i am your gas measurement and monitoring guide

Track gas use and control costs

northmoregordon

The content of this guide was developed by Northmore Gordon Pty Ltd. Northmore Gordon combines advanced engineering techniques with traditional financial analysis tools to help companies identify and implement projects to reduce greenhouse gas emissions. Further information is available at www.northmoregordon.com.

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1 Introduction

1.1 Document background

Gas[1] is an important energy source and significant cost for many organisations in New South Wales (NSW). It has many different uses, from combustion in a boiler for steam production, to use as a chemical feedstock. The diversity of uses and equipment involved can make gas consumption difficult and expensive to measure and monitor. However, by having a clear set of goals and understanding your gas use, you can develop a targeted and cost effect plan to manage it.

This guide offers advice, tools and methodologies to prepare and implement a gas measurement and monitoring plan. It outlines how to better understand the wording and structure of gas bills in order to optimise gas use for your contract conditions, and to track gas-based energy use at your site (including steam and hot water) by installing gas measurement and monitoring systems.

Decisions relating to a site's gas use involve aspects of management, finance, operations and maintenance (Figure 1). Different sections of this guide provide answers to questions frequently asked by personnel within industrial and commercial settings who work in these roles.

Management

- ✓ How do I justify gas measurement and monitoring?
- ✓ What are the steps to create a gas measurement and monitoring plan?

Finance

- ✓ What does gas measurement and monitoring cost?
- ✓ Do the benefits justify the costs?
- ✓ How do I build a business case for gas measurement and monitoring?

Operations and maintenance

- ✓ What do I need to measure and where?
- ✓ What technologies are available?
- ✓ How do I design a suitable gas measurement and monitoring plan?

Figure 1: Key benefits of the guide for site personnel

Each section is supplemented with appendices to allow you to drill down into the topics that interest you.

1.2 Reasons for gas measurement and monitoring

Control costs

A business employing someone full-time at a cost of $50–$100,000 over a year would closely monitor the activities of that person. Failing to manage energy use costing a similar amount is like employing someone and not knowing what they have been doing all year.

Energy is expensive, yet it is one of the easiest things to waste. In order to manage energy use and costs, you must first measure them. Historically, measuring consumption of gas and related

[1] In this guide 'gas' also includes LPG as well as natural gas. This could be mainly methane supplied in reticulated networks, or propane/butane mixes delivered via on-site storage systems.

flows has been technically challenging and costly. As a result, organisations have had limited knowledge about where their energy is used. Figure 2 illustrates this limited knowledge of gas use: the site can quantify only its overall gas input and production outputs.

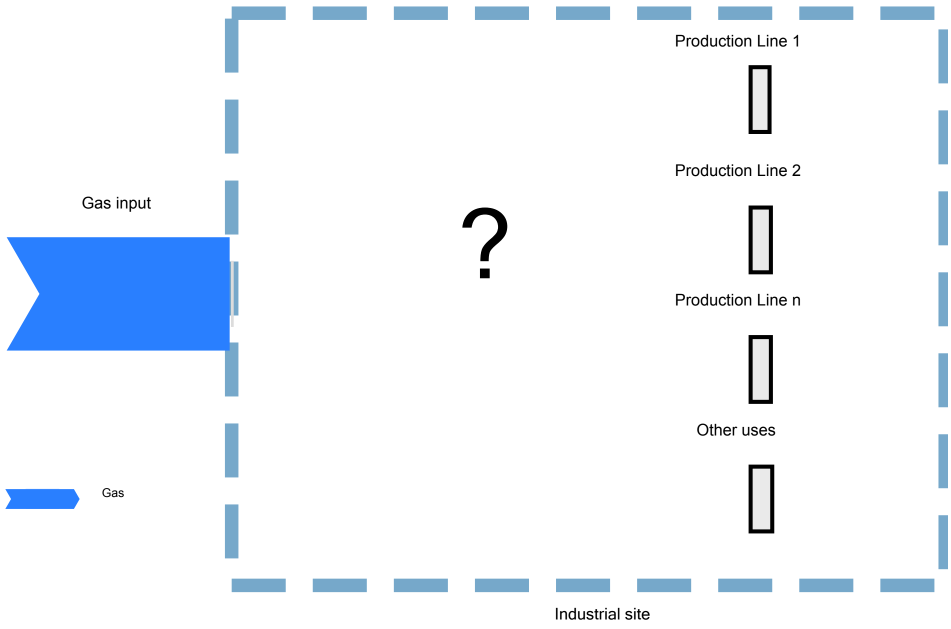
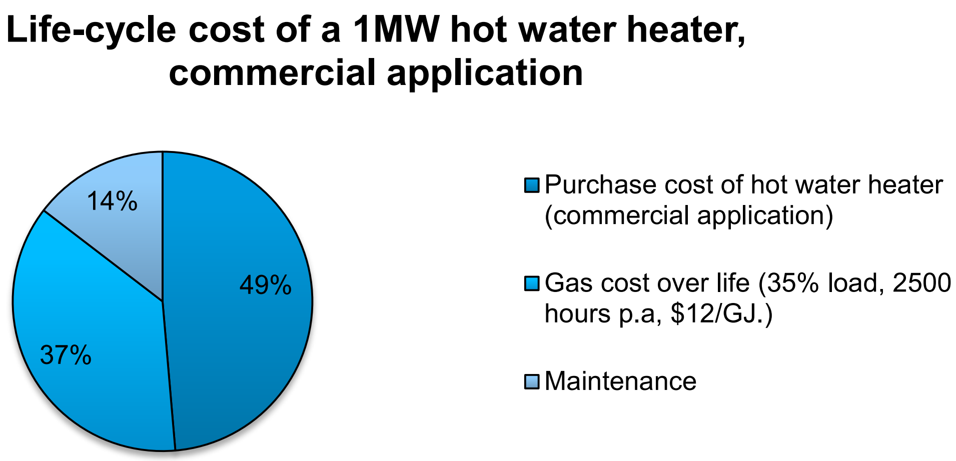


Figure 2: Sankey diagram[2] highlighting limited knowledge of gas use at an industrial site

Knowing the distribution and end-use of the various forms of energy is required to build an energy balance. For this reason, tracking the cost of energy should be a normal part of an organisation's operations in the same way that all other operating expenses are regularly monitored.

Manage the life cycle costs of your assets

For many types of equipment, the cost of energy usage during their lifetime can be greater than the purchase of the equipment itself. As seen in Figure 3, between 35% and 60% of the life-cycle cost of a boiler or hot water heater is associated with its energy use. The variation depends on the operating hours and loading on the boiler.



[2] A Sankey diagram displays flows of mass and/or energy that are proportional to the width of the line.

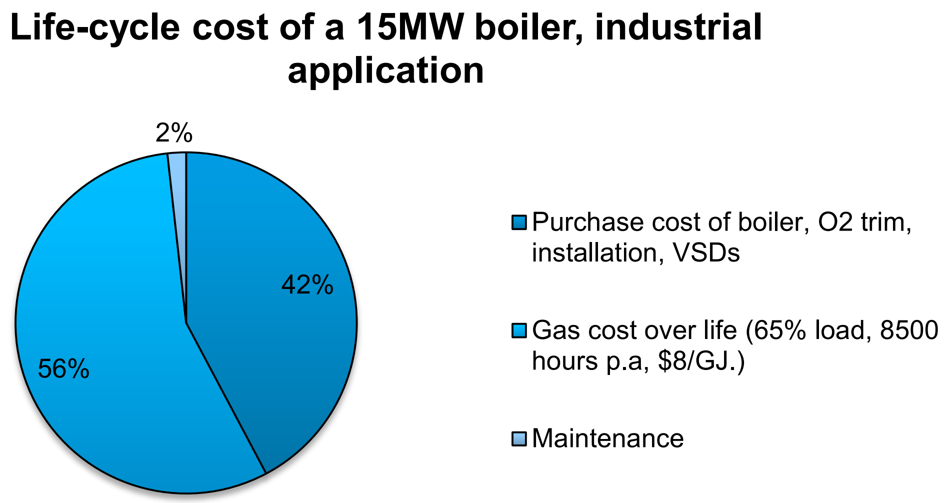


Figure 3: Typical life-cycle costs for a commercial and an industrial boiler respectively, over 10 years

Gas measurement and monitoring systems are becoming increasingly commonplace for new equipment installations. This is particularly important when the financing of a project uses leases, debt or government funding, and where repayment depends on the energy savings that will be achieved.

Identify efficiencies

Gas measurement and monitoring has the potential to improve process control. In fact, studies[3] suggest a minimum 5% energy savings can be attributed directly to actions that result from access to better data. A new high quality gas meter was installed on an industrial oven that was experiencing high rates of out-of-specification product. The result was better tracking of energy content in the gas, and better control of oven conditions, resulting in thousands of dollars savings in production waste and an improvement in energy efficiency.

See the case studies in Appendix D for more details and Appendix A for a full list of benefits.

[3] Office of Energy Efficiency of Natural Resources Canada, *Achieving Improved Energy Efficiency*, available at www.nrcan.gc.ca/energy/publications/efficiency/industrial/emis/6769

2 Getting started

2.1 Understanding how gas is supplied and metered

There are two main types of companies involved in supplying gas – retailers and distributors (see Figure 4):

- **Gas retailers** send you a bill and collect money to cover the cost of the gas commodity itself. Your contract for the gas commodity is negotiated with gas retailers. They also collect money on behalf of gas distributors.
- **Gas distributors** own and operate the pipelines that distribute gas to sites all around the state. Often it is the distributors that own, read and maintain the gas meters used for billing. Gas distributors set network tariffs that appear on the bill sent to you by the retailer. The network tariffs and network tariff structures are generally not negotiable and are set with the Australian Energy Regulator using annual tariff variations within a five-year regulatory agreement.

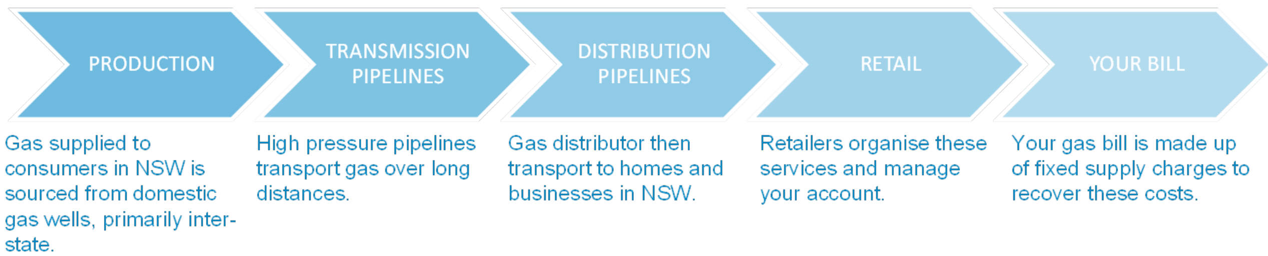


Figure 4: Getting the gas to you[4]

Gas is measured by volume (m^3) using gas meters, and then converted and charged to you according to the energy content used (gigajoules, GJ). Gas volume is converted from m^3 to GJ using either a special utility meter that is corrected for variations in temperature and pressure, or by industry-accepted standardised formulae.

Self contracting for gas supply

It is possible for large customers to directly contract within the wholesale gas market, becoming a 'market customer' and avoiding the need for a gas retailer. This decision should not be taken lightly since you would take on risks of more volatile pricing, but with potential advantages in reduced mark-ups of intermediaries. To do this you would need to discuss it, apply and register with your gas distributor and the Australian Energy Market Operator (AEMO). The advantages, disadvantages and risks of this approach are not discussed in detail in this guide and it is recommended you seek sound commercial and legal advice.

