Water and energy monitoring and efficiency in feedlots

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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 tax which will lead to higher energy costs. These drivers provide incentives for the industry to act now on these issues.

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 water and energy are used around the feedlot. Remember, *measure to manage.*

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.

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.

This paper outlines the steps involved and the tools required for implementing a framework for water and energy monitoring and efficiency and understanding what the numbers mean.

Step 1. Identifying Water and Energy Using Activities

This step will identify the major water and energy using areas and activities, and form the foundation for the development of a framework for monitoring water and energy usage.

Breaking down the activities involved will provide the best perspective on water and energy use efficiency and 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

Figure 1 and Figure 2 are tree diagrams outlining the water and energy using activities and their approximate contribution to total water and energy usage. These data were obtained from MLA industry research undertaken between March 2007 and February 2009 which quantified the clean water and energy usage of individual activities in seven representative Australian feedlots. 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 1 shows that cattle drinking water consumes the majority of water (78-91%). Drinking water requirements are predominantly governed by environmental conditions therefore are largely beyond the control of feedlot management.

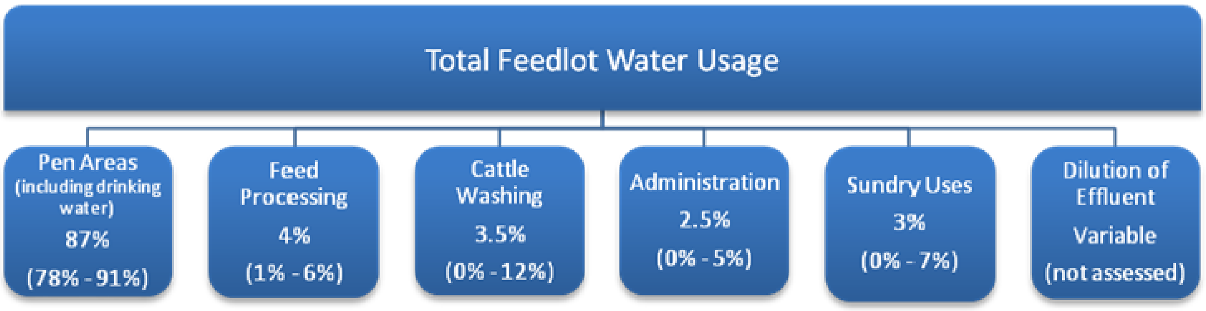

Figure 1: Water Usage of Individual Activities as a Percentage of Total Water Usage

- 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 the whether water is recycled for use, the dirtiness of the cattle and cleanliness requirements.
- 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.

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.

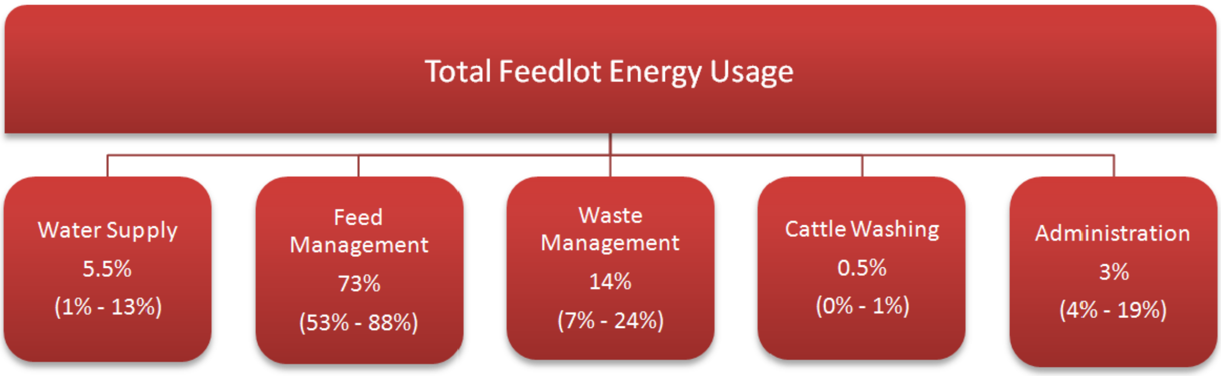

Figure 2: Energy Usage of Individual Activities as a Percentage of Total Energy Usage

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 e.g. 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.

