.	Can we convert wastes into co-products?	
4.	Can we beneficially use our wastewater?	

Tips for generating ideas

- Review the ideas listed in the checklist in Table 7.6 and refer to the additional information provided in the manual.
- Hold a workshop with staff (operators, cleaners, engineers) to brainstorm possibilities. They may have some good ideas.
- Consult with other people in the industry (equipment suppliers, other associated meat plants, industry associations, consultants).

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Table 7.6

Areas of saving

No or minimal capital costs	**Section in this manual**	**Water**	**Steam**	**Water heating**	**Electricity**	**Chemicals**	**Packaging**	**Co-product yield**	**Wastewater**	**Check if appropriate**
Minimising receipt of very dirty stock	2.2.3	•								
Dry cleaning manure from stockyards before washing	2.2.6	•						•	•	
Use of chlorinated detergents instead of hot water for washing viscera tables	2.2.12			•						
Water level control on pig scald tanks	2.2.22	•	•							
Improved dry cleaning practices prior to wash down	2.2.30	•		•				•		
Timers on water taps	2.2.34	•		•						
Reducing water entrainment in rendering materials	3.2.1		•							
Rationalisation of boiler use	3.3.1		•							
Matching steam supply with demand	3.3.2		•							
Rectification of steam leaks	3.3.3		•							
Fine tuning of boiler operation	3.3.6		•							
Optimising heat recovery from rendering	3.5.1		•							
Turning off refrigeration at night during weekends	3.6.4				•					
Improving efficiency of air compression	3.6.6				•					
Avoiding and rectifying over-capacity of motors	3.6.8				•					
Optimising piping layout to reduce pumping load	3.6.10				•					
Rationalising use of cleaning and sanitising agents	5.2.1					•				
Use of environmentally-friendly cleaning and sanitising agents	5.2.3					•				

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Table 7.6 (Continued)

		Areas of saving								
Low capital cost (<$10,000)	**Section in this manual**	**Water**	**Steam**	**Water heating**	**Electricity**	**Chemicals**	**Packaging**	**Co-product yield**	**Wastewater**	**Check if appropriate**
Fitting efficient spray nozzles	2.2.1	•		•						
Centralised control of water supplies	2.2.2	•		•						
Avoiding under utilisation of spray capacity for stock washing	2.2.4	•								
Intermittent flow for viscera (bleed) table wash sprays	2.2.9	•		•						
Setting and maintaining minimum flow rates for viscera table wash sprays	2.2.10	•		•						
Flow control on continuous flow sterilisers	2.2.14	•		•						
Spray sterilisers	2.2.15	•		•						
Sensor control of automatic carcase washing	2.2.18	•								
Water sprays on splitting saws to reduce bone dust and reduce carcase washing	2.2.19	•								
On/off controls for cooling water on breaking saws	2.2.20	•		•						
Efficient water use in tripe and bible washing machines	2.2.24	•		•						
Limiting water use in casings washing	2.2.25	•								
Water efficient gut washing systems	2.2.26	•						•	•	
Water-efficient shower roses for edible offal washing	2.2.27	•								
On/off control of flow for edible offal washing	2.2.28	•								
Automatic controls for hand washing	2.2.35	•		•						
Maximising condensate recovery	2.2.36	•	•							

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Table 7.6 (Continued)

	Section in this manual	Water	Steam	Water heating	Electricity	Chemicals	Packaging	Co-product yield	Wastewater	Check if appropriate
		Areas of saving								
Conductivity controlled blowdown on cooling towers	2.2.37	•								
Insulation of steam lines	3.3.4		•							
Rationalisation of steam lines	3.3.5		•							
Use of tallow instead of fuel oil for steam raising	3.4.2		•							
Reducing heat ingress to refrigerated areas	3.6.1				•					
Improving efficiency of refrigeration compressors	3.6.2				•					
Energy-efficiency lighting	3.6.12				•					
Automatic dosing systems for dispensing cleaning and sanitising agents	5.1.2					•				
Medium capital cost ($10,000 – $50,000)										
De-dagging to avoid stock washing at domestic meat plants	2.2.5	•								
Efficient continuous flow sterilisers	2.2.13	•		•						
Dry dumping of paunch contents	2.2.23	•						•	•	
Automatic spray washer for edible offal	2.2.29	•								
Automatic washers for tubs, cutting boards and trays	2.2.32	•		•		•				
Floor cleaning machines for large areas	2.2.33	•				•				
Rainwater harvesting	2.4.1	•								
Automatic diversion valves in bleed area to avoid blood dilution and blood loss	3.2.2.		•					•		