2.2 Understanding your gas bill

There are three main types of gas network tariff classes relevant for businesses in New South Wales:

- **regulated** tariff class – for those (generally small) businesses that have not entered a market contract with a gas retailer
- **volume** tariff class – for small–medium businesses generally consuming less than 10,000 GJ per annum

[4] Source: Jemena

- **demand** tariff class – for single business customers, usually large sites with very high gas consumption, generally where gas use exceeded 10,000 GJ in the preceding 12 month period or exceeded 10 GJ in any hour during the preceding 12 months.

Each customer can be classed in various sub-categories depending on the gas distributor, and can be charged differently based on sub-class and location in the network.

Contracts for both demand and volume business customers are usually billed monthly, and include some or all of the following items (Jemena network tariffs used as an example).

Customers on a volume tariff will experience the following:

- **variable energy charges** – a rate ($/GJ) negotiated with a retailer and applied to the actual amount of gas consumed
- **variable network charges** – a rate ($/GJ) that may be included in the above
- **fixed and/or variable ancillary or supply charges** – fixed or variable cost for the length of a contract and usually charged on a monthly basis.

Customers on a demand tariff will experience some or all of the following depending on their customer type and tariff class:

- **variable energy charges** – a rate ($/GJ) negotiated with a retailer and applied to the actual amount of gas consumed
- **demand charges** – the 'demand charge' is the main variable network charge. It is set by the distributor and reflects the impact that large customers can have on the gas network operations, structured as either $ per GJ of chargeable demand ($/GJ.CD), or $ per GJ throughput ($/GJ)
- **fixed and/or variable ancillary or supply charges** – fixed or variable costs for the length of a contract and usually charged on a monthly basis.

These items are listed in various ways on the bill depending on the retailer and distributor.

Perhaps the most confusing aspect can be how gas distribution companies set chargeable demand in different ways. The following two examples provide guidance on two such methods.

Chargeable demand in the Albury Envestra network

Chargeable demand in the Albury Envestra network comprises a variable component ($/GJ) that in summary is calculated as the maximum quantity of gas used in one hour that either:

a) reflects actual historical MHQ[5] in any given 60 minute period over the last calendar year or most recent complete billing period, or
b) a quantity agreed between the customer and the gas distributor, or
c) a quantity set by the gas distribution company that reflects how much they reasonably expect to be drawn from their network in any given 60 minute period.[6]

Chargeable demand in the Jemena network from 1 July 2015

A new tariff regime for setting chargeable demand on the Jemena network was recently agreed with AEMO. The high level summary is that for existing demand tariff customers; if the chargeable demand applicable on 1 July 2015 is greater than the amount calculated below, Jemena will reduce the chargeable demand to the larger of the following three values:

a) the ninth highest quantity of gas withdrawn in any one day between 1 July 2014 and 30 June 2015

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[5] MHQ: maximum hourly quantity of gas used in any given one-hour period

[6] *Access Arrangement for Envestra's Albury Gas Distribution System 2013–2017*, April 2013, Annex C (now Australian Gas Networks)

b) ten times the MHQ on 30 June 2015, and
c) the MDQ[7] on 30 June 2015.

Maximum daily quantity and annual contract quantity for demand tariff classes

If your gas use exceeds 10,000 GJ a year, or 10 GJ an hour, you are likely using a demand tariff class. The conditions of contracts are site-specific, but there are two particularly important quantities that you need to consider:

- **Maximum daily quantity (MDQ)** is the maximum quantity of gas you can use on any given day. It is significant because it tells the distributor how much gas they need to be able to supply to different parts of the network. If you reduce your maximum daily demand through improved production scheduling or efficiencies, you may be able to reduce your chargeable demand (see Section 3.4). However, if your daily gas use exceeds the MDQ on any given day, you may have to pay over-run costs.
- **Annual contract quantity (ACQ)** is the amount of gas you are contracted to purchase in a year. This figure tells the gas retailer how much gas they need to purchase from the wholesale market on your behalf. You will generally need to purchase a minimum percentage of the ACQ whether you use it or not. This is sometimes referred to as ‘take or pay’ or ‘minimum ACQ%’.

For example, if you have an ACQ of 100,000 GJ, and a minimum ACQ of 80%, the minimum amount you can consume for the year is 80,000 GJ. If you do not consume this amount by the end of the contracted term, you will likely be required to pay the difference.

You may be able to get a better deal if you set a higher ACQ. However, you need to be sure that you’re going to use at least the minimum ACQ%. If you’re planning to implement an efficiency project, you will also need to consider if it could reduce your gas use below the minimum ACQ%.

To most effectively negotiate your contract, you need to understand what affects your daily, monthly and annual usage. This will help you tailor your contract to suit the gas usage profile of your business.

2.3 Obtaining utility data

Accessing historical data

Historical hourly or daily gas usage data from your gas meter can be obtained through your retailer if you are a demand customer. It is free, and represents a valuable source of information to understand how energy is used at your site.

In New South Wales, historical data is obtained by making a request to your gas retailer, who will send you the data in the form of an electronic file (e.g. comma separated variable, CSV).

Market customers[8] are able to access data directly from an AEMO portal.

Accessing real time data

It may also be possible, but not guaranteed, to connect directly to your utility gas meter to access real time usage data. Having gas usage data in real time can provide many benefits:

- helps to minimise your chargeable demand under your contract if you are a demand customer

[7] MDQ: maximum daily quantity of gas used in any given 24-hour period
[8] Market customers: large customers who secure gas supply by directly contracting with the wholesale gas market and not an energy retailer

- helps to understand patterns of gas use by matching it up with actual operations on the day, or in the hour it occurs
- reduces the time involved in chasing historical data for energy performance or cost analysis
- allows you to set performance indicators and thresholds for real time alerting and alarming around gas use.

Utility gas metering systems generally measure gas volumes, not energy content. They do this in two main ways – either volume (m^3) at actual temperatures and pressures, or volume (m^3) corrected to standard temperature and pressures. They may also provide a pulse output where one pulse represents either a corrected or uncorrected volume of gas.

As such, to convert a measured volume to energy use you need to multiply any measurements by a 'standard' calorific value (GJ/m^3). This will not be the same calorific value as the utility uses to calculate your bill, and hence you need to be aware that your calculated energy usage may differ from the utility bills.

To access your utility meter data in real time, you need to connect your site Supervisory Control and Data Acquisition (SCADA) system or Building Management System (BMS) to the gas meter or volume corrector[9] provided by the gas distributor. As gas distributors normally own the metering equipment, only they can approve connections, and they require a certain safety standard to be met.

As an example, the process for accessing real time data from a gas meter on the Jemena network in New South Wales is set out below.

1. An end-customer requiring a connection to their gas meter should apply through their gas retailer.
2. The process for a retailer to apply for a connection on behalf of an end-customer is set out in detail in Appendix J, and summarised here:
   a) The retailer initiates the process by completing and returning an application document to the gas network operator, along with details of the proposed customer interface equipment, and photos of the proposed pulse output.
   b) Discussions are held between the gas network operator and the end-customer (or their equipment installer) to ensure that the designs are suitable and meet the network's requirements.
   c) Assuming the network owner approves the connection, the end-customer is permitted to install their scope of the interface equipment. The network owner will likely inspect, complete the final termination to the meter, and commission the meter outputs.

Some key considerations for connection of a gas meter to your SCADA or BMS are:

1. Many meters have pressure and temperature correction on them, but not all. A volume corrector may also need to be installed.
2. The gas network operator may encourage bench testing of the connection between the data logger and your SCADA or BMS to prove that it works before installing it.
3. The gas network operator may require that the person conducting the data logger installation is a licenced electrician.
4. The gas network operator may be the only one allowed to install either a volume corrector and/or meter if needed and will charge for this.

[9] Volume corrector: a device connected to some utility gas meters to convert the physical metered volume (m^3) to a volume at standard temperature and pressure conditions

5. Data from existing meters may be either corrected, uncorrected, or partially corrected, and needs to be clarified prior to the design being approved.

2.4 Using your utility data

Utility data can be used to identify daily, weekly or monthly patterns, and help to understand the drivers of energy cost.

Strategies for optimising gas use within the contract

The two examples below show strategies that can be implemented to reduce costs. The approach used by each type of customer is different; while both customers have an incentive to reduce consumption, the demand customer also needs to control MHQ and MDQ to minimise the network charges.

Example 1: volume customer

A business is running 10 hours per day on weekdays only. Short-term spikes in gas usage are not penalised. Billing is received on a monthly basis and the site has no regular access to data to observe its gas usage patterns. Being a volume customer, savings in gas at any time of the day are of the same value.

Recording and comparing the historical gas consumption over a period of time can help to identify months where the energy consumption was higher than expected and take corrective actions. Figure 5 shows the monthly gas consumption for this business since January 2013.

This chart shows a very stable energy consumption pattern for 2013, 2014 and 2015. However, the energy consumption in September 2015 is higher than September 2013 and 2014 (41% higher). This gas consumption is similar in the previous months, and without comparison tools, this increase could have remained unnoticed. Investigation could be undertaken to identify why this increase happened and corrective actions taken if possible.

Permanent sub-metering would allow the site to respond to these opportunities and reduce energy costs much faster.

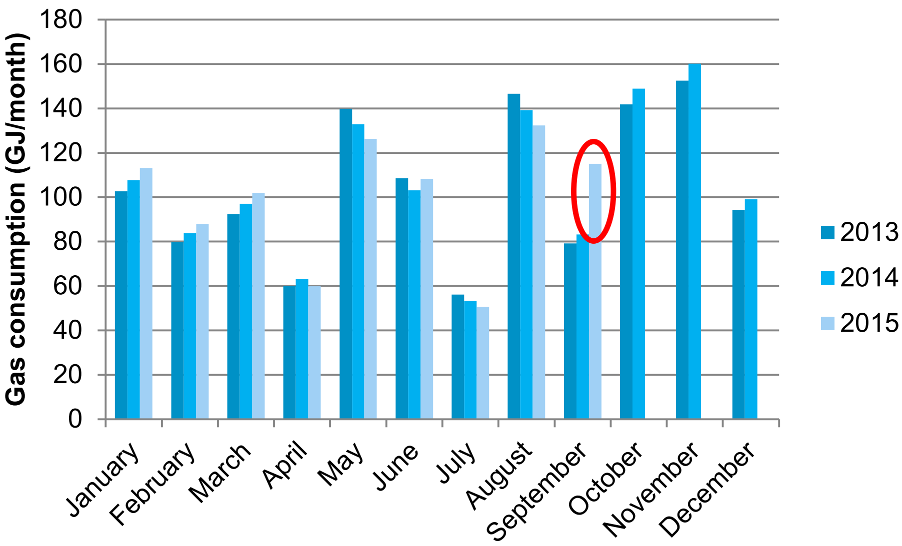


Figure 5: Gas usage profile for a volume customer

Example 2: demand customer – managing chargeable demand using daily data

An industrial site on a demand tariff consumes 79 GJ/day on average. The energy and other variable supply charges have been variable over the last three years. However demand charges that represent almost 30% of the gas bill have been constant. For this consumer, the key cost components on their bill are:

- a volume based energy charge of $8/GJ, agreed with the gas retailer, and
- a chargeable demand (CD) of 140 GJ/day set by the gas distributor, being the ninth highest quantity of gas withdrawn in any one day between 1 July 2014 and 30 June 2015.

In recent months, changes to the industrial process mean that the daily gas use has become much lower than before. Figure 6 shows the daily gas consumption of the site for October 2015.

