METERING AND MONITORING – M13

Eco-efficiency opportunities for Queensland manufacturers

You can't manage what you can't measure!

The information contained within this fact sheet is provided to assist Queensland manufacturers understand the basic elements of metering and monitoring their water and electricity usage. Implementation of these strategies will assist in reducing resource consumption and improve operational efficiency. The information provided should be used as a guide only and detailed information should be collected from suppliers before installing any metering and monitoring system.

Why meter and monitor?

You can't manage what you don't measure

Establishing a metering system and monitoring regime can help manufacturers:

- understand how their processes operate
- verify what they are being charged by suppliers
- benchmark performance indicators
- identify areas of inefficiencies/abnormal operation and improve environmental and economic performance
- assess the performance of resource efficiency initiatives.

Manufacturers should consider monitoring water, energy, raw materials, wastewater and solid waste. While raw materials are usually closely monitored, as a minimum, manufacturers should also implement a metering and monitoring regime for water and energy consumption. This fact sheet will cover key issues relating to water flow and electricity metering and provide a general overview of monitoring requirements. Water quality meters have not been addressed.

Metering

There are many different types of meters to chose from, depending on which parameters need to be measured. Choosing the correct meter for the job can be as important as taking the measurements. Also, installing the meter in the most suitable location will improve the benefits of metering.

Water meters should be installed on all process equipment that uses a significant amount of water.

Water

What to meter and where?

- **Process equipment:** Meter the inlet and outlet of all major water consuming process equipment. It is considered best practice to sub-meter any area of the process consuming a significant proportion of the site's total water use. Refer to Queensland Water Commission (QWC) www.qwc.com.au for sub-metering requirements.
- **Cooling towers:** Cooling towers can account for up to 60% of a manufacturer's water use. Sub-meters should be installed and monitored on the make-up and blowdown lines of all cooling towers. All cooling tower operators in Southeast Queensland are required to meter the make-up and blowdown streams of their cooling tower systems as part of the QWC Water Efficiency Management Plan (WEMP) process.
- **Amenities:** Toilets, showers, hand basins and urinals should only be monitored if they are considered to be consuming a significant proportion of site water use.
- **External water use:** Landscape and cleaning water use areas should be metered.
- **Rainwater tanks:** Water level and outlet from rainwater tank levels should be monitored.
- **Water and wastewater treatment systems:** Water used during the treatment process and output of the treatment process can be significant and should be measured where applicable.

What type of meter is appropriate and what to look for in a meter?

There are three common types of water meters; positive displacement, differential pressure and velocity.

Positive displacement meters are generally used for low flow applications whilst velocity and differential pressure meters are used for higher flow rates.

Differential pressure flow meters include: venturi, orifice and nozzle flow meters. These flow meters work on the principal that pressure drop and velocity are proportional and that as fluid passes an obstruction, a change in pressure is experienced. Differential pressure flow meters have a wide range of industrial applications providing a high degree of accuracy over a wide range of flowrates, fluids and operating conditions. Differential pressure flow meters are inline systems and are specific to the fluid properties, pipe size and flow conditions present.

Velocity flow meters are used extensively as flow meters for water metering. The meters are simple, easy to use and low cost compared to more complex pressure differential meters. Electromagnetic velocity meters also have the ability to be used as external metering devices without impacting flow characteristics. Table 1 provides a summary of the key differences between the most commonly used velocity flow meters.

Table 1 - Comparison of commonly used velocity flow meters[1]

	Mechanical (turbine)	Mechanical (paddle)	Mechanical (propeller)		Ultrasonic
Power required?	No	No	No	Yes	Yes
Accuracy	2%-5%	2%-5%	2%	0.5% - 2%	< 2%
Flowrate indication available?	No	No	Yes	Yes	Yes
Turndown ratio[1]	30 to 1	Between 9 to 1 and 15 to 1	Between 6 to 1 and 16 to 1	Up to 1000 to 1	150 to 1
In-line or external?	Inline	Inline	Inline	Inline and external	Inline
Pressure loss[2]	200 mm	400 mm	120 mm	Negligible	Negligible
Remote reading capability	Optional	No	Optional	Yes	Yes
Display and units	Numerical gauge with set units	Numerical gauge with set units	Numerical gauge with set units	Digital display, units can be altered	Digital display, units can be altered

1 Information provided above has been summarised from: Australian National Committee on Irrigation and Drainage (ANCID), 2002, Know the Flow: Flowmetering Training Manual.

