factsheets

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

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contents

A framework for water and energy monitoring and efficiency in feedlots

Overview

Water and energy are essential inputs for feedlot operation. However, there are growing pressures for the industry to improve the efficiency of water and energy usage to reduce costs and meet regulatory requirements. These are likely to increase in the future with the introduction of a carbon trading scheme which will lead to higher energy costs. These drivers provide incentives for the industry to act now on these issues.

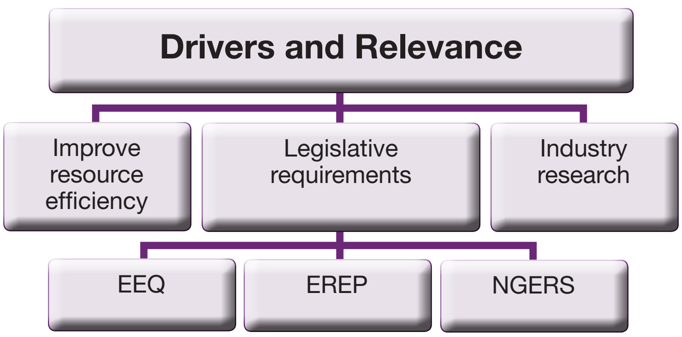

Figure 1: Drivers and Relevance Flowchart

Resource efficiency

Water availability and cost of supply is changing rapidly, driven by increased demand for industry, urban water supply and the environment. With droughts adding to low river flows, water supplies are very tight in many feedlot regions. Capped water supply and water trading in the Murray Darling Basin have increased the value of water significantly. In Victoria, large feedlots are now required to quantify and reduce their water usage. These pressures will promote careful management of water resources throughout the industry to ensure continued supply and minimise costs.

Energy usage is an increasing input cost for feedlot operation. These costs will rise significantly with the introduction of a carbon tax on energy production. These factors will make energy savings an important focus area for feedlots.

Saving costs will also contribute to lower carbon emissions which will benefit the environment. The first step to making savings is to understand where energy is used around the feedlot. Remember, measure to manage.

Key benefits

- The feedlot industry depends on water and energy resources and will face increasing competition for these resources.
- Improved use of resources will enable better management of climate impacts, avoid shortages and protect environmental assets.
- *Remember measure to manage*

Legislative requirements

The lot-feeding industry is under pressure from all levels of Government to report and reduce energy usage and GHG emissions. The growing competition for water has also led the government in Victoria to introduce water efficiency regulations.

Currently, federal energy and greenhouse gas reporting obligations only apply at relatively high levels of energy usage (0.5 petajoules of energy (EEO), 25,000 tonnes of CO_2-e for a single facility or 125,000 tonnes of CO_2-e for a corporation (NGERS)). Large, vertically integrated agricultural companies may meet these thresholds, resulting in reporting requirements for all subsidiary companies and feedlots in their control.

In Victoria, participation in the Environmental Resource Efficiency Plan (EREP) program is mandatory for feedlots that use more than 120 ML of water. This represents the water requirements for about a 5,000 head feedlot. There are other initiatives such as the National Pollutant Inventory (NPI) which could provide energy resource profiles. Further information can be found at:

EEO: www.energyefficiencyopportunities.gov.au

NGERS: www.climatechange.gov.au

EREP: www.epa.vic.gov.au/bus/erep

NPI: www.npi.gov.au

Industry research

Foreseeing these drivers for industry change, MLA has provided significant investment to quantify the water and energy usage of individual activities at Australian feedlots. This puts valuable information in the hands of the industry to improve resource efficiency, meet the requirements of legislation and improve the sustainability of the industry in the face of a variable climate.

Measuring and understanding water usage factsheets

This is the first phase in developing the framework. Factsheets in this series outline the steps involved and the tools required for implementing water usage measurement and understanding what the numbers mean.

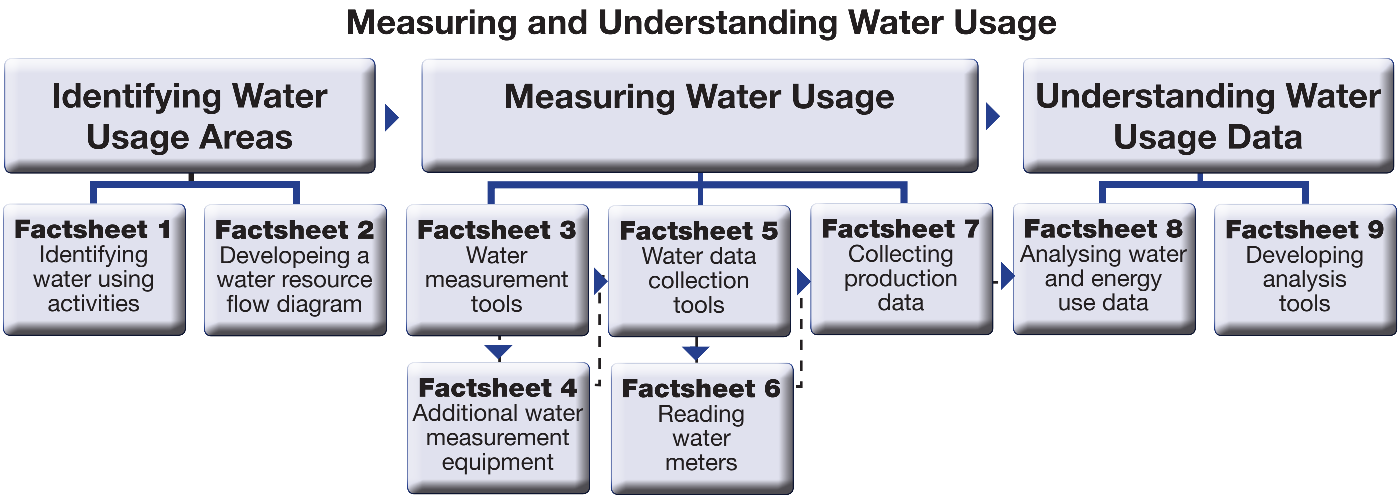

Figure 2: Measuring and understanding phase flowchart for water usage

Water and energy factsheets

To assist the feedlot industry to improve water and energy efficiency, a series of fact sheets have been developed to step through the process of measuring and reducing water and energy usage at the feedlot. The fact sheets are arranged in 3 series:

- Measuring and Understanding resource usage,
- Benchmarking, and
- Improving resource efficiency.

The fact sheets cover water and energy separately. The following figures show the structure of the water fact sheets.

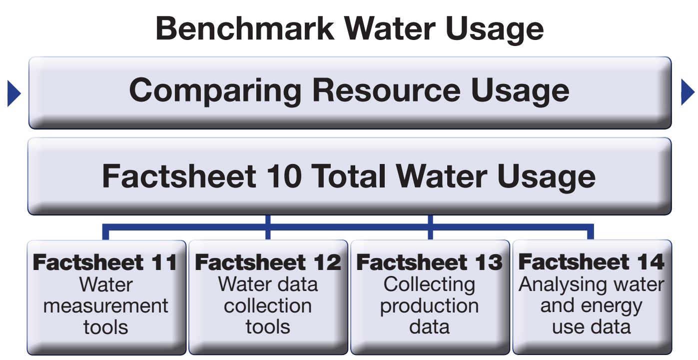

Figure 3: Benchmarking Phase Flowchart for Water Usage

Benchmarking water usage factsheets

This is the second phase in developing the framework for water usage. Factsheets in this series provide Industry data on water usage within individual activities which you can use to benchmark your water usage levels against.

Improving Factsheet Series

This is the last phase in developing the framework. Factsheets in this series provide case studies which you can use to gain a better understanding of the process and to benchmark your water usage levels.

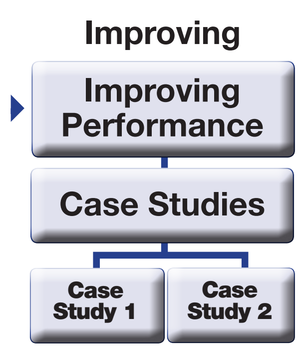

Figure 4: Improving phase flowchart for water usage

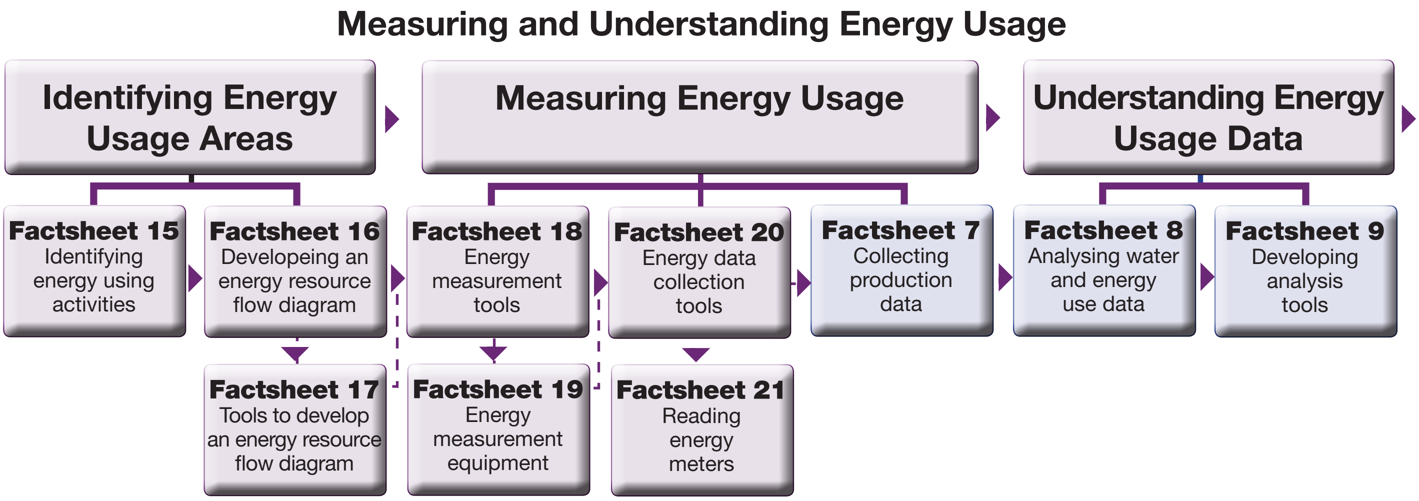

Figure 5: Measuring and understanding phase flowchart for energy usage

Measuring and understanding energy usage factsheets

This is the first phase in developing the energy usage framework. Factsheets in this series outline the steps involved and the tools required in implementing energy usage measurement and understanding what the numbers mean.

Benchmarking energy usage factsheets

This is the second phase in developing the framework for energy usage. Factsheets in this series provide Industry data on energy usage within individual activities which you can use to benchmark your energy usage levels against.

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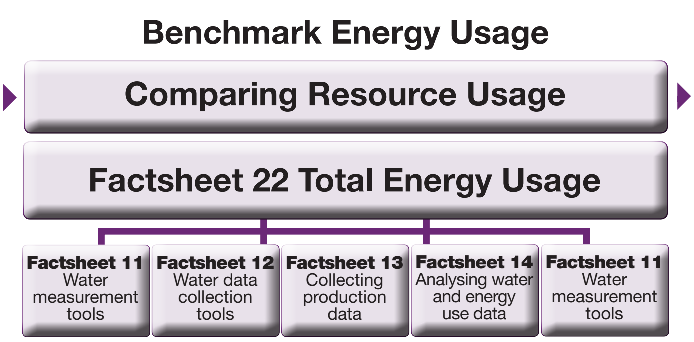

Figure 6: Benchmarking Phase Flowchart for Energy Usage

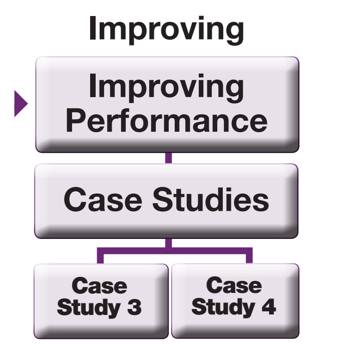

Figure 7: Improving phase flowchart for energy usage

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Factsheet 1: Identifying water using activities

This factsheet will assist in identifying the major water using areas and activities and form the foundation for the development of a framework for monitoring water usage.

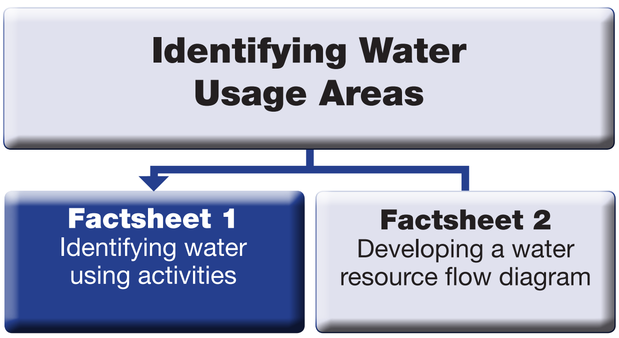

Figure 1: Identifying Water Usage Areas Flowchart

Why identify your water using activities

To provide the best perspective on approaching water use efficiency, it may help to breakdown the activities involved.

This approach will provide context in relation to:

- the complexity of the site
- main activities and where to target efficiency opportunities
- what the inputs and output of the systems are
- how inputs and outputs are monitored

Key benefits

- Identify key water use activities
- Cattle drinking water consumes about 87% of total water
- The contribution of sundry water uses to total water usage should not be underestimated.

Water using activities

Figure 2 is a tree diagram outlining the water using activities and their approximate contribution to total water usage. These data were obtained from MLA industry research undertaken between March 2007 and February 2009 which quantified the clean water usage of individual activities. Sundry water uses are defined as that used in trough cleaning, hospital cleaning, induction yard cleaning, vehicle washing and evaporation from open water storages (water troughs/turkey's nest). This diagram quickly identifies those areas where further investigation is warranted and which areas may be of interest to you.

Figure 2 shows that cattle drinking water consumes the majority of water. Drinking water requirements are predominantly governed by environmental conditions therefore are largely beyond the control of feedlot management.

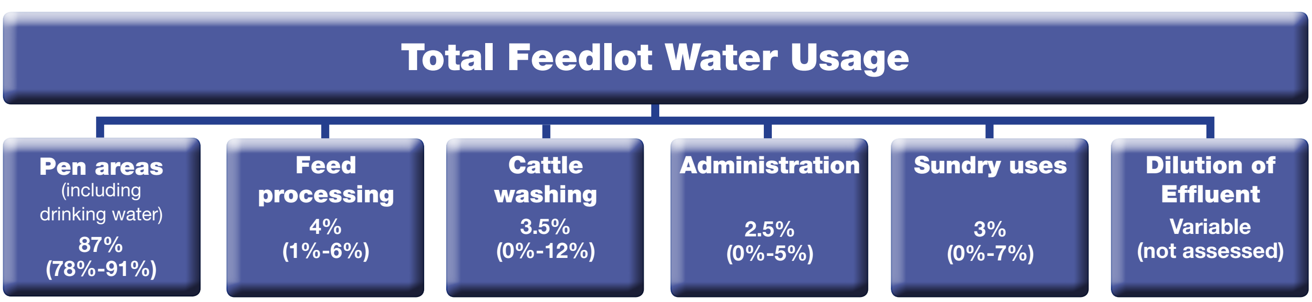

Figure 2: Water Usage of Individual Activities as a Percentage of Total Water Usage

Which areas are important to you?

Knowing where water is used in the feedlot and having an understanding of approximate proportions of total water use, will let you target the areas that are of the greatest interest to you.

These may include total water used in the feedlot, or individual activities such as water used in feed processing or cattle washing.

Cattle drinking water 78% - 91%

The volume of water that cattle consume is mostly driven by environmental conditions. The hotter or drier the conditions, the more water cattle will consume. Water is taken in mainly by drinking but a small amount is contributed by feed. Leaking troughs may also contribute to the apparent volume of drinking water used.

Feed processing 1% - 6%

Processing of grain significantly improves the digestibility for beef cattle. The amount of water added will vary depending on the initial grain moisture content and the final target moisture content. During tempering and reconstitution the total water used is about the amount of water added to the grain. When steam flaking there are additional losses through steam.

Cattle washing 0% - 12%

Washing cattle removes dags on cattle going to slaughter. The amount of clean water used during cattle washing depends on whether water is recycled for use, the dirtiness of the cattle and cleanliness requirements.

Figure 3: Cattle washing activity

Administration 0% - 5%

Water used in the administration of the feedlot may include office, staff amenities and landscape maintenance. Typically this represents about 2.5% of total water use.

Sundry uses 0% - 7%

The contribution of sundry water uses to total water usage should not be underestimated. In particular, if you have high evaporation and large open water storages.

Dilution of effluent – variable

The amount of clean water used to dilute effluent for irrigation is extremely variable and will depend on water availability. This was not measured in the B.FLT.0339 and B.FLT.0350 projects.

Site layout plan

Tools to assist you in understanding how water is distributed to and from your areas of interest are a site layout plan and resource flow diagram.

A site layout plan is a visual representation of key site activities. Most sites will have a map of some description. This may be as simple as a sketch or as complex as a professionally drafted plan. A resource flow diagram shows how water moves around the site and is described in detail in Factsheet 2: *Developing a water resource flow diagram*

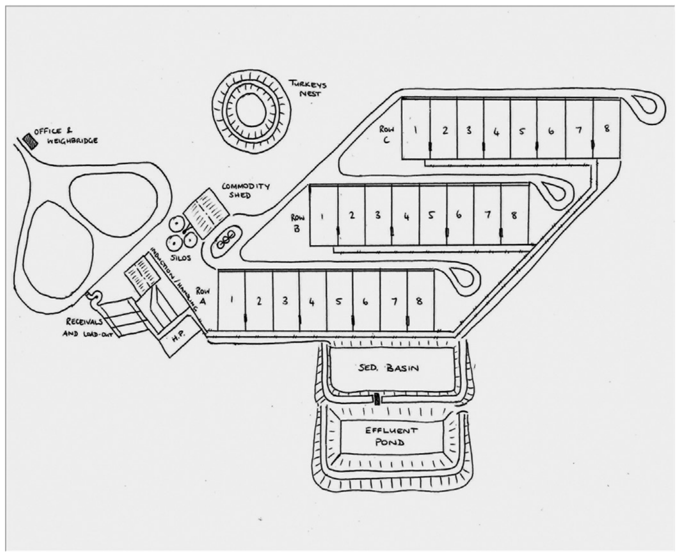

Figure 3: Example site layout plan

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Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 2: Developing a water resource flow diagram

The resource flow diagram is an extension of developing a site layout plan and is the second step in developing the framework for water usage (Figure 1). It should group the common water use areas together and show how water is distributed around the feedlot. A number of steps are required to develop a resource flow diagram.

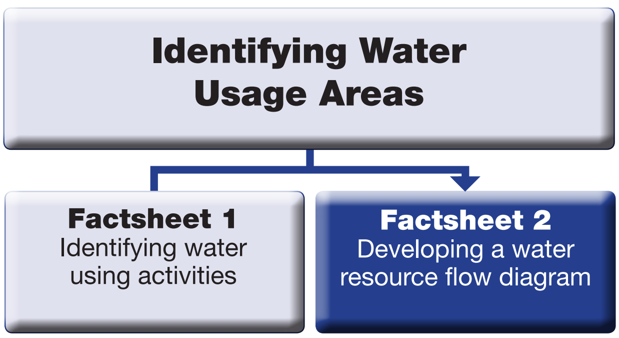

Figure 1: Identifying Water Usage Areas Flowchart

Site layout schematic

The first step in preparing a resource flow diagram is to develop a site layout schematic.

Use a site layout map as a basis to develop a simple schematic which groups together water using activities (Figure 2) or have a professional plan drafted which outlines water resource distribution for this purpose (Figure 3).

The schematic should show how water flows around the site i.e. where it is sourced, pump locations, distribution lines, etc. You may be able to prepare the schematic from a site layout plan.

Once the basic schematic is drawn, the areas of interest as described in *Factsheet 1: Identify water using activities, should be defined.*

Simply mark a line that surrounds the elements associated with each area of interest as shown in *figure 3*.

Key benefits

- A resource flow diagram shows how water is distributed around the feedlot.
- Develop a resource flow diagram from a site map and plan
- Mark inflows and outflows and existing metering

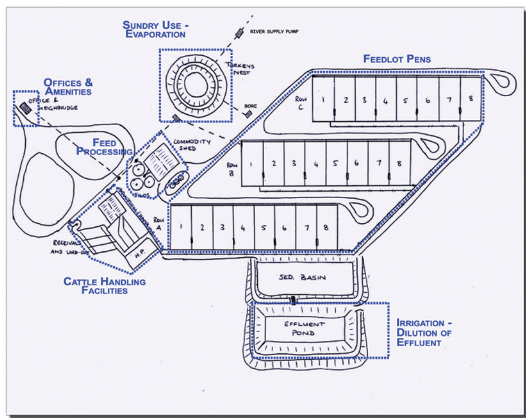

Figure 2: Example of a site schematic from site map

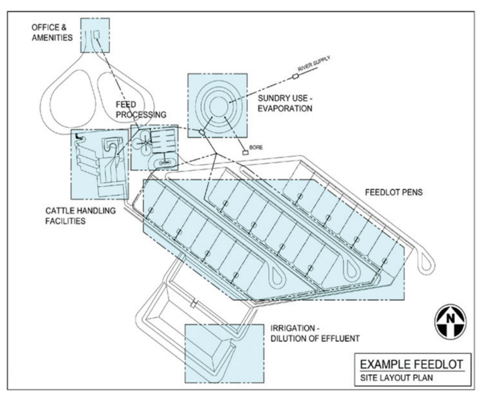

Figure 3: Example of schematic from ACAD plan

Identify inflows and outflows

The next step is to identify all of the water inflows and any outflows from those areas of interest. A simple line connecting areas to denote inputs and outputs will suffice (*Figure 4*). Alternatively, a detailed pipe layout plan may be available. Some areas will have multiple inflows and multiple outflows. For example feed processing water supply may also supply residences, with excess returning to tanks etc.

It is a good idea to highlight the manual operations, for example, washing down floors, vehicles, dust suppression etc. This will help to make sure that all the uses are captured on the diagram.

Understanding where water flows will help to highlight where monitoring equipment is positioned and where it may be required.

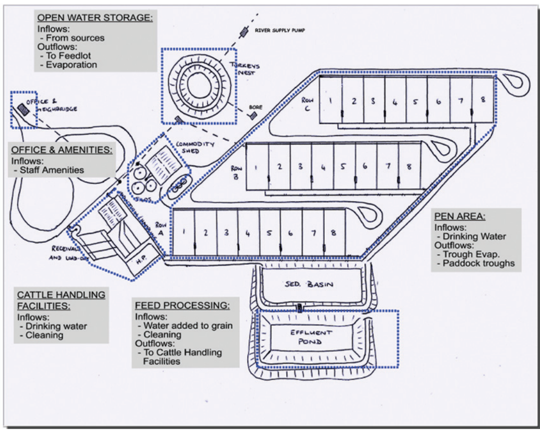

Figure 4: Adding the inflows and outflows to each area of interest

Existing inflow and outflow metering

It is important to identify the location of existing water metering equipment on the site schematic diagram (*Figure 5*). This will highlight any inflow or outflow lines from an area of interest. A mass balance approach may need to be used to determine usage in some areas.

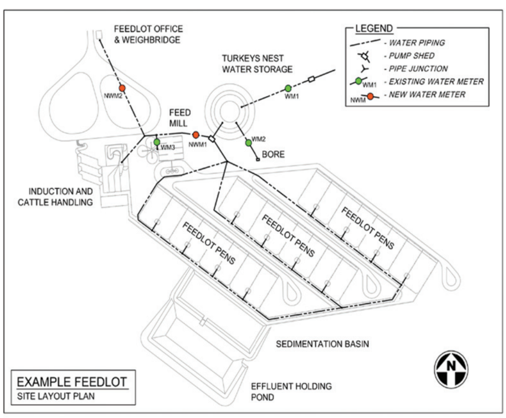

Figure 5: Identify existing metering equipment

Additional metering equipment can then be sourced and installed in these locations if required. See *Factsheet 3: Water measurement tools* for more information on techniques and tools for measuring water usage.

Mass balance

Depending on your level of assessment, a mass balance approach may be undertaken to provide an estimate of water usage. Mass balance is based on a simple idea: what goes in must come out.

Completing a mass balance can provide insights into where losses really happen and which processes are creating waste. A mass balance may need to be undertaken if an area has too many inflows or outflows to be monitored economically with inline water metering equipment.

A mass balance simply requires that the sum of the inputs must equal the sum of the outputs. Since the output side of a meter often supplies a number of separate processes, further metering and subtraction will be needed to isolate an individual process usage.

Mass Balance Calculation Examples

Example 1:

Calculating the water used in the Pen Area (Figure 5)

Volume used =Water entering the turkeys nest -
Water used in other areas of the site -
Evaporation and seepage* from the turkeys nest

Water entering the turkeys nest = WM1 +WM2
Water used in other areas of the site = NWM1
Evaporation (ML) = Surface area (ha) x pan evap. (mm) x KOW /100

Volume used =WM1 +WM2 –NWM1 (- evaporation and seepage)

**further detail on evaporation and seepage can be found on Factsheet 5: Water Data Collection Tools*

Example 2:

Calculating the water used in the induction and cattle handling facilities

Volume used = Water used in all areas other than pens -
Water used at the feed mill -
Water used at the office and weighbridge

Water used in all areas other than pens = NWM1
Water used at the feed mill = WM3
Water used at the office and weighbridge = NWM2

Volume used = NWM1 - WM3 - NWM2

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Factsheet 3: Water measurement tools

This factsheet describes the various methods that can be used to help quantify water use. It is the first step in the "Measuring water usage" phase of the framework (Fig1).