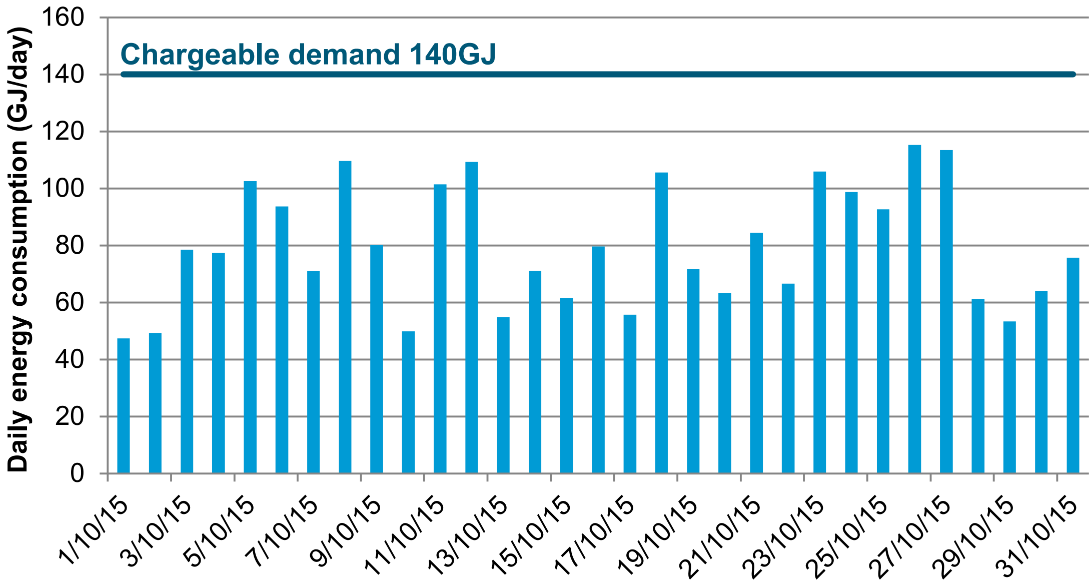


Figure 6: Gas usage profile for a demand customer

The daily gas consumption is now always lower than 120 GJ/day. If the gas consumption is maintained under this level, a request to the gas retailer to reduce the chargeable demand could be made, which would represent a potential 14% cost saving on the chargeable demand.

Example 3: demand customer – analysing gas use with hourly data

Hourly utility data can also help to map gas consumption within a day in order to create comparison trends and quickly identity unusual energy consumption.

For instance, an industrial site consuming 30,000 GJ per year extracted the last two years' hourly gas usage data from their sub-meter and SCADA system. The following chart was developed to represent the average hourly gas consumption for each day of the week over 24 months (Figure 7).

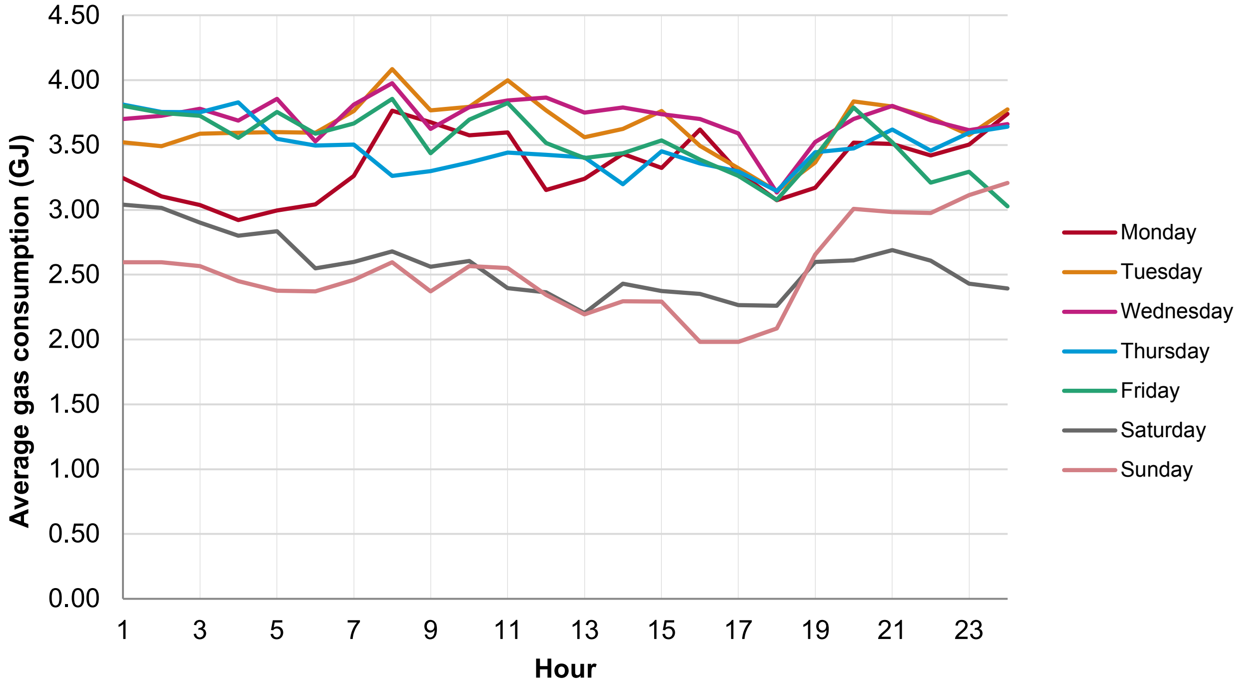


Figure 7: Daily trends based on the average of two years of data

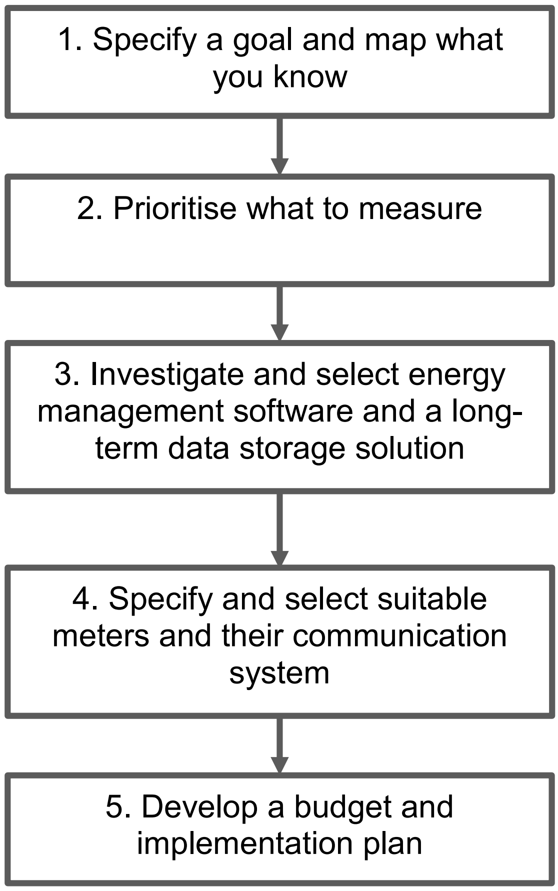
Some facts are known:

- production runs at double the rate on weekdays compared to weekends
- the factory never shuts down.

The chart therefore raises some interesting questions:

- The gas consumption is 29% lower on the weekend compared to weekdays, but production is at 50%, so there could be some non-essential equipment left on.
- On weekdays, there is a spike in gas usage around 8:00 am. This spike could coincide with a shift change, and might indicate that specific devices or processes are started and stopped at this moment that may have a negative impact on overall maximum hourly quantity or maximum daily quantity – ultimately risking a negative impact on network charges.
- There is a slow declining gas use during the day on Saturdays and Sundays that warrants investigation. It may indicate there is potential to be more disciplined in turning off equipment before the weekend shifts start.

3 How to develop a gas measurement and monitoring plan



3.1 Step 1 – Specify the goal and what you know

Set a primary goal

A primary goal encapsulates what you want to achieve and becomes the main driver for your project. Examples might be:

- accurately measure and monitor 80% of gas energy used at the sub-process level
- accurately allocate costs to major process areas
- better allocate costs to tenants in a building
- measure the energy savings from a planned energy conservation measure.

Being specific will help determine the success and cost effectiveness of the project. Achievement of the goal may require short and long-term targets, involve several aspects of the business, cover only a part of the site or include specific actions for inclusion in a wide range of engineering projects.

Specify what is known

Once the main goal and the extent of the project are defined, list all existing gas-using equipment (including equipment that uses secondary services such as steam or hot water) and all existing meters. Estimate gas usage as accurately as possible (recognising that you are not likely yet to have all relevant gas measurement and monitoring equipment to do this).

A Sankey diagram helps to visualise the energy flows and communicate them to other site personnel. An example is shown in Figure 8.

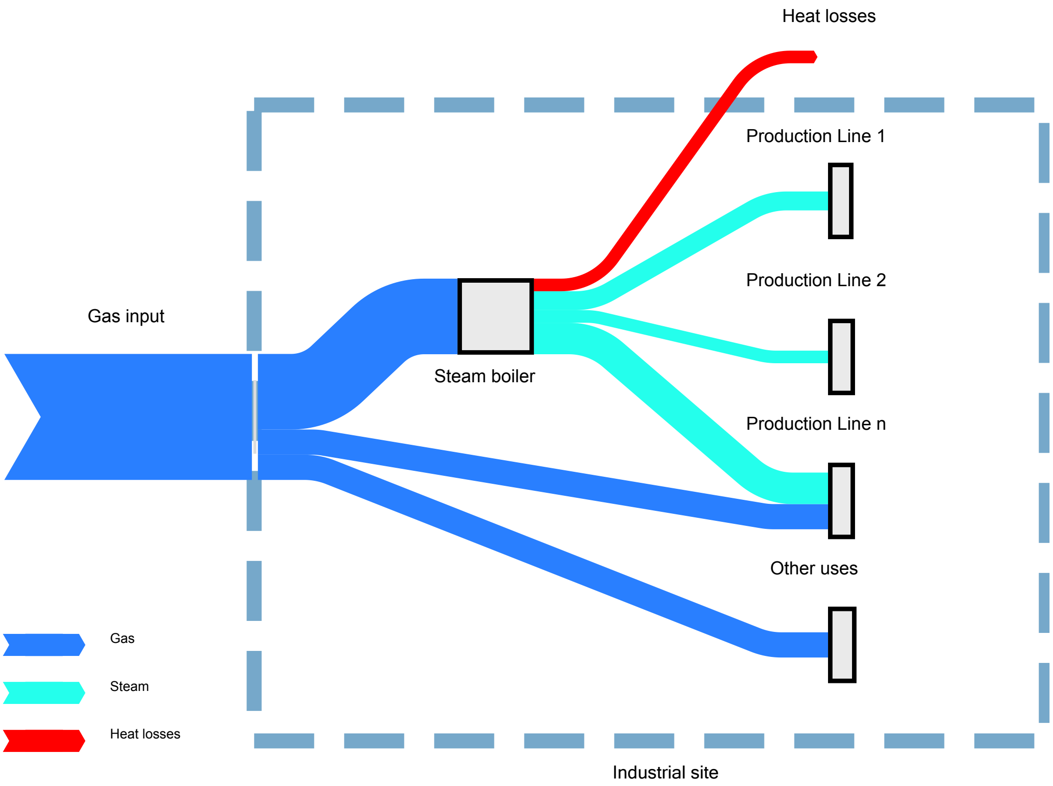


Figure 8: Sankey diagram identifying all gas users on an industrial site

Identify all existing meters

Use the diagram to identify the location of all existing meters (flow, pressure and temperature) on the gas network and other relevant flows. For each existing meter, refer to Appendix B and ask:

- What is the meter type (e.g. a flowmeter could be vortex, variable area, ultrasonic transit time or electromagnetic)?
- What is being measured (e.g. services, product flows)?
- Where is the meter physically located?
- Is there any record of its last verification or calibration? Is there a way to cross-check its operation (e.g. temperature gun, manual temperature or pressure gauges, engineering calculations)?
- Can the data from the meter also be used for process control, safety or other purposes?
- Is the meter connected to a SCADA system?
- Is the meter in an appropriate location (distances and pipe orientations vary according to the technology, e.g. for a flowmeter, minimum lengths of straight pipe are required upstream and downstream from the meter)?