	Mechanical (turbine)	Mechanical (paddle)	Mechanical (propeller)		Ultrasonic
Calibration	Pre-calibrated	Pre-calibrated	Pre-calibrated	Calibrated during installation	Calibrated during installation
Average operational life	8 years	4 years (water quality dependant)	8 years	20 years	15 years
Additional comments	Requires clean water. Turbine can foul. Accuracy deteriorates with wear.	Requires relatively clean water. Inaccurate at low flows. Propeller can foul. Accuracy deteriorates with wear.	Requires relatively clean water. Possible to use same meter in a wide range of pipe sizes. Accuracy deteriorates with wear.	High resistance to blockages. Can handle dirty water. Minimal wear and no moving parts.	Same meter can be used in a wide range of pipe sizes (recalibration required). Measures bi-directional flow. Not suitable with filtered water. Can handle dirty water.

Compound meters incorporate both velocity and positive displacement and should be considered for applications with highly variable flow rates.

When selecting a meter, the following should be considered:

- Accuracy: Generally accepted accuracy levels for water and flow meters are around +/- 5%. Flow meters should operate with this accuracy over the flow range required.
- Operation: Flow meters should be simple to operate and read and be appropriate to the application. Operational considerations include: flowrate, pipe size, pressure loss and safety.
- Installation: Vandal proof and correctly installed, inline, external or insertion type meters.
- Maintenance: Ongoing maintenance and calibration requirements of the meters should be considered.
- Certification: Both the manufacture and installation of the meter should comply with Australian Standard AS 2360: Measurement of fluid flow in closed conduits.
- Price: Economic considerations should balance the above requirements with the capital, installation and maintenance costs.

Table 2 provides a comparison of the four main types of water meters against some of the criteria listed above. The table should be used as a guide only. The relative benefits of each meter will depend upon the specific operating requirements of individual processes. Further information should be obtained from meter manufacturers before selecting the appropriate meter.

Table 2 - Qualitative comparison of water meters[2]

					Measurement		Lifespan			
Device	Accuracy	Cost	Flow span	Head loss	Rate	Volume	Moving parts	Electricity required	Installation	Maintenance
Differential pressure (venture, orifice etc.)	1	3	3	Varies	1	3	1	1	Inline	2
Mechanical velocity (propeller, turbine, paddle etc.)	2	1	2	1	Varies	Varies	3	1	Inline	3
Electormagnetic	2	2	2	1	1	2	2	3	External	3
Ultrasonic	3	2	3	1	1	2	2	3	Insertion	3

Scale: 1 = more appropriate/better performing, 3 = less appropriate/poorer performing

2 The information contained within this table has been adapted from United States Department of the Interior Bureau of Reclamation, Water Measurement Manual, 2001.

Energy

What to meter and where?

Energy is consumed in most areas of a manufacturing process and is typically a significant cost. Energy can be consumed in a range of forms such as:

- **burning fuel:** natural gas or biofuels for heating, petrol for transport etc.
- **electricity:** lighting, refrigeration systems, control systems etc.
- **steam:** imported from offsite or generated onsite for heating or cleaning applications.

It is recommended to sub-meter >90% of all incoming energy sources. This will ensure enough information is available to prioritise and target energy efficiency initiatives. The Green Building Council of Australia recommends metering all processes and equipment utilising 100 kVA of electricity. It is also recommended to separately meter every floor, section or zone, along with separate metering for lighting, heating, cooling and industrial processes and process equipment (pumps, fans etc.).