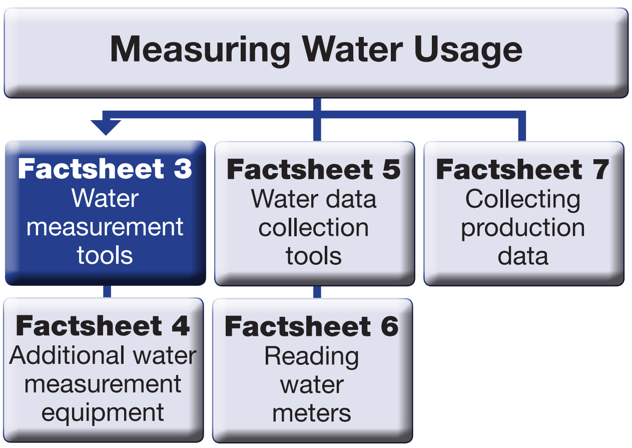

Figure 1: Measuring water usage flowchart

Measuring water usage is an ongoing process, and a regular monitoring and recording system should be established.

The range of measurement tools vary from very simplistic manual measurement to electronic metering equipment. These tools have been described with examples below.

Simple manual measurement

The simple bucket and stopwatch approach is not adequate for high volume or multipoint water uses (eg cattle drinking water) but may be a valuable tool for calculating smaller volumes at point sources around the feedlot. This method is quite inaccurate and relies on several assumptions regarding flow rate and total usage time.

Key benefits

- There are various methods for measuring water usage.
- Select the method that is most appropriate for your level of assessment.

For example: The hospital is cleaned with a hand held high pressure hose, approximately once per day all year round. It takes 1 hour to cleandown.

Using the high pressure hose, it takes 24 seconds for the operator to fill a 15 L bucket.

High pressure hose flow rate = (bucket volume/time taken to fill)

= 15 L / 24 seconds

= 0.625 L /s

0.625 L /s x (60 sec/min) x (60 minutes /hour) = 2,250 L/hour

Each week the hose is used for 5 hours

2,250 L/hour x 5 hours/week = 11,250 L per week

Hospital cleaning is undertaken 52 weeks per year

11,250 L/week x 52 weeks/year = 585,000 L/year or 585 kL/year or 0.585 ML/year.

Operational data

Water consumption from regular onsite activities including dust suppression, can often be estimated using operational information.

For example: The water cart is filled twice daily for 6 days per week for 16 weeks. The total capacity of the water cart is 12,000L

24,000 L per day x 6 days/week x 16 weeks/year =

2,304,000 L/year, 2,304 kL/year or 2.304 ML/year.

Manufacturer's information

If water on-site is supplied from a bore, the pump manufacturer may provide some information on the rate of supply specifications. This data, along with history of use, may be used to estimate water usage.

For example: At a given head, the pump can supply 20 L/ second. The pump automatically switches on between 7 am and 12:30 pm to top up the turkeys nest which then gravity feeds to the pens for drinking water.

20 L/s x (60 sec/min) x (60 min /hour) = 72,000 L/ hour7:00 am to 12:30 pm = 5.5 hours

72,000 L/hour x 5.5 hours/day = 396,000 L/day

396,000 L/day x (365 days/year) / (1,000,000 L/ML)

= 144.5ML/year.

Water flow meters

Water flow meters are the most accurate of the water measurement tools. They are positioned in-line and directly measure the volume of water used. There are various types of water flow meters (described in *Factsheet 4: Additional water measuring equipment*) that are suited for measuring water consumption in feedlots.

The cost of installing water flow meters will vary according to size and functionality. Factors to consider include pipe size, flow rate (L/ min), fluid quality (e.g. incoming potable water, wastewater, process water), type of power supply (mains, battery or solar) and installation costs. It is also important to consider ongoing maintenance and recalibration costs.

Water flow meters directly measure the flow volumes rather than rely on estimations as described earlier. Flow meters are also useful for measuring 'standing still' water consumption during periods when equipment is not operating, in order to detect possible leaks.

Flow meters may have a digital or an analogue display and many can have data loggers fitted to them to record not only total flow but also provide profiles on how much water is used at various times of the day, month or year.

Figure 2: Typical in-line water meter

Many sites will have existing flow meters that can be used to measure flow along certain pipes in the network. However as explained in *Factsheet 2: Developing a water resource flow diagram* this may not be sufficient to gain a full understanding of how much water is used in the individual activities of the feedlot.

All flow meters should be calibrated for accuracy on a regular basis or according to the manufacturer's recommendations. Remember that any informed decision-making must be based on accurate data.

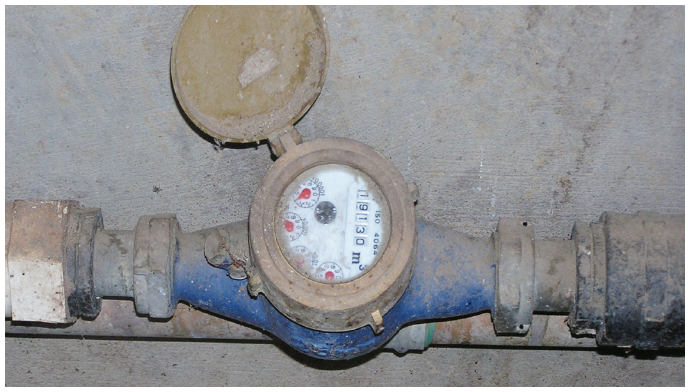

Figure 3: Typical in-line water meter

Gap Analysis

To identify the need for additional measurement equipment a gap analysis can be undertaken. Using the Water resource flow diagram that has been developed using *Factsheet 2: Developing a water resource flow diagram*, the gap analysis can show how to gain additional water use information from each additional water meter installed. (*Figure 4*)

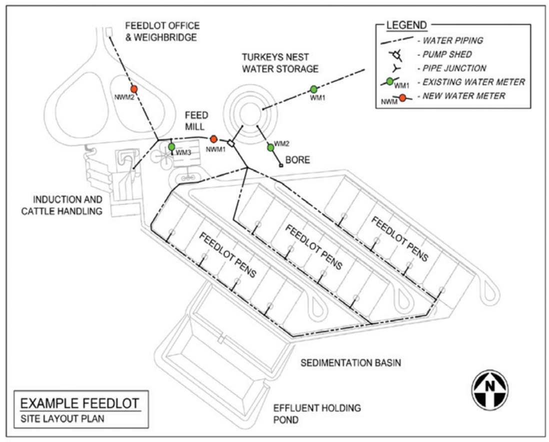

Figure 4: Example of resource flow diagram identifying locations of additional flow metering equipment

For example: If drinking water is to be measured then a water flow meter (e.g. NWM1) will need to be installed. This will allow estimation of drinking water by mass balance. Similarly, if the water used in administration is of interest then a additional water flow meter would need to be installed (e.g. NWM2).

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Factsheet 4: Additional water measurement equipment

This factsheet is an extension to Factsheet 3 (Figure 1) and provides additional information on water flow meters for those that require new or replacement water measurement equipment.

It provides a description of the various types of water flow meters that are available, typical application as well as some information on the correct methods for installation. It is recommended that specialist advice is sought before purchasing and installing a new water meter.

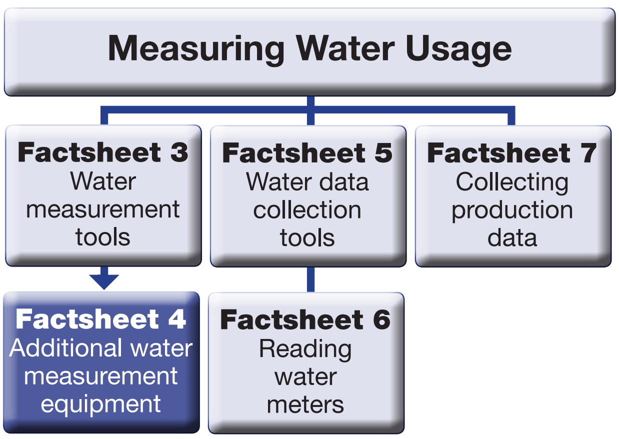


Figure 1: Measuring water usage flowchart

Key benefits

- There are two main types of water flow meters – mechanical and non-mechanical.
- Consider accuracy, repeatability, ability to handle dirty water, the effect of wear on their performance and cost when comparing water meters.
- Correct installation of a water flow meter is as important as the choice of water flow meter

Types of meters

There are two categories of water meters available - mechanical and non-mechanical (*Figure 2*).

Each has its own advantages and disadvantage when used in different operating conditions. For example, mechanical meters are generally suited to clean water, while, non-mechanical generally cope better with debris.

Mechanical meters are generally inexpensive to purchase but may require more maintenance, while non-mechanical meters are more expensive, but generally less prone to wear and tear.

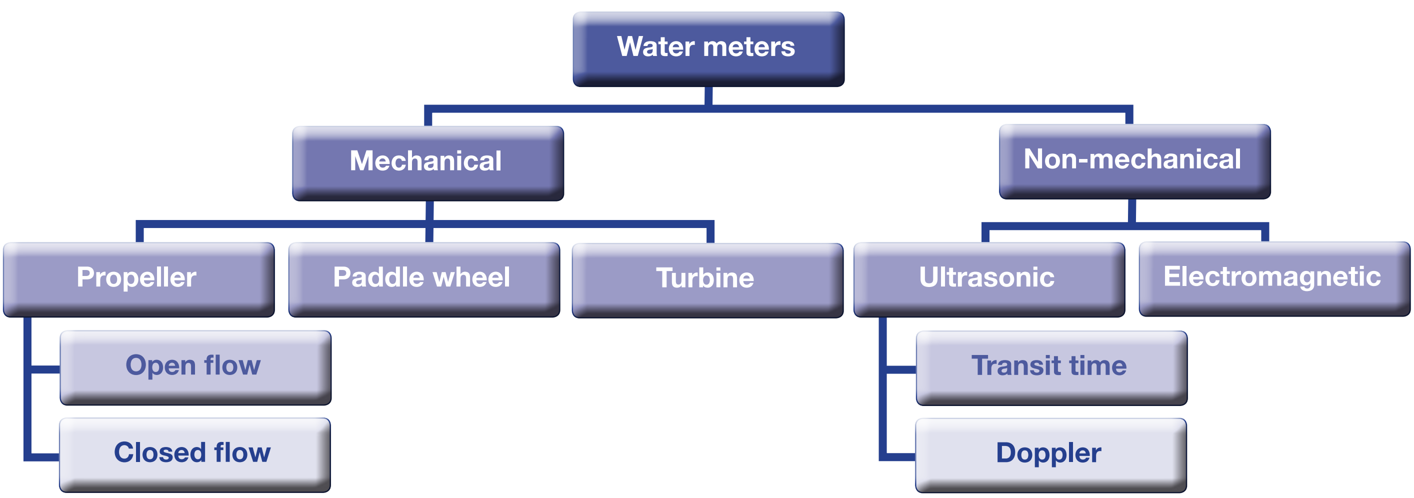


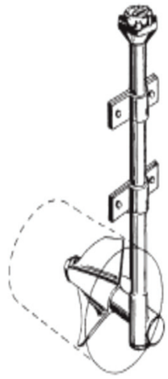
Figure 2: Types of water flow meters

Mechanical meters include propeller actuated, paddlewheel and turbine meters. Non-mechanical meters include ultrasonic and electromagnetic meters.

Propeller

Open flow

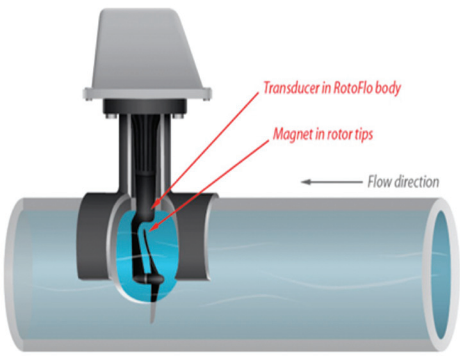
The open flow propeller meter often consists of a spindle shaft and plastic propeller which is mounted at the end of an open pipe. The pipe must always flow full of water. The rate of propeller rotation provides a measure of flow rate from which flow volume can be derived and recorded



Open flow meter (source ANCID 2002)

Closed flow

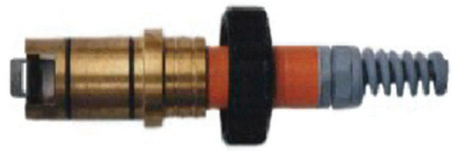
A closed flow meter consists of a metal or plastic propeller mounted inside a pipe section with its rotation axis set parallel to the water flow. This meter also requires full pipe flow



Closed flow meter (source ANCID 2002)

Paddle wheel

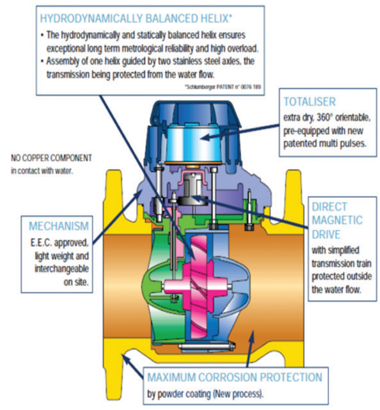
A vertically orientated impeller is rotated by the velocity of water passing through the meter. The meters are available in various sizes and require full flow for accurate measurement.



Paddle wheel meter (source ManuFlo)

Turbine

Turbine flow meters consist of a bladed turbine rotor installed in a flow tube. The rotor is suspended on its axis in the direction of flow through the tube. The blades of the turbine rotor will tend to travel toward this low pressure area as a result of this pressure differential across the blades.



Turbine meter (source Woltex)

	Mechanical			Non Mechanical	
Meter Type	**Propellor**	**Paddlewheel**	**Turbine**	**Ultrasonic**	**Eltromagnetic**
Advantages	• reasonably accurate • easy to use • reasonably robust • no power • low cost	• reasonably accurate • easy to use • reasonably robust • no power • low cost	• reasonably accurate • easy to use • reasonably robust • no power • low cost	• highly accurate • no moving parts • no wear • bi-directional flow • suits a range of pipe sizes • negligible pressure losses	• highly accurate • no moving parts • no wear • robust • low pressure loss
Disadvantages	• accuracy deteriorates with wear • inaccurate at low flows	• accuracy deteriorates with wear • inaccurate at low flows • wear of bearings and vanes • difficult to detect tampering • specialist skills to repair	• accuracy deteriorates with wear • wear of bearings and vanes	• not suitable for filtered water • specialist skills to repair	• requires power • requires full pipe • specialist skills to repair

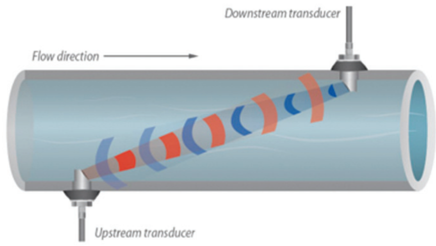
Ultrasonic

Ultrasonic meters use transducers or sensors that measure water velocity in full pipe flow. Transducers can be fixed on the outside of the pipe. These are known as 'non-wetted' types. They can also be inserted into the pipe and consequently these are known as 'wetted'.

Transit time meters

The Transit Time method calculates velocity from differences in time for an impulse to pass between two transducers located on opposite sides of the pipe.

Transit time meters are also known as acoustic meters.

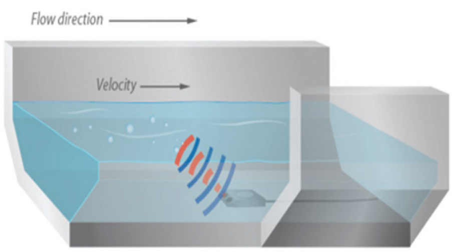


Schematic of transit time meter with wetted transducer (source ANCID 2002)

Doppler

The Doppler Method calculates the velocity by bouncing sound pulses out into the water mass and reading the pulses that are returned after reflecting from moving particles within the water mass such as air bubbles. This is similar to how radar works. Meters using the Doppler method generally consist of a sensor that is installed within an existing pipe or structure so the sensor is wetted.

Ultrasonic Doppler meters are capable of measuring flow in full pipe, partial pipe, pumped or gravity fed pipes.



Schematic of Transit time meter with wetted transducer (source ANCID 2002)

Electromagnetic

An electromagnetic meter consists of a section of pipe with a magnetic field across it and electrodes to detect electrical voltage changes. Electrodes in the probe detect the voltages generated by the flowing water. This type of meter is produced in a range of standard sizes and flow capacities.

Ultrasonic and electromagnetic meters have no moving parts and maybe used in cattle washing or other dirty water areas.

ManuFlow AquaMaster Electromagnetic Flow Meter (source ManuFlow)

Installation

In general water meters should be installed by experienced professionals. However all installers should follow some simple rules.

Meters should not be placed:

- immediately after a pump,
- immediately after a gate valve,
- immediately after a bend. The worst type of bend is one with two out-of-plane 90° bends – this will induce a swirling flow that will cause large errors in the metered flow (ANCID, 2002).

Poor installation locations cause inaccuracies in the volume of water measured regardless of the type of meter used.

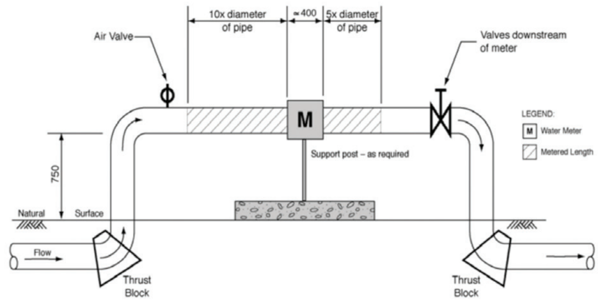


Figure 3: Typical water meter installation diagram (Source: Lund 2006)

Most manufacturers specify a minimum distance of straight pipe equivalent to 10 pipe diameters upstream of the meter and five pipe diameters of straight pipe downstream of the meter. These distances are to prevent turbulence from adversely affecting flow meter readings. Essentially, the greater the length of straight pipe used for the meter installation, the better (ANCID, 2002).

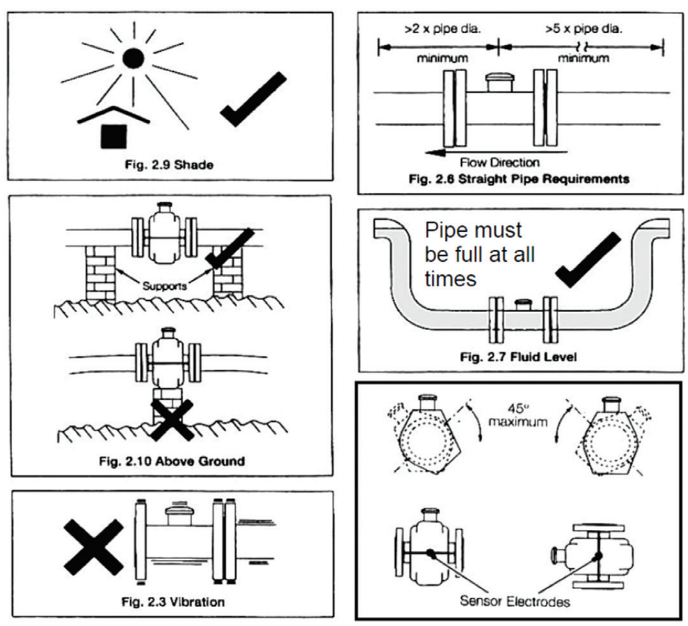


Figure 4: Installation Tips

Meter displays

Analogue

With mechanical meters the water flow turns the impeller or paddle, causing gear wheels to rotate the dial or output device. The output device indicates the flow rate and/or cumulative flow.

Figure 5: Analogue Output Device

Digital

Some meters have electronic modules with digital displays that can display the flow rate as well as cumulative volume of discharge. The electronic nature of these meters allows the flow display to be remotely mounted if required.

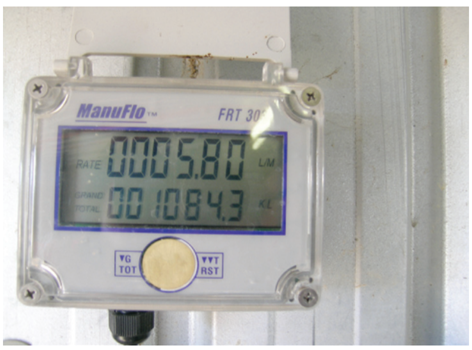


Figure 6: Digital Output Device

Data logging

Some mechanical and non-mechanical meters may be able to be connected to data loggers to record water flow at preset time intervals. The data from the logger can be downloaded for processing.

References

ANCID 2002, Know the Flow - Flow Metering Training Manual, Australian National Committee on Irrigation and Drainage

Lund 2006, The Water Meter Installation Process, Queensland Department of Natural Resources and Water, Facts—Water W86

ManuFlo, www.manuelectronics.com.au

Woltex, www.actaris.com

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Further information

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factsheet

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 5: Water data collection tools

This factsheet forms part of the Measuring water usage phase of the framework (Figure 1).

This factsheet introduces the various methods for collecting water usage data. The most obvious tools for collecting usage data are water flow meters (discussed in *Factsheet 4: Additional water measurement equipment*). But there are several other tools that can provide a less accurate but often adequate measure of water usage.

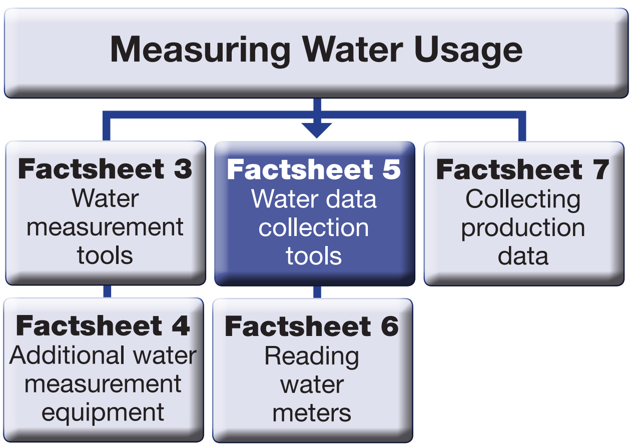

Figure 1: Measuring water usage flowchart

Water usage data can be obtained from a number of sources.

These include:

- water corporations - water obtained by agreement (e.g. Sunwater)
- checking and recording in-line water flow meters
- estimates from operational data
- rainfall captured in open water storages

Key benefits

- There are number of methods available for estimating water usage.
- One or a combination of methods may be used.
- Develop a pro-forma for reporting water usage data.

Water corporations

Water for feedlots may be sourced from shallow and artesian bores, rivers, creeks, irrigation channels, water harvesting of overland flow into on-farm dams and reticulated pipelines. Lot feeders may have an entitlement or authority to take or interfere with water under their relevant state government water act.

In some cases the take may be metered with a water supplier meter and the user charged based on volume of water taken. In this case, the water supplier will usually read the meter and supply a meter reading report. This report can be used to determine water usage.

Water flow meters

Documenting water flow meter readings will provide the required information to enable better analysis of usage from water using activities.

It is important to develop a reporting pro-forma tool to provide a simple and effective way to internally record usage from water using activities.

The simplest form is a paper-based record, which allows you to simply record the reading of each water flow meter. Data records are a legal and auditable document and must be kept safe at all times. It is good practice to have one sheet for each meter, which records the date on which the meter is read, the meter reading, meter location, the reading units and any other notes.

Example of data collection sheet—water flow meter usage

Meter ID: WM05

Date	Time	Meter location	Reading	Units	Comments
1 January 2009	7.00am	inflow to mill shed	1203.55	m^3	meter in good condition
1 February 2009	7.00am	inflow to mill shed	2209.81	m^3	meter required cleaning otherwise good

Figure 2: Data collection sheet for water flow meters

Example of data collection sheet—water usage from operational data

Activity: water tanker

Date	Time	Tank Fill	Volume (L)	Comments
1 January 2009	7.00am	1	15,000	
1 January 2009	11.00am	1	25,000	

Figure 3: Example data collection sheet for operational data

The reader is then able to quickly check the current reading with the previous readings and assess the quality of the data. An example of a simple form is shown in *Figure 2*.

Operational data

Documenting operational data from which water usage will be estimated will require a simple reporting pro-forma tool or logbook. This method will most likely be used with minor water usage activities (e.g. dust suppression). An example of a simple form is shown in *Figure 3*.

Captured rainfall

If you have a large surface area from one or more open storages you may wish to estimate the volume of water captured by net rainfall into your water usage. That is, after evaporation losses are taken into account. This may be positive or negative.

To estimate this you need to estimate the total surface area and the total rainfall for the period.

Evaporation from open water storages can be estimated from a evaporation factor for your area and surface area.

For example:

Evaporation:

The volume of water lost to evaporation is calculated the same way. The evaporation rate (often called the Class 'A' Pan evaporation) can be found at the Bureau of Meteorology website (www.bom.gov.au). Pan evaporation rates must be adjusted by a coefficient (KOW, usually 0.7—0.8) so that they represent the open water evaporation from a storage.

So, 120mm of pan evaporation during the month for a 4ha surface area will lose:

Pan Evap. x KOW x Surface Area ÷ 100 = Evap. Loss

120 mm x 0.75 x 4 ha ÷ 100 = 3.6 ML

Rainfall:

Assuming that the storage does not collect any runoff i.e. turkeys nest, the volume of rainfall captured by incident rainfall (ML) = rainfall (mm) x surface area (ha) /100

So, 50 mm of rainfall during the month on a 4ha surface area will produce: **50 mm x 4 ha ÷ 100 = 2 ML**

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Sample data collection sheet—water flow meter usage

Water meter ID______________________________

Date	Time	Meter location	Reading	Units	Comments

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FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 6: Reading water meters

This factsheet is an extension on Factsheet 5: Water Data Collection Tools (Figure 1), and provides detail on how to take meter readings from various digital and analogue type water flow meters.