3.2 Step 2 – Prioritise what to measure

Build an energy balance

Taking into account your primary goal, determine where your money would be best spent on gas measurement and monitoring.

Begin by building a preliminary energy balance based on what you already know. Use the results of your investigations into how much gas goes into the site (from gas bill information and identification of main areas of gas usage). Calculate or estimate how much gas is consumed by each area, process or major piece of equipment. Using this method, you should be able to quantify at least 80% of the total energy consumption to a suitable level of accuracy.

See the example at the end of this section for a sample high-level energy balance that will help you set priorities for metering.

If feasible, first build a coherent, reasonably accurate energy balance without the use of permanent metering. Rather than installing new meters, focus on analysis and monitoring of existing data.

If the existing data sets are not sufficient, state clearly what information is missing, then investigate how you can collect this information. Is a meter required or can you find out by another means (e.g. you may be able to establish a connection to the gas utility meter, or use hourly data from your gas retailer for the investigation)? Is a permanent meter needed that might require the plant to shut, or would a temporary meter suffice at this stage?

Temporary meters and data loggers can be a cheaper way to collect data and prioritise capital expenditure before installing a permanent meter. They also have another advantage: they don't disrupt production. For temperature, small data loggers can be installed easily along pipework or in tight spaces. For flow of liquids and gases at high pressures, a clamp-on ultrasonic flowmeter can be installed on the pipe.

Table 1 presents some common methods for estimating gas use when no meter is available.

Table 1: Common methods for estimating gas use at a site without existing meters

Typical energy stream	Temperature indicators	Equipment/flow indicators	Example of engineering method to calculate an energy stream
Air	Surface measurement, infrared thermometers, SCADA/BMS data	Differential pressure method using pitot tubes in ducts Equipment cycle times and operating manuals Fan curves and duct pressures Utility bill analysis	Energy carried by air can be measured when the mass flow is known at two different temperatures. The mass flow can be estimated using engineering calculations based on fan curves, along with motor power, and system characteristics such as pressure differentials and/or damper positions. Temperatures loggers can be installed along pipework.
Steam	Surface measurement,	Temporary ultrasonic flowmeter	Energy carried by steam is difficult to measure directly.

Typical energy stream	Temperature indicators	Equipment/flow indicators	Example of engineering method to calculate an energy stream
	infrared thermometers, SCADA/BMS data	Control valve positions and valve flow characteristics Heat exchanger characteristics Equipment cycle times and operating manuals Empirical theoretical calculations of heat required by processes Utility bill analysis	One approach is to look at all end-user equipment manuals to estimate the energy flow of the steam. Another is to align end-use equipment times with the firing rate of the boiler. Another is to look at steam control valve positions, using the pipe diameter, valve characteristics, and system pressures to estimate a steam balance across the system.
Water	Surface measurement, infrared thermometers, SCADA/BMS data	Temporary ultrasonic flowmeter Control valve positions and valve flow characteristics Heat exchanger characteristics Pump curves and system pressures Pump motor current and system pressures Pipe sizes Equipment cycle times and operating manuals Empirical theoretical calculations of heat required by processes Utility bill analysis	Energy carried by water can be measured when knowing the water mass flow and two different temperatures. The flow can be measured with a temporary ultrasonic clamp-on flowmeter, or estimated using pump curves and pump power measurements. Temperatures loggers can be installed along pipework.

Select equipment to measure and monitor

No organisation has an unlimited budget, so it is important to prioritise the equipment you want to measure and monitor. Determine priorities by comparing the amount of gas usage to the potential for that end-use equipment process to generate savings (which may be energy or production-related costs). Even with an incomplete energy balance, you can estimate the main equipment and areas of gas use by, for instance, using operations manuals for major equipment, directly observing equipment operation, estimating energy use from process conditions and valve positions, or through engineering calculations.

Review the goal and information required

When prioritising areas of gas use, involve site personnel that use or are affected by this equipment, process, building or area. They may be a valuable source of information when selecting and designing the most suitable metering system, and they may suggest additional benefits that improve other aspects of site operations.

Questions for site personnel:

- Do you have a recurring issue that could be solved with additional meters?
- If you had better information on energy use in your area of responsibility, how would you use it?
- With additional metering, you will know how much energy is used in your area. How could you use energy performance indicators (e.g. GJ per tonne of product, or GJ per m^3) to improve what you are doing?

3.3 Step 3 – Investigate and select energy management software and a long-term data storage solution

Ideally any new meter should be integrated into a SCADA system or BMS. A robust data collection and management system is essential for maximising the value of your meter and should form part of your gas measurement and monitoring plan. Such systems cover a wide range of hardware systems and software services with one example shown in Figure 9.

However, there are situations (for safety reasons for instance) where it is beneficial to keep the energy monitoring separate from process control systems.

Guidance on how to design a SCADA system or BMS is beyond the scope of this guide. However, some suggestions are provided below regarding:

- communication technologies in metering devices
- long-term data storage
- energy management software.

Communication technologies in metering devices

Metering devices measure a parameter and generate an output. This output needs to be interpreted into a value that can be recorded by the BMS or SCADA system.

Typically a meter is connected to a data logger or programmable logic controller (PLC), which interprets the meter output and sends the value to the data acquisition server. Increasingly, metering devices include interpretation and communication capabilities to send data in a format directly readable by the SCADA system.

Different communication technologies are used between metering devices and SCADA/BMS systems with the most common being:

- dedicated wire connection
- microwave/VHF/UHF radio
- ethernet, Modbus, Wi-Fi
- cellular network 3G/4G.

When selecting a communication technology for a new meter, the cheapest option is usually to select one that is consistent with the existing data acquisition system. However, wireless technologies can significantly reduce installation costs related to wiring.

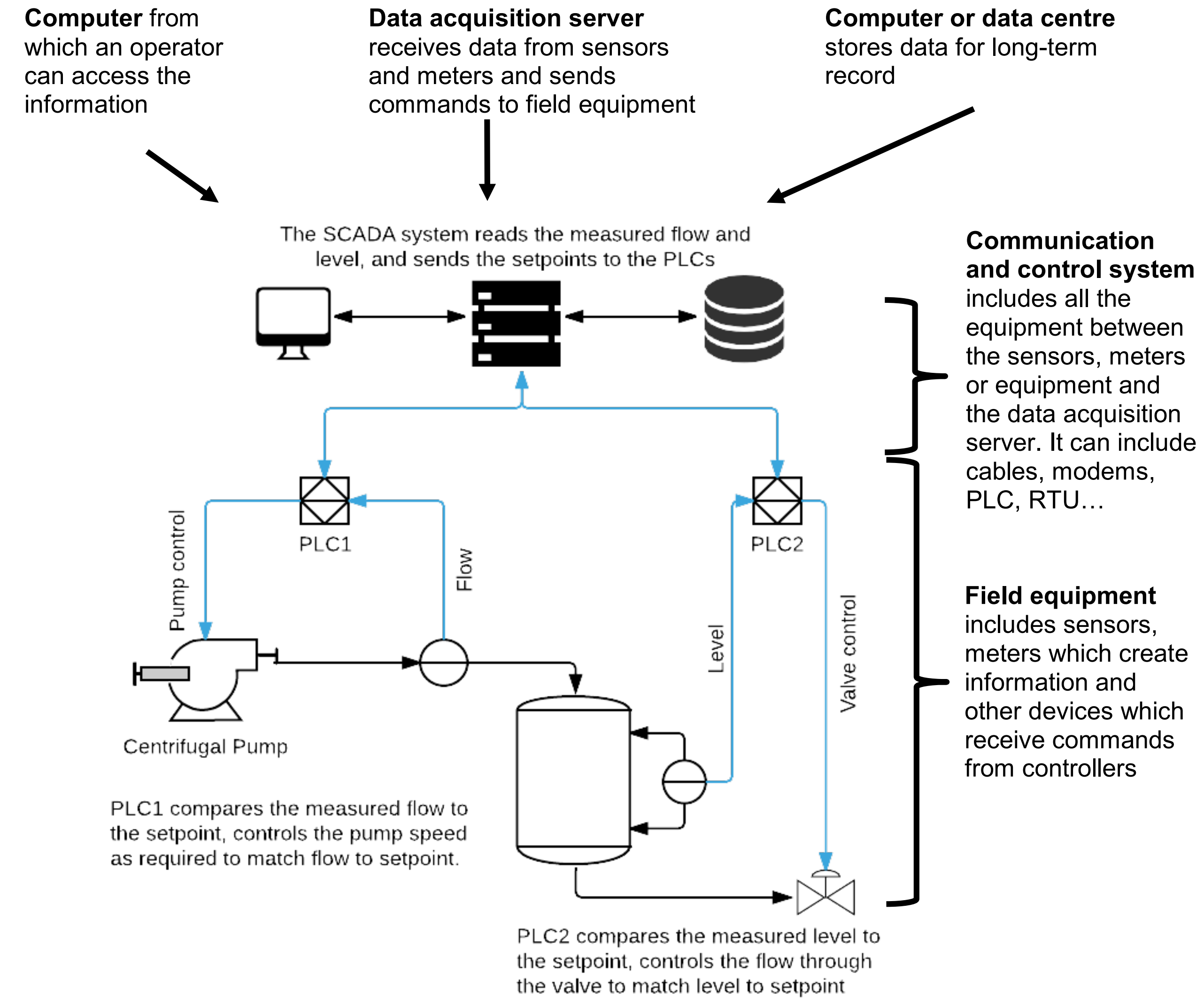


Figure 9: Example of a process SCADA system

Long-term data storage

Over time metering devices generate a significant amount of data that needs to be collected and stored into a database. For energy management, data covering several years are a valuable source of information. As such, the database is a critical part of a SCADA and overall energy management system. This database (software) is stored in a computer or data centre (hardware).

There are several commercial and technical possibilities for long-term data storage. The three main technical options are:

- **storage on site** – data and hardware are located within the facility (the data centre may be managed by the data owner or a third party)
- **storage off site** in a dedicated facility (co-location for instance) – a space is leased in a facility specially designed to accommodate hardware for data storage (the data centre can be managed by the data owner or a third party)
- **cloud computing** – everything is outsourced to a third party data centre provider (the actual data centre can be virtually anywhere).

Appendix I provides a checklist to help with the process of selecting a data management solution.

Energy management software

Data needs to be analysed and preferably used via energy management software (software). The main benefit of software is reporting capability, and it also offers the possibility of tracking comparative performance over time of plant, buildings, process and facilities. Amongst other features, software can have alerting capabilities (via SMS or email), which can help in the early detection of energy waste.

Choosing software can be difficult due to the wide range of products and commercial offerings available. These include software-only, hardware-only, and hybrid software and hardware products. Software can be local or cloud-based. Pricing and business models differ and include outright purchase, payments based on shared savings, or blended models.

Therefore, a clear definition of the need for energy management software is essential before you commit.

The main steps in selecting software are:

1. Define and prioritise the needs of the different services required from software.
2. Assess the existing tools and software used within the site.
3. Define needs related to real-time data and time-criticality.
4. Evaluate available technical and commercial software offerings.

Further guidance is provided in Appendix H.

3.4 Step 4 – Specify and select suitable meters and their communication system

Specify meter requirements

As a minimum, consider the following three aspects when formulating specifications for any new permanent meter:

- purpose of the new meter:
  - What parameter will be measured (flow, temperature, gas composition, pressure)?
  - How will data from the flowmeter be used – for process control, safety checks, billing purposes or as a source of basic information (this indicates what accuracy and repeatability may be required of the meter)?
- environment in which the new meter will be placed:
  - Where will it be located (e.g. base of building, indoor/outdoor, chemical use area)?
  - What size and type of pipe will be required (if a flowmeter)?
  - What are the characteristics of the fluid to be measured:
    - nature of the fluid: liquid, gaseous or a mixture
    - flow, temperature, pressure range (depending on which parameter is to be measured)
    - other characteristics such as cleanliness of the fluid, potential for corrosion and conductivity?
- communication system which will be associated with the new meter:
  - Will the meter be connected to the existing SCADA system?
  - If yes, what is the preferred communication technology (e.g. Wi-Fi, ethernet cable)?