Table 7.6 (Continued)

		Areas of saving								
	Section in this manual	Water	Steam	Water heating	Electricity	Chemicals	Packaging	Co-product yield	Wastewater	Check if appropriate
Solar pre-heating of boiler feed water	3.4.4		•							
High efficiency air compressors	3.6.7				•					
Variable speed drives	3.6.9				•					
Dewatering paunch manure using screw press	4.2.3							•		
Dosing system for dispensing chemicals and sanitising agents	5.2.2					•				
High capital cost ($50,000 – $100,000)										
Suspended mesh flooring in stockyards	2.2.8	•						•	•	
High-pressure water ring main for cleaning	2.2.31	•		•						
High efficiency boiler	3.3.7		•							
Conversion to cleaner fuel boiler (gas)	3.4.1		•							
Heat recovery from sources other than rendering	3.5.2			•						
Energy efficient freezing systems	3.6.5				•					
Composting of manure	4.2.5							•		
Vacuum pack tubing for reducing off-cut waste	5.3.4						•			

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Definitions

Aerobic digestion	The decomposition of organic matter in the presence of free oxygen to produce carbon dioxide.
Actuation	Completion of one cycle of a process
Anaerobic digestion	The decomposition of organic matter in the absence of free oxygen. In this process, a mixture of different species of micro-organisms degrade organic matter to produce compounds such as methane.
AQIS	Australian Quarantine Inspection Service
Benchmark	An indication of the best practice performance for a particular industry or operation.
Biodiesel	A fuel derived from vegetable or animal derived fats and oils
Biogas	The gas produced from the digestion of organic material under anaerobic conditions. Biogas is made up mostly of methane and carbon dioxide but also contains other gases.
BOD	Biochemical oxygen demand: a measure of the quantity of dissolved oxygen consumed by micro-organisms as the of the breakdown of biodegradable constituents in wastewater.
BSE	Bovine spongiform encephalopathy
Calorific value	Calorific value or heating value is the amount of heat released when a fuel is combusted.
COD	Chemical oxygen demand: a measure of the quantity of dissolved oxygen consumed during chemical oxidation of wastewater.
Condensate	The water produced when steam condenses back to a liquid in a steam system.
CSTR	Constantly stirred tank reactor, which is a form of anaerobic digestion technology.
DAF	Dissolved air flotation, which is a type of wastewater treatment technology.
DEE	Double effect evaporator

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DEFINITIONS

Eco-efficiency	The definition of eco-efficiency according to the World Business Council for Sustainable Development is "the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth's estimated carrying capacity".
EMS	Environmental Management System is a management system put in place by a company to manage its environmental impacts.
Greenhouses gases	Gas that contribute to the greenhouse effect of the earth's atmosphere. The major greenhouse gases are carbon dioxide, methane and nitrous oxide.
H_2S	Hydrogen sulphide, which is an odourous, gaseous substance produced as a byproduct of the digestion of organic material under anaerobic conditions.
HSCW	Hot Standard Carcase Weight is a standard unit of production used by the Australian meat industry, which describes the weight of animal carcases after slaughter, dressing and evisceration and prior to chilling and boning. This unit takes into consideration the variations in weight between the multiple species that may be slaughtered at the one site.
MIRINZ	Meat Industry Research Institute of New Zealand
MLA	Meat and Livestock Australia
N	Nitrogen, expressed as total nitrogen
Na	Sodium
NCV skins	No commercial value skins
NMP waste	Non manure or paunch waste
Non-renewable	Non-renewable as it relates to resources means that a resource is being consumed faster than it can be replenished by nature.
LPG	Liquified petroleum gas
P	Phosphorous, expressed as total phosphorous
Paunch	The first compartment of the stomach of ruminants
Paunch manure	The contents of cattle paunches (first compartment of the stomach), which is primarily undigested grass and feed.