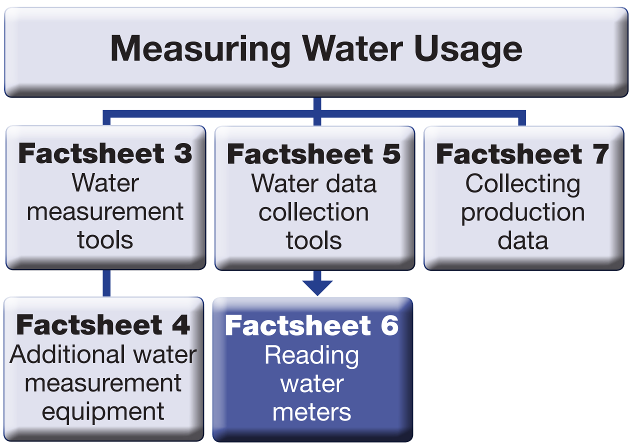


Figure 1: Measuring Water and Energy Usage flowchart

Correct selection and installation of flow meters is only the first step in gathering water use data. Collecting and recording the water flow meter readings is of critical importance.

Reading the meter

The onus is on the meter reader to collect the most accurate data possible. The meter reader will require:

- Some method of identifying the meter (a tag or serial number). Important to check that it is the correct meter.
- A data collection sheet. A dedicated proforma will be a permanent record and is much better than numbers written on the back of an envelope.
- An understanding of the system (purpose for collecting data, supply network, flow directions, etc).

Key benefits

Common errors include:

- Not recording the unit that the meter reads (L, kL, m^3).
- Not recording the appropriate level of accuracy .
- Not understanding the multiplying factor (x 1, x 10 etc).
- Reading the flow rate rather than the volume (on digital meters).
- Not recording the date and time the meter was read.

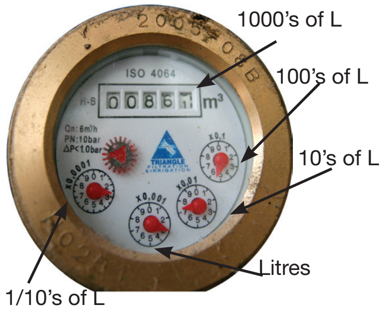
Irrespective of the type of meter, the reader should:

- Read the meter at a similar time of the day each week or month. If more than one meter is to be read and usage estimated by deduction then all meters should be read without significant delay.
- Immediately write the reading down on the data collection sheet for that meter (see Factsheet 5: Water Data Collection Tools). If possible, compare the current reading with the previous reading as a check on the accuracy of the reading. It must be the same or more than the previous reading.
- Record the reading in consistent units (m3, L, kL, etc)
- Check the general condition of the meter. Is it working i.e. dials spinning, display not cracked/glazed, not leaking etc.

Reading mechanical meters

Typically mechanical meters have analogue displays with a sequence of black numbers and a number of dials. The numbers may have one or two red digits. There may be a rotating star for leak detection. When reading meters:

- Read the numbers first, noting the last full number that has passed. This is the total flow measurement
- Read the dials from largest multiplication factor (eg. x 0.1) to smallest multiplication factor (eg. x 0.001), recording the last full number that the pointer has passed.



Example 1:
1.Read Numbers.
Read 860 and units are m^3

2.Read Dials:
100's of litres (x 0.1) = 5
10's of litres (x 0.01) = 7
Litres (x 0.001) = 3
1/10 of a litre (x 0.0001) = 2.5

So, this meter is reading
***860.57325** m^3, or 860,573.25 L*

Figure 2: Example 1 – Manuflo MEH Multi-Jet meter

Accurately reading meters is an important task. Make sure that someone with an understanding of the instrumentation and the system is involved in this process. If the meter reader understands the system they are more likely to recognise any potential errors or problems.

Example 2:
1. Read Numbers:
Read 7272.3 and units are in m^3

2. Read Dials: 10's of litres (x 0.01) = 5
Litres (8 x 0.001) = 8
1/10 of a litre (x 0.0001) = 5

So, this meter is reading
7,272.3585 m^3, or 7,272,358.5 L

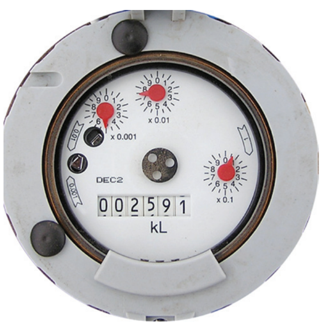
Figure 2: Example 2—ARAD Analogue Meter

Example 3:
1. Read Numbers: 153,030 and with a x10 multiplication factor, and units are in m3

1000's of litres (x 1) = 6
100's of litres (x 0.1) = 8
10's of litres (x 0.01) = 7.5

So, this meter is reading
153,036.875 m^3, or 153,036,875 L

Figure 4: Example 3—Analogue Meter Reading



Example 4:
1. Read Numbers:
2,591 and units are in kL

100's of litres (x 0.1) = 0
10's of litres (0.01) = 7
Litres (x 0.001) = 5

So, this meter is reading
2,591.075 kL, or 2,591,075 L

Figure 5: Example 4—Elster Helix H4000

Quick conversions

Volume	L	kL	m³	ML	Gallon
1 L =	1	0.001	0.001	0.000001	0.220
1 kL =	1,000	1	1	0.001	219.97
1 m3 =	1,000	1	1	0.001	219.97
1 ML =	1,000,000	1,000	1,000	1	219,969
1 Gallon =	4.546	0.0005	0.0005	0.000005	1

Flow	ML/year	L/day	L/sec	Gallons/hour
1 ML/year =	1	2,739	0.032	30.16
1 L/sec =	31.53	86,400	1	951.02
1 Gallon/hour =	0.033	90.84	0.001	1

Reading digital meters

The most important question to ask is what is the meter displaying and what do you need to record.

- Is it grand total or flow since last reset
- Is it instantaneous or average flow rate
- What is the unit of the output (m^3, kL/day)?

Example 5:
Mace Rotoflo
The 4-digit upper line of numbers is the flow rate and in this case is 2831 L/Day.

The 8-digit lower line is the volume totaliser count or Grand Total in kL. This is the sequence of numbers to be read.

The reading is 187789 kL or 18,778,900 L

Figure 6: Example 5—Mace Rotoflo Digital Meter

Example 6:
ManuFlo meter
The 6-digit upper line of numbers is the flow rate and in this case is 5.8 L/min.

The Grand Total is the sequence of numbers to be read.

The reading is 1084.3 kL. or 1,084,300 L

Figure 7: Example 6—ManuFlo Digital Display

Do the numbers make sense

Once the data has been recorded on the collection sheet, simple common sense checks should be undertaken. These include:

- Is the current reading the same as or larger than the previous reading of the meter?
- Do the units of measurement match up?
- Is the change in volume what you would expect or considerably higher or lower than expected?

Acknowledgement

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factsheet

FEEDLOTS

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Factsheet 7: Collecting production data

This is the final factsheet in the Measuring water usage phase (*Figure 1*). This factsheet is also used in the Measuring energy usage phase of the framework. Therefore, it discusses converting both water usage and energy usage into useful information.

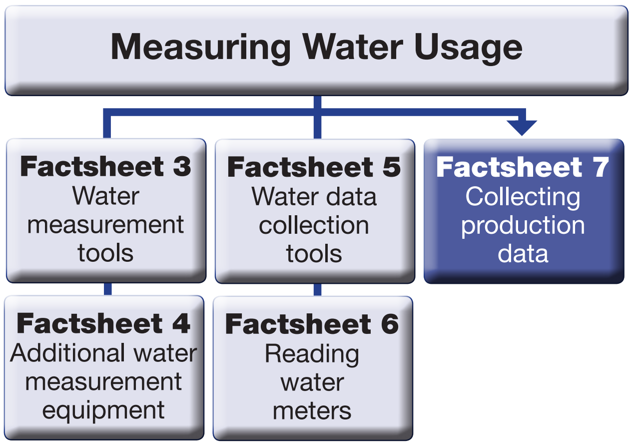
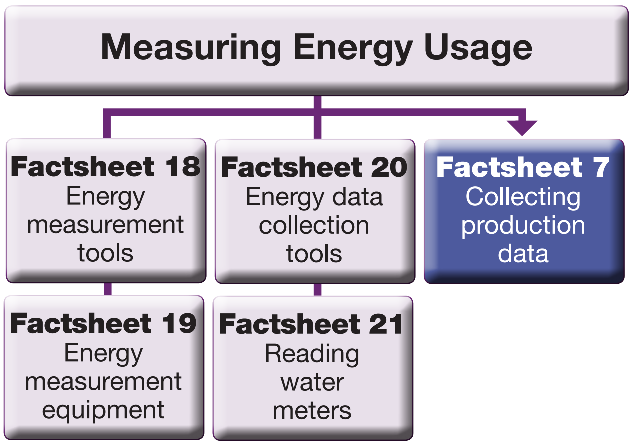


Figure 1: Measuring water and energy usage flowcharts



Key benefits

- Standardise water and/or energy usage with one or more production parameters
- You can compare your data with industry data
- Collect production data over the same time period as water and/ or energy usage data.
- Use dedicated report from FY3000 if you are using this software.

Water and/or energy resource usage will need to be given some perspective. The simplest and most obvious indicator to use is volume of water or energy used per time period, i.e. kL/day, ML/year, kWh/hour, MJ/year.

For Example:

A water meter had a reading of 175,000 m3 on the first of January 1 2007. The meter was read on the 1 February 2007 and a reading of 185,000 m3 recorded. The water usage per day = (Reading Feb 1 minus Reading Jan 1) divided by no of days

= (185,000 - 175,000)/ 31 days

= 10,000 / 31

= 322.5 m3 / day

= 322.5 kL/day

This volume per time information is useful for whole of feedlot resource use information or for total resource requirements. However, it does not link to inputs or outputs of the feedlot activities. Therefore, it is more important to standardise resource usage with a production based indicator. This will allow comparison between different periods and between feedlots.

Feedlot production parameters

Typically, input and output production parameters are used to track a number of business activities such as cost of production. These parameters can also be used to give water and energy resource usage data some perspective.

Some typical production parameters include:

- per head-on-feed;
- per head washed;
- per tonne of grain processed;
- per tonne of dry matter grain processed;
- per kilogram of live weight gain;
- per kilogram of hot standard carcase weight 'gain'
- per kilogram of dry matter ration 'delivered'

You may choose to use one or more parameters and the choice will depend on what you want to use the information for and what parameters are easily available. Typically, feedlots use dedicated cattle feeding software systems to assist operations in better managing assets, inventories, commodities and maintenance of financial records. This software such as Bunk Management System, Possum Gully or Feedlot 3000 could be used to directly obtain the required parameters.

Resource efficiency indicators

A number of water resource efficiency indicators were used in the benchmarking series of fact sheets. These included:

- L of water consumed / number of head-on-feed
- L of water consumed / kg 'liveweight' gain
- L of water consumed during washing / number of head washed
- ML of water used per 1000 head-on-feed
- L of water used per tonne of grain processed

Energy usage was converted from raw measurement units to an energy equivalent (Factsheet 8: Analysing Water and Energy Use Data). The indicators used included:

- MJ of energy consumed / number of head-on-feed
- MJ of energy consumed / kg liveweight gain
- MJ of energy consumed during washing / number of head washed
- MJ / kg of HSCW gain
- MJ of energy per tonne of ration delivered

Herd management software

A dedicated report from FY3000 is being developed which collates some of the before mentioned production parameters.

Data period

A very important point to note is that the period for which resource usage data is collected must be the same as the period for which production parameter data is collected.

For example, if water and/or energy data is collected monthly then production parameter data should be collected from the monthly period.

It can introduce large errors if you attempt to convert monthly or quarterly water use data, to match daily or monthly production parameters.

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FEEDLOTS

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Factsheet 8: Analysing water and energy use

This factsheet is the first in the Understanding Usage Data phase of the framework (Figure 1) and is a common element with both water and energy usage. It discusses the importance of data checking, data analysis, interpreting results and presenting. This approach can be utilised for both water usage and energy usage. There are some simple worked examples but the majority of the methods used will be specific to each individual feedlot.

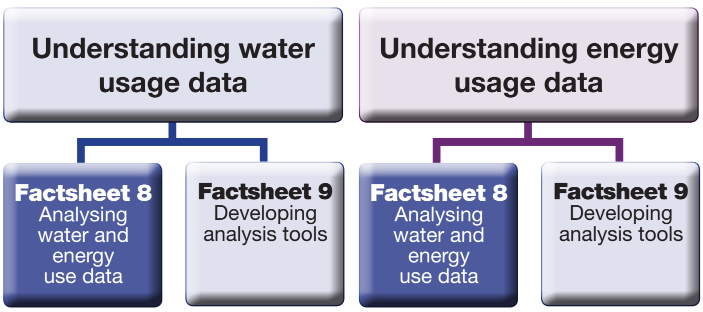

Fig 1: Understanding Water and Energy Usage Data flowcharts

Data checking

The resource usage data should be checked to ensure the best quality data is available. There is a risk that the person who took the meter reading made an error in recording the data or the data was recorded correctly but is wrong to start with (e.g. wrong units). The data should be checked individually by a person familiar with all the processes. The data checking could be undertaken after the data is entered for analysis.

The data should be checked for quality and consistency. There may be more than one error in the reading. This may include:

- are the units correct?
- how does the reading compare with previous?
- are there any duplicate numbers?
- is the decimal point in the right location?
- it is vital each character is checked?

Key benefits

- Check the data—ensure any inconsistencies are corrected .
- Collate data into a spreadsheet to allow data sorting, data analysis and data presentation.
- Present the data to show the main characteristics of the information. This may be numerical tables or graphs.

- reality check— has too much or too little water been used?

The most common errors are duplicated numbers, decimal point in the wrong location, a zero missing (particularly if entered into a spreadsheet). Any questionable data should be investigated.

For example: The following table illustrates some common errors when recording water flow meter readings. These errors can be easily addressed by data checking.

Date	Time	Meter location	Reading	Units
1 Jan 2009	7:00 am	Inflow to mill shed	1203.55	m^3
1 Feb 2009	7:00 am	Inflow to mill shed	13259.8	m^3
1 Mar 2009	7:00 am	Inflow to mill shed	1482.1	m^3
1 Mar 2009	7:00 am	Inflow to mill shed	15537.13	m^3

Line 2 error: Decimal point in wrong location
Line 3 error: Missing last digit
Line 4 error: Duplicate number 5

For example: The following table illustrates some common errors when recording electrical power meter readings. These errors can be easily addressed by data checking

Date	Time	Meter location	Phase 1	Phase 2	Phase 3	Total	Units
1 Jan 2009	7:00 am	Power authority- Main switchboard	9467	1234	5678	16379	kwH
1 Feb 2009	7:00 am		10567	11009	7899	22003	kvarh
1 Mar 2009	7:00 am		18456				kwH
1 Mar 2009	7:00 am		125537	1678	7802	22017	kwH

Line 2 error: Reading is in kVarh not Kwh
Line 3 error: Phase 1 reading is total reading
Line 4 error: Duplicate number 5 in phase 1 reading.

Data collation

Water and energy use monitoring generates a lot of quantitative data. Once you have collected the data from available sources, the data will then need to be brought together and presented in a manageable form. This will include the relevant performance parameters for each activity. This process is called collation.

There are two ways to collate data:

- Summarising data from the same data elements but different sources.
- Summarising data from the same source but over a specific time period.

The successful collation of data will allow a descriptive analysis to be undertaken.

In order to enable easy interpretation and analysis, collation will usually involve summarising and tabulating the information. This is best completed in a spreadsheet package such as excel. A spreadsheet can sort the data and, perhaps most importantly, analyse the same data in a number of different ways.

Comparing energy use data

Converting all consumption data to megajoules allows comparison between areas using different sources and lets you add together the energy used to get a total energy used at the feedlot. This is not essential if you are wanting to compare your usage for a single area of interest over time.

Quick conversions

Energy

J Joule (1 W = 1 J/s)
kJ Kilojoule (1kJ = 1,000 J)
MJ Megajoule (1 MJ = 1,000 kJ)
GJ Gigaloule (1GJ = 1,000 MJ)

Gas

Natural Gas m^3 (1 m^3 = 38.5 MJ)
LPG - Propane Litres (1 L = 38.5 MJ)
LPG - Butane Litres (1 L = 28.1 MJ)
LPG - Butane m3 (1 m3 = 122.1 MJ)

Electrical Energy

kW Kilowatt (1 kW = 1,000 W)
kWh Kilowatt hour (1kWh = 3.6 MJ)
MWh Megawatt hour (1MWh = 1,000kWh = 3.6 GJ)
GWh Gigawatt hour (1GWh = 1,000MWh = 3,600 GJ)

Fuel

Diesel Litres (1L = 38.6 MJ)
Unleaded Litres (1 L = 34.2 MJ)

Presenting data

Once the data is collated, it is often useful to think of ways to display effectively the main characteristics of the information. This may be numerical tables or graphs.

It is quite possible to make use of a spreadsheet package to produce tables or graphs to help you at this stage (*see Factsheet 9: Developing Data Analysis Tools*). Graphical display can quickly illustrate the variation or patterns in the data.

The important point is to select the most appropriate display that will present the data's properties clearly.

See *Factsheets 10 to 14* for examples of bar chart displays for presenting usage data. Line displays can also be used.

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Further information

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factsheet

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 9: Developing data analysis tools

This factsheet is an extension on Factsheet 8: Analysing Water and Energy Use Data (Figure 1). It provides methods that may be used to assist in the analysis of data to develop meaningful production related water and energy use figures.

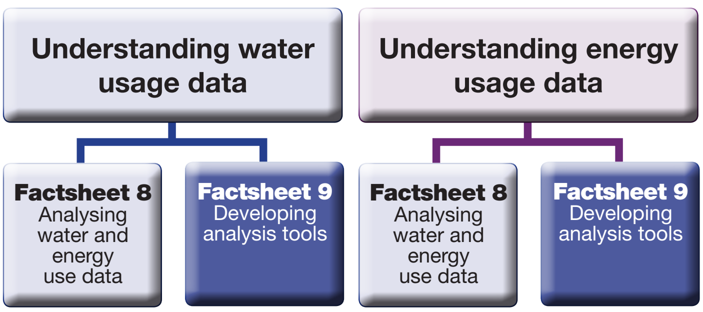

Fig 1: Understanding Water and Energy Usage Data flowcharts

Water and Energy usage should be, as a minimum monitored on a monthly basis. As water and energy usage varies with time and with level of activity this frequency will allow you to identify patterns in the data.

Analysis tools are methods to bring the usage information together to assess resource usage. The most common tool is a computer based spreadsheet calculator.

Computer based

The data analysis is best built up in the form of a spreadsheet calculator that will enable the profiling of water and energy use with the various activities within the feedlot.

The simple data analysis calculator will provide your enterprise with an electronic estimator that enables calculation and presentation of the amount of water and energy used.

Key benefits

- Data analysis is best built up in the form of a spreadsheet calculator.
- The spreadsheet calculator will need to be tailored to your site.
- The spreadsheet calculator should include:
  - Input worksheet for the raw water and energy data,
  - Input worksheet for production parameters,
  - Analysis worksheet and
  - Output worksheet.

Most enterprises will have electronic based data recording systems. Raw data such as fuel usage may already be entered into an electronic calculator for processing.

The methods outlined here for the development of a spreadsheet calculator are based on the Microsoft Excel™ spreadsheet due to its wider availability and familiarity to most general users.

The spreadsheet calculator will need to be tailored to your site. It is very difficult to prepare a generic template given the calculations for each activity area may be based on one or more water flow, energy meters and no of vehicles and no of operations.

The spreadsheet calculator should include:

- input worksheet for the raw water and energy data,
- input worksheet for production parameters,
- analysis worksheet and
- output worksheet.

The input data worksheet and the analysis worksheet may be the same worksheet.

The output worksheet would typically present the data in tabular or graphical form.

Input worksheet

The input worksheet will allow users to enter the raw data from water flow and energy meters and the production parameters which will be used to standardise the data.

Therefore it may be better to have a separate input worksheet for water usage, energy usage and production parameters. Each worksheet can then be tailored to the number of measurement techniques and data collection sheets.

It is good practice to have the data collection sheet and input worksheet as identical layouts. This allows ease of transposing

Date	Period (days)	M1-Main Supply ($x10m^3$)	M2-Feed mill (Tempering) ($x10m^3$)	M3-Feed mill (Boiler) (kL)
1 Jan 2009	-	1203.55	11100.5	1125.56
1 Feb 2009	31	2209.18	12109.1	1568.51
1 Mar 2009	28	3219.81	12897.4	1890.38
1 April 2009	31	4358.56	13567.0	2456.77

Figure 2: Example water input data table

Analysis worksheet

The analysis worksheet takes the raw water flow and energy meter readings and converts them into usage for the respective periods. In most cases the analysis can be done in separate columns on the input worksheet.

The energy resource usage data for each activity should be converted into the equivalent megajoules using the conversion factors for each respective energy source. You should ensure that the raw data unit and the conversion factor unit are the same.

Date	Period (days)	M1-Main Supply ($x10m^3$) L	M2-Feed mill (Tempering) ($x10m^3$) L	M3-Feed mill (Boiler) (kL) L
1 Jan 2009	-	-	-	-
1 Feb 2009	31	2209.18-1203.55= 1005.53x10x1000= 10056300 (10.056ML)	12109.1-11100.5= 10008.6 x 1000 = 10008600 (1.009 ML)	1568.51-1125.56 = 442.95 x 1000 = 442950 (0.442ML)
1 Mar 2009	28	3219.81 - 2209.18 = 1010.63 x 10 x 1000 = 10106300 (10.106 ML)	12897.4 - 12109.1 = 788.3 x 1000 = 788300 (0.788ML)	1890.38 - 1568.51 = 321.87 x 1000 = 321870 (0.321ML)

Figure 3: Example Water Data Analysis Table

Date	Period (days)	M1-Power Autority Meter Main Supply (CT Ratio 80/5) (kWh)	M2-Power Authority Meter Bore 1 (kWh)	M3-Network Monitor Feed Processing (kWh)
1 Jan 2009	-	1100.56	989568	23678
1 Feb 2009	31	2568.51	998800	40652
1 Mar 2009	28	3890.38	4560*	56789

** Meter has a maximum of 6 digits. Hence, count restarted.*

Figure 4: Example Electrical Energy Input Data Table

Date	Period (days)	M1-Power Autority Meter Main Supply (CT Ratio 80/5) (Actual kWh)	M2-Power Authority Meter Bore 1 (kWh)	M3-Network Monitor Feed Processing (kWh)
1 Jan 2009	-	-	-	-
1 Feb 2009	31	2568.51 - 1100.56 = 1467.95 x (80/5) = 23487.2	998800 - 989568 = 9232	40652 - 23678 = 16974
1 Mar 2009	28	3890.38 - 2568.51 = 1321.87 x (80/5) = 21149.92	4560 + (1000000 - 998800) = 5760	56789 - 40652 = 161.37
1 April 2009	31	4456.77 - 3890.38 = 566.39 x (80/5) = 9062.24	14120 - 4560 = 9560	72354 - 56789 = 15565

Figure 5: Example Electrical Energy Data Analysis Table

Output worksheet

The output worksheet summarises the data entered by the user for each activity or meter. It also presents the total resource use for each activity for the respective period.

It may be better to have a separate output worksheet for water usage and energy usage. Each output worksheet can include a presentation of data in tabular or graphical form.

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factsheet

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 10: Total water usage

With increasing variability in climate and greater stresses being placed on water resources, water availability and security cannot be taken for granted. Water is a critical resource for lot feeding and can be a significant expense. But how much water does the average feedlot use? In reality, it varies from one feedlot to the next, but a reasonable benchmark has been established through research at Australian feedlots.

This fact sheet gives information on water usage measured at seven feedlots in Eastern Australia and can be used as a benchmark for comparing the water usage at your feedlot. It also presents information on water use for beef cattle for comparison with agricultural industries.

Water is essential for cattle drinking needs, feed processing, cleaning (including yards, machinery and cattle washing) and other general practices around the feedlot. Water is also 'used' or lost as evaporation and seepage from open storages. Of these, the vast majority of water is used for cattle drinking requirements. Further detail on water usage in each sector of the feedlot is supplied in other fact sheets of this series.

Increasingly, water is becoming an expensive and competitive resource for lot feeding. An accurate understanding of water usage in the industry is important for determining license requirements for water supply. This fact sheet provides information on total water used for lot feeding, which represents all the water stored or pumped into the feedlot. This includes uses such as evaporation from open storages.

For licensing purposes, the total average annual water requirement for feedlots in Queensland is approximately 24 ML/1000 head (Skerman 2000).

Key benefits

- Water is a critical and valuable resource for feedlots in Australia.
- Water usage may be lower than previously believed.

The Research:

- Total water usage measured at seven feedlots in Eastern Australia
- Feedlots ranged in size from 1000 to over 25,000 head capacity
- Research carried out over 24 month period
- Water usage broken down for all components of the feedlot
- Water usage measured against feedlot productivity

It is anticipated this number will be adopted by the revised National Feedlot Environmental Guidelines. The Queensland feedlot manual states that this does not allow significant water usage for feed processing, dust control or dilution of effluent. For the feedlots studied, water usage and production data were collected so that water usage could be reported on the basis of the number of head-on-feed. The results for total water usage can be seen in Figure 1.

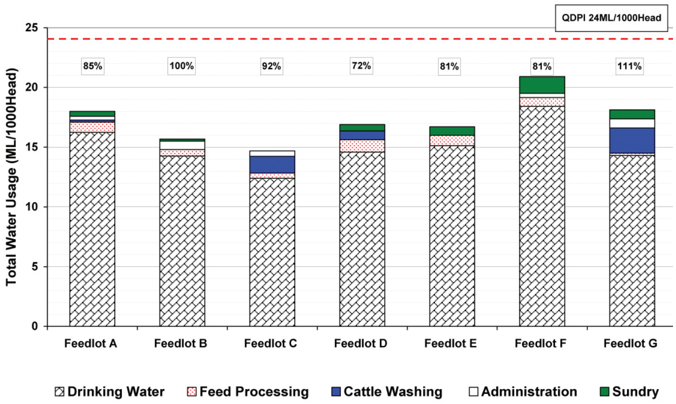

Figure 1: Total water usage (ML/1000 Head-on-feed) and occupancy 2007

Figure 1 shows a range in water use of 14.5 to 20.5 ML/1000 head-on-feed/year. The variation in water use is caused by climatic factors and the type of cattle on feed. For example, feedlot C is located in a milder climate with higher annual rainfall than other feedlots in the study. This is contrasted with feedlot F, which is located in a sub-tropical environment. It should be noted that the data collection year (2007) had a mild summer in many regions of eastern Australia, possibly lowering summer drinking water requirements.