As part of your gas measurement and monitoring plan, identify the existing meters that would benefit from verification, calibration or replacement, or that could be removed.

Suppliers are a good source of guidance on questions to ask during the specification stage.

Select the meters

The selection of the most suitable metering devices can be an iterative process with the different suppliers. Selection decisions should be based on:

- the technologies available for your application
- your specification
- ease of installation and maintenance
- life-cycle costs
- budget allowance.

If the meters are going to come into contact with hazardous fluids or will be installed in a hazardous area, request confirmation from the supplier that the meters meet these requirements.

Measuring flow and converting to energy

Unlike measuring temperature and pressure, measuring the flow of a fluid is more technically complex and costly, and therefore is less common. However, it is essential for monitoring energy use. Specific guidance on specifying and selecting a flowmeter is provided in Appendices B and C.

In many thermal applications, measuring total energy supply to a process or area requires several pieces of data: typically flow (kg/s), supply temperature, return/outlet temperature pressure, and the specific heat capacity of the fluid (kJ/kg.K). Each situation is unique and it is difficult to generalise, so engineers should be consulted on the specific process conditions that should be monitored to evaluate energy flows.

Converting utility gas flowmeter data to energy is relatively straightforward if you have volume data corrected for temperatures and pressures. The gas volume can be multiplied by an industry average calorific value to equate to energy in GJ. A more accurate calculation would be to multiply the corrected gas volumes by the calorific values published specifically for your part of the gas network. Section 2.3 explains how to directly connect to your gas utility meter.

The important message here is that if you get the right process data, the energy flow calculation can be completed in the PLC, SCADA or BMS system.

3.5 Step 5 – Develop a budget and implementation plan

Budget considerations

Consider all aspects of meter installation and how the data will be captured and used. The table below summarises associated areas of cost beyond the cost of the meters themselves.

Table 2: Budget considerations for a meter installation

Costs	Description
Installation considerations	• Purchase of the meters and associated equipment • Work needed to physically install the meter and its associated components into the system, e.g. additional flanges, modification to pipework, power supply for the meter, hazardous area protection • Disruptions to production and planning related to the meter installation • Integration to data-recording systems (data cabling, computers, software licences) • Costs related to its later removal, if the meter is installed on a temporary basis
Maintenance and recalibration during the life of the meters	• Maintenance (cleaning, replacement of components or sensors) • Verification and possible recalibration
Data collection and storage	• The preferred data acquisition system – existing or new • Storing the data • Making data available for different analysis or reporting systems
Data analysis and reporting	• Procedures and systems to interpret and use the data acquired from the gas measurement and monitoring program
Training	• Training is often marginalised, under-funded or, at worst, forgotten. Unless operational managers and plant staff receive adequate training on new techniques and equipment, the data won't be used and many of the projected savings will not be realised

Implementation plan

The implementation plan must take into account:

- **Procedures** – What procedures need to be followed in this installation? Are all subcontractors inducted and permitted on the site?
- **Schedule** – Can the meters be installed during a weekend, in a way that minimises disruption to production or office activities? Will this incur penalty rates for installers?
- **Commissioning** – Are new control settings required? How long will commissioning take?
- **Communication** – Will there be disruptions to services? Who needs to know?
- **Fine-tuning and validation** – After the initial commissioning, how will results be tested to ensure they are realistic?
- **Reporting and alerts** – What procedures will be put in place for energy monitoring, responses to alerts and reporting?
- **Safety** – How will the installation be completed safely?

- **Training** – Which personnel will be trained in the operation and maintenance of the new meters and data management system?

Mapping out all the tasks required in the project, and understanding the links between them (e.g. installation can only occur after the parts have been delivered) helps to develop a realistic schedule. A Gantt chart is one way to visualise how tasks link together and probable timeframes for final delivery of the project (see Appendix F, Step 5).

For industrial applications, the single biggest impact on the delivery schedule is likely to be the need to organise an installation of flowmeters around production.

Setting responsibilities and procedures

Management and responsibility assignments must be developed alongside metering to realise the full potential of data analysis and energy monitoring.

Too often industries implement good metering and data collection but nobody is made responsible for monitoring the data and taking action if required.

Thinking about safety

Be aware of any safety requirements related to the installation of meters and associated instrumentation. Intrinsically safe electrical designs are required for electrical equipment in areas around utility gas meters.

When installing flowmeters and associated electrical equipment in your plant or building think about:

- explosive zones – the installation of, and connection to flowmeters in some industrial plants could require design and installation of intrinsically safe equipment
- use of personal protective equipment (PPE)
- working at heights
- presence of chemicals
- fire and explosion risks
- working in confined spaces
- equipment isolation procedures
- approvals
- electrical safety.

SafeWork NSW[10] has a wide range of tools and resources to help small and large businesses manage work health and safety.

[10] www.safework.nsw.gov.au

4 What to do next

4.1 Write a gas measurement and monitoring plan

The task of gas measurement, monitoring and analysis is never finished. Think of it as a journey rather than a destination. There are always other things that could be metered, additional data to analyse or maintenance to be done.

This guide has provided five steps to help you get started on writing your gas measurement and monitoring plan. Using this guide will be the first step to start the journey.

4.2 Write a business case

Having a sound gas measurement and monitoring plan is no guarantee that it will be implemented. One of the most challenging steps is to convince others of the need for change. An effectively written business case is a vital part of the process. If you have worked through this guide, you should have all the information you need to write an effective business case that sets out the costs, benefits and risks of a gas measurement and monitoring program.

A sample business case is provided in Appendix G, or you may prefer to use your organisation’s business case format. The gas measurement and monitoring plan can be included as an attachment.

When preparing the internal business case think about:

- who in the organisation is going to approve the gas measurement and monitoring plan (stakeholders)
- who will benefit from its implementation (allies)
- what reporting will be required (exception-based or continuous alarming when parameters drift out of pre-set boundaries) and who will have responsibility for monitoring
- who will take action if energy use is higher than expected
- whether your gas measurement and monitoring plan is sufficiently robust and is based on evidence from your initial investigations.

To motivate people to change, consider making your case by:

- creating **dissatisfaction** with the current situation by quantifying the potential energy waste in $/annum, or total cumulative cost over the next five to 10 years
- creating **vision** by setting goals and potential benefits that are easy to visualise and quantify – a gas measurement and monitoring plan is a long-term project with short-term and long-term benefits, and stakeholders will have different views on their importance
- articulating the **steps** to achieve what you want.

4.3 Contact OEH

The NSW Office of Environment and Heritage provides support through periodic funding programs, and pre-qualified contractors to assist in the implementation of gas measuring and monitoring systems. For more information, please contact the Markets and Finance team on 1300 361 967.

Appendix A: Benefits of gas measurement and monitoring

Gas measurement and monitoring brings a range of benefits for site personnel.

Table A1: Potential benefits of a gas measurement and monitoring system and its data

Potential benefits	Management and finance	Operations and maintenance
Supports decision-making and budgeting processes • Data highlights variations in energy use and provides guidance on remedial action. • Data can be used to set energy cost budgets.	✔	
Allocates energy costs to cost-centres • Knowing energy consumed by different end-users allows better allocation of costs (e.g. to tenants or departments in a commercial building, or product types in a factory).	✔	
Helps to optimise gas consumption based on your tariffs • When you understand gas tariffs and how gas is used on your site, costs may be managed by shifting some gas usage to periods with cheaper tariffs or smoothing out energy demand to make it more consistent throughout the day.	✔	✔
Helps to prioritise opportunities and control energy use • Knowing how gas is used on your site helps to identify your main gas energy consumers and to prioritise actions to control energy consumption and carbon emissions.	✔	✔
Tracks performance against energy performance targets • KPIs can be developed at a granular level across a site, making possible the tracking of energy performance over time.	✔	✔
Provides better control of processes and systems • Accurate metering of energy flows can improve control of many industrial processes or building systems.		✔
Detects poor performance early • Metering can help identify faults quickly, such as equipment left operating unnecessarily, or processes that are operating outside of the normal range. • Long-term monitoring identifies slow increases in energy consumption, such as those related to leaks, and speeds up repair processes. It also helps with maintenance planning. • Operators or maintenance personnel can use alerts via email or SMS to take immediate action when energy consumption exceeds pre-set thresholds (see Appendix H).		✔

Potential benefits	Management and finance	Operations and maintenance
Measures performance of new equipment and processes • Good data allows the comparison between actual performance of an upgrade project with the forecast performance.	✔	✔
Improves reporting for government programs • Government programs designed to reduce carbon emissions or support the implementation of energy conservation measures increasingly require project reporting based on measurement and verification of energy savings. Gas measurement and monitoring provides the data necessary for these reports.	✔	
Promotes competitive advantage • Your site operates in a competitive environment where profit margins are under pressure. Gas measurement and monitoring allows for fine-tuning and maintaining tight cost control in operations, leading to sustained competitive advantage.	✔	✔

Appendix B: Choosing and installing a suitable flowmeter

Apply the specifications

Step 4, *Specify and select suitable meters and their communication system* outlines three main aspects to consider when specifying a new meter. These requirements are all relevant for a flowmeter. Applying this information to decision-making processes helps to identify the most suitable flowmeter for your site.

Estimate maximum, minimum and nominal flows

Maximum, minimum and nominal flows are the most difficult values to estimate, especially in situations where there is no monitoring of fluid.

The **maximum** flow is the easiest to estimate. For gas input to a boiler or hot water heater, the maximum flow is calculated using the maximum heating output of the appliance. For steam, the maximum energy flow is determined by the heat exchanger capacities.

The **nominal** flow represents the usual flow under normal operating conditions. When selecting a flowmeter, it is the reference value at which the accuracy and repeatability of the meter should be at a maximum. The two main methods for determining nominal flow are by:

- monitoring the system with a temporary logger, or
- estimating the normal energy requirements of the end-users based on engineering calculations or direct observation.

The **minimum** flow is the minimum flow possible under normal operating conditions. If the flow is lower than this limit, the system is considered 'off' or a low accuracy of the measured flow is considered acceptable. For example, the minimum flow for gas input to a boiler is calculated from the heating output of the boiler at low fire. For steam, it can be estimated from the minimum heat required by the end-users.

The ratio between the minimum and maximum flows gives the **turndown ratio** required from the proposed new meter.

Weigh up accuracy vs. repeatability

Accuracy is the degree to which the result of a measurement conforms to the true value.

Repeatability is the variation in measurements taken by a single instrument in the same application, under the same conditions.

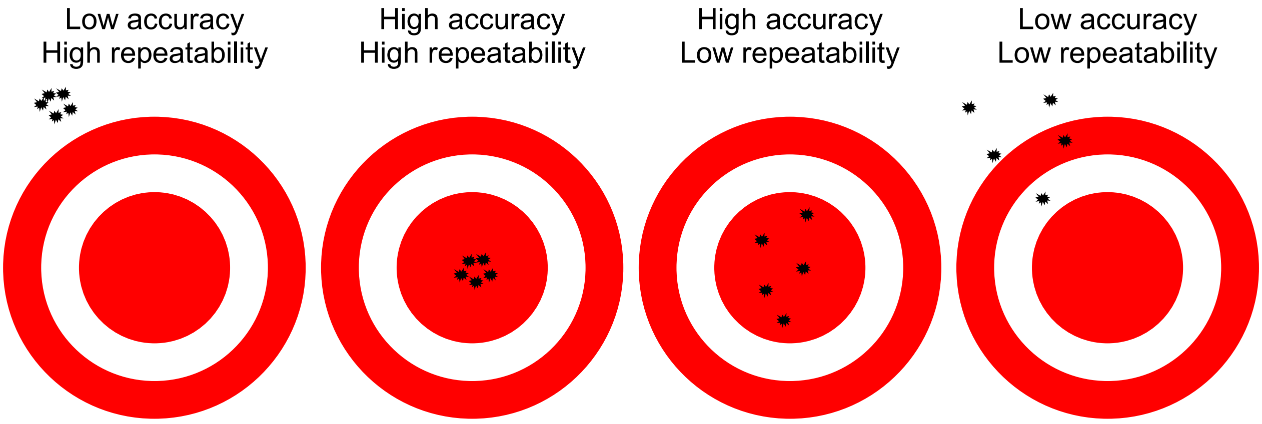


Figure B1: Visual representation of a comparison between accuracy and repeatability

In most cases, the repeatability and accuracy of a flowmeter are related to the technology that it uses. The recommended default position is to select a flowmeter with high repeatability over one which has high accuracy but low repeatability. This option offers the most consistent results over time.