- 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.

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

Step 2: Prepare Site Layout Plan and Resource Flow Diagram

The next step is to understand how water and energy is distributed to and from your areas of interest. For this, a site layout plan and resource flow diagram are needed.

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 is an extension of developing a site layout plan shows how water moves around the site. A water distribution plan showing the water pipe network may already be developed for your feedlot.

Similarly, for energy usage, 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.

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.

Once a site layout plan and resource flow diagram are prepared, all of the water and energy inflows and any outflows from those areas of interest should be identified. 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. Figure 3 illustrates an example water resource flow diagram.

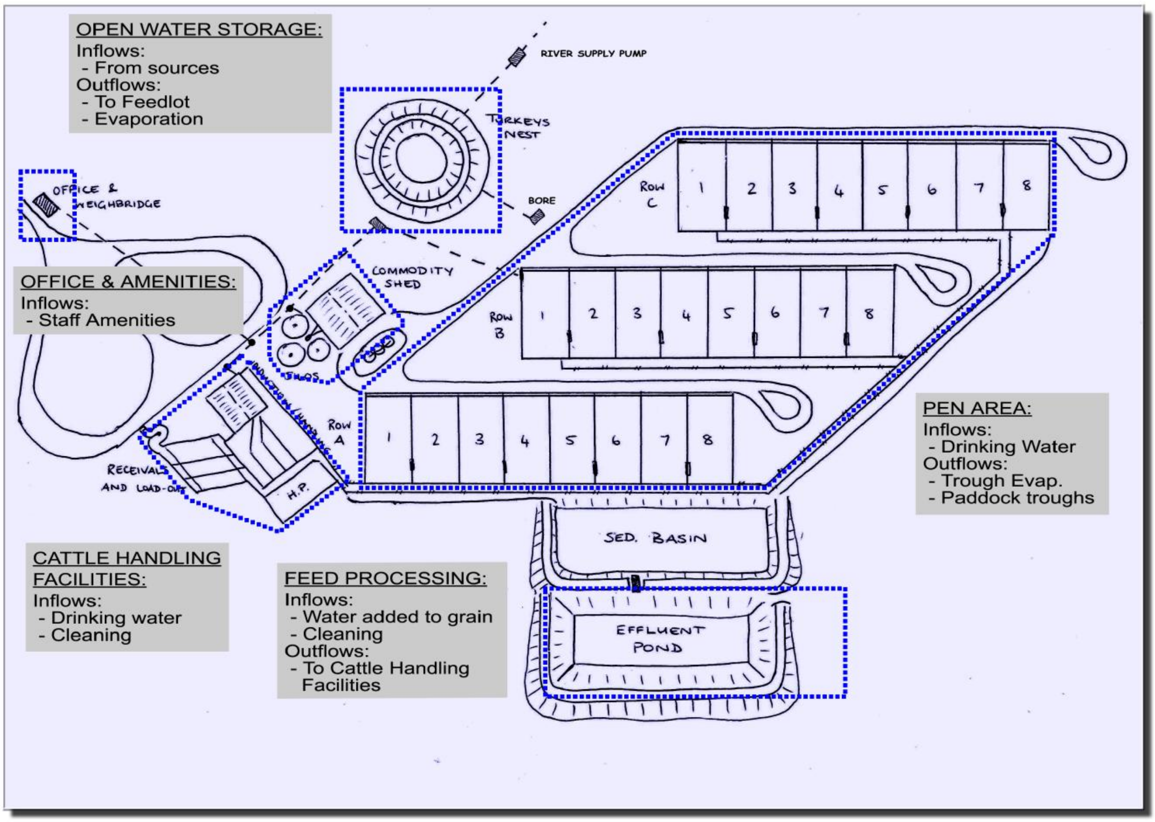

Figure 3: Water Resource Flow Diagram with inflows and outflows in each area of interest

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 as shown on Figure 4. A mass balance approach may need to be used to determine usage in some areas.

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 water or 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.