While these results suggest lower water demand than generally required for licensing, a conservative approach is recommended to ensure a sufficient annual supply of water, particularly if this is to be accessed from a variable supply system.

Feedlot water usage will vary throughout the year, mainly as a result of climatic influences on drinking water. *Figure 2* shows this variation per unit of production, in this case kilograms of Hot Standard Carcass Weight (HSCW) gain for one study feedlot. At this feedlot, gain is roughly 1 kg HSCW gain/day, therefore drinking water consumption per kg HSCW gain/day is relatively similar to L/head/day.

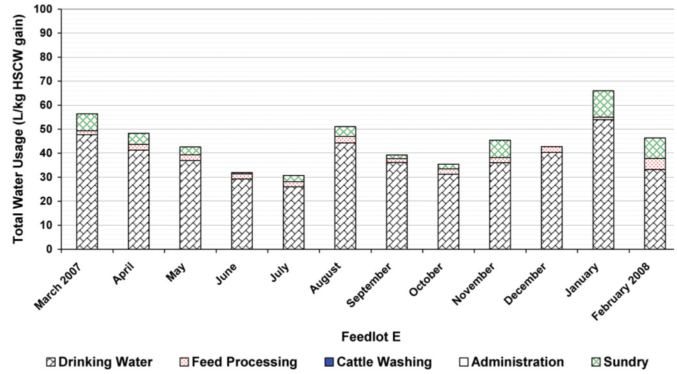

Figure 2: Monthly total water usage (L/kg HSCW gain

Peak feedlot water requirements

Feedlot water usage can vary greatly from season-to-season. Water requirements are closely linked to temperature and rainfall and generally peak in summer when drinking requirements are greatest. Peak water demand measured 92 L / kg HSCW / day for one feedlot in February. This is equivalent to approximately 90-100 L / head / day. The average water demand in February, across the 7 feedlots, was about 54 L / kg HSCW / day, or 50-60 L / head / day.

Measuring feedlot water requirements

Total water usage at your feedlot will largely be driven by climate and management. However, water usage in and around the feedlot can be minimised through implementation of a monitoring program. To help with water usage monitoring, MLA have developed a series of fact sheets to guide this process. These outline the process required to establish a water monitoring program which can be used to improve water usage efficiency over time.

References

Skerman, A 2000. Reference Manual for the establishment and operation of Beef Cattle Feedlots in Queensland, Queensland Cattle Feedlot Advisory committee (FLAC), Department of Primary Industries, Queensland, Information series Q199070.

Acknowledgement

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fact**sheet**

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 11: Drinking water usage

Drinking water is an essential input for feedlot cattle and must be supplied at required levels constantly to maintain cattle performance. Drinking water is the largest component of water used at the feedlot and can vary greatly from week to week and month to month because of changes in climate and management.

Cattle drinking water requirements are typically reported as 5 L / 50 kg of live weight. On this basis, the water requirements for a 600 kg steer (a Standard Cattle Unit - SCU) will be approximately 60 L/day.

However, recent research shows that the overall yearly average for drinking water in Australian feedlots is closer to 40 L/head/day. The research showed maximum average drinking water consumption of 46 L/head/day (over a period of twelve months) for a feedlot located in a sub-tropical environment, while the lowest average drinking water consumption (31 L/head/day) was recorded at a feedlot which experiences cold winters, mild summers and high rainfall. This can be seen in *Figure 1*.

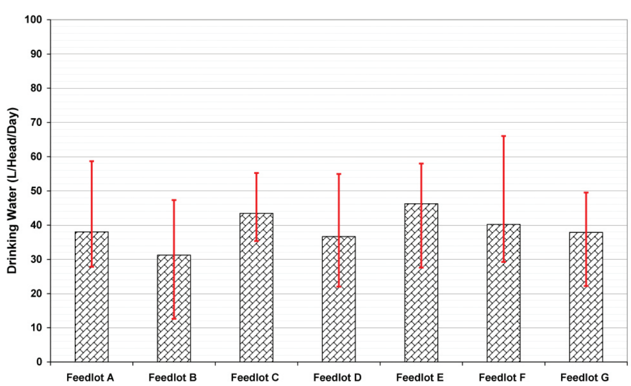

Figure 1: Average drinking water consumption at 7 feedlots with bars showing maximum and minimum monthly water consumption (L/head/day)

Key benefits

- Drinking water is the largest component of water used at the feedlot.
- Drinking water can vary greatly from week to week and month to month because of changes in climate and management.

Figure 1 shows error bars with the maximum and minimum average drinking water consumption measured for any one month at each feedlot.

The highest monthly average drinking water consumption was 66 L/head/day, measured at one sub-tropical feedlot during the month of January.

Monthly variation in average water consumption is shown in *Figure 2*. These data were taken from one Queensland feedlot measured over 12 months. At this feedlot, peak monthly water demand reached 50 L/head/day (averaged for the month of March).

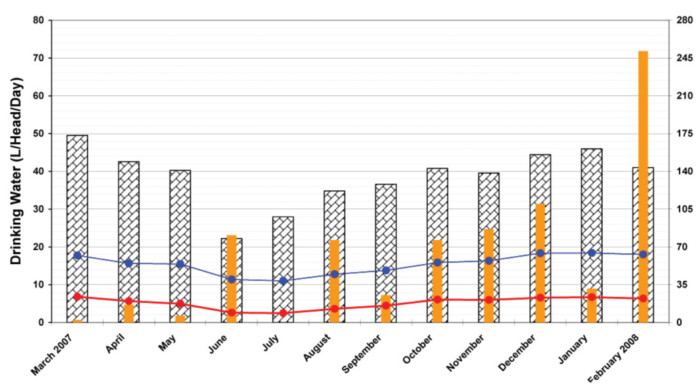

Figure 2: Feedlot drinking water showing rainfall, temperature and heat load (L/head/day)

At one feedlot, daily drinking water consumption could be measured directly, allowing analysis of day to day changes in drinking water (*Figure 3*).

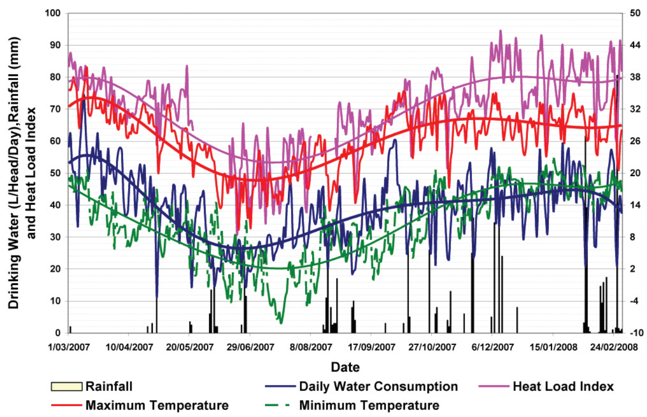

Figure 3: Daily variation in drinking water consumption measured over 12 months (L/head/day)

The daily drinking water consumption at this feedlot ranged from 11 L/head/day for one day in April to 75 L/head/day for one day in March. The relationship between drinking water consumption, heat load index and rainfall is clearly evident on a daily basis. During periods of rainfall, drinking water consumption is suppressed, whilst during periods of high heat load, drinking water is at its highest.

The effect of temperature on drinking water consumption can be seen in *Figure 4*. As expected, there is a linear increase in consumption with increasing temperature.

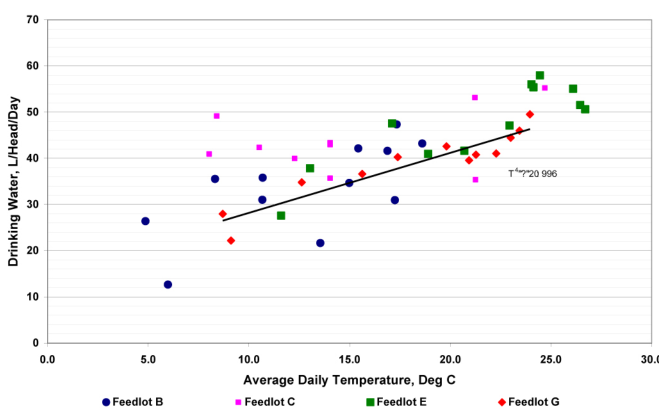

Figure 4: Drinking water consumption (L/head/day) versus average monthly temperature across 4 feedlots

Water consumption will also vary during the day, based on cattle drinking behaviour. *Figure 5* shows the drinking water diurnal variation between two days, one from summer and one from winter for a feedlot in Queensland.

This graph shows a distinct drinking pattern, with peak drinking water requirements being in the afternoon soon after peak heat load. The flow rate recorded was standardised on a 1000 head-on-feed per minute basis, and there was no rainfall on either of the days. Hourly heat load index is also presented.

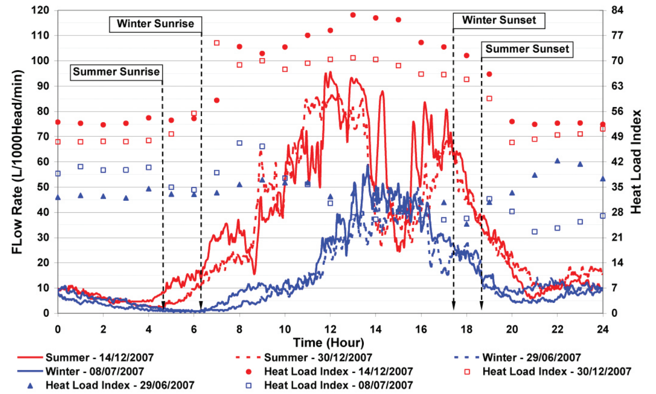

Figure 5: Diurnal variation in drinking water consumption - summer and winter (L/1000 head/min)

The peak flow rate, measured in summer, was around 95 L/1000 head/minute and another peak of 100 L/1000 head/minute was observed during spring. Hourly water demand was in the order of 5.5 L/head/hour. This can be used as a basis for calculating peak water flow requirements when designing or expanding feedlots.

Drinking water is of key importance to the performance of feedlot cattle, hence producers should aim to provide water to meet the peak demand for drinking water in summer. However, when calculating annual demand, the water requirement is significantly lower than previously reported by some Australian research. This can be taken into account when creating feedlot water budgets.

Feedlots usually aim to maximise access to and consumption of water by feedlot cattle to maximise performance. Water savings are best targeted towards other areas of the feedlot operation. Water usage in other parts of feedlot operation is reported in this fact sheet series.

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fact**sheet**

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 12: Cattle washing water usage

Cattle washing is a widely used practice for decreasing hide contamination of feedlot cattle prior to slaughter. Cattle washing can require large volumes of water, depending on the system used, cleanliness requirements and the dirtiness of cattle. In months when cattle are being washed, this can contribute up to 25% of the total water used at the feedlot.

Key benefits

- Can contribute up to 25% of the total water used at the feedlot in months when cattle are washed.
- Measured up to 2,100 L/head of clean water usage.

Cattle washing – the process

Cattle washing is a common process for feedlot cattle because of abattoir requirements (aimed at reducing faecal contamination during slaughter). A large percentage of outgoing feedlot cattle need to be washed during the wet season when there is more wet manure to form dags in the pens. In southern Australia, this occurs in winter, when pens have less opportunity to dry out.

Photograph 1: Interior of a feedlot cattle wash showing ground mounted belly sprays

Cattle washing systems can be automated or manual, or a combination of both. Washing typically involves a soaking phase followed by a high-pressure washing phase. During soaking, groups of 30-150 cattle are exposed to belly sprays for between ½ hour and 8 hours in soaking yards to soften the dags. Cattle can then be manually hosed with high-pressure hoses for up to 10 minutes after soaking. Automatic systems can sometimes require 20-30 minutes of high-pressure washing, depending on the amount of soaking.

Some lot feeders have the capacity to recycle cattle wash water which reduces the total clean water requirement for washing. When using recycled water, most operators use clean water for the final wash down.

The cattle most affected by hide contamination and dag formation are British breeds commonly found in areas with a winter dominant rainfall pattern. Short haired cattle (Bos indicus) typically found in northern feedlots require less washing due to summer dominant rainfall and dags form less readily on their coats. *Figure 1* shows the average total water usage for washing cattle (L/head) for four feedlots measured in eastern Australia, broken into clean and recycled water usage.

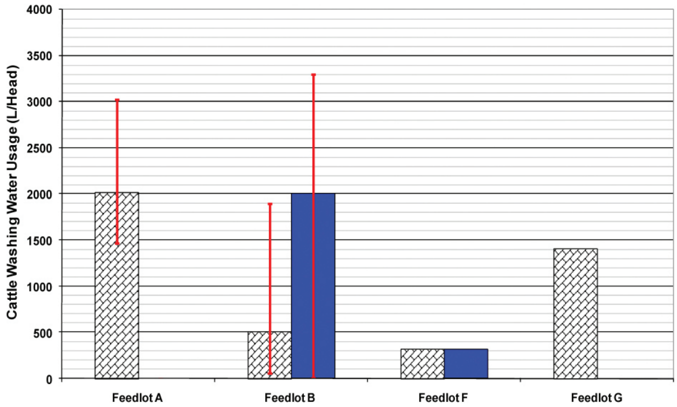

Figure 1: Cattle washing water usage (L/head) showing clean water and recycled water usage and bars showing monthly maximum and minimum usage.

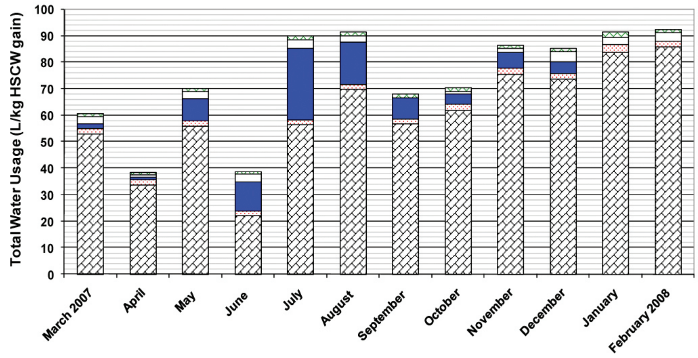

Figure 2: Monthly total water usage at one feedlot showing water used for cattle washing (L/kg HSCW gain)

Feedlots C and E do not wash cattle. Feedlot D has cattle washing facilities, but did not wash any cattle during the study period.

The annual average cattle washing water usage ranged from 700 L to 2500 L/head. However, monthly average water usage of up to 3500 L/head was recorded at two feedlots. These large volumes of water were required in periods where prolonged wet weather had resulted in particularly dirty cattle.

Figure 1 shows that recycling can significantly reduce the amount of clean water required for the cattle washing process. This is one key area where a feedlot can reduce their water usage.

Figure 2 shows the contribution that cattle washing can make to an individual feedlot's total water usage. At this feedlot, water use in July represented over 25% of total water usage for the month.

Considering the contribution cattle washing can make to overall water usage, it is worthwhile to measure water usage and consider options for reducing water usage.

Water usage can be assessed by maintaining water meter records and details on the number of cattle washed during a period. More details can be found in other fact sheets in this series. Recycling water in a cattle wash is another option to reduce overall water usage. Provided clean water is available for the final wash down, this practice offers a cost effective way to reduce annual water usage.

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factsheet

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 13: Feed processing water usage

Feed processing is the second largest source of water usage at many feedlots. Depending on the type of system operated, this may amount to 6% of total water usage. This fact sheet explains water usage levels used in feed processing at seven feedlots in Eastern Australia.

Key benefits

- Feed processing is the second largest source of water usage at many feedlots.
- Feed processing accounts for around 5% of total water usage.

Feed processing water usage

Feed preparation usually involves altering the physical (and sometimes chemical) nature of feed to optimise utilisation by animals and to enhance mixing and stability of the diet. Methods used for feed processing are usually categorised as either 'dry' or 'wet' depending on if water is added during the process or not. The most common dry processing method is roller milling. Wet processing methods include tempering, steam flaking and reconstitution.

The amount of water used in feed preparation depends upon the feed preparation process used. Water is often added as a tempering agent before or during the processing by direct liquid application and/or as steam.

Feed processing water usage is the second highest consumer of water in feedlots where cattle washing is not practiced. *Figure 1* illustrates the average feed processing water usage on a tonne of grain processed basis for the seven feedlots that participated in the water usage investigation. The minimum and maximum feed processing water usage, on a tonne of grain processed basis, for any one month is also presented.

Feed processing water has two components. They are:

- water stored in the moistened grain (moisture difference between dry and wet grain), and
- unaccounted-for losses, which are a function of the feed processing method.

Average feed processing water usage ranges from **90 to 390 L/t grain processed**. The total water added to the grain ranges from 45 to 90% of the total water used in feed processing. Three different feed processing systems are represented within the seven feedlots. Feedlot F tempers grain only, Feedlot C tempers and reconstitutes grain whilst the remaining feedlots temper and steam flake grain.

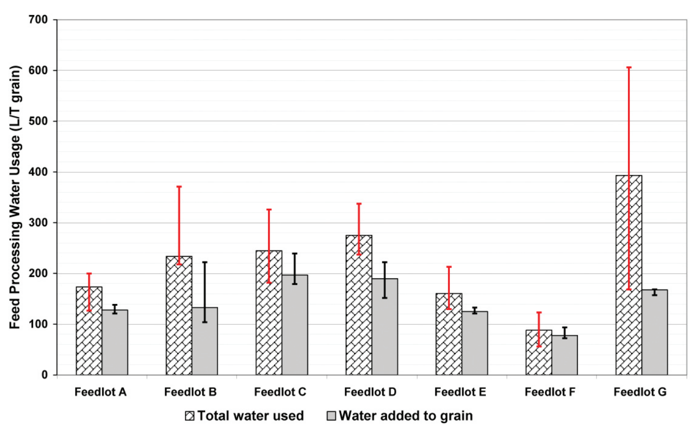

Figure 1: Total feed processing water usage (L/t grain) with bars showing maximum and minimum monthly usage

The wide variation in water usage between these feedlots is related to differences in the feed processing system employed, grain type, target moisture and management of the system.

At the majority of feedlots, the feed processing water can be divided into tempering, boiler and reconstitution water usage. Figure 2 illustrates the average feed processing component water usage on a tonne of grain processed basis for the seven feedlots. The minimum and maximum water usage for each component for any one month is also presented (not all of these feedlots used both components).

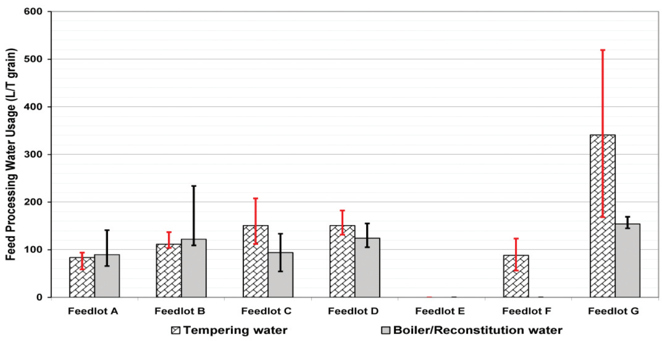

Figure 2: Feed processing water usage (L/t grain)

The measured tempering water usage generally ranges from 80 to 150 L/t grain processed though this can be significantly higher depending on management. Steam flaking boiler water usage generally ranges from 80 to 150 L/t grain processed.

Steam flaking uses the greatest amount of water during processing, much of which cannot be easily reduced. This is because of the inherent losses of steam associated with normal operation. However, operators may be able to optimise operations to keep these losses to a minimum if water usage is a concern.

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FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 14: Sundry water usage

Sundry water uses generally make up 2-7% of total feedlot water usage at the feedlot. Of these, evaporation is the most significant loss.

Key benefits

- Sundry water uses generally make up 2-7% of total feedlot water usage at the feedlot.
- Evaporation is the most significant loss.

Sundry water uses at the feedlot

Water is used at cattle feedlots in a number of minor water use activities, including:

- evaporative losses from holding storages,
- cleaning (troughs, pens, vehicles etc),
- dust control in pens and on roads,
- drinking water for horses or other stock.

To accurately assess total water use and identify areas where savings can be made, these uses should be considered.

Evaporation is the largest 'minor' water use. Evaporation is the transfer of water, as water vapour to the atmosphere. Evaporative losses could be a significant source of water use depending on the surface area of open storages and is one of the most variable losses between feedlots. This is due to the variation in the size, number of open water storages and net evaporation at individual feedlots.

For an open storage, some water is lost by evaporation. The net evaporation loss can be estimated as:

E = Open water pan coefficient (KOW) x pan evaporation (EP) less rainfall (P)

The evaporation loss for Dalby (for example) could be estimated as follows. Mean annual pan evaporation is approximately 2000 mm and mean annual rainfall is approximately 600 mm, KOW value (for Dalby) is 0.74. Thus,

E = (0.74 x 2000 – 600) mm/year
= 880 mm/year

For a 10,000 head feedlot, seven days of temporary drinking water storage (kept to ensure supply in case of a line breakdown) is approximately 5 ML. A turkey's nest storage of this capacity would have a surface area of about 1600 m^2. Hence, with a net evaporation loss of 880 mm per year, this represents **1.40 ML/year** or 3,850 L/day on average. This is about **0.4 L/head/day**, which is a minor water loss compared to drinking water intake which is in the order of 40 L/head/day.

Table 1 presents the overall evaporation losses for all feedlots from both troughs and storages together with evaporation referenced to the average number of head/day for comparison.

Cleaning is necessary for hygiene management around the feedlot. The main areas that require regular cleaning are troughs and induction/dispatch and hospital yards. Cleaning results in relatively small overall quantities of water used. For example, trough cleaning water losses amount to between 0.01 and 0.1 L/head/day (*Table 1*).

The most effective way to reduce sundry water losses is to reduce the evaporative area on storage dams. This can be done by installing evaporation covers for smaller storages. Some feedlots have reported significant water savings by installing liners in storages also, thereby minimising seepage losses. Minor savings can also be made by minimising water loss during trough cleaning. Best practices for trough cleaning ensure that clean water supply is shut off during the cleaning process to minimise losses.

Table 1: Estimated evaporation and trough cleaning water usage for seven feedlots

	Feedlot ID						
Loss type	**A**	**B**	**C**	**E**	**F**	**G**	**H**
Net evaporation (mm/yr)	775	948	1217	792	78	796	565
Evaporation loss (L/hd/d)	0.63	0.002	3.99	2.5	0.01	0.44	0.001
Trough cleaning (L/hd/day)	0.10	0.07	0.04	0.030	0.01	0.003	0.04

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Further information

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FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 15: Identifying energy using activities

This fact sheet will assist in identifying the major energy using areas and form the foundation for the development of a framework for monitoring energy usage (*Figure 1*). It highlights those areas of the feedlot where energy is used to identify the areas where further investigation is warranted.

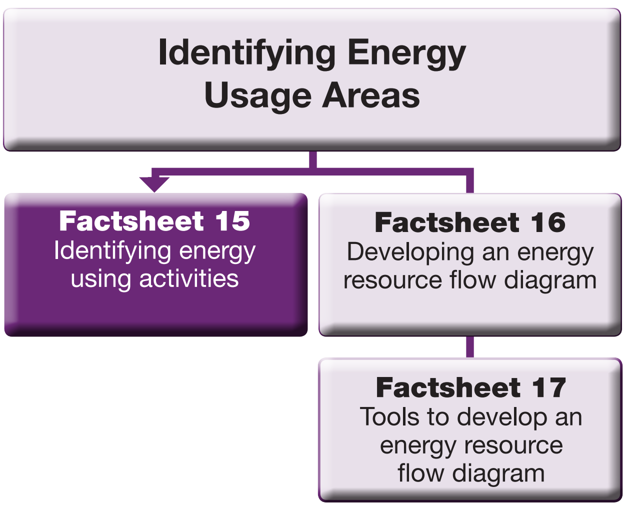

Figure 1: Identifying Energy Usage Areas Flowchart

Why identify your energy using activities

To provide the best perspective on approaching energy efficiency, it may help to breakdown the activities involved. This approach will provide context in relation to:

- The complexity of the site,
- Main activities and where to target efficiency opportunities,
- What the inputs and output of the systems are,
- How inputs and outputs are monitored.

Key benefits

- Identify key energy using activities.
- Feed management consumes about 73% of total energy usage.
- The contribution of waste management energy usage to total energy usage use should not be underestimated.

Energy using activities

Figure 2 is a tree diagram outlining the energy using activities and their approximate contribution to total energy usage. These figures were obtained from MLA industry research undertaken between March 2007 and February 2009 which quantified the energy usage of individual activities within Australian feedlots. This diagram quickly identifies those areas where further investigation is warranted and which areas may be of interest to you.

Figure 2 shows that feed management (processing and delivery) is the major energy using activity consuming about 73% of the total energy requirements of a feedlot. Waste management (pen cleaning, stockpiling and spreading) was found to be the second largest component consuming about 14%, depending on the operations involved.

Which areas are important to you?

Knowing where energy is used in the feedlot and having an understanding of approximate proportions of total energy use, will let you target the areas that are of the greatest interest to you.