Make the final decision

Select a suitable flowmeter for your site based on the previously defined specification and considerations such as:

- budget allowance
- ease of installation and maintenance.

Keep in mind that no meter currently available is likely to meet all of your criteria optimally and you will have to select a system that represents an appropriate compromise.

A low cost meter is not always the best long-term choice. Take into account the full life-cycle cost of the system when comparing metering system prices. This includes the cost of installation, calibration and recalibration, maintenance and replacement. Evaluate these costs against the potential benefits that might come from installation of the meter.

Appendix E provides a list of flowmeter technologies and their main characteristics. Request the advice of a specialist as technologies evolve to help narrow the possible choices.

Avoid common mistakes

According to various metering suppliers, the most common mistakes when installing a flowmeter relate to:

- **wrong turndown ratio** – the technology of every flowmeter has an associated turndown ratio. This must align with the meter's intended use. For instance, if maximum flow is calculated as 1000 kg/hour of steam and the minimum flow is 100 kg/hour, the turndown ratio is 10:1. If the flowmeter selected is a variable area meter, which has a common turndown ratio of 10:1, it will not be able to provide accurate information for a flow above 300 kg/hour
- **wrong nominal flow** – a meter might be over or undersized even though the turndown ratio in a contract is correct. For instance, a vortex flowmeter has a turndown ratio of 40:1; however, if the pipe is oversized, the actual minimum flow that can be measured by the meter will be 500 kg/hour (the maximum will be 40x500=10,000 kg/hour). Therefore, when the steam flow is lower than 500 kg/hour, the measurement will be inaccurate. In this kind of situation a pipe reduction may be necessary to match the flowmeter with the steam flow
- **wrong location** – each flowmeter requires a minimum length of straight pipe upstream and downstream of the meter. For example, an orifice plate flowmeter meter will require approximately 20 times the pipe diameter of straight pipe upstream and seven times the pipe diameter downstream. These numbers can change according to the type of obstacle upstream or downstream (bend, valve, pipe reduction). If these distances are not respected, the flowmeter will not read accurately
- **poor quality installation** – the flowmeter installation needs to be performed by a correctly trained professional
- **issues related to meters for flammable gases** – additional safety procedures, specific meter ratings for hazardous environments, meter certification, and/or installer certification may be required for the installation of meters for flammable gases.

Appendix C: Fact Sheet 2 – Selecting a suitable flowmeter

1. Define the purpose of the meter

• What will the data be used for? This will give an indication of the accuracy and repeatability required for the meter. Usage can include (but is not limited to):
  ○ process control
  ○ safety check
  ○ billing purposes.

2. Collect information about the environment of the meter

• Size and type of pipe
• Preferred location of the future meter
• Length of straight pipe available
• Characteristics of the fluids to be measured:
  ○ nature of the fluid – liquid, gaseous or mixture
  ○ temperature and pressure ranges
  ○ other characteristics such as cleanliness of the fluid, potential for corrosion, conductivity. Do not forget to review other products (such as chemical treatment) that could affect the integrity of the meter.

3. Estimate maximum, minimum, nominal flows and turndown ratio
These values can be measured, estimated or calculated from: • temporary monitoring • energy characteristics of end-user equipment • using engineering calculations to estimate energy flows.
4. Define the communication system to be associated with the meter
How will the meter data send to the SCADA system (Wi-Fi, ethernet cable, other)?
5. Select the flowmeter
Select the most suitable meter from all products and technologies that are available, considering the specifications for, and requirements of, the meter and the budget allowance. As a default, in order to have consistent results over time, give preference to a flowmeter with high repeatability over a flowmeter with high accuracy but low repeatability.

Keep in mind four common mistakes
• **Wrong turndown ratio selected**: meter turndown ratio not appropriate for the actual flows • **Wrong nominal flow used**: over or undersized flowmeter because the nominal flow was poorly estimated, even with a correct turndown ratio • **Wrong location**: insufficient upstream or downstream straight pipe length • **Poor quality installation**

Appendix D: Case studies

Case study 1 – Getting data from a gas utility meter

Summary

Company:	**Coca-Cola Amatil**
Location:	**Northmead, NSW**
Industry:	**Beverages**
Project:	**Connect the utility gas meter to the site SCADA system**
Cost:	**$13,000**

Background

Coca-Cola Amatil (CCA) uses a significant amount of natural gas in four hot water heaters, a steam boiler and forklifts. They are charged as a ‘demand’ customer where some of their gas costs are set by maximum daily quantity (MDQ). Gas usage data was available at one-hour intervals from their gas retailer upon request.

In order to better gain control of gas costs, and to get better visibility about how gas was used on the site, CCA decided to gather data directly from their utility gas meter.

Objective

To connect the gas usage data from the utility meter to the site SCADA system.

Results

The overall timeframe of the project was around six months from order to commissioning. Now, the meter provides gas usage data on a 5-minute basis directly to CCA’s SCADA system. The data will be used to:

- confirm the site gas use against the production of the site
- compare the metered gas to the billed amount of gas
- identify spikes in gas consumption immediately.

The project was successful, with gas usage data (m^3/minute corrected for pressure and temperature) now flowing directly to CCA’s SCADA system. The results and lessons from the project will become clearer once they have had time to collect and analyse the data.

Comments

- The project appeared simple, but involved submitting an application form to the gas retailer who then notified the gas distributor. The distributor then provided CCA with its standards for connection.
- The distributor enforces strict standards for all electrical works in the zone around the utility gas meter since it is classed as a hazardous environment.
- Works by a local, licenced electrical contractor involved installing a pulse-output connection point outside the hazardous zone around the meter and connecting it to the site SCADA system using standard industrial practices.
- The gas distributor, as the meter owner, is the only company authorised to connect the pulse output connection point to their meter or flow corrector.
- The site SCADA system was programmed to accept pulse input from the meter. Data conversion and aggregation was required to accommodate the meter data into the CCA’s SCADA system.
- The site has a long-term data historian solution that will store gas data over the long term.

Case study 2 – Sub-metering a steam boiler

Summary

Company: **Austcor Packaging**

Location: **Wetherill Park, NSW**

Industry: **Cardboard packaging**

Project: **Sub-meter the gas boiler, install data logger, flue gas analysis**

Cost: **$6000 (excluding project management)**

Background

Austcor produces corrugated cardboard packaging. Gas is used in the process for helping the corrugation and gluing processes, as well as in forklifts. It is a significant cost but the site had no data on the breakdown between forklifts and the main steam boiler. It was estimated that the boiler was using around 80% of the gas on site.

The gas burner fitted to the 5 MW boiler has a turndown ratio of 7:1. Thus the boiler minimum fire is about 3⁄4 MW.

In order to better understand the gas usage profile of the boiler, a permanent gas meter and temporary data logger were installed. This included installation of:

- 24 VDC power supply and circuit breaker for the gas meter
- a thermal mass flow gas meter sized for the boiler load of 5 MW
- a temporary data logger to totalise the pulse output and allow simple downloading of the data.

The service provider used to install the gas meter was a specialist boiler and combustion company. A thermal mass flowmeter was selected as the best to match the following criteria:

- suited for natural gas flows 0–200 standard m^3/h
- temperature of the gas to be measured 5–50°C
- pulse output where one pulse equals one standard cubic meter of gas flow
- standard temperature and pressure environment
- accuracy of ±3%
- local display
- repeatability of better than ±0.5%
- vertical flow application.

Objective

The objective was to build a gas usage profile for the boiler. This could then be used to ensure that the boiler turndown matched the steam demand from different processes.

Results

The gas usage profile showed that when the boiler was running it ranged between 982 and 3750 kW. The minimum firing rate corresponded to the burner's maximum turndown. There was good evidence of limited consumption on non-production days, meaning that existing shutdown procedures were effective.

Lessons learnt

- In this case, a simple wiring issue between the meter and the data logger led to lengthy trouble-shooting post installation. Ensure that commissioning occurs when all suppliers are on site.
- There needs to be good coordination between several service providers to ensure the system works together including:
  - project manager (in this case a consultant)
  - gas meter supplier
  - equipment installer
  - data logger supplier.

Appendix E: Reference guide to flowmeter specifications, costs, benefits and applications

Reference guide contents

Table E1: Broad areas of flowmeter applications

		Liquid								Gas/Vapour					Miscellaneous				
		General liquid flows (<5 cP)(<0.005 Pa.s)	Low liquid flows (<0.12 m^3/h)(<5L/min)	Large liquid flows (>1000 m^3/h)(>1.7x10^4 L/min)	Large water pipes (>500 mm bore)	Hot liquids (temperatures >200°C)	Viscous liquids (>5 cP)(>0.005 Pa.s)	Cryogenic liquids	Hygienic liquids	General gas application	Low gas flows (<150 m^3/h)	Large gas flows (>5000 m^3/h)	Hot gases (temperatures <200°C)	Steam	Slurries and particulate flows	Liquid/liquid mixtures	Liquid/gas mixtures	Corrosive liquids	Corrosive gases
Group	**Type**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	**S**	**T**
1. Conventional differential pressure types	Orifice	+	?	+		+		+		+	?	+	+	+		+	?	?	?
	Venturi	+		+		+				+	?		?	?	?	+	?	?	?
	Nozzle	+		+		+				+	+	?	?	+	?	+	?	?	?
2. Other differential pressure types	Variable area	+	+			#	?		+	+	+							?	
	Target	+				#				+				+		+	?		
	Averaging pitot	+		+	+	+	?	+		+		+	+	+		+	?	?	?
	Sonic nozzle									+	+	?	?						
3. Positive displacement types	Sliding vane	+		#			+		+							?			
	Oval gear	+	+	#		#	+		+							?		+	
	Rotary piston	+	?			#	+		+							?		#	
	Gas diaphragm									+	+								
	Rotary gas									+	+								
4. Inferential types	Turbine	+		+	#	+	?	+	+	+		+				?	?	#	
	Pelton	+	+			+		+		?	?					?		?	
	Mechanical meter	+													#	?			
	Insertion turbine	+		+	+	+		+		+		+	+	?		?	?		
5. Fluid oscillatory types	Vortex	+				+		+		+		?	+	+		?			
	Swirlmeter	+								+									
	Insertion vortex	+		+	+	?		?	?	+		+	?	+		+		?	?
6. Electromagnetic types	Electromagnetic	+	+	+	+	#	+		+						+	+	?	+	
	Insertion electromagnetic	+		+	+	?			+						?	+	?	+	
7. Ultrasonic types	Doppler	+		?	?	#			?						+	+	?	?	
	Transit time	+	?	+	+	#	?	#	+	#						?		#	#
8. Direct and indirect mass types	Coriolis (direct)	+	+			#	+	+	+	?					?	?		#	
	Twin rotor (indirect)	+																	
9. Thermal types	Anemometer	+		?	?	#				+									
	Thermal mass		#							+	+								

+ is suitable, generally applicable
? is worth considering, sometimes applicable
is worth considering, limited availability or tends to be expensive
A blank indicates unsuitable, not applicable