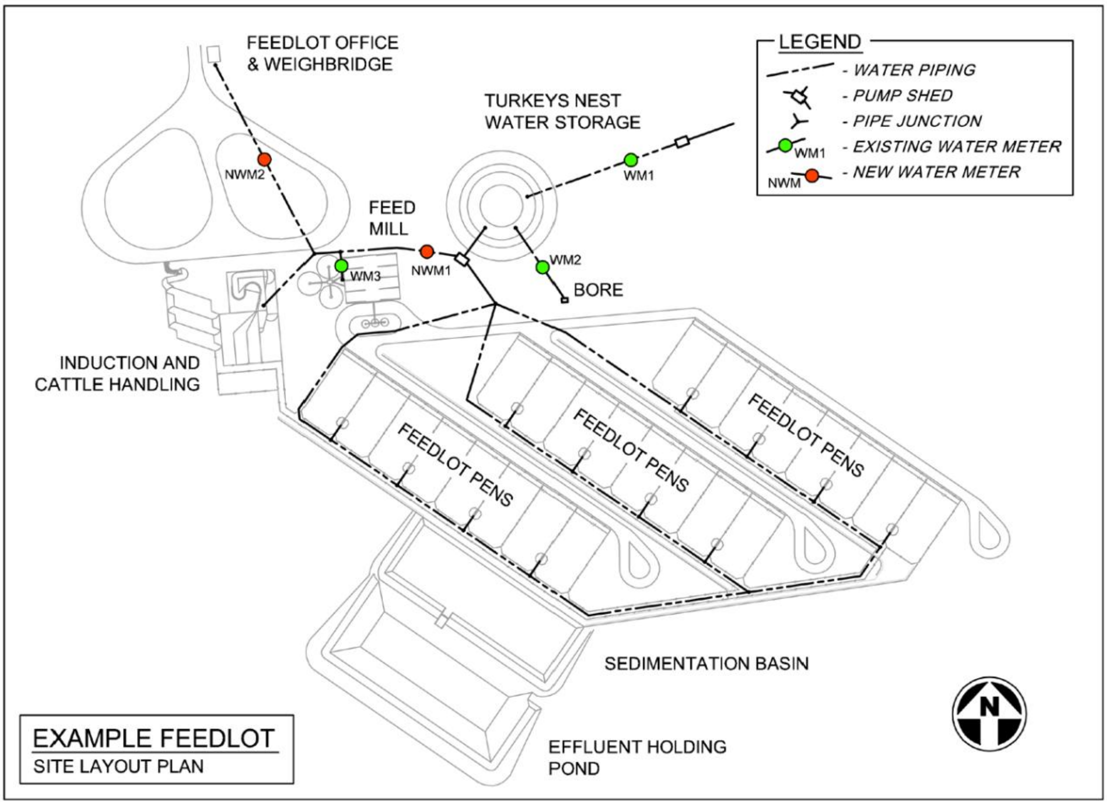

Figure 4: Water Resource Flow Diagram with inflows and outflows in each area of interest

For energy usage, 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. It is important to identify the location of existing energy metering equipment on the site layout diagram as shown on Figure 5. 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 as described previously.