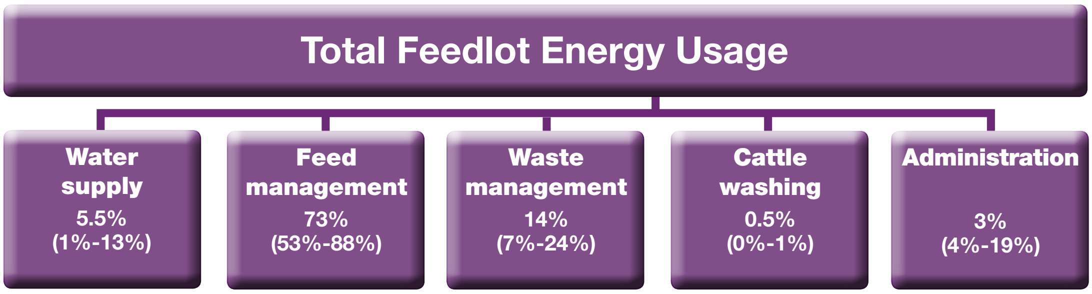

Figure 2: Energy Usage of Individual Activities as a Percentage of Total Energy Usage

These may include total energy used in the feedlot, or gas associated with feed processing. Some activities may be grouped i.e. Administration and cattle management to reduce the amount of effort involved in data collection.

Water supply 1% - 13%

The energy usage for supplying water to the feedlot and for reticulation is a direct function of the system design (gravity, pumped), pumping requirements (source of water, pumping head, distance), efficiency of the pumping system and power source (diesel, electric).

Figure 3: Feed Delivery Equipment

Feed management 53% - 88%

Feed management includes grain processing and delivery. Processing of grain significantly improves the digestibility for beef cattle. The amount of energy used in feed processing will vary depending on the type of system used—tempering, steam flaking, reconstitution, dry rolling etc. A number of components such as grain movement and milling are required irrespective of the processing method. Electricity is predominantly used for grain movement/processing and gas is the predominant energy source for boiler equipment used in heat/steam generation.

The energy used in feed delivery will be determined by the type of feed-out system installed, the tonnes delivered, kilometres travelled and type and number of equipment used. Diesel fuel is the predominant energy source for mobile equipment.

Waste management 7% - 24%

The energy used in pen cleaning, stockpiling and spreading of manure is a significant component of total energy usage.

Mobile equipment such as excavator, grader, box scraper, wheel loader, and bobcat are used for the pen cleaning activity. Trucks of all shapes and sizes are used to cart the manure from the pens to the stockpiles. Equipment may also be used at the stockpile to screen, load and/or compost manure. These machines usually operate using diesel fuel.

Figure 4: Water Truck for Road Maintenance and Dust Suppression

Cattle washing 0% - 1%

Washing cattle removes dags on cattle going to slaughter. The amount of energy used is directly proportional to the volume of water used during cattle washing. Electricity or diesel may be used as energy sources for pumping equipment.

Administration 4% - 19%

Energy usage in the administration and operation of feedlots is important. Administration energy usage is that used in office facilities, staff amenities and for operation of staff vehicles around the facility. It also includes energy used in cattle management and repairs and maintenance

Induction/ dispatch and processing

Energy used in cattle induction/dispatch/processing and hospital activities, was predominantly comprised of electricity used for lighting, cleaning and restraint facilities.

Repairs and maintenance
Energy is also consumed in repairs and maintenance activities around the feedlot. The majority of feedlots have a workshop facility, in which minor repairs to vehicles, mechanical equipment and infrastructure are undertaken.

The size and capability of the workshop is mostly dependent on the location of the feedlot from a major retail centre. Repairs and maintenance energy usage has been defined as that used in workshop facilities and mobile plant used for road maintenance, etc.

Site layout plan
Tools to assist you in this process are site maps (an indication of energy use distribution) and resource flow diagrams.

A site layout plan is a visual representation of key site activities. Most sites will have a map of some description. This may be as simple as a sketch (*Figure 5*) or as complex as a professionally drafted diagram.

A resource flow diagram is an important guide and is further explained in *Factsheet 16: Develop an energy resource flow diagram.*

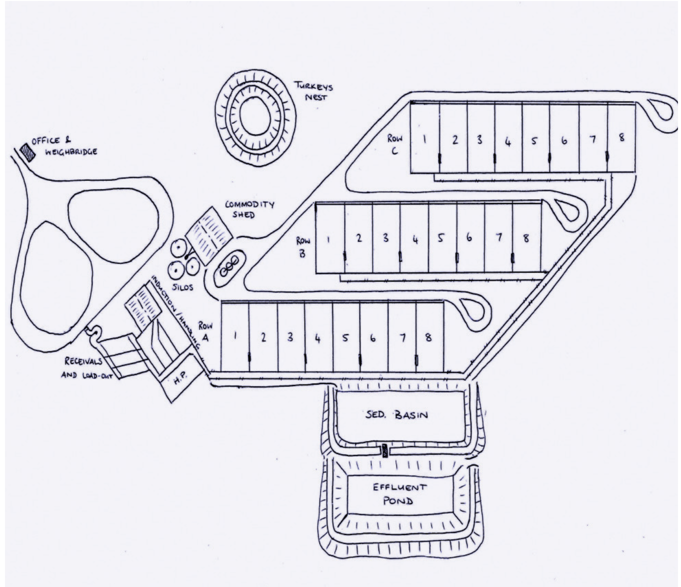

Figure 5: Example Site Layout Plan

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Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 16: Developing an energy resource flow diagram

The resource flow diagram provides a visual indication of where energy is used around the feedlot and is the second step in developing a framework for monitoring energy usage. The diagram should include a layout of the feedlot with individual activities labelled. It should include where energy is used and the source (i.e. electricity, gas, diesel).

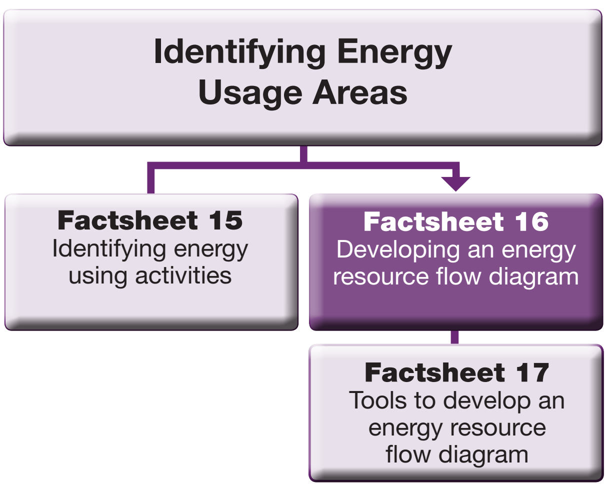

Figure 1: Identifying energy usage areas flowchart

Site layout schematic

The first step in preparing a resource flow diagram is to develop a site layout schematic.

Use a site layout map as a basis to develop a simple schematic which groups together energy using activities (*Figure 2*) or you may have a professional plan which outlines resource networks for this purpose (*Figure 3*).

The schematic should show which activities use energy and what form of energy is used. e.g. overhead electricity supply line, switchboards, where mobile equipment is used, gas or solid fuel.

Once the basic schematic is drawn, the areas of interest as described in *Factsheet 15: Identify energy using activities*, should be defined.

Key benefits

- Identify key energy using activities.
- Feed management consumes about 73% of total energy usage.
- The contribution of waste management energy usage to total energy usage use should not be underestimated.

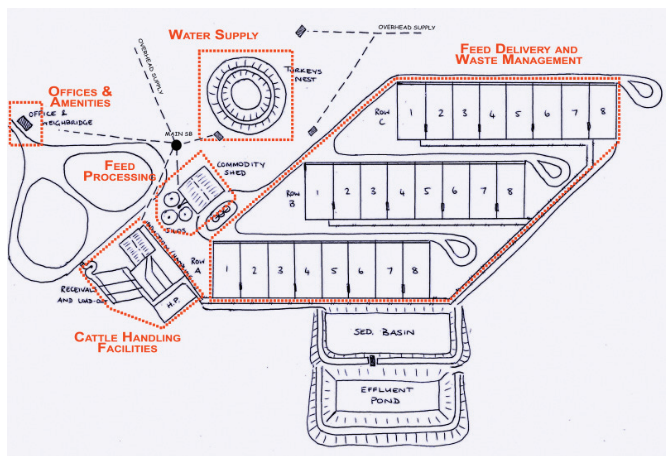

Figure 2: Example of feedlot energy schematic

Simply mark a line that surrounds the elements associated with each area of interest.

Identify inputs and outputs

The next step is to identify all of the energy inflows and any outflows from those areas of interest. A simple line connecting areas to denote inputs and outputs will suffice. For electricity supply a supply line diagram may be available. The electrical supply for some activities may be routed through other activities.

It is a good idea to note where mobile plant and equipment is used. This will help to make sure that all the uses are captured on the diagram.

Understanding where energy is used will help to highlight where monitoring equipment is positioned and where it may be required.

Existing input and output metering

It is important to identify the location of existing energy metering equipment on the site schematic diagram. This will highlight any input or output from an area of interest. A mass balance approach may need to be used to determine usage in some areas.

Additional metering equipment can then be sourced and installed in these locations as required. See Factsheet 17: Energy Measurement Tools for more information on techniques and tools for measuring energy usage.

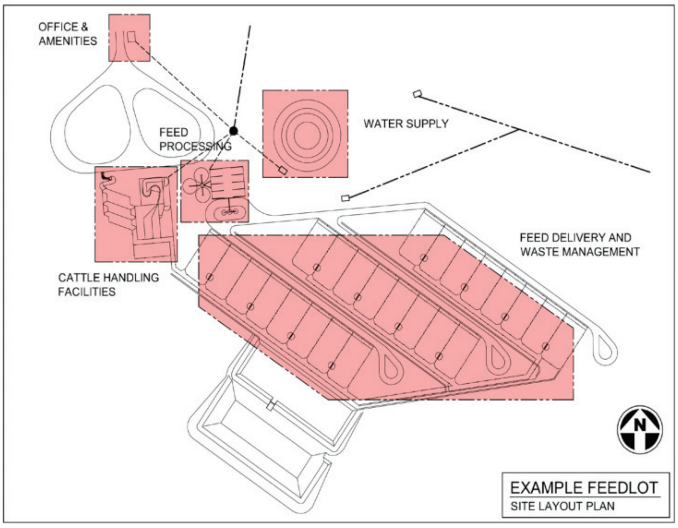

Figure 3: Example of ACAD plan schematic

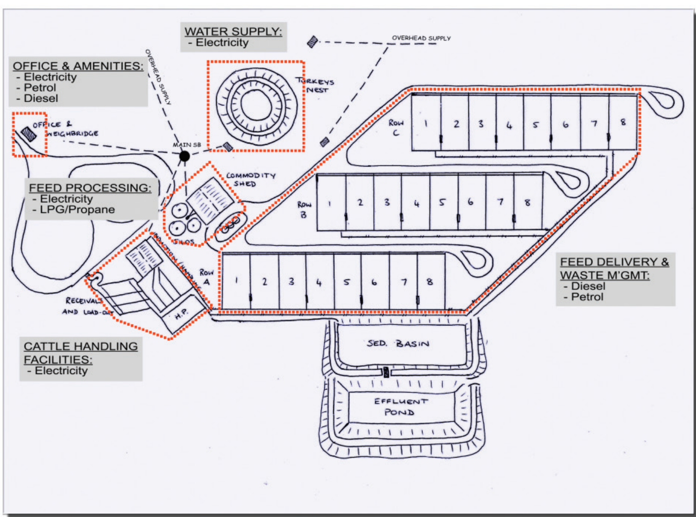

Figure 4: Adding the inputs and outputs to each area of interest

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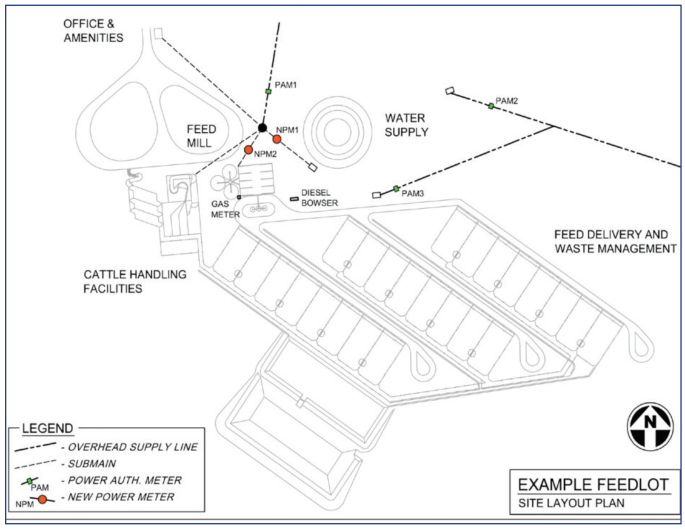

Figure 5: Connecting the network with all existing meters

Mass balance

Depending on your level of assessment, a mass balance approach may be undertaken to provide an estimate of energy usage. This may be of particular importance for electricity usage. Mass balance is based on a simple idea: what goes in must come out.

Completing a mass balance may need to be undertaken if an area has too many outputs to be monitored economically with power metering equipment.

A mass balance simply requires that the sum of the inputs must equal the sum of the outputs. Since the output side of a meter often supplies a number of separate processes, further metering and subtraction will be needed to isolate an individual process usage.

Mass Balance Calculation Examples

Example 1: Calculating the Electricity used in Cattle Handling and Administration (Figure 5)

Electricity used in Cattle processing and Administration =
Total Electricity through Power Authority Meter 1 -
Electricity used in Water Supply -
Electricity used in Feed Processing

Total Electricity through Power Authority Meter 1 = PAM1
Electricity used in Water Supply = NPM1
Electricity used in Feed Processing = NPM2

Electricity used = PAM1 - NPM1 - NPM2

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FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 17: Tools to develop an energy resource flow diagram

The following factsheet is an extension of Factsheet 16: *Developing an energy resources flow diagram* (*Figure 1*) and provides additional information on how to develop the Energy resource flow diagram. The electrical energy network on the Energy resource flow diagram will be significantly more complex than for other energy sources.

In many cases, the electricity distribution layout at a feedlot may be a complex network of sub mains and sub boards. This is primarily due to evolutionary design as some feedlots have expanded and developed over time.

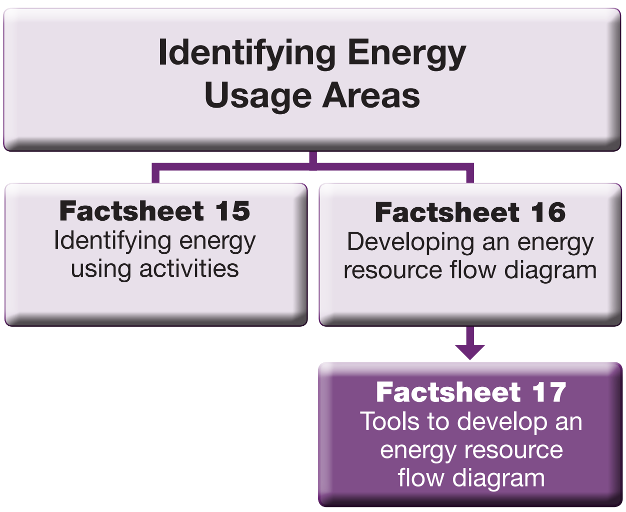

Figure 1: Identifying energy usage areas flowchart

Electrical distribution layout

The complexity of the electrical energy distribution network varies considerably between sites. This variation is due to a number of reasons including initial setup, modifications/upgrades and expanded capacity. The electricity supply and distribution layout will be the most difficult to prepare and thus the most difficult to ascertain where metering equipment is located or is required.

Electricity may be provided through one or more supply points. All overhead supplies, and where they terminate, should be labelled on the site map or plan. Each overhead supply will have a power authority meter.

The overhead supply will terminate at a distribution board (or panel). This is where the power authority meter will be located. Large facilities may have a dedicated main switch room where the board is located.

The distribution board divides the electrical power feed into subsidiary (submain) circuits, while providing a protective fuse or circuit breaker for each circuit, in a common enclosure. Normally, a main switch and circuit breakers and one or more residual-current devices (RCD) will also be incorporated.

Key benefits

- Electrical energy distribution network can be very complex and it varies considerably between sites.
- Request an as-built single line diagram from your electrical contractor.
- A line diagram is very simplified and will give you a basic understanding of the function of the components of the system as part of the total system.

Figure 2: Power authority meters at end of overhead service line

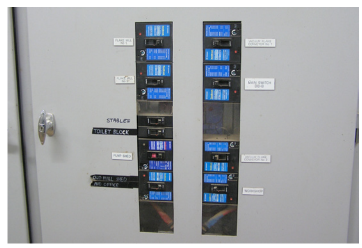

Figure 3: Typical distribution main board

Example single line diagram

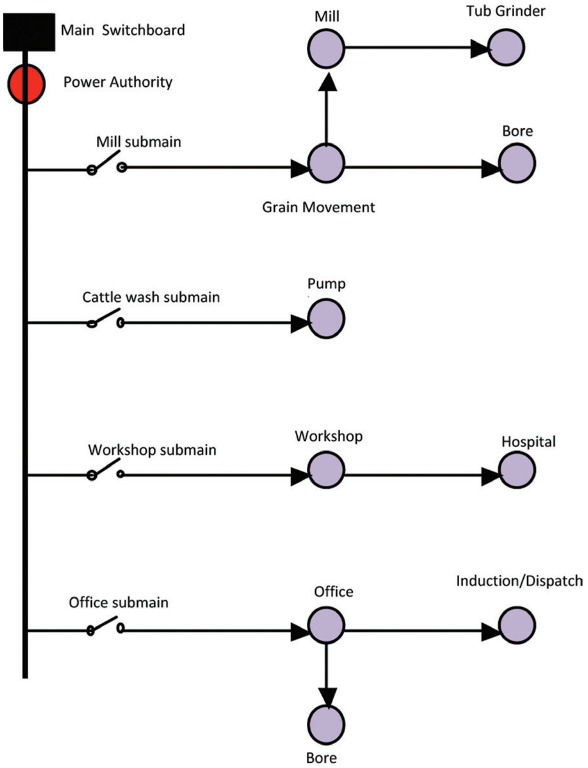

Figure 4: Example feedlot single line diagram

Sub boards may be located downstream of the main distribution board on the submain circuits. The sub boards may be located in a enclosure such as a meter box . Further protective fuses or circuit breaker for the circuit are provided.

To assist in understanding the electrical power distribution across your feedlot, an as-built single line diagram should be developed by your electrical contractor.

A line diagram is very simplified and will give you a basic understanding of the function of the components of the system as part of the total system.

This line diagram should show any existing power meters and will show how electrical energy is connected to all the various areas (*see Figure 4*).

The single line diagram shows all components in a single line and there is no interconnections between the components.

The single line diagram will most likely be a hand drawn diagram. Your electrical contractor may have a block or circuit diagram, however these diagrams will show connections between components and are too complex to visualise.

The single line diagram is very simplified and should be used primarily to learn (in very broad terms) the function of each of the various components as a part of the total system

Figure 4 illustrates a schematic single line diagram for a example feedlot. The existing power authority meter is shown.

The following example shows how to interpret the example Single line diagram shown in *Figure 4*.

Example: The single line diagram shown in figure 4 shows that there are four submains in the network. These are Mill, Cattlewash, Workshop and Office submain.

The processing facility and bore 2 are supplied by the office submain. Bore 2 is an aerial from the office subboard.

The hospital is supplied from the workshop submain.

The tub grinder is supplied from an aerial off the mill, the mill is supplied from the grain movement subboard. Bore 1 is also supplied from the grain movement subboard.

The cattlewash is supplied directly from the main switchboard.

Gap analysis

The electrical energy network will usually be complex. A single line diagram with locations of existing meters will identify the need for additional measurement equipment. Figure 5 illustrates the example feedlot single line diagram with common activities grouped together.

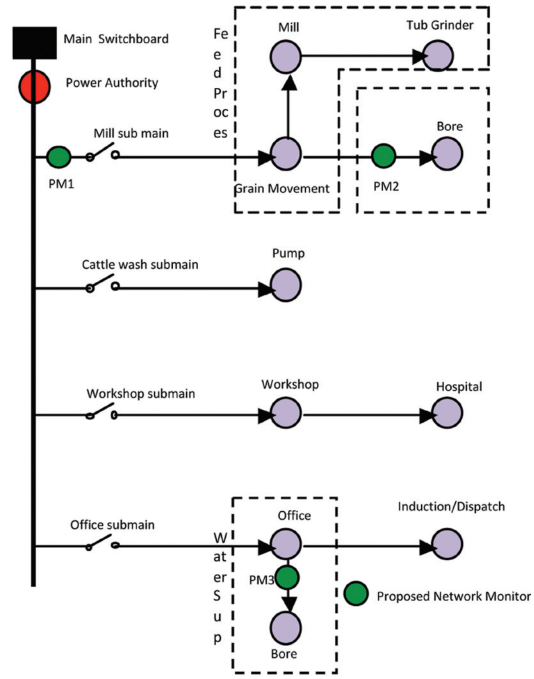

Figure 5: Example feedlot single line diagram with proposed metering

Example 2: Figure 5 shows proposed locations of network monitors. This allows feed processing and water supply to be measured. Mass balance technique would be used to determine feed processing.

Feed Processing Electrical Energy = PM1 — PM2

Water Supply Energy = PM2 + PM3

Additional network monitors could be installed on submains to measure other activities if required.

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FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 18: Energy measurement tools

The following factsheet describes the various methods that can be used to help quantify energy use. It is the first in the 'Measuring energy usage' phase of the framework (*See Figure 1*).

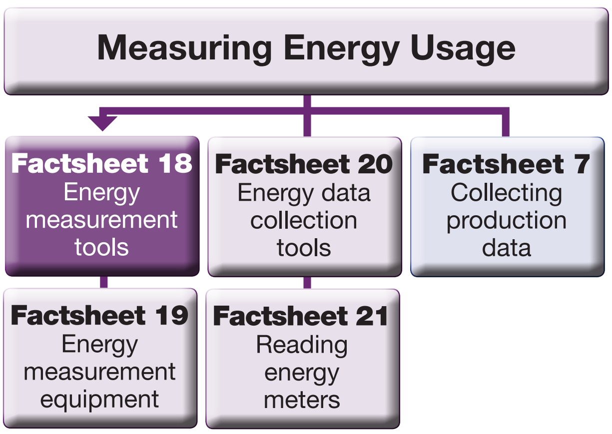

Figure 1: Measuring energy use flowchart

Measuring energy usage is an ongoing process, and a regular monitoring and recording system should be established. The range of measurement tools vary from obtaining data from suppliers to various levels of electronic measuring equipment.

Supplier data

Energy usage from the various energy sources for the whole site can be sourced from supplier's data. These include electrical energy from your relevant power authority, fuel supply from fuel company and gas from your gas supply company. There may be other point source supply such as solid fuel usage which can be obtained. This information is usually contained on suppliers invoices.

Electrical metering

Power meters are the most accurate of the electrical energy measurement tools. They are positioned in-line and directly measure the electrical energy used.

Power authority meter
All sites that use electrical energy will have power authority electricity meters. The most common unit of measurement on the electricity meter is the kilowatt hour, which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000 joules.

Key benefits

- There are various tools for measuring energy usage.
- Select the method that is most appropriate for your level of assessment.

The most common type of electricity meter is the Thomson, or Electromechanical induction watt-hour meter (*Figure 2*).

Some newer electricity meters are solid state and display the power used on an LCD (*Figure 3*). Some electronic meters can also be read automatically.

Figure 2: Electromechanical Induction meter

Figure 3: Solid state meter

The power authority meter/s may not be sufficient to gain a full understanding of how much electrical energy is used in the individual activities of the feedlot as explained in *Factsheet 16: Developing an energy resource flow diagram.* Hence, proprietary power monitors may need to be installed.

Power meters, meter electrical energy by one of two ways. These are direct metering or current transformation metering.

Direct Metering
Typically, direct metering will be used in applications requiring less than 100 amps. Electromechanical or digital power meters are installed at the switch board. There will be a separate meter for each phase. Hence, three phase applications will have three meters.

The solid state electricity meter may have the capacity to display several different measurement including voltage or current in the circuit and display the energy usage in each of the 3 phases separately or as a total.

With direct metering, the meter reading is the actual kilowatt hours used.

Figure 4: Typical current transformer installation

Current transformation (CT)
In a number of instances, the range of line currents is relatively large, from very small line currents to relatively large line currents, such as in 150 A, for example. Thus, the size of the conductor to measure the relatively large range of line currents and to produce an appropriately scaled output becomes prohibitively large. In such instances, a current transformer is typically employed in conjunction with the electrical meter and the internal current sensing device of the meter. *Figure 4* illustrates two current transformers and associated wiring.

Conventional current transformers create a scaled output current, proportional to the line current which is supplied to the electrical load. The output current is sensed by the electrical meter and the power consumption of the associated electrical load is measured. Therefore, the transformation ratio needs to be known to calculate the actual power usage. An example is given on *Factsheet 21: Reading energy meters*.

Power factor
Victoria, Tasmania, NSW and Western Australia have introduced some form of kVa or power factor electricity tariffs. The power factor is a measure of how effectively electrical power is being used by a system. A poor power factor indicates ineffective utilisation of electricity, while a good power factor indicates effective electricity and asset utilisation. It is important that enterprises understand the implications of their power factor and power factor correction.

Other electrical energy measurement methods

Run hour method
For equipment that has a constant load and draws about the same amount of power all the time you may be able to use this method to estimate energy usage. This is usually a lower cost than installing power monitors.

This method will require a run hour meter to be installed by an electrical contractor. The electrical contractor will also need to undertake a one-off test with hand held instruments to measure the parameters to enable input power and part-load power of the equipment to be determined.

The part-load power usage in kilowatt hours multiplied by the run hours gives kilowatt hours. It is difficult to accurately calculate consumption of appliances which have a varying load with this method.

Portable metering
A one-off energy assessment to quantify energy consumption of various processes can be undertaken by a electrical contractor. This method uses portable measuring equipment which is installed onsite for a predetermined period to monitor and records the load on the electrical system per unit of production (e.g. per tonne grain processed). The measurement equipment is then removed from the site or repositioned on another electrical network onsite. These data are then extrapolated over longer time periods.