Table E2: Performance factors in flowmeter selection

Group	Type	Linearity (%)	Repeatability (%)	Turndown ratio range (XX:1 to YY:1)		Pressure drop at maximum flow	Flow parameter measured	Response time
				XX	YY			
1. Conventional differential pressure types	Orifice	#	#	3	4	3/4	R	#
	Venturi	#	#	3	4	2	R	#
	Nozzle	#	#	3	4	2/3	R	#
2. Other differential pressure types	Variable area	1 to 5 FS	0.5 to 1 FS	10		3	R	No data
	Target	NS	NS	3		3	R	NS
	Averaging pitot	#	0.05 to 0.2R	#		1/2	Vm	#
	Sonic nozzle	0.25	0.10	100		3/4	R	NS
3. Positive displacement types	Sliding vane	0.1 to 0.3 R	0.01 to 0.05 R	10	20	4/5	T	>0.5 s
	Oval gear	0.25 R	0.05 to 0.1R			4	T	>0.5 s
	Rotary piston	0.5 to 1 R	0.2 R	10	250	4/5	T	>0.5 s
	Gas diaphragm	No data	No data	100		2	T	>0.5 s
	Rotary gas	1	0.20	25		2	T	>0.5 s
4. Inferential types	Turbine	0.15 to 1 R	0.02 to 0.5R	5	10	3	R	5 ms to 25 ms
	Pelton	0.25 to 0.2 R	0.1 to 0.25 R	4	10	4	R	5 ms to 25 ms
	Mechanical meter	No data	1 FS	10	280	3	R	50 ms
	Insertion turbine	0.25 to 5 R	0.1 to 2 R	10	40	1/2	Vp	5 ms to 25 ms
5. Fluid oscillatory types	Vortex	1 R	0.1 to 1 R	4	40	3	R	0.5 s min
	Swirlmeter	<2 R	NS	10	30	3	R	NS
	Insertion vortex	2 R	0.1 R	15	30	1	Vp	5 ms to 25 ms
6. Electromagnetic types	Electromagnetic	0.5 to 1 R	0.1 to 0.2 FS	10	100	1	R	>0.2 s
	Insertion electromagnetic	2.5 to 4 R	0.1 R	10		1	Vp	NS
7. Ultrasonic types	Doppler	No data	0.2 FS	5	25	1	Vm, R	
	Transit time	0.1 to 1 R	0.2 to 1 FS	10	300	1	R	0.02 s to 120 s
8. Direct and indirect mass types	Coriolis (direct)	NS	0.1 to 0.25 R	10	100	2/5	R	0.1 s to 3600 s
	Twin rotor (indirect)	No data	No data	10	20	3/4	R	50 ms
9. Thermal types	Anemometer	No data	0.2 FS	10	40	2	Vp	No data
	Thermal mass	0.5 to 2 FS	0.2 FS to 1 R	10	500	2	R	0.12 s to 7 s

R is the flow rate
Vm is the mean velocity
1 is low
% R is the percentage flow rate
NS indicates not specified
T is the volume flow
Vp is the point velocity
5 is high
% FS is the percentage full scale
# is dependent on differential pressure measurement

Table E3: Selection by fluid property constraints

Group	Type	Maximum pressure (bar)	Temperature range (°C) Min	Max	Minimum ReD	Gas (G) or Liquid (L) G	L	Two or more phases
1. Conventional differential pressure types	Orifice	400		650	30,000	+	+	P
	Venturi	400		650	100,000	+	+	P
	Nozzle	400		650	20,000	+	+	
2. Other differential pressure types	Variable area	700	-80	400	No data	+	+	
	Target	100		120	30,000	+	+	S
	Averaging pitot	400		540	10,000	+	+	
	Sonic nozzle	400		650	25,000	+		
3. Positive displacement types	Sliding vane	100	-30	200	1,000		+	
	Oval gear	100	-15	290	100		+	
	Rotary piston	170	-40	170	100		+	
	Gas diaphragm	200	-30	200	250	+		
	Rotary gas	100	-40	150	1,000	+		
4. Inferential types	Turbine	3500	-268	530	10,000	+	+	
	Pelton	3500	-225	530		+	+	
	Mechanical meter	600	-25	200		+	+	
	Insertion turbine	70 to 250	-50	430		+	+	
5. Fluid oscillatory types	Vortex	260	-200	430	20,000	+	+	P
	Swirlmeter	100	-40	110	No data	+		
	Insertion vortex	70	-30	150	5,000	+	+	
6. Electromagnetic types	Electromagnetic	300	-60	220	No limit		+	S/P
	Insertion electromagnetic	20	5	25	No data		+	
7. Ultrasonic types	Doppler	*	-20	80	5,000		+	S
	Transit time	200	-200	250	5,000	+	+	P
8. Direct and indirect mass types	Coriolis (direct)	390	-240	400	100		+	P
	Twin rotor (indirect)	400	-240	350	10,000		+	
9. Thermal types	Anemometer	20	-200	400	No data	+	+	
	Thermal mass	300	0	100	No data	+	+	

S is suitable
P is possible
* is dependent on the rating of the pipe wall

Table E4: Selection by installation constraints

Group	Type	Horizontal flow (H)	Upward vertical flow (VU)	Downward vertical flow (VD)	Inclined flow (I)	Unidirectional flow (U)	Bidirectional flow (B)	Quoted range of minimum upstream lengths per pipe diameter		Quoted range of minimum downstream lengths per pipe diameter		Filter	Pipe bore range (mm)	
								Min	Other min	Min	Other min		Min	Max
1. Conventional differential pressure types	Orifice	+	+	+	+	+	+	5	80	2	8	N	6	2,600
	Venturi	+	+	+	+	+		0.5	29.5	4		N	6	
	Nozzle	+	+	+	+	+		5	80					
2. Other differential pressure types	Variable area		+			+		0		0		P	2	600
	Target	+	+	+	+	+		6	20	3.5	4.5	N	12	100
	Averaging pitot	+	+	+	+	+	+	2	25	2	4	P	25	
	Sonic nozzle	+	+	+	+	+		5		0		N	5	
3. Positive displacement types	Sliding vane	+	+	+	+	+		0		0		R	25	250
	Oval gear	+				+		0		0		R	4	400
	Rotary piston	+	+	+	+	+		0		0		R	6	1,000
	Gas diaphragm	+				+		0		0		N	20	100
	Rotary gas	+	+	+	+	+	+	0	10	0	5	R	5	400
4. Inferential types	Turbine	+	+	+	+	+	+	5	20	3	10	P	5	600
	Pelton	+	+	+	+	+		5		5		R	4	20
	Mechanical meter	+	+	+	+	+		3	10	1	5	R	12	1,800
	Insertion turbine	+	+	+	+	+	+	10	80	5	10	P	75	
5. Fluid oscillatory types	Vortex	+	+	+	+	+		1	40	5		N	12	200
	Swirlmeter	+	+	+	+	+		3		1		N	12	400
	Insertion vortex	+	+	+	+	+		20		5		N	200	
6. Electro-magnetic types	Electromagnetic	+	+	+	+	+	+	0	10	0	5	N	2	3,000
	Insertion electromagnetic	+	+	+	+	+	+	25		5		N	100	
7. Ultrasonic types	Doppler	+	+	+	+	+	+	10		5		N	25	
	Transit time	+	+	+	+	+	+	0	50	2	5	N	4	
8. Direct and indirect mass types	Coriolis (direct)	+	+	+	+	+		0		0		N	6	150
	Twin rotor (indirect)	+	+	+	+	+		20		5		N	6	150
9. Thermal types	Anemometer	+	+	+	+	+	+	10	50	No data		R	25	
	Thermal mass	+	+	+	+	+		No data		No data		R	2	300

P is possible
R is recommended
N is not necessary

Appendix F: Gas measurement and monitoring plan template

Replace the information in the sample below with your own company's details. The information provided below is only intended as a guide to the kind of information to include.

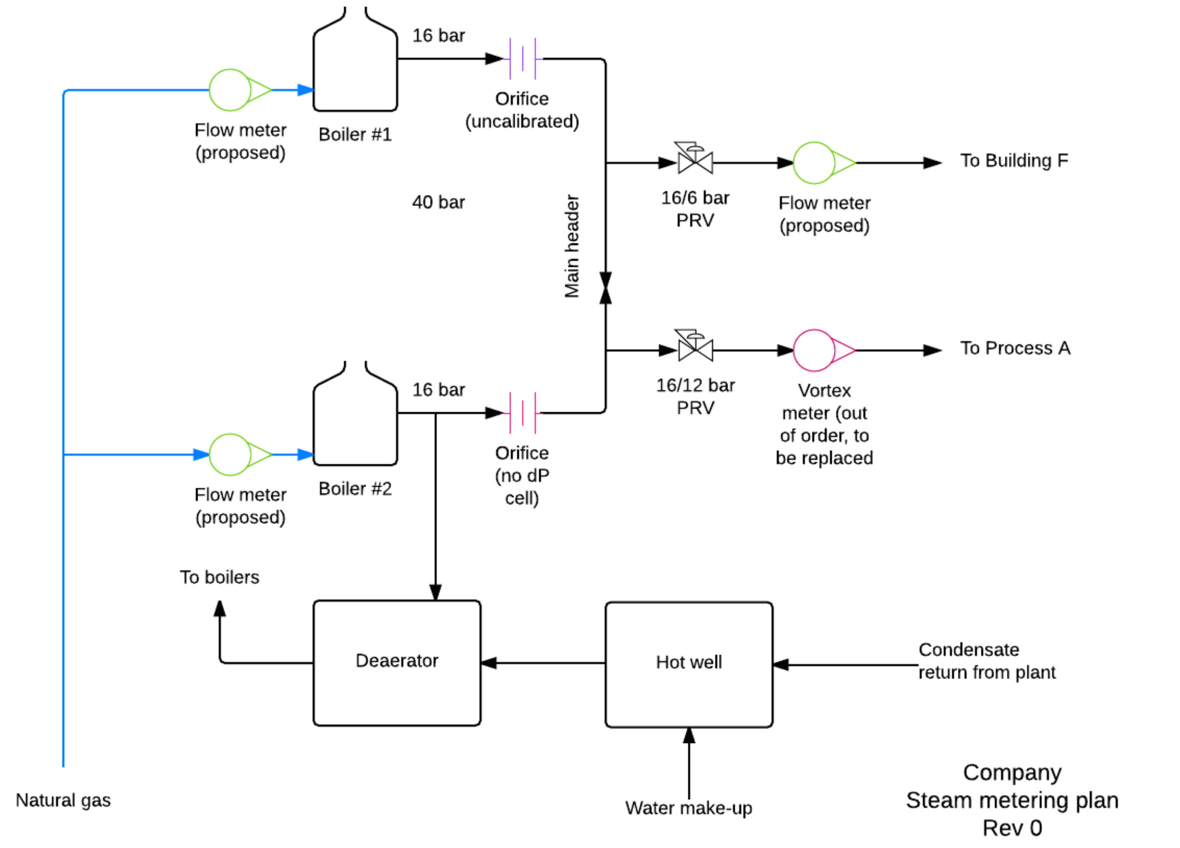
<table>
<tr><th colspan="4">OVERVIEW</th></tr>
<tr><td rowspan="2">1</td><td colspan="3">Background</td></tr>
<tr><td colspan="3">The company produces widgets. Gas costs over $500,000 per annum and is the third largest operating cost on the site. Recently the company negotiated its gas contract, and prices are set to rise for the coming two years. The international market for widgets is competitive and control over costs is important.