It may be necessary to meter different parameters for different process equipment to determine operating efficiency. For example, to understand how efficiently a boiler is operating, it may be beneficial to monitor parameters such as the consumption of fuel, the boiler temperature and/or pressure, the temperature of cooling water and flue gas and blowdown volume and conductivity.

Table 3 details some examples of manufacturing process equipment that should be monitored to ensure optimal energy consumption and performance.

Table 3 - Standard monitoring options for process equipment [3]

System	Typical Problems	Monitoring frequency
Process operations	Incorrect set-points	Hourly
	Fouled heat exchangers	Daily
	Advanced controls switched off	Hourly
	Poor control timing	Hourly
Boilers	Operating conditions hours (on/off) and outputs (low/high)	Daily
	Poor air-fuel ratio	Hourly
	Fouled heat exchangers	Daily
	Excessive blowdown	Hourly
	Incorrect excess air ratio	Daily
	Air leakages	Daily
	Poor fuel quality	Daily
	Inappropriate heat recovery (incorrect boiler selection)	Yearly
Steam	Leaks	Hourly
	Failed traps	Hourly
	Poor isolation insulation	Hourly
	Incorrect set-points	Hourly
	Low condensate return	Hourly
Refrigeration	Reduced air flow, e.g. fouled condenser, faulty fan/motor	Daily
	Air in condenser	Daily
	Incorrect superheat settings	Daily
	High head pressure settings	Daily
	Incorrect compressor settings	Hourly
Compressed air	Leaks	Daily
	Poor compressor control	Monthly
	Incorrect pressure	Hourly

3 The information contained within this table has been adapted from Australian Government Department of Natural Resources, Energy and Tourism, 2008, Energy savings measurement guide: How to estimate, measure, evaluate and track energy efficiency opportunities, Version 1.0.

Space heating/ cooling	Excessive space temperature	Hourly
	Excessive fan power use	Hourly
	Overcooling	Hourly
	Heating and cooling	Hourly
	High chilled water temperature	Hourly
Power generation	Poor engine performance	Hourly
	Incorrect control settings	Hourly
	Poor cooling tower operation	Hourly
	Fouled heat exchangers	Daily
Transport	Real time driver tracking (idling time, behaviour)	Hourly
	Traffic congestion	Daily
	Engine running hours high (truck maintenance due)	Weekly

VISY SCHEDULES FOR SAVINGS[4]

Visy Beverage PET plants utilise a compressor scheduling system that continuously monitors air consumption in the plant. The system then optimises air supply from the compressors with process demand. Energy consumption and maintenance requirements are lower due to reduced running times of the compressors, saving both time and money.

Measuring electricity use can assist manufacturers to understand how it is used within the process.

Electricity

Electricity is a significant source of energy and cost for manufacturers. It is crucial that manufacturers understand how electricity is used in their process and ensure it is efficiently utilised.

What type of electricity meter is appropriate and what to look for in a meter?

Generally the desired outcome for electricity metering is to determine total electricity use (kWh) or the rate of electricity use (kW). Meters generally measure different parameters to determine total electricity use such as volts, amps and power factor. A basic meter will measure amps and use assumed values for the remaining parameters to calculate kWh.

There are two main types of meters widely used for electricity; electromechanical and solid state.

Electromechanical induction meters operate by counting revolutions of a metallic disc that is acted on by voltage and current forces proportional to the electrical power load.

Solid state meters utilise a current transformer to measure current which is then converted to an electrical load. Solid state meters can usually be read remotely and have the ability to meter a range of other electrical parameters (such as reactive power) simultaneously.