Gas metering

Figure 5: Gas meter installed beside the storage tanks

For enterprises that use gas as an energy source, gas flow meters are the most accurate tool for measuring gas usage. Gas flow meters come in many different shapes and forms and directly measure the mass flow of gas. The type of meter you have will depend on certain factors like what sort of pressure you have available to you and what type of regulator is on the meter. Supplier gas flow meters may be installed (*Figure 5*) or proprietary mass flow rate meters can be retrofitted into existing piping if required.

Fuel metering

Fuel flow meters are the most accurate tool for measuring fuel usage. Typically, enterprises have onsite fuel storage facilities. These may be aboveground or underground tanks. Direct fuel flow metering may be installed or alternatively low cost direct fuel flow meters can be retrofitted to the fuel delivery system.

Figure 6: Inline fuel flow meter

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FEEDLOTS

A Framework for Water and Energy Monitoring and Efficiency in Feedlots

Factsheet 19: Energy measurement equipment

This factsheet is an extension of *Factsheet 18: Energy Measurement Tools* (*Figure 1*) and provides more detailed information on various types of meters for measuring energy usage.

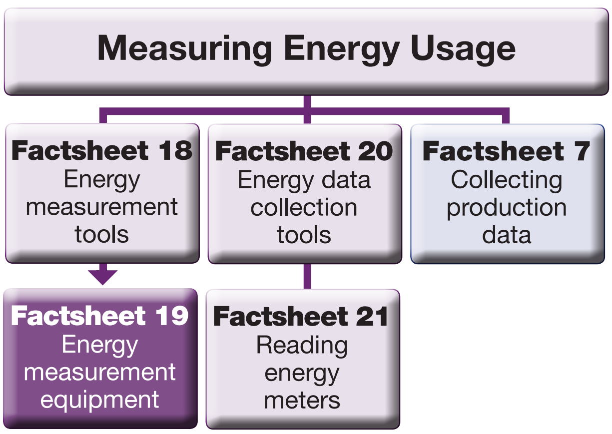

Figure 1: Measuring energy usage flowchart

Direct energy consumption can be calculated from the electricity, gas and diesel fuels used on site. Each of these sources are measured differently. Electricity (kWh) is measured by either electromechanical induction or solid state type meters. Gas is measured through inline flow meters (L or m^3). Diesel fuel is often measured in Litres with inline flow meters at the storage tank .

To compare the various energy sources, the raw data will need to be converted into a standard unit for energy measurement, the megajoule (MJ). This allows for direct comparisons between various activity areas using different power sources, as well as the calculation of a total energy usage across the feedlot.

Electrical energy meters

Electrical energy is measured in kilowatt hours (kWh). However, Tasmania, NSW and Western Australia have introduced some form of kilovolt amps (kVa) or power factor electricity tariffs. In Victoria, it is likely that a kVa tariff will be introduced within the next twelve months.

Key Benefits

- Consider the accuracy, future needs (logging, control etc) and cost when selecting electrical power monitors.
- Electrical power monitors can be supplied and must be installed by a licensed electrical contractor.
- Mechanical flow meters are relatively inexpensive. Check the flow rate range when selecting meter.
- Gas meters can be supplied and installed by a licensed gasfitter.

It is important that the reading in kWh is recorded not the voltage (V) or current (A) or any other parameter.

Each overhead supply line will have a power authority meter (*Figure 2*). The meter may be electromechanical or solid state type meter (Factsheet 18: Energy Measurement Tools). These meters have a high level of accuracy (0.01%).

Figure 2: Electromechanical induction meter

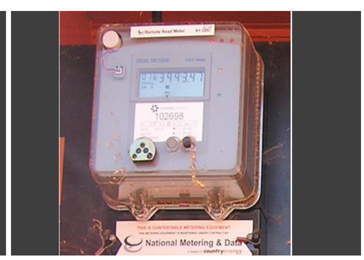

Figure 3: Solid state meter

Power authority meter

The electromechanical induction meter operates by counting the revolutions of an aluminum disc which is made to rotate at a speed proportional to the power. Hence, they are sometimes referred to as rotating disc meters. This is the power meter installed on residences.

Some newer electricity meters are solid state and display the power used on an LCD, which can be read automatically (*Figure 3*). In addition to measuring electricity used, solid state meters can also record other parameters of the load and supply such as maximum demand, power factor, and reactive power used etc. They can also display the power used on each phase separately.

Proprietary power monitors

Proprietary power monitors are available from specialist sensing and instrumentation suppliers. These can be installed within electrical networks to allow metering of processes or equipment. These monitors will need to be installed by a licensed electrical contractor.

Monitors are available to monitor single-phase (50-290v) or three-phase (80-500v) networks. The majority of monitors measure all the main quantities of a three-phase network, including voltage (phase and linked), current (phase and neutral), power (phase and three-phase active), power factor, frequency and working hours and minutes. The quantities are displayed on an LCD.

Power monitors have a relatively small physical size compared with power authority meters. The IME nemo shown in *Figure 4* is enclosed in a 72mm (wide) x 72mm (breadth) x 75mm (depth) housing.

Proprietary power monitors are available with varying levels of accuracy. In general, the more accurate the meter, the more expensive. The IME Conto (*Figure 4*) and Nemo (Figure 5) have a reading accuracy for power of ± 1.0% and ± 0.5% respectively.

Multi-function monitors are available with programmable pulse outputs and RS485 communication for control and logging capabilities.

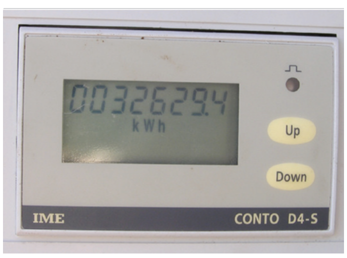

Figure 4: IME Conto D4-S power monitor

Figure 5: IME Nemo 72-L power monitor

The cost of supply and installation of proprietary monitors will vary according to capabilities and functionality required. Power monitors will also require dedicated current transformation (CT) devices and associated switchgear.

Run hour meter

Run hour meters are available from specialist sensing and instrumentation suppliers. Your local electrical contractor will need to install these devices, and should also be able to source them.

Figure 6: Run hour meter

The hour meters provide a continuous display of total run hours.

Hour meters are available with analogue or LCD display. The analogue display have a sequence of white on black and/or red on black numbers.

Fuel metering

Some enterprises have a metered bowser pump associated with their diesel fuel storage facility. If there is no bowser a simple inline mechanical flow meter can be installed to measure the transfer of diesel or petrol.

Figure 7: Alemite mechanical flow meter

Inline mechanical fuel flow meters are available from fuel suppliers. An example of a Alemite inline flow meter is shown in *Figure 7*.

This meter is a low cost ($500) mechanical fuel meter which can meter fuel accurately between 15 and 120 LPM.

Gas metering

Gas measurement is usually an inline flow meter (*figure 8*) installed between the gas storage tank and the boiler. Gas meters usually report in cubic meters or in litres.

Figure 8: Inline gas flow meter

Gas flow meters come in many different shapes and forms and directly measure the mass flow of gas. Gas meters are expensive and need to be installed by a licensed gasfitter.

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A framework for water and energy monitoring and efficiency in feedlots

Factsheet 20: Energy data collection tools

This factsheet forms part of the Measuring energy usage phase of the framework (*Figure 1*).

This factsheets outlines the various methods for collecting energy usage data. The most obvious tools for collecting usage data are supplier metering.

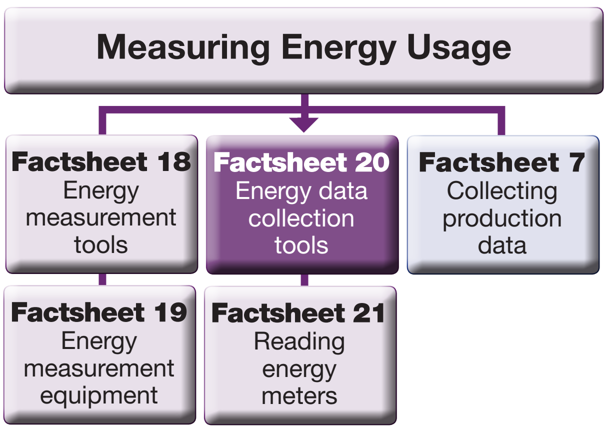

Figure 1: Measuring energy usage flowchart

Key benefits

- There are number of methods available for estimating energy usage.
- One or a combination of methods may be used.
- Develop a pro-forma for collecting energy meter usage data.

Supplier data

Energy usage from the various energy sources for the whole site can be sourced from supplier's data. These include electrical energy from your relevant power authority, fuel supply from fuel company and gas from your gas supply company. There may be other point source supply such as solid fuel usage which can be obtained. These data are usually contained on invoices.

Electricity
All sites that use electrical energy will have power authority electricity meters. It is important to identify the location of existing power metering equipment. There will be a power authority meter or multiple meters on each overhead supply point coming into the property.

Each power authority meter has a identifier number. This identifier appears on the supplier's invoice/statement along with the meter reading at the start of the period and at the end. The supplier may also be charging different tariffs to better reflect the costs of generations and transmission. The kilowatt hours used are presented for each meter and each tariff.

Fuel
Total fuel delivered to the site measured in litres will be available from the supplier. Depending on the storage capacity and storage levels the fuel delivered may not equal the fuel usage.

To estimate actual fuel usage, the volume in storage at the beginning of the period and at the end can be used, along with the total volume of fuel delivered.

Example 1: A total of 25,000L of fuel was supplied to the feedlot from the 1 June to 30 June. There is 5,000L of onsite storage. The estimated volume of fuel in the bowser on June 1 was 1,000L. The bowsers were full on June 30.

Total fuel usage = Fuel delivered - (Volume in Storage June 30 - Volume in Storage June 1)

= 25,000 - (5,000 - 1,000)

= 21,000 L

Gas

Total gas delivered to the site measured in litres or cubic metres (m^3) will be available from the supplier. Depending on the volume of onsite storage and storage levels, the fuel delivered may not equal the fuel usage.

To estimate actual fuel usage the volume in storage at the beginning of the period and at the end can be used along with the total fuel delivered will be required. Follow the method outlined in *Example 1* to estimate gas usage.

Energy Meter usage

Electrical, fuel and gas usage may be documented directly from metering equipment. Recording meter readings will provide the required information to enable better analysis of activity energy usage.

It is important to develop a reporting pro-forma tool to provide a simple and effective way to internally record activity energy usage from the different sources.

The simplest form is a paper-based record, which allows you to simply record the reading of each energy meter. Data records are a legal and auditable document and must be kept safe at all times. It is good practice to have one sheet for each meter, which records the date on which the meter is read, the meter reading, meter location, the reading units and any other notes.

The reader is then able to quickly check the current reading with the previous readings and assess the quality of the data. An example of a simple form is shown in *Figure 2*.

For electricity meters energy usage on different tariffs, may also be recorded.

For fuel usage the pro-forma may also record the vehicle and activity undertaken.

Example of data collection sheet—energy meter usage

Meter ID: 978596

Date	Time	Meter location	Reading	Units	Comments
1 January 2009	7:00 am	main switchboard	1203.55	kWh	-
1 February 2009	7:00 am	main switchboard	2209.81	kWh	-

Figure 2: Data collection sheet for energy meters.

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Example of data collection sheet—energy meter usage

Meter ID: 978596

Date	Time	Meter location	Reading	Units	Comments

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factsheet

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 21: Reading energy meters

This factsheet is an extension of *Factsheet 20: Energy data collection tools (Figure 1)*. It provides instruction on reading the various types of energy metering devices - specifically electricity meters

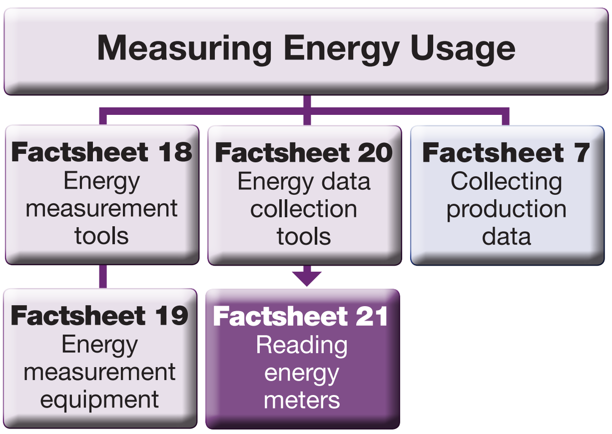


Figure 1: Measuring energy usage flowchart

Energy consumption at the feedlot, includes electricity, gas (LPG, butane, natural gas) and diesel. It may also include solid fuel (e.g. coal) and petrol. These power sources have different methods of measurement. Electrical energy is measured by electricity or power meters. Gas usage is measured by inline flow meters. Measurement of liquid fuel is usually metered by mechanical meters at storage facilites.

Reading the Meter

The onus is on the meter reader to collect the most accurate data possible. The meter reader will require:

- Some method of identifying the meter (a tag or serial number). Important to check that it is the correct meter.
- A logbook or record sheet. A permanent record is much better than numbers written on the back of an envelope
- An understanding of the system (purpose for collecting data, supply network, etc).

Key benefits

- Ensure the meter is reading correctly.
- Record the units that the meter reads (kWh, L, m3).
- Read individual phases rather than just one meter (on 3 phase supply).
- Record the date and time the meter was read.
- Record the meter identifier.

The meter reader should:

- Read the meter at a similar time of the day each week or month (if more than one meter is to be read and usage estimated by deduction then all meters should be read without significant delay).
- Immediately write the reading down in a logbook or data sheet. Compare the current reading with the previous reading as a check. It must be the same or more than the previous reading.
- Check that the meter display is not cracked or glazed over
- Record the reading in consistent units (kWh, MJ, L, m3, etc)

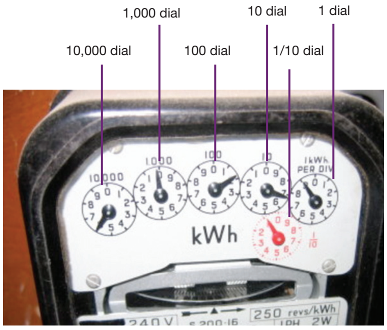
Reading Electricity Meters

Electricity meters can be either electromechanical (rotating disc type) or solid state (digital). Power authority metering will have an electromechanical meter for each phase. Typically, only one digital power authority meter will be installed which can provide the reading for each phase.

Electromechanical (Rotating Disc)

Electromechanical meters read the total energy usage (kWh) since the meter was installed (Figure 2). These meters usually consist of a sequence of black numbers and a series of dials indicating the number of times a spinning disc has rotated. When reading electromechanical meters:

- Read the numbers first



Example 1:

1. Read Dials:
10,000 dial = 6
1,000 dial = 0
100 dial = 1
10 dial = 6
1 dial = 9
1/10 dial = 1

So, this meter is reading 60,169.1 kWh

Figure 2: Electromechanical type electricity meter (note the opposing direction of the dials)

- Read the dials from largest multiplication factor. If the needle is between two numbers, you should record the smaller of the two numbers. If it is between 9 and 0, you should record the 9.

Solid State Meter
Solid state meters *(Figure 3*) are more versatile than electromechanical meters. Some solid state meters can measure all of the main quantities of a three-phase network including voltage (phase and linked), current (phase and neutral), power (phase and three-phase active), power factor, frequency and working hours and minutes.

Some meters will cycle through various other measurements (e.g. Voltage (V), current (A), etc.) it is important that the reading taken is in kWh. Usually, there is only one display and each quantity is displayed for a few seconds in an continuous cycle. Therefore more care is required to record the correct reading.

Example 2:

Wait until the display shows the total kWh.

The six digit line of numbers is the total reading and is the sequence of numbers to be read.

The reading is 59,410 kWh

Figure 3: Solid State Power Authority Electricity Meter

Example 3:

The top 3 figures are the voltages of each of the 3 phases.

The eight digit bottom line of numbers is the total reading and is the sequence of numbers to be read.

The reading is 81754.4 kWh

Figure 4: Solid State Power Monitor

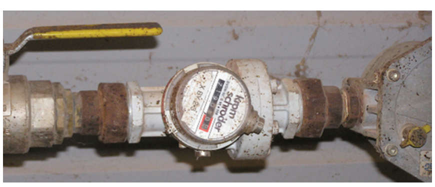


Figure 5: Analogue Gas Meter

An off-the-shelf solid state power monitor is shown in figure 4. This meter may have a reset function so that usage over a period can be easily defined. Some digital meters may also have the capacity to log or record power usage overtime. This meter may also has the capacity to change the units of measurement between kWh and MJ.

Gas metering

Similar to electrical meters, gas meters can be either analogue or digital. Both types of meters will have a sequence of black only or black and red numbers.

Gas meters often measure volumes of gas in cubic meters (m^3) or litres.

Diesel and petrol metering

Diesel and petrol is usually measured by mechanical meters either at a bowser pump (Figure 5) or through a simple mechanical inline flow meter (Figure 6).

Some mechanical meters (see Figure 6) have a total flow measurement and a resetable flow measurement

Do the numbers make sense

Once the data has been recorded on the collection sheet, simple common sense checks should be undertaken. These include:

- Is the current reading the same as or larger than the previous reading of the meter?
- Do the units of measurement match up ?
- Is the change in volume what you would expect or considerably higher or lower than expected?

Figure 5: Diesel Bowser

Example 4:

The top line of large digit numbers in Figure 5 show the volume used since the last reset. This may be used for different vehicles etc.

A total reading is shown in the lower small digit sequence of numbers.

Figure 6: In line fuel flow meter

Acknowledgement

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factsheet

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 22: Total energy usage

Energy is a significant input cost for feedlot production. Energy is also primarily sourced from limited fossil fuel reserves which contribute carbon emissions to the atmosphere. For these reasons there is an incentive for feedlots to reduce energy consumption. This can greatly benefit the bottom line for the enterprise and the environment.

Feedlot energy usage

Energy (in the form of electricity, liquid and gas fuels) is essential for feedlot operation. Energy is an important input cost for feedlots, and energy costs have risen significantly in recent years.

This series of fact sheets report the results of recent Australian research done to determine the energy usage at feedlots and investigate options to reduce energy demand. The research covered seven feedlots throughout Eastern Australia. Feedlots use energy directly to operate machinery and equipment, to mill grain, and to carry out administrative functions. Energy is also used indirectly through the transport of incoming and outgoing cattle and commodities. *Figure 1* shows the very large variation in energy costs between the feedlots studied.

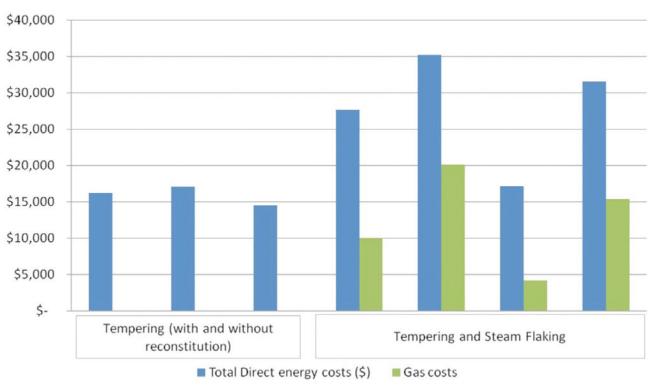

Figure 1: Total direct energy costs for seven feedlots (energy usage and costs standardised per 1000 head/year)

Key benefits

- Energy is primarily used in feed processing and delivery.
- Significant amounts of energy may also be required for pen cleaning and administration.

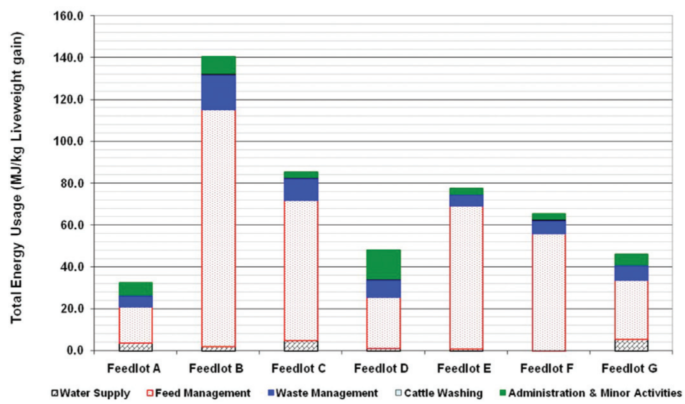

Figure 2: Total energy usage (MJ/kg liveweight gain)

Energy can be a considerable input cost for feedlots, and variability in the order of 100% suggests that major savings can be made.

Figure 2 presents the total direct energy usage for seven feedlots over a twelve month period. Total direct energy usage is the combination of water supply, feed management (processing and delivery), waste management, cattle washing (where this practice is undertaken), administration and minor activities uses (such as repairs and maintenance and cattle management).

Total direct energy usage varied from 2.35 to 10.8 MJ/kg liveweight gain across the seven feedlots. On a per head basis total annual energy usage ranged from 444 MJ/head to 1483 MJ/head, and was primarily dependent on the type of feed processing system in use.

Overall efficiency will depend on maximising production of the whole system. However, this can skew the data against feedlots that do not target growth rate (as is the case for feedlot B). *Figure 3* presents the total energy usage on a 'per head-on-feed' basis.

Variation is largely driven by the feed management and processing system employed by the feedlot. Feedlots A and D employ tempering systems, while all other feedlots used steam flaking. As can be seen from *Figure 1*, steam flaking accounts for a large proportion of total energy usage, representing over 75% of energy usage at two feedlots. Feed management energy usage incorporates both the processing and feed delivery activities. Options for improving energy efficiency associated with feed management are given in another fact sheet in this series.

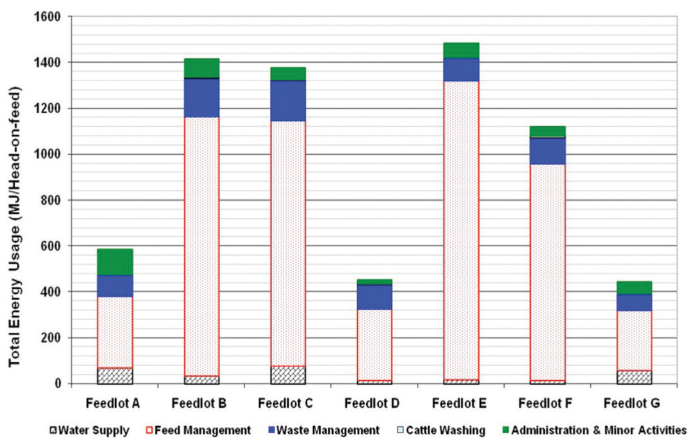

Figure 3: Total energy usage (MJ/head-on-feed)

Waste management (mainly pen cleaning) is the second highest source of energy usage at the feedlot. This makes up some 10-20% of direct energy usage. Other contributors to energy usage include administration and water supply, which vary greatly from one feedlot to the next.

Energy usage can vary significantly from month to month because of irregular activities such as pen cleaning. Energy required for feed management has also been shown to vary greatly from month to month, suggesting variable efficiency in the operation of feed processing equipment (see *Figure 4*).

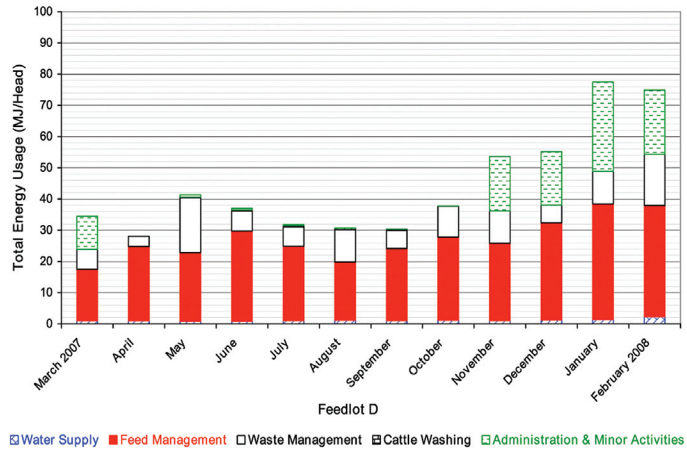

Figure 4: Monthly total energy usage at feedlot D (MJ/head-on-feed/month

The variability in energy for feed processing and delivery between feedlots, and from month to month within feedlots, suggests that significant improvements to energy efficiency could be made in this area. For further information see the fact sheet in this series *Factsheet 23: Feed management energy usage* and *Factsheet 24: Feed delivery energy usage.*

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FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 23: Feed processing energy usage

Feed management energy accounts for greater than 80% of energy consumption at some feedlots. This is largely driven by energy consumption during feed processing. Energy usage from one feedlot to the next can be highly variable, suggesting that significant improvements in energy consumption may be made. Feed management energy usage consists of energy used in feed processing at the feed mill and energy used for feed delivery. This fact sheet focuses on the energy required in feed processing at the mill.

Key benefits

- Feed management uses up to 80% of the energy at a feedlot.
- For steam flaking systems, boiler efficiency is the main driver of energy efficiency.
- Improving performance may save thousands of dollars.

Feed processing energy usage

Feed processing is a highly energy intensive activity, accounting for the majority of energy used in feedlot beef cattle production. However, energy usage varies greatly with feed processing system and from feedlot to feedlot where the same system is used. It is likely that a review of system energy usage will result in cost saving opportunities for many feedlots.

Feed mills typically use electricity and or gas (LPG, butane and others). Figure 1 shows the average energy usage per dry matter tonne of grain processed for the seven feedlots. This calculation of energy usage includes electricity and gas used in grain storage, movement and preparation, although tub grinding is excluded.