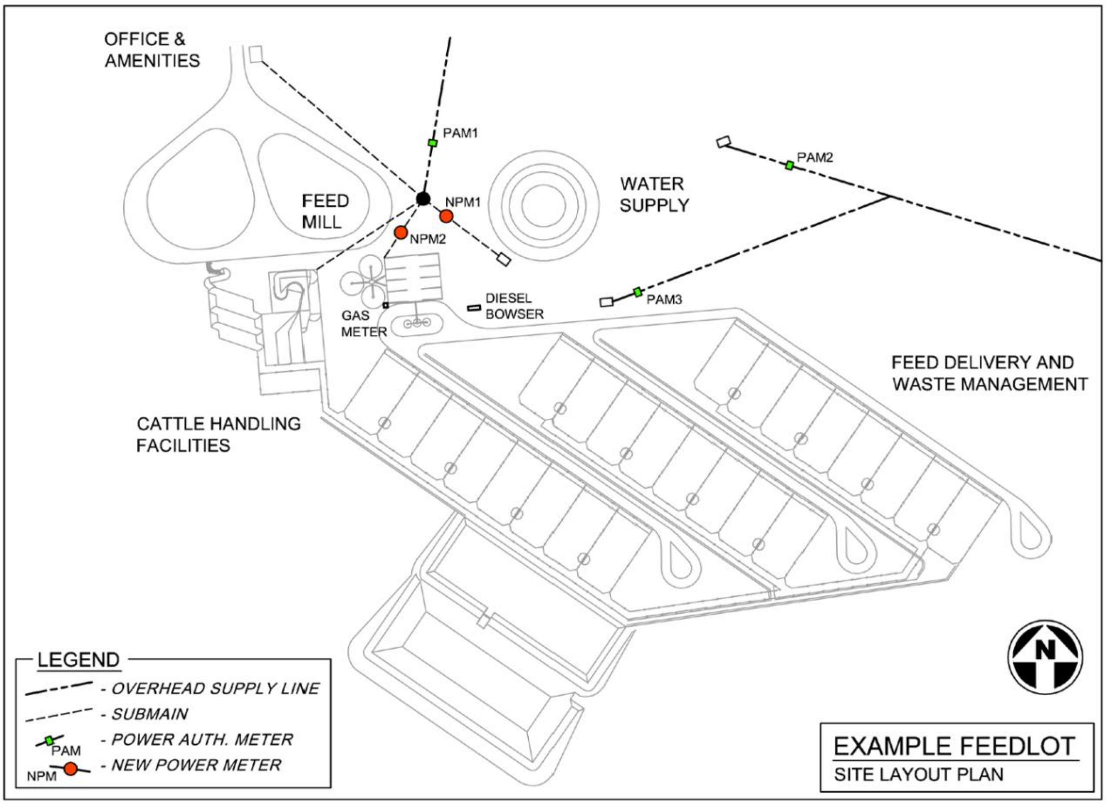

Figure 5: Energy Resource Flow Diagram with metering locations identified

Step 3: Water and Energy Measurement Tools

There are various methods that can be used to help quantify water and energy use. The method that is most appropriate for your level of assessment is the method to select.

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 include:

- The simple bucket and stopwatch approach is not adequate for high volume or multipoint water uses (e.g. 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.

- 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.

- Manufacturer's Information may also be useful. For example, 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.

- 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 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.

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.

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 can be found in MLA Tips and Tools series on Water and Energy usage. It is recommended that specialist advice is sought before purchasing and installing a new water meter.

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. Examples include:

- 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.

- Power Authority Meters - 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. The most common type of electricity meter is the Electromechanical induction watt-hour meter. This is similar to the type installed in domestic residences. Some newer electricity meters are solid state and display the power used on an LCD. Some electronic meters can also be read automatically. 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. Hence, proprietary power monitors may need to be installed.

- 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 meters, meter electrical energy by one of 2 ways. These are direct metering or current transformation 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, 3 phase applications will have 3 meters.

The digital electricity meter may have the capacity to display several different measurements 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.

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 amps, for example. Thus, the size of the conductor to measure the relatively large range of line currents and to produce an output 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.

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 or CT ratio needs to be known to calculate the actual power usage.

- 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.

- 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 or proprietary mass flow rate meters can be retrofitted into existing piping if required.

- 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.

- 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. The start and operating current will also need to be measured by your electrical contractor.

To identify the need for additional measurement equipment a gap analysis can be undertaken. Using the Water or Energy Resource Flow Diagram that has been developed, the gap analysis can show how to gain additional water and/or energy use information from each additional water or power meter installed.

For water usage, 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. 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.

For energy usage, 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.

Common errors include:

- Not recording the correct power unit (Kwh, KVa, V, A).
- Not applying the correct CT Ratio (x 60/5, 100/5 etc).
- 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. 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 (m^3, L, kL, Kwh etc)
- Check the general condition of the meter. Is it working i.e. dials spinning, display not cracked/glazed, not leaking etc.

Step 4: Analysing Data

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. 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.

All raw energy consumption data must be converted to megajoules prior to comparison. This 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.

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 m^3 on the first of January 1 2007. The meter was read on the 1 February 2007 and a reading of 185,000 m^3 recorded. This equates to 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.

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

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.

Remember, *measure to manage.*