4 Visy, 2009 VISY's Commitment to Water & Energy Efficiency, **www.visy.com.au/?id=379**

A Best Practice Guide to Measurement and Verification of Energy Savings details a range of typical electrical metering applications. A summary of this information is provided below:[5]

Table 4 Electrical metering applications

Application	Features/Comments
Utility meter	• Measures electricity entering a site. • Metered quantities correspond with service provider billing. • Consumption either monitored on a regular basis (i.e. monthly or quarterly) or estimated from previous billing. • Maintained by service provider.
Sub-meter	• Meters that monitor specific points within the process after the utility meter. • Generally operated by the manufacturer. • Can be installed as inline, insertion or portable external meters. • Monitored either manually by facility staff, or remotely by automated computer systems.
Consumption meters	• Measure quantity and cumulative consumption. • Labour intensive manual meter reading is generally required. • Manual metering reading associated with larger errors. • Data is generally not available in an appropriate format and may need manipulation and analysis.
Demand meters	• Measure the peak demands for certain intervals (i.e. monthly peak demands). • Multiple supply and sub-metering points may record different peaks at different times of the day, subsequently not accurately recording the highest combined peak demand for the site. • Able to identify short-term abnormalities associated with potentially faulty process equipment. • When trying to establish a baseline year, short-term abnormalities may skew data and subsequently these abnormalities may need to be disregarded and a longer baseline period adopted.
Time-of-use (TOU) meters	• TOU meters are accumulation meters. • Measure time of use consumption for periods such as peak, shoulder and off-peak. • Typically used when assessing an energy efficiency initiative incorporating changes to time of use patterns (e.g. moving to off-peak, assessing maximum off-peak demand and load shifting).
Smart meter	• Automated meter reading. • Automated and remote meter management. • Continuous measurement. • Computational abilities. • Multiple parameters metered. • Smart meters may be required for large electricity supply.

Monitoring

Establishing a monitoring regime

A good metering system requires an appropriate monitoring regime to ensure the right parameters are being metered and the system is operating as efficiently as possible. Water and energy monitoring should occur as frequently as possible.

A monitoring system can be improved dramatically by installing a Building Management System (BMS) which monitors all meters remotely and can provide continuous monitoring, process control and alert functions, conduct baseline measurements and assist with reporting requirements whilst significantly reducing labour costs.

5 Australasian Energy Performance Contracting Association, 2004. A best practice guide to measurement and verification of energy savings, **www.aepca.asn.au/documents/BPGtoMeasurementandVerificationofEnergySavings.pdf**

BP BULWER ISLAND[6]

Bulwer Island continuously monitors its energy performance on a daily basis, using a benchmarking tool that rates it against world best practice energy standards. This tool allows comparison of energy efficiency over previous years to determine if implemented energy projects are providing the expected outcomes. Targets are set on an annual basis and all levels of the business have responsibility toward achieving this continual improvement. BP's global refining community set out in 2001 to improve energy efficiency (based on benchmarking figures) by 10% by 2011. Since making this commitment Bulwer Island have seen an improvement of 11.2% to the end of 2007.

The Queensland Government's ecoBiz program provides a good system for benchmarking performance indicators and assessing the performance of resource efficiency initiatives. The ecoBiz Toolbox provides an electronic resource for assessing raw materials, water and energy consumption and waste generation. The tool allows benchmarking of resource use against key business performance indicators. These benchmarks can then be compared on a regular basis against new monitoring data to assess continual improvement.

The following is a list of things to consider when developing a metering and monitoring regime:

Understand the site and process -

- what services are used? Water, electricity, natural gas?
- who is the service provider?
- how is each resource consumption charged? Estimates/meter reading? Quarterly? Monthly?
- what is the current annual resource consumption? What is the breakdown of this? Electricity vs natural gas? Is there seasonal variation in production?
- what metering is currently available? Who is responsible for monitoring? Do onsite records match service provider bills?