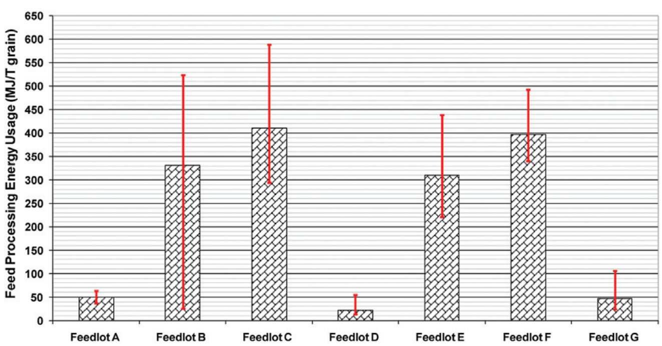

Figure 1: Total Feed Processing Energy Usage (MJ/t DM grain) with bars showing maximum and minimum energy usage recorded on a monthly basis.

As can be seen from Figure 1, the average feed processing energy usage measured ranges from 20 to 410 MJ/t DM grain processed.

This is mainly because of the difference in energy usage between steam flaking and tempering systems.

Feedlots in the study used three forms of feed processing systems:

- three feedlots utilised tempering with/without reconstitution (Feedlots A, D & G)
- four feedlots utilised tempering and steam flaking (Feedlots B, C, E & F)

For feed processing systems other than steam flaking, average energy usage is typically less than 50 MJ/t DM grain processed. For steam flaking, the total energy usage ranges from 310 to 420 MJ/t DM grain processed. The variation in energy usage between feedlots utilising steam flaking suggests an opportunity to improve efficiency in this area.

The red bars on Figure 1 show maximum and minimum monthly feed processing energy usage for each feedlot. Feedlots using steam flaking show considerable variability in energy usage from month to month. The particularly large variation in Feedlot B can be explained by a change in feed processing system during the study period from tempering only to steam flaking. Typically steam flaking requires more energy during the cooler winter months to heat water and compensate for increased heat transfer losses. The efficiency of boiler systems will also influence total energy usage.

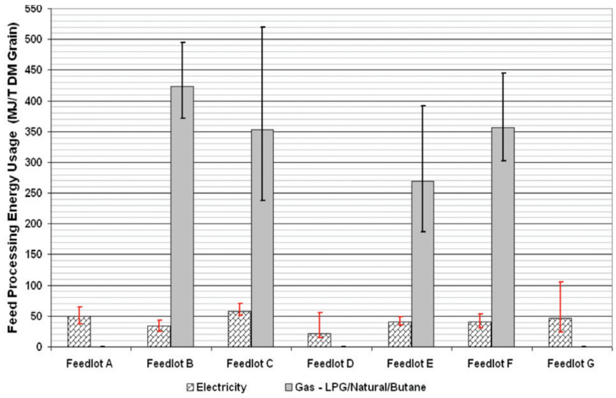

Figure 2: Feed Processing Energy Usage (MJ/t dm grain)

The average feed processing electricity energy usage ranges from 20 to 50 MJ/t grain processed with the majority of feedlots using between 40 and 50 MJ/t DM grain processed. The variation in electricity energy usage may be attributed to monthly variation in grain delivery, movement, storage and milling efficiency (tonnes per mill). Reducing electricity usage by 20% will lead to savings in the order of $4,000-5,000/year for a 5,000 head feedlot.

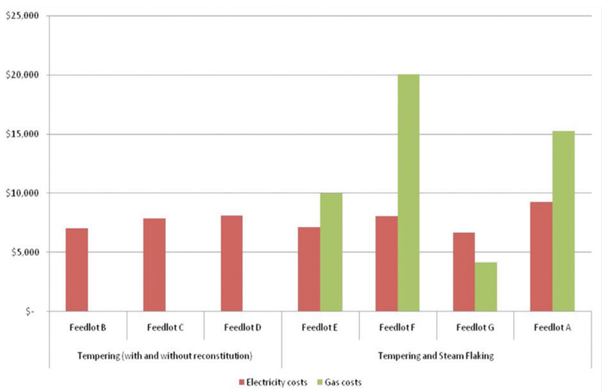

Figure 3: Electricity and gas costs for 7 feedlots standardised to a 'per 1000 head / year basis'

Figure 3 shows that expenditure on gas can vary greatly for feedlots utilising steam flaking systems. This is primarily driven by the efficiency of the boiler and gas usage. For steam flaking systems, average gas energy usage ranged from 270 to 430 MJ/t DM grain processed across four feedlots. There were three types of gases used within the four feedlots with steam flaking systems.

These include LPG, butane and natural gas. Some of the variation in gas usage and total cost can be attributed to heating efficiency during winter months. The energy savings associated with reduced gas usage are shown in the following example.

Gas costs for grain processing

Savings achieved by reducing gas usage by 20% (i.e. 50 MJ/t DM grain processed).

Assume: 10,000 t grain processed per year

Assume LPG is used (energy = 25.4 MJ per m^3)

LPG cost = 2.2c per MJ

Total cost saving = approximately $10,100 / yr.

Opportunities for improving performance

- The first step to improving performance is to measure energy usage at your feedmill. This can be done with a simple energy audit and benchmarking exercise.
- Boiler efficiency (for steam flakers) is the main driver of energy efficiency. Regular professional review of boiler performance can result in big gas savings.
- A review of feed processing energy usage can also result in significant annual savings.

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fact**sheet**

FEEDLOTS

Implementing a Framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 24: Feed delivery energy usage

Feed delivery at feedlots represents a significant source of energy demand and cost for the enterprise. This can vary by as much as 100% between feedlots and represents one area where significant efficiency gains could be made.

Feed delivery energy usage

Feed delivery is an energy intensive activity, accounting for a significant amount of energy used in feedlot beef cattle production. However, energy usage varies greatly with the feed delivery system employed, the equipment used and the layout of the feedlot.

Figure 1 shows the average feed delivery energy usage per tonne of ration delivered at 7 feedlots, measured over a 12 month period. Feed delivery energy use comprises electricity used by stationary mixers, diesel consumed by loaders during feed loading and by feed trucks delivering ration to pens.

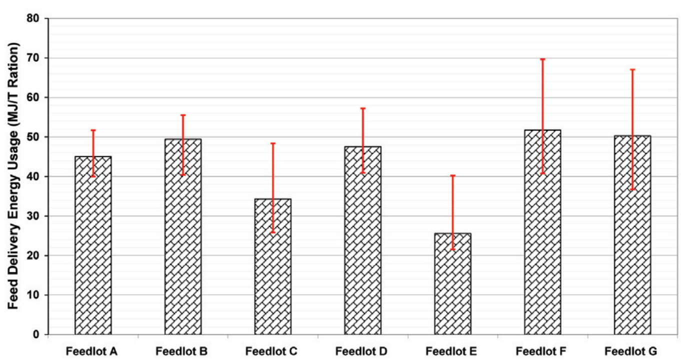

Figure 1: Total feed delivery energy usage (MJ/t ration) with red bars showing maximum / minimum monthly energy usage

Key benefits

- Significant energy and cost savings can be made by improving feed delivery efficiency.
- Variation between feedlots can be as much as 100%.

Average energy usage ranged from 26 to 52 MJ/t ration delivered. A number of different feed delivery systems are represented across the feedlots, including stationary mixing, bunker system, batch-boxes, and a variety of feed out equipment (tractor/trailed mixer units, ROTO-Mix trucks, screw mixer trucks).

Two feedlots, Feedlot C (34 MJ/t ration) and Feedlot E (26 MJ/t ration have considerably less energy usage when compared with the remaining feedlots. This is because of machinery and system efficiency, pen layout and feed-out method. At Feedlot E, feed delivery is undertaken with two primary ROTO-Mix trucks with a combined horsepower of 535 hp (26 hp per tonne capacity) and cattle are fed twice per day. Feedlot E delivers finisher rations to consecutive rows and pens, minimising travel distance and energy usage.

At the majority of feedlots there is large variability in energy usage for feed delivery (as shown by monthly maximum and minimum bars). This suggests that even for feedlots with the best performance, improvements may still be made by maintaining efficiency throughout the year.

At all but one feedlot, the total feed delivery energy usage could be divided into energy for loaders and feed trucks. This allows more detailed assessment of where energy is being used and where gains can be made (*Figure 2*).

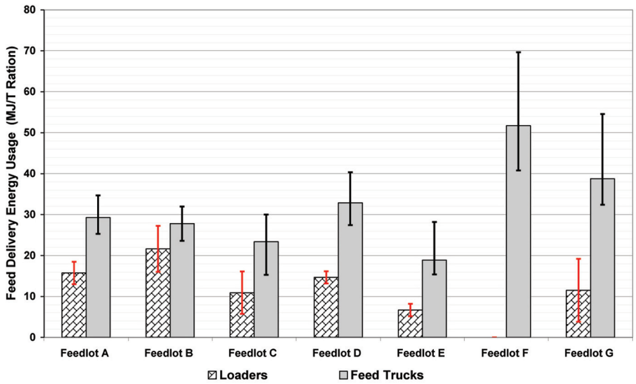

Figure 2: Feed delivery energy usage (MJ/t ration) showing contribution from loaders and feed trucks

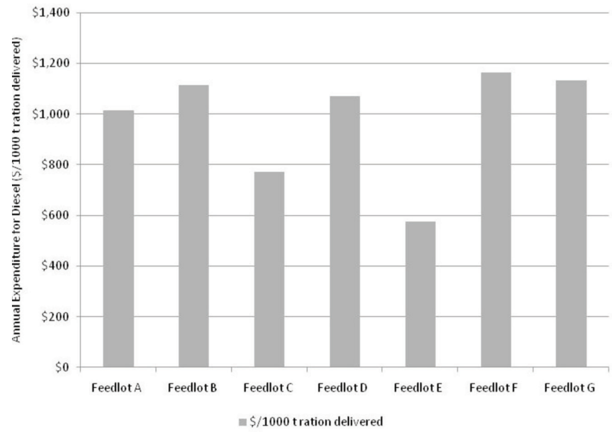

Figure 3: Expenditure for Diesel at 7 feedlots, standardised to $/1000 tonnes ration delivered (trucks and loaders)

The average energy usage by loaders ranged from 7 to 22 MJ/t ration delivered. The energy used by loaders is dependent on the size of loader, bucket capacity, number of ingredients loaded and the other feed related activities that the loader/s may be used for.

The average energy usage by feed delivery equipment (mainly trucks) ranges from 19 to 39 MJ/t ration delivered. The energy used by feed trucks is dependent on a number of factors including the number of vehicles used, the volumetric capacity, engine capacity, commodity loading positions and pen layout, and some of these factors may be difficult to alter. The variation in energy usage may result in greater costs of many thousands of dollars for less efficient feedlots (see *Figure 3* and example below).

To place these figures in more useful terms, the following example may be useful. Improvements to feed delivery efficiency may be easier than you think. Selecting a more efficient truck and taking time to design the most efficient feed out pattern around your feedlot can yield significant improvements.

COST SAVING by improving delivery efficiency by 15%

Energy efficiency improvement =
15% (i.e. 5 MJ less energy / t ration delivered).
Assume the feedlot delivers 100,000 t of ration / yr.
Assume diesel fuel is used (energy rating = 38.6 MJ/L)

Reducing energy usage by 5 MJ/t ration delivered will reduce energy usage by 500,000 MJ/year.

This will reduce diesel usage by about 13,000 L.

At 82c/L, (including rebate) this equates to about $10,500/year.

Efficiency can also be improved by training drivers to operate machinery in a fuel efficient manner. This is clear when considering the fuel usage of loaders, which varied up to 200% across the feedlots. No doubt some variation will always occur because of the structural layout of a feedlot and other management aims that relate to energy efficiency, but in most cases simple changes could save considerable amounts of money in the long term.

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factsheet

FEEDLOTS

Implementing a Framework for water and energy resource monitoring and efficiency in feedlots

Factsheet 25: Waste management energy usage

Waste management is generally the second largest source of energy demand at the feedlot after feed management. Waste management requires an array of machinery and trucks and is heavily reliant on diesel fuel. The annual energy usage figures for this activity ranged from 7-24% of total energy usage, with an average of 14% across 7 feedlots.

Waste management incorporates all aspects of pen surface maintenance, drain maintenance, manure harvesting, handling and reuse on farm land (where applicable).

Pen maintenance is essential to ensure good feedlot production and environmental performance. Good pen maintenance can also minimise health issues and dags.

Energy usage (and cost efficiency) is related to cleaning frequency, the physical nature of manure, feedlot design, manure storage and disposal. Selection of appropriate machinery and correct operation will also have an effect on energy usage. Differences in management mean that overall energy usage can vary greatly between feedlots. *Figure 1* shows that energy usage for five feedlots in the study was around 100 MJ/head/year or less, while two feedlots used significantly more than this.

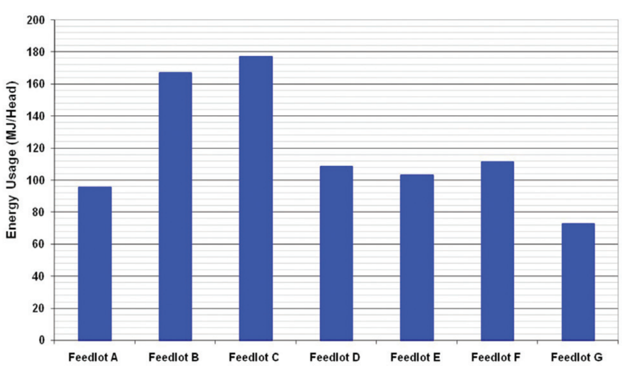

Figure 1: Waste management energy usage for seven Australian feedlots (MJ/Head)

Key benefits

- Waste management relies almost totally on expensive energy sources such as diesel.
- Energy usage can be reduced through machinery, system and operational improvements.

The data shown in *Figure 1* are averaged over a twelve month period to overcome monthly variability. High energy usage at feedlot B and C is likely to be related to higher cleaning frequency than practiced at other feedlots. Feedlot B also uses more machinery during the process than other feedlots in the study.

Energy usage for waste management represents a direct input cost for feedlot operation from diesel usage. *Figure 2* shows the expenditure on diesel for the seven feedlots, standardised to a 'per 1000 head-on-feed per year' basis. For larger feedlots these differences will contribute to significantly higher input costs, particularly with high diesel prices such as those experienced during 2007-08.

When it comes to assessing waste management energy usage, it is important to note that energy requirements are likely to vary greatly from month to month at most feedlots This variation is shown for one feedlot in *Figure 3*. Generally pen cleaning activities must 'fit in' with other feedlot operations, stock movements, weather conditions and machinery availability. For this reason, a reasonably long time period with 'normal' pen cleaning activities is required for benchmarking. This may be 6-12 months.

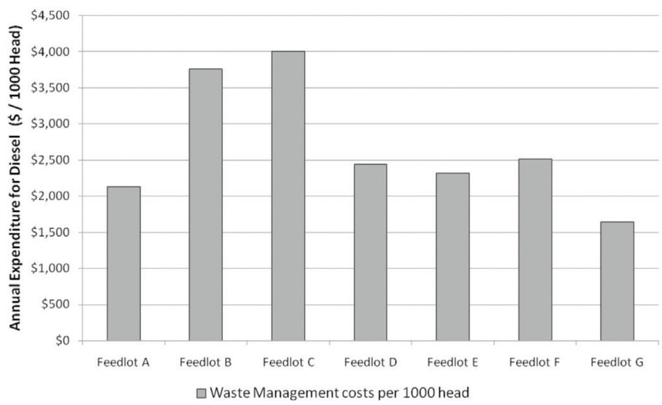

Figure 2: Annual diesel expenditure for waste management at seven Australian feedlots($/1000 head—based on diesel cost of 87c including rebate)

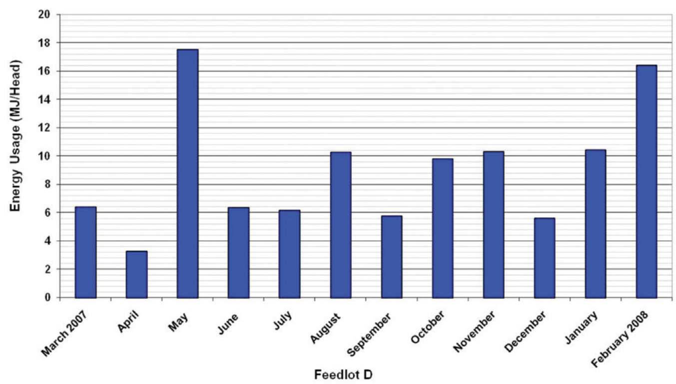

Figure 3: Waste management energy demand by month for one Australian feedlot (MJ/Head)

Considering the variability in energy usage between feedlots and the contribution to feedlot expenses, most feedlots would benefit from benchmarking their performance and targeting this area for efficiency improvements.

Further information on improving pen cleaning efficiency is presented in a case study as part of this series.

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factsheet

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 26: Water supply and cattle washing energy usage

Energy required for water supply and reticulation at feedlots represents a relatively minor energy usage (ranging from 1-13% of total energy usage). Depending on the system used, savings may be made by reviewing system performance and layout. Cattle washing also requires a minor amount of energy for water movement.

Water supply and reticulation is a necessity for feedlot operation, however the annual energy requirement to source and supply water can vary greatly from one feedlot to the next (*Figure 1*).

Energy used for water supply is closely related to the distance and head (in meters) that water needs to be pumped for the feedlot. In most cases, it is difficult to reduce this if water is sourced from deep artesian bores or from some distance from the feedlot—such as Feedlots A and C in *Figure 1*. This should be kept in mind when siting feedlots, as the energy requirement for water supply will be ongoing over the life of the feedlot.

Energy required for reticulation is generally significantly lower than water supply, as most feedlots are designed to gravity feed water to most sectors of the feedlot. However, one feedlot within the energy use study (Feedlot G—*Figure 1*) used significant amounts of energy for water reticulation. It may be possible to significantly reduce annual energy usage and costs by changing this system to gravity feed. Energy is also required for cattle washing where this is undertaken. Cattle washing generally requires high pressure water for soaking and hand washing of cattle. This can contribute an additional 1% to total feedlot energy usage.

Key benefits

- Energy used for water supply is related to the distance and head (in meters) that water needs to be pumped and the volume of water used.
- Significant amounts of energy may be used for water reticulation.
- Energy for cattle washing is proportional to the water used.

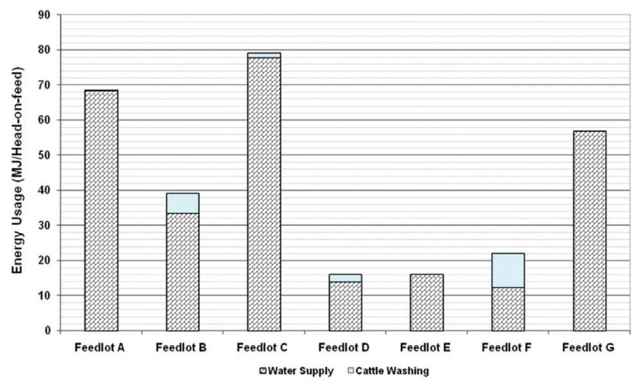

Figure 1: Energy usage for water supply, reticulation and cattle washing at seven Australian feedlots.

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factsheet

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Factsheet 27: Administration and minor activities energy usage

Administration and minor activities (such as maintenance and the operation of workshop and other buildings) varies greatly between feedlots, though for most feedlots the average energy usage is around 4-5% of total energy demand. Most of this energy is used in office buildings for heating and cooling.

Administration and minor activities such as workshop operation use a small to moderate amount of energy at the feedlot. Generally this is less than used in waste management and is similar to energy used for water delivery.

Administration energy usage was measured over a twelve month period for seven Australian feedlots (*Figure 1*). This figure shows the wide variation in energy usage measured. Typically, usage is less than 100 MJ/head-on-feed.

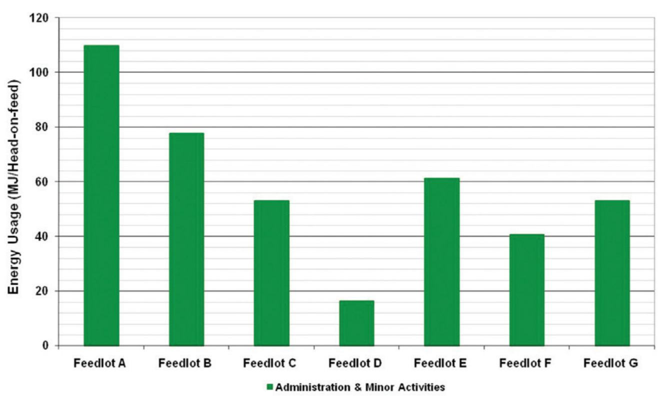

Figure 1: Energy usage for administration and minor uses at seven Australian feedlots (MJ/Head-on-feed)

Key benefits

- Administration and other minor energy uses generally contribute around 4-19% to total energy requirements.

The variation in energy usage is primarily driven by the need for heating and cooling of office facilities. This is highly energy intensive and can result in a seasonal shift in energy usage.

While the variation in energy usage can be high, energy demand for administration and minor activities is only a small proportion of total energy usage at the feedlot.

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case study

FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Case study 1: Water saving topics

Background

Under dry seasonal or drought conditions around Australia, many lot feeders are looking at options to reduce their water consumption in the feedlot. For many this is a direct result of reduced access to water, for others it is an attempt to ensure water supplies are maintained for as long as possible.

Water is often viewed as a cheap resource. This is not surprising, considering that Australians pay more for 1kg beef than for 1,000L of water. Increasingly, however, we are seeing a shift away from this attitude, with an increased community awareness of the value of water and a trend by water regulators towards full cost recovery for the supply of clean water.

The true value of water is often underestimated. Some of the components making up the true cost of water for lot feeders are:

- purchase price
- treatment of incoming water
- heating or cooling
- pumping
- maintenance (pumps, corrosion of pipework & equipment)
- capital depreciation

Steps towards saving water

There are a few fundamental steps that can be taken to reduce water usage. These include:

- **Increased awareness**: promote water efficient practices and encourage responsible use of water, and regular monitoring of water use will help to identify variations in demand.
- **Reduce demand**: convert water-using operations to more efficient processes wherever possible to reduce the water demand.
- **Reduce losses**: increase water use efficiency by minimising wastage.
- **Increase availability**: investigate alternative water sources that are currently not exploited, such as recycling waste water and capturing rainfall.

Key points

- Water is often viewed as a cheap resource, but the true value of water is easily underestimated.
- Steps towards water savings include; increasing awareness, reducing demand, reducing losses and increasing availability.
- Drinking water can account for 90% of total water usage, and the design of water reticulation systems must consider peak demand as well as daily consumption requirements.

Topic areas

In a typical feedlot, water saving measures can target the following areas:

- cattle drinking water
- facility cleaning
- feed processing
- cattle washing
- dust suppression
- water storages
- alternative sources

Cattle drinking water

About 90% of the water used in the feedlot each day is used in cattle drinking water. Feedlots typically require on average around 40L/head each day, although this water use varies significantly between facilities. Up to 80L/head/day of drinking water consumption was recorded at one feedlot during the summer period.

The demand throughout the day is an important design component of the feedlot water supply and reticulation system. This is influenced by diurnal variation of heat load and feeding times. There is a lag of around two hours between peak heat load and peak drinking water consumption. The peak demand flow rate measured at one Darling Downs feedlot was almost 5L/head/hr.

Hence, it is important that the reticulation system be capable of supplying sufficient volumes of water to the cattle to satisfy peak demand requirements.

Drinking water is primarily dependent on climatic conditions and little can be done to reduce usage, although shade is known to have an influence. Regular monitoring of cattle drinking water usage will help in identifying water demand trends and possible leaks/losses.

Slowly leaking troughs waste hundreds of litres per week, resulting in boggy areas and additional pumping costs. Float valve assemblies can be completely replaced for about $70. Damage to valves can be minimised with covers (on rectangular troughs) or baffles. Round troughs can be plumbed with the inlet in the bottom, reducing the likelihood of it being damaged.

Trough cleaning operations often require large volumes of water. The wastewater is usually discharged to the ground or drained to a collection pond. Cleaning operations should try to minimise water use, or wastewater could be captured and reused for other purposes.

Facility cleaning

Water sprays are often used in feedlots for washing equipment or work areas. The majority of facility cleaning operations are done with simple open-ended hoses, and taps are often left open while hoses are unattended. A hose delivering 3L/sec left on unnecessarily for a total of 30 minutes per day can waste about 5500L of water each day. Operators should be made aware of potential water savings in their cleaning activities and encouraged to adopt efficient practices.

Water savings could be achieved by using more efficient cleaning equipment, such as trigger-style nozzles on hoses and high-pressure water cleaners. A trigger operated hose nozzle can range in cost from $20 to $100. Where possible, 'wet' cleaning operations may be replaced with 'dry' cleaning methods to reduce water usage. Leaks in valves, hoses and fittings should be fixed as soon as they are noticed to reduce water losses.

Water used for cleaning facilities is generally not required to be of high quality. Waste water from other feedlot processes (e.g. trough cleaning) may be of sufficient quality for use in cleaning equipment and/or facilities.

Feed processing

Feed processing is the second largest source of water usage at many feedlots, and accounts for around 5% of total water usage. Water can be lost in grain wetting processes when holding tanks are overfilled, and leaks can form in pumps, valves, fittings and pipes. Level control systems (as simple as a float valve) can reduce wastage from overfilling of tanks. Water reticulation systems should be inspected regularly for leaks.

Boilers used in feed preparation can consume large volumes of water. Water lost in the form of steam condensate should be recovered as much as possible to reduce both water and energy input requirements. Steam traps and condensate recycling systems should be installed and inspected regularly to maintain optimum efficiency.

Cattle washing

Cattle washing can account for up to 25% of the total water used at a feedlot during months when cattle are being washed. Cattle are spray-soaked for an extended period, followed by a short high-pressure wash. Possible water savings may be found by investigating the impacts of water pressure, flow rate and washing time on total water use. Shortening the washing time by 5 minutes in a system delivering 3L/sec would save 900L for each group of cattle being washed (30—150 cattle typically).