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PVC	Poly-vinyl chloride compounds, which are an important component of some plastics.
Saveall	A device for physically separating solid and floating phases from wastewater.
Specific heat of water	The specific heat of water is the amount of energy required to increase 1L by a degree Celcius—4.18 MJ/L/°C.
Stickwater	This is the wastewater stream generated from the wet rendering process.
Tallow	Refined fat produced from beef animals
TSS	Total suspended solids
UASB	Up-flow anaerobic sludge blanket, which is a type of anaerobic digestion technology
Viscera	The digestive tract of an animal
VS	Volatile solids

Units and conversion factors

Units of production for meat processing

t HSCW	tonne hot standard carcase weight

Mass

mg	milligram (1 mg = 10^{-3} g)
g	gram
Kg	kilogram (1 kg = 1,000 g)
t	tonne (1 t = 1,000 kg)
Kt	kilotonne (1kt = 1,000 t)

Volume

L	litre
kL	kilolitre (1 kL = 1,000 L)
ML	megalitre (1 ML = 1,000 kL)
m3	cubic metre (1 m^3 = 1 kL)

Length

mm	millimetre
cm	centimetre (1cm = 10mm)
m	metre (1m = 100cm)
Km	kilometre (1km = 1000m)

Flow

L/sec	L per second
L/min	L per minute

Pressure

Pa	Pascals
kPa	kilo Pascals

Energy

J	joule (1 W = 1 J/s)
KJ	kilojoule (1 kJ = 1,000 J)
MJ	megajoule (1 MJ = 1,000 kJ)
GJ	gigajoule (1 GJ = 1,000 MJ)

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Electrical energy

kWh	kilowatt hour (1 kWh = 3.6 MJ)
MWh	megawatt hour (1 MWh = 1,000 kWh)
GWh	gigawatt hour (1 GWh = 1,000 MWh)
kW	Kilowatt

Temperature

°C	degrees Celcius

Pollutant load

kg BOD	kg of biochemical oxygen demand
kg COD	kg of chemical oxygen demand

Time

s	seconds
min	minute
h	hours
yr	year

Software

Refrigeration Loads Analyser

A software package that enables food industry engineers to calculate refrigeration heat loads and evaluate refrigeration process alternatives. You can use it to analyse the performance of existing refrigeration plants, carry out designs, and verify designs carried out by other people for new plant facilities. Cost: $NZ750.

Meat Plant Utilities Modeller

A program that enables meat plants to monitor and analyse their energy and water usage, yielding valuable information for cost control. Cost: $NZ500. More information about this software as well as a demonstration copy is available at
http://www.dever.com.au/mpum/meat.htm

The development of these software tools was funded by Meat New Zealand, Meat and Livestock Australia (MLA) and MIRINZ Food Technology and Research (MIRNZ). It is available at a cost of $NZ750 from Food Systems and Technology, AgResearch Ltd., Private Bag 3123, Hamilton, New Zealand, Attention: Robert Kemp.

Cogeneration “Ready Reckoner”

The Cogeneration Ready Reckoner is a program to assist users conduct an initial technical and financial analysis of cogeneration at their site.

It is available from the web site of the Australian Cogeneration Association –
http://www.ecogeneration.com.au

Rendering Yield Calculator

An Excel spreadsheet that estimates the production of meat meal and protein content of meal from different raw products. Developed by Food Science Australia.
http://www.meatupdate.csiro.au/downloads.htm.

US Department of Energy, Office of Industrial Technologies

Has downloadable software tools for motor efficiency, pumping systems, steam systems and insulation. http://www.oit.doe.gov/bestpractices/software_tools.shtml

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