Assess information requirements and identify missing information -

- assess what information is required: How much data and information is required to achieve >90% breakdown in resource use? What processes may need to be metered? What time intervals are required? Over what period should be data be collected to capture variation in resource use? What level of detail? How should the information be accessed?
- compare this to available information and decide on what information is missing: How many meters might be required? For what applications?
- assess available technologies: What is the cost of metering infrastructure, communication systems, software, installation and maintenance? Is the technology applicable to the situation? Is the technology accurate for the required task?
- are time and resources available to acquire data?
- are there other influencing factors which need to be considered? Weather/seasonal variance? Areas, occupancy and production levels?

Install metering system and implement monitoring regime

- select an appropriate baseline period
- nominate responsible persons
- designate monitoring frequency
- identify areas of high resource use and target these areas for efficiency initiatives
- monitor following implementation of initiatives

6 Australian Government Department of Resources, Energy and Tourism, BP Regional Australasia Holdings Pty Ltd Energy Efficiency Opportunities First Public Report, 2008. **www.bp.com/liveassets/bp_internet/australia/corporate_australia/STAGING/local_assets/downloads_pdfs/b/BP_RAH_Pty_Ltd_EEOpublic_report_2009.pdf**

How to monitor water use?

Water meter readings should be monitored on a daily or weekly basis. It is preferable to utilise electronic metering with Supervisory Control and Data Acquisition (SCADA) operation that can be remotely monitored. These types of systems provide continuous monitoring to accurately assess and report baseflow conditions, leaks and abnormal operation. The systems also have the ability to trigger alarms or warnings if abnormal operation is detected. Alternatively a monitoring plan for manual meter reading can be developed. The plan should contain:

- location, type and number of meters to be monitored
- details of the process and equipment being monitored, and standard operating conditions
- the responsible person
- frequency of monitoring required
- remedial action plans for when abnormal operation is identified
- reporting requirements
- required calibration frequency.

REAL TIME MONITORING LEADS TO SAVINGS[7]

Castlemaine Brewery in Queensland installed a total of 17 water meters within the brewery to measure water usage in each functional area. The meters were connected to the utilities information system to provide managers and team leaders with real time information on water usage in their area of operation as well as statistical information and trending data. The visibility of usage as a result of installing these meters has led to significant water savings.

For further information on **water metering and monitoring** visit:
United States Department of the Interior Bureau of Reclamation, *Water Measurement Manual*, 2001.
www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/

Australian National Committee on Irrigation and Drainage (ANCID), 2002, *Know the Flow: Flowmetering Training Manual*

How to monitor energy use?

The Energy Efficiency Opportunities (EEO) program is a nationally run program that targets energy reduction in the top 250 energy consuming companies in Australia. Whilst it captures large organisations, the guidelines are applicable to companies of all sizes.

The EEO Industry Guidelines suggest a reasonable level of investment in measurement and metering is approximately 1.5% of annual energy costs.

The EEO program proposes the following steps for measuring and understanding energy consumption:

1. establish the baseline
2. complete an energy balance
3. measure, meter and capture energy use data
4. identify opportunities
5. estimate energy savings
6. assess accuracy of energy analysis
7. evaluate and prioritise opportunities
8. implement efficiency opportunity
9. measure and track energy consumption
10. monitor and report.

The site assessment should be within an accuracy level of +/- 5%.

7 The UNEP Working Group for Cleaner Production in the Food Industry, 2004, Eco-efficiency Toolkit for the Queensland Food Processing Industry.

For further information on **energy metering and monitoring** visit:

Australasian Energy Performance Contracting Association, 2004, A Best Practice Guide to Measurement and Verification of Energy Savings, www.aepca.asn.au/documents/BPGtoMeasurementandVerificationofEnergySavings.pdf

Australian Government Department of Natural Resources, Energy and Tourism, 2008, Energy savings measurement guide: How to estimate, measure, evaluate and track energy efficiency opportunities, Version 1.0, www.ret.gov.au/Department/Documents/energy_savings_measurement_guide.pdf

Carbon Trust, www.carbontrust.co.uk

This series of fact sheets provides examples and suggestions to the modern manufacturer on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website www.ecoefficiency.com.au for more ideas and case studies.

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