Dust suppression

Dust suppression is important to animal health and can represent a large water use in feedlots in drier climates. There are opportunities for water savings in these operations, particularly in recycling water from other feedlot operations rather than using fresh water. One possible practice is to reuse the water from the animal troughs after emptying the troughs for cleaning. This practice can save up to 5ML/yr of water and a cost saving of between $500 — $1,500, depending on the feedlot size.

Water storages

Evaporation losses from open water storages and seepage losses from earthen storages are significant contributors to total water losses at many feedlots. Tanks and lined/covered storages are the most water efficient methods of storing water, but are expensive.

Evaporation losses from open storages can be minimised by a number of methods; from chemical layers applied periodically to water surfaces (Water$aver™) to floating balls and other physical covers (E-vapCap™).

Alternative sources

Supply for various water using activities may be sourced and/or supplemented from alternative sources to reduce total water use at the feedlot. A possible source of large volumes of water is in recycling of wastewater from other processes for further use. It is important to consider the water quality requirements of a process and the expected quality of the recycled water to be used. If the water to be recycled is not of sufficient quality, some form of treatment may be necessary.

Feedlots often have a number of buildings with considerable roof areas. Roof runoff should be captured in gutters and used wherever possible. In a moderate rainfall area (700mm/yr), a 25m x 30 m feed storage shed would generate over 0.5ML/year of roof runoff; enough to supply water for many administration and cleaning operations.

Acknowledgement

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FEEDLOTS

Implementing a framework for water and energy resource monitoring and efficiency in feedlots

Case study 2: Cattle washing water usage

Cattle washing is a widely used practice for decreasing hide contamination of feedlot cattle prior to slaughter. Cattle washing can require large volumes of water, depending on the system used, cleanliness requirements and the dirtiness of cattle. In months when most cattle are being washed, this can contribute up to 25% of the total water used at the feedlot. This fact sheet outlines the approach of one feedlot to reduce the volume of clean water usage during cattle washing.

Background

The most common intervention strategy employed by lot feeders to reduce faecal contamination of carcasses during slaughter is cattle washing. Cattle washing is predominantly carried out during or after periods of wet-weather when there is more wet manure to form dags in the pens. In southern Australia, this occurs in winter, when pens have less opportunity to dry out.

The volume of water used to wash cattle will depend on the dirtiness and number of dags on the cattle, the cleanliness standard required at the processing plant, number of cattle washed and level of wastewater recycling implemented.

In months when most cattle are being washed, this can contribute up to 25% of the total water used at the feedlot. Under dry seasonal or drought conditions around Australia, many lot feeders are looking at options to reduce their water consumption in the feedlot. For many this is a direct result of reduced access to water, cost of water or to ensure water supplies are maintained for as long as possible.

Assessment overview

Cattle washing is a usual practice at Cargill's Jindalee feedlot during the winter months. The winter dominant rainfall pattern combined with the coat type of the Bos taurus cattle types translates into the formation of dags and hide contamination. Typically, washing commences in late May and ceases in mid-September.

Key points

- Cattle washing contributes up to 25% of the total water used at the feedlot in months when cattle are washed.
- Measured up to 3,000 L/head of total water usage.
- Ozone treatment reduced soak and wash time of 15 – 20 minutes per batch.
- Ozone treatment reduced recycled water coliform count by 85% and noticeably reduced holding pond odour.

The water supply for the Jindalee feedlot is from reticulated pipeline through the Goldenfields Water County Council and as such is a expensive and valuable resource.

In early 2007, a review of their cattle washing system was undertaken to assess the water usage and identify potential strategies for obtaining the required cleanliness of cattle exiting the feedlot.

System process

The cattle washing process at Jindalee is a two step process which involves a soaking phase followed by a high-pressure washing phase.

The first step involves penning a group of about 60 cattle in the soaking yard. The soaking yard has a concrete floor which is overlaid with a series of pipes. These pipes also extend up and along the rails of the yard. Water is pumped through the pipes and exits through a series of pin holes, thus spraying water onto the belly and sides of the cattle. The cattle are soaked for one to two hours, to soften the dags.

Once the cattle are soaked, they are then moved to an elevated race with semi-enclosed sides. In this race an operator manually washed individual animals with a high pressure hose for about 10 minutes to remove as many dags as practical.

The cattle wash water is directed to an effluent holding pond where it is recycled back through the cattle wash. At the start of the cattle washing period, clean water is used until sufficient water is available for recycling.

Jindalee Feedlot Cattle Wash

Recycling effluent water for cattle washing has always been a priority for Jindalee Feedlot due to the high cost of reticulated cleanwater.

Prior to May 2007, there was no direct treatment of the effluent water for recycling. The treatment comprised only the natural removal of solids through the natural processes of settling whilst in the holding pond. The high organic content of the water was also a potential issue with respect to workplace health and safety.

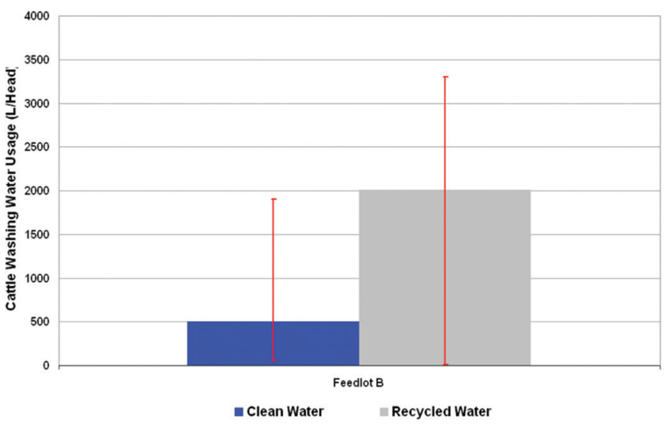

Figure 1: Average Cattle Washing Water Usage per Head May-September 2007.

In early 2007, Jindalee feedlot management investigated a variety of simple, cost-effective options for improved treatment of effluent water for use as cattle wash water. They approached Oxion Australia.

Ozone treatment system

Ozone treatment is a very strong, broad spectrum disinfectant that has been used for many years, particularly in Europe for the treatment of municipal water supplies and commercial pools. Development in ozone technology over recent years have enabled manufacturers to produce smaller more economical generators.

Ozone is a sky-blue gas and is formed naturally by the action of the suns UV rays splitting an oxygen molecule (O^2) and one individual oxygen atom attaching itself to another oxygen molecule. It can also form when a large electrical discharge passes through oxygen (e.g. lightning).

Ozone is made by passing oxygen through ultraviolet light or a “cold” electrical discharge.

The treatment process consists of creating ozone on-site and bubbling ozone gas through the effluent water to saturate it with ozone which rapidly breaks down into dissolved oxygen and hydroxyl ions as it reacts with impurities in the effluent.

The capacity of ozone to disinfest water is affected by organic matter present, water pH, salts (conductivity), and amount and type of iron chelates in the water. The rate of ozone breakdown increases at high water pH and its effectiveness is reduced by organic matter and higher salt concentrations.

Outcomes

Trials with ozone treated recycled water used for cleaning cattle found a reduction of required soak and wash time of 15 – 20 minutes. The reduction of soak and wash time decreased animal stress as well as overall labour process on a per head basis.

Recycle water coliform count was reduced 85% with the application of ozone treatment. An additional benefit of treating wash water was a notable reduction of lagoon odour.

Acknowledgement

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FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Case study 3: Energy efficiency assessment

Energy is an important input cost for feedlots, and energy costs have risen significantly in recent years. Energy usage from one feedlot to the next can be highly variable, suggesting that significant improvements in energy consumption may be made. This fact sheet outlines the systematic approach for two energy efficiency assessments undertaken at two feedlots.

Key points

- Energy is an important input cost for feedlots, and energy costs have risen significantly in recent years.
- A review of energy usage will result in cost saving opportunities for many feedlots.
- Electrical energy, boiler and steam system assessments are the most relevant to lot feeders.

Background

Energy (in the form of electricity, liquid and gas fuels) is essential for feedlot operation. Energy is an important input cost for feedlots, and energy costs have risen significantly in recent years. Variability across feedlots in the order of 100% suggests that major savings can be made.

Variation is largely driven by the feed management and the processing system employed by the feedlot. Electricity is predominantly used for grain movement/processing and gas (Natural, LPG, Butane) is the predominant energy source for boiler equipment used in heat/steam generation.

It is likely that a review of energy usage will result in cost saving opportunities for many feedlots. Electrical energy, boiler and steam system assessments are the most relevant to lot feeders. Australian standard AS/NZS 3598:2000 provides guidance on what level of assessment is appropriate for their needs and a guide when commissioning energy assessments.

Two feedlots have undertaken these assessments over the past 12 months to identify the best ways to reduce energy usage.

Electrical energy assessment

Summary

The electrical energy assessment performed at Charlton Feedlot identified potential annual savings of $16,000, in two areas of interest with an estimated initial capital requirement of $6,000.

Assessment overview

Elders initiated an electrical energy assessment at its Charlton Feedlot. The objectives of this assessment were to analyse activity electrical energy use and to identify efficiency opportunities. The assessment was carried out by the FG Dixon Group of electrical contractors.

The scope of the electrical energy assessment included the following actions:

- Electrical and control diagrams were reviewed to understand the uses of electrical energy.
- Electrical loads were measured during operations to identify their contribution to site maximum demand and consumption.
- Analysis of electrical load profiles. Load profiles can be obtained from your electricity supplier i.e. Country Energy.
- Review existing maintenance and operating procedures including intervention levels or trigger points for maintenance.
- Review existing electrical supply contract to understand the implications of modifying the electrical load profile.
- Develop an improvement strategy to optimise the electricity demand and consumption without adversely impacting the operation of the feedlot.
- Recommend key performance indicators to benchmark energy consumption.

Electricity is principally used for grain movement, feed processing, administration and to pump water from bores and to wash cattle.

Specific actions identified in the assessment

The assessment identified two key areas for further analysis, and estimates of cost savings. These were demand management and compliance.

Demand management

A program is being implemented to manage the timing of various operations to achieve improvements in demand management.

Improvements to demand management could be gained by ensuring that the feed mill and tempering activities do not occur simultaneously (as is dictated by the process design) and the tub grinder not be used whilst either of these activities is underway.

However, manipulating activities is not straightforward, particularly at full capacity where there is less opportunity to only have one process in operation at one time. There are a number of practical considerations such as grinding hay outside of normal milling hours. For example, if mills operate for approximately seven hours during the day, then tub grinding is required outside of normal hours to improve demand management. This presents additional issues for consideration such as labour and OHS requirements.

Compliance

Victoria, Tasmania, NSW and Western Australia have introduced some form of kVa or Power Factor electricity tariffs. The Power Factor is a measure of how effectively electrical power is being used by a system. A poor Power Factor indicates ineffective utilisation of electricity, while a good Power Factor indicates effective electricity and asset utilisation. For this feedlot, the regulation Power Factor requirement is 0.85. The assessment found a minimum Power Factor of 0.59, which is poor. The average Power Factor was found to be 0.76, and at maximum demand is 0.72.

Hence, improving the demand and consumption to meet the electricity supply regulation Power Factor requirement of 0.85 is being considered.

Results and recommendations

Implementation of energy conservation measures identified during the electrical energy assessment could result in potential annual savings of $16,000 in two key areas with an estimated initial capital requirement of $6,000. Of the total savings, the demand management and optimised compliance items can result in a payback period of less than twelve months.

Boiler and steam system assessment

Summary

The boiler and steam system assessment performed at Rangers Valley Feedlot identified a number of actions which can be implemented immediately to improve efficiency of the steam flaking mill.

Fitting removable insulating covers on all valves is estimated to produce annual savings of between $2,460 to $4,300 after an initial payback period of 0.75 yrs to 1.25 yrs for gas prices of $0.40/L and $0.70/L respectively.

Installation of a flue gas economiser is estimated to produce annual savings of between $9,600 and $17,000 after an initial payback period of 2.9 yrs to 1.6 yrs for gas prices of $0.40/L and $0.70/L respectively.

Assessment overview

The Rangers Valley Feedlot Steam Flaking Mill was designed to provide steam-flaked grain for up to 32,000 head of cattle. The mill is a large consumer of energy and in 2008, 21.8TJ of energy was used for heat/steam generation. Rangers Valley management initiated a review of the practices and infrastructure associated with the steam flaking mill. The objectives of the review were to identify improvements in energy efficiency for cost savings and in the process improve their environmental standing. The review was undertaken by Trainee Supervisor Judith Grauer.

The mill is equipped with a twenty yr-old 2.5 MW water tube boiler operating at approximately 850 kPa. There is no external de-aerator, economiser, oxygen trim or systems of the like but chemical de-aerator is utilised. Most of the steam lines are insulated, however many valves are bare and a few lines are also uncovered. Recently a new burner, control panel and steam modulating valve where installed (Grauer 2009).

As part of the review, two independent assessments were commissioned on the boiler and steam system to get an overview of the current standard of the equipment and to provide recommendations to improve efficiency and suggestions for infrastructure upgrade. A boiler assessment was conducted by East Coast Steam and a steam system assessment was undertaken by Spirax Sarco.

The scope of the independent boiler assessment included the following actions:

- Review of the layout and control systems of the boiler and associated equipment (piping etc.) to understand the inputs, outputs and operations of the boiler.
- Review of historical boiler performance from input records and assess operating performance against benchmarked data.
- Assess combustion efficiency through measurement of stack temperature and flue gas composition under normal operating conditions.
- Inspect (where possible) the condition of the boiler for scale build-up and the performance of blow-down systems.
- Inspect the boiler for leaks and/or pressure losses.
- Assess the condition of insulation of the boiler (if applicable).
- Review existing operating and maintenance procedures and identify where improvements can be made.
- Develop an improvement strategy to optimise the operational efficiency without adversely impacting the operation of the feedlot.

The scope of the independent steam system assessment included the following actions:

- Review of the layout and control systems of the steam system to understand where steam is generated, used and circulated.
- Review the performance of heat-recovery systems (where systems are installed), or assess the opportunities for heat-recovery systems to improve efficiency.
- Assess the condition of any existing insulation and the opportunities for further insulation of pipes and process vessels.
- Inspect pipes, valves, joints and flanges for steam leaks and pressure losses.
- Inspect the condition and assess the performance of steam traps to ensure optimum efficiency of the steam system is achieved.
- Review the performance requirements of the steam system to assess whether the system is over or under performing.

Overview of specific actions identified in the assessments

The assessments identified a number of key areas for review and recommendations to improve performance. The key areas identified for each assessment are outlined below.

Boiler Audit

The recommendations for addressing the identified issues were provided by East Coast Steam and by Rangers Valley from their background review.

- Age of steam traps - The age of the steam traps may lead to increased faults. An audit of the steam traps should be considered to assess their condition.
- Large steam separator is un-insulated. Insulate with clad – box insulators.
- Bottom header continually fills up with sludge that settles in the bottom of the tank. The timer based automatic blow-down system fitted to the boiler is not sufficient to remove the sludge, therefore manual blow down should be undertaken more frequently. Additional recommendations include:
  - install TDS based automatic blow-down system
  - consider reverse osmosis to improve water quality
- For low and high fire, the combustion efficiency of the burner is 79 %. The efficiency of the boiler may be improved by:
  - installing an oxygen trim system (O^2 Trim)
  - installing a flue gas economiser. This will reduce energy consumption by about 4 %.
- reduce environmental byproducts e.g. CO from flue gases and gas consumption. These may be reduced by:
  - Installing an oxygen trim system (O^2 Trim)
  - Alternative fuel sources

Steam System Audit

The recommendations for addressing the identified issues were provided by Spirax Sarco and by Rangers Valley from their background review.

- The boiler has a capacity of 3,750 kg/hr of steam at a pressure of 1,000 kPa. At the time of the assessment the boiler was operating at a pressure of 800 kPa. This reduces boiler efficiency. Operating the boiler at its maximum capacity (1,000 kPa) will improve efficiency. Additionally, a small modular boiler attachment for heating water more quickly and reducing time in low fire could be considered.
- Higher than expected gas usage. At current operation (14 hrs/day, 6 days/wk), the boiler gas usage is about 42,000 L per month with a peak of 62,000 L during winter months. Under normal conditions gas usage should average about 34,000 L/month. Gas usage during winter months may be improved by investigation of insulation of pipework, sealing boiler room (e.g. door), improvements to burner efficiency – oxygen trim, reduce heat of flue gases and feed water heating.
- Higher steam pressures than normal on Flaker #1 and #2 (400-600kPa). Leading to steam emitting from the top. Actions to address this issue include:
  - Operating pressures need to be reviewed to ensure correct pressures are used. Flaker manufacturers should be consulted.

- Steam sparge pipes need to be replaced to improve efficiency.
- Steam modulator operating to maintain steam pressure.

- The 'Nett Positive Suction Head' (NPSH) provided by the boiler feed water tank to pump inlet is inadequate at temperatures above 70 deg C. At higher temperatures pumps will cavitate and 'burn out' impellors if the NPSH is too low. Actions to address this issue include:
  - Increase height of feed tank to 3m.
  - Increase temperature of feed water closer to 100 deg C to minimise oxygen in water and reduce thermal shock to boiler.
  - Use flue gas condenser to reduce energy needed to heat makeup water.
  - Insulate steam line from boiler used to heat feed water.
  - Insulate condensate return lines to feed water tank.
- High TDS levels were measured in boiler water. This can lead to scaling of the heat transfer sources, resulting in localised hot spots and burn out of the tubes. Actions to address this issue include:
  - installation of a TDS sensitive blow-down system
  - reduce chemical usage/wastage
  - improve water quality pre-boiler
  - improve water flow scum – e.g. bottom of tank when water runs out.

Results and recommendations

From both assessments a number of immediate actions and areas for further investigation have been identified. Prior to implementation, the capital cost and payback periods will be considered along with the lifespan of the equipment to be installed. An important consideration is the current age of the boiler, and if replacement was required in the next ten years would new equipment be able to be retrofitted to a new boiler or would a redesign of the system be required (Grauer, 2009).

The immediate actions include:

- All un-insulated steam lines will be insulated. Insulating all valves and replacing old and deteriorating insulation is also being considered.
- Replacement of the current feed-water tank and position new tank at 3m.
- Installation of a flue gas economiser to recover heat for heating feed-water.
- Improving water quality including reducing total dissolved solids. The actions for this include improving water filtration, water softening, settling tanks and ensuring blow-down and dosing are working accurately and timed for water quality.
- Other operational recommendations include operating the boiler at higher pressures closer to the recommended maximum and reducing start-up periods by running longer but fewer shifts.

Overall there are some simple immediate savings that have proved to be a positive outcome of this project which should contribute to a much more energy efficient and cost effective steam flaking mill.

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Grauer, J. (2009). Boiler and Steam Systems - Review: Improving energy efficiency in the feed mill. Rangers Valley Cattle Station Pty Ltd Internal Report. MLA Graduate Program.

Further information

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casestudy

FEEDLOTS

A framework for water and energy monitoring and efficiency in feedlots

Case study 4: Feed delivery energy usage

Feed delivery is an energy intensive activity, accounting for a significant amount of energy used and thus cost in feedlot beef cattle production. However, energy usage varies greatly with the feed delivery system employed, the equipment used and the layout of the feedlot.

Key points

- Significant energy and cost savings can be made by improving feed delivery efficiency.
- Cost savings in diesel usage alone of around $100 per month per 1000-head-on-feed were measured.

Background

A number of feedlot delivery systems are represented within Australian feedlots. This includes stationary mixing, bunker system, batch-boxes and a number of varying combinations in mobile equipment. Mobile equipment combinations include tractor/trailed mixer units, ROTO-Mix trucks (various capacities and number), loaders (number and bucket capacities) and screw mixer trucks.

Feed delivery energy use comprises electricity used by stationary mixers and batch-boxes, diesel consumed by loaders during feed loading and by feed trucks delivering ration to pens.

Feed delivery energy usage accounts for 25 to 50 percent of the total feed management energy usage depending on feed processing system in use.

The majority of feedlots have a bunker feed delivery system. This system consists of each of the feed commodities being stored in bunkers, handled via a front-end loader, which directly transfers the commodities into a truck mounted mixer feeder (feed truck).

A new method of feed delivery in Australia is the batch box system. This system is similar to the bunker system; however it incorporates an additional component, a side-dump batch box. This system is reported to offer improved efficiency over the bunker system.

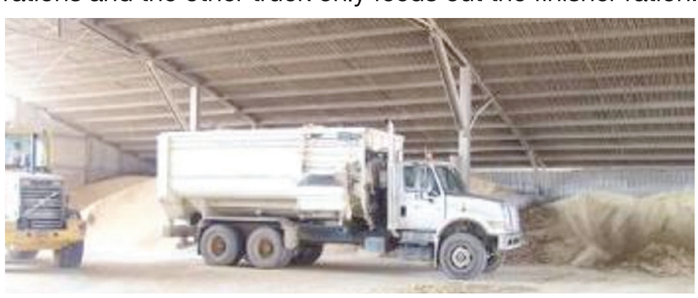
Assessment Overview

In 2006, at Rangers Valley feedlot, development was underway to expand the licensed capacity of the feedlot to 30,000 head and eventually to 50,000 head. As part of this process, a study of the existing bunker system feed delivery was undertaken to assess time and energy efficiency and any limitations with this system in the expanded feedlot. The feed delivery study showed that there were three areas that could be improved to obtain time and energy efficiencies.

These included the speed of the molasses pump, travel time from the liquid supplement bay to the commodity shed and the loading of the dry commodities. The introduction of a batch box system into the feed delivery process offered the potential to deliver the required efficiency gains needed to feed the increased number of cattle.

Bunker system configuration

The bunker feed delivery system comprised a 90 series Volvo front end loader (140 Hp) with a four cubic metre rollover bucket and two 10 T ROTO-Mix feed trucks (285 Hp). At a capacity of 30,000 head, the labour requirements for the feeding crew were eleven full time staff on a roster system. One truck feeds out the starter, grower and finisher rations and the other truck only feeds out the finisher ration.



ROTO-Mix truck inside the commodity shed.

The feed delivery process commenced at 5.30am, with the bunk reading.

At approximately 7.30am loading of commodities for the first load of the day commences with the molasses being poured into the truck via a pipe system over the top of the truck. The truck then moves into the commodity shed and loaded with the required amounts of the dry commodities including grain, silage, hay etc.

Each pen is fed twice a day and the second feeding was usually completed by about 4.00pm each day.

Implementation of a batch-box system

Encouraged by reported efficiency gains from feedlots who have already installed the batch-box system, Rangers Valley initiated a change to their feed delivery system.

In June 2008, a batch-box system was installed and commissioned. The batch-box system incorporates dual 31cu.m boxes each with 30kW electric drives.

The installation of the batch-box system required the existing molasses delivery system to be repositioned so that molasses is directly dispensed into the front of the batch box. A liquid supplements system was also installed to replace the dry supplements system. This removed two steps in the previous process, travel from the old molasses dispatch area and dry supplement preparation.

Along with the repositioning of the molasses delivery system a new 110 series Volvo front end loader (231Hp) with a custom six cubic metre capacity bucket replaced the smaller capacity 90 series loader.

System comparison

For an accurate comparison the complete system pre and post changes should be undertaken. Hence, energy, labour and time should be considered in any assessment. However, for this analysis only the direct energy usage for feed delivery of both systems are presented. It is acknowledged that additional electrical energy is consumed by the operation of the batch-box drives and liquid supplement and molasses pumps. However, this is not metered separately and is unable to be disaggregated from the total feed mill electricity usage. Improved labour efficiency has been achieved with the new system. This has included a reduction in the number of personnel required in the feeding crew to 7.5 full time equivalents and a reduction in the time taken to feed out. This also represents significant cost savings, however they are not reported here.

Figure 1 illustrates the feed delivery (loaders + trucks) energy usage expressed per head-on-feed for the period March 2007 to February 2009. The repositioned molasses delivery system was commissioned in April 2008 and had little impact of reducing energy cost. However, the commissioning of the batch-box system in June 2008

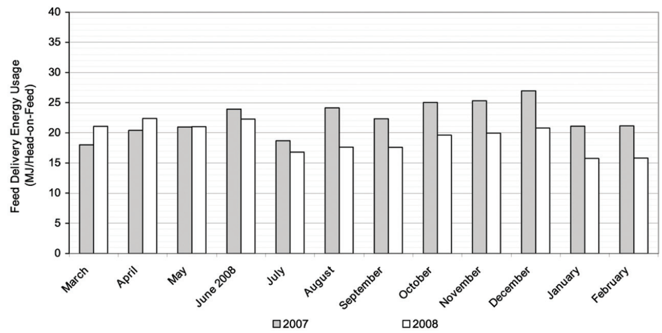


Figure 1: Feed Delivery Energy Usage (MJ/Head-on-Feed)

can be clearly identified and has directly resulted in a reduction in energy usage. This translates directly into cost savings. The cost savings since implementation of the batch-box expressed as a difference between previous months are shown in figure 2. Figure 2 shows that fuel savings are about $100 per 1000 head-on-feed per month with the new system.

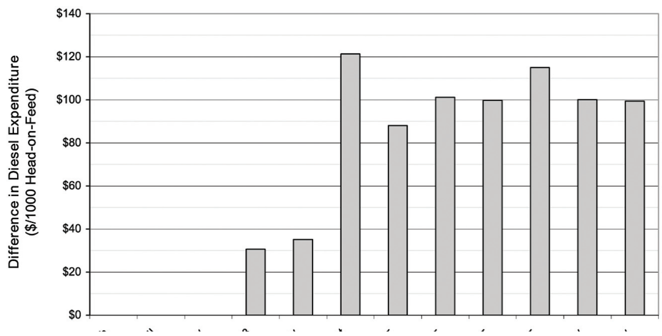


Figure 2: Monthly Difference in Diesel Expenditure since batch-box system commissioning (June 2008).

Summary

The implementation of a batch-box system, liquid supplements, repositioned molasses delivery system and upgraded feed loader have resulted in an average feed delivery energy cost saving of about $100 per month per 1000 head-on-feed.

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