The company is therefore interested to better understanding gas use at its Smith Street site through the use of a gas measurement and monitoring system. The metering is focused on the boiler systems, which are thought to consume most of the gas used at the site.</td></tr>
<tr><td rowspan="6">2</td><td colspan="3">Provide participant details below</td></tr>
<tr><td colspan="2">Name of participant organisation</td><td>Company</td></tr>
<tr><td colspan="2">Business address</td><td>Smith Street, New Territory, NSW 2XXX</td></tr>
<tr><td colspan="2">Name of nominated project manager</td><td></td></tr>
<tr><td colspan="2">Project manager contact number</td><td>04XX XXX XXX</td></tr>
<tr><td colspan="2">Project manager contact email address</td><td>Energy.i.love@company.com.au</td></tr>
<tr><td rowspan="5">3</td><td colspan="3">Describe how gas is used directly at your site in major equipment or areas</td></tr>
<tr><td></td><td>Major equipment</td><td>Fluid and conditions</td></tr>
<tr><td>1</td><td>The site has two main natural gas boilers operating at 16 bar, feeding a common steam header. The boilers do not have economisers or oxygen trim control, and blowdown is operated on a timer.</td><td>Gas at 70kPA

Steam at 16 bar</td></tr>
<tr><td>2</td><td>An oxidiser uses gas to maintain oxidation temperature.</td><td>350°C</td></tr>
<tr><td>3</td><td>Two industrial ovens use gas to heat air for circulation around the product.</td><td>Air at 250°C</td></tr>
</table>

4	**Describe how gas is used *indirectly* at your site in major equipment or areas (e.g. in the form of steam, hot water, or hot air)**		
		Major equipment, processes or areas	*Fluid and conditions*
	1	Process A requires steam at 12 bar for a major piece of custom equipment. The steam pressure is critical to the widget quality but other process parameters have been changed in recent times and it is unknown what reductions in flow rate may be possible. The major process operates 12 hours per day, five days per week.	Steam at 12 bar pressure
	2	Building F contains a number of hot water systems that supply heating requirements to multiple areas of the building. Steam is used to heat the hot water in centralised tanks, which is then distributed throughout the site 24 hours per day. Water flow out of each water tank varies for process reasons, but the temperature is constant.	Hot water at 85°C

STEP 1 – SPECIFY THE GOAL AND WHAT YOU KNOW				
1	**Goal of this measurement and monitoring plan**			
	The company has set a goal of reducing annual gas use by 10% within 12 months. It believes that the first step in achieving this is to monitor the steam production profile and boiler performance, and develop an energy performance indicator (e.g. GJ of gas / tonne of steam produced by the boiler). This plan will help achieve this.			
2	**Annual site energy consumption**	*Gas (GJ)*	*From:*	*To:*
3	**Annual site energy cost**	*Gas ($)*	*From:*	*To:*
4	**Simplified schematic of relevant systems, existing and new meters**			
	A process flow diagram of the whole gas system is not available. A simplified schematic of the boilers and steam system is provided in the figure below. The boiler and steam system consists of 2 x Brand ACME boilers with a discharge pressure of 16 bar. There are two pressure-reducing valves (PRVs) that drop the steam pressure to 12 and 6 bar respectively for different end-users. It is not known for certain which boiler or end-use consumes the most energy.			



5 What meters exist?

Area	*Meter location*	*Description*	*Qty*	*Specification and calibration records*	*Communications, data storage, alarms/reports*
Boiler house	Exit of Boiler 1	Steam meter	1	Brand ZZ orifice plate No calibration records	Local readout only
Boiler house	Exit of Boiler 2	Steam meter	1	Brand ZZ orifice plate with no differential pressure cell No calibration records	No monitoring
Boiler house	Near PRV on 12 bar line	Steam meter	1	Brand XX vortex meter No calibration records	Meter not working

6	**Critical process conditions that need to be considered in the gas measurement and monitoring plan**
	• Maintenance staff were consulted and indicated that the hot water tanks in Building F are undersized (i.e. they cannot always maintain hot water needs at the set point during cold weather). • It is believed that Process A uses the majority of the steam but this is an estimate only. • Steam traps across the network have been failing for over a year. • Short-term direct observation confirmed that Boiler 1 is run more often by the operators since it is perceived to be more 'reliable'. • Operations staff indicate that the process control over steam use to Process A is not fine enough and product quality is being affected, potentially causing $50,000 in product loss each year. • There are no gas meters on the boiler fuel lines.

STEP 2 – PRIORITISE WHAT TO MEASURE

1 High level gas energy balance

List of main areas of gas use	*Gas use (GJ per annum)*	*% of total gas consumption*	*Priority*	*How the gas use was calculated*
Oxidiser	10,000	10%	Med.	Gas consumption estimates were based on annual working hours of the oxidiser and a fuel consumption rate from the operating manuals.
Steam boilers	70,000–80,000	70–80%	High	Gas consumption was estimated using theoretical calculations of process and hot water needs.
Two industrial ovens	10,000–20,000	10–20%	Med.	Usage is estimated at 10–20% based on the remaining amount of unaccounted-for gas use. Burners maintain temperature in the ovens by controlling gas flow. One oven is much larger than the other.

2 Steps to improve the understanding of energy use

The energy balance was deemed sufficient for developing the targeted gas measurement and monitoring plan, remembering that the goal is to measure energy flows through the boiler and steam system.

As the steam boilers are the primary consumer of gas, having permanent gas and steam meters could help to track long-term boiler performance, assist with trouble-shooting the reasons for spikes in gas usage, and provide an input into process optimisation and cost control.

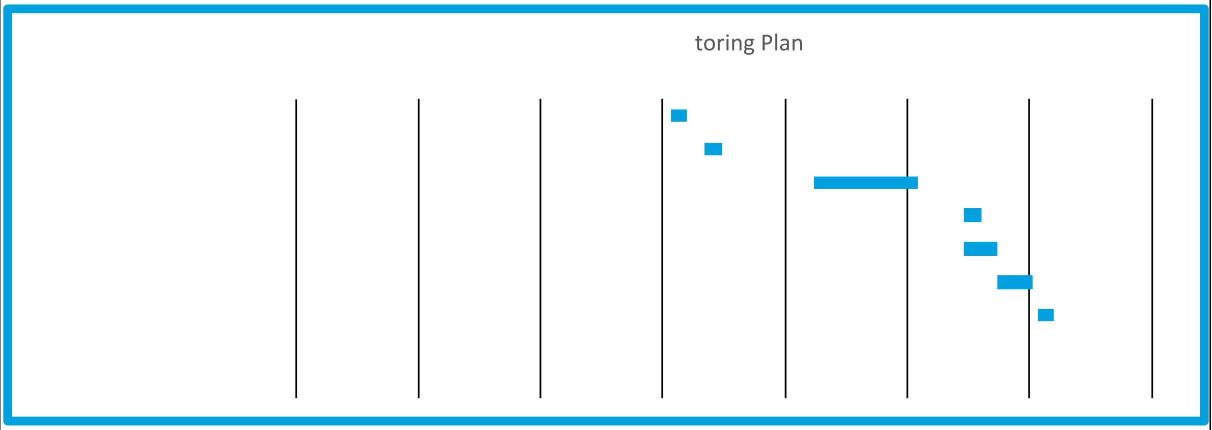
3	**Priorities**
	• Metering of steam used in Process A and Building F. • Metering of gas used in the boilers. • These data can be combined to develop: (i) a boiler system KPI of GJ/tonne steam, and (ii) a production KPI of tonnes of steam used per output of Process A. Note that the boiler system KPI is not equivalent to the boiler efficiency.

STEP 3 – SELECT ENERGY MANAGEMENT SOFTWARE AND LONG-TERM DATA STORAGE SOLUTION	
1	**Energy management software currently in use**
	A SCADA system is already implemented on site. This is the system that all operators and engineers use for analysing the process and reporting on variations from process conditions. All metering must be integrated into this.
2	**Reporting, alerts and alarms**
	Site personnel will perform data analysis by extracting data from the SCADA system. Adding energy management capability to the SCADA system is currently not a priority. Automated alerts and alarms will be considered as part of a site-wide upgrade later in the financial year.
3	**Long-term data storage**
	There is currently a data historian system that already captures and stores data from the SCADA system. This will be used for long-term data storage.

STEP 4 – METER SELECTION ***(ensure proposed meters are shown on schematic)***					
Area	*Meter location*	*Description*	*Qty*	*Specification*	*Communications, data storage, alarms/reports*
Steam flow to Process A	Close to widget processing machine	Steam meter	1	100 mm diameter Vortex shedding 0–20 bar high turndown ratio high accuracy Nominal flow = UNKNOWN (recommend temporary flowmetering be completed so meter can be sized accurately)	Meter output will be wired to the PLC and a new addition to SCADA screen completed. Operators to receive graphical indication of flow rate at the operator control centre.

Area	*Meter location*	*Description*	*Qty*	*Specification*	*Communications, data storage, alarms/reports*
Boiler house	Gas supply lines to boilers	Gas meter	2	75 mm diameter Thermal mass flow 70 kPA high turndown ratio Nominal flow = can be sized from boiler capacity	Meter output will be wired to the PLC and a new addition to SCADA screen completed. Operators to receive graphical indication of flow rate at the operator control centre.

STEP 5 – BUDGET AND IMPLEMENTATION PLAN	
1	**Implementation plan**
	Key considerations include: • meter supply lead times • preferred contractors • work permits • requirements of the gas network owner • production planning • communications.
2	**Schedule**
	(propose to use the M&V Excel template tool here)



3	**Safety considerations**
	• Complete job safety analysis

4	**Proposed costs**	
	Meters	
	Electrical and communications works	
	Piping and mechanical works	
	Civil works	
	Project management	
	Installation contractors	
	Other	
	TOTAL	

Appendix G: Sample business case for gas measurement and monitoring

<table>
<tr><td>BUSINESS CASE</td><td colspan="2">Purchase meters for boiler and steam system measurement and monitoring</td></tr>
<tr><td>Detailed Description</td><td colspan="2">
Preliminary investigation has identified that the company uses $800,000 of gas per annum. There is currently limited quantifiable knowledge of the patterns of this gas use, but it is estimated that the boilers and steam system consume 70–80% of this gas.
The measure involves a structured approach to: a) install sub-meters, b) establish management processes, c) install monitoring systems to track energy intensity, d) establish baseline energy intensity and key performance indicators, e) educate operations staff in modified operation and maintenance procedures, and f) implement regular management review.
Examples of actions that may improve efficiency include:

install a boiler economiser
improve management of steam pressure to reduce losses across the machines in a given pass, thereby reducing over-processing
minimise billing costs by smoothing out gas usage over the day
implement operator training to reduce incidence of machines operating while empty
change the way the system deals with line stoppages to reduce incidence of machines operating while empty
reduce variation in quality of product output through closer monitoring of individual machine output
use alternative heating techniques and waste heat capture.

The savings associated with this program cannot be estimated with accuracy at this stage but based on the success of other similar programs and observations and discussions held to date, an allowance of 10% improvement has been made.
The monitoring equipment alone for this project has been quoted at around $50,000.
A quotation has been provided to assist with project management and installation of the project. An allowance of $30,000 has been made for the purposes of this business case.
The cost estimate excludes the value of rebates that we understand are available, through discussion with the NSW Office of Environment and Heritage, to reduce the cost of the project.
Note: the benefits below do not include the value of ESCs which are not yet available for gas savings.
</td></tr>
<tr><td>Operational benefits</td><td colspan="2">

Quality – Equipment that is operated and maintained to best practice may produce a more consistent product and reduce the percentage of off-spec product.
Production – Properly managed equipment may be more reliable and process more product per year.
Operational cost management – Tracking energy use will enable more accurate cost allocation to areas.

</td></tr>
<tr><td rowspan="4">Business case assumptions</td><td>Project life (years)</td><td>10</td></tr>
<tr><td>Inflation rate</td><td>2%</td></tr>
<tr><td>Discount rate for NPV
(company cost of capital)</td><td>13%</td></tr>
<tr><td>Fuel cost escalation rate</td><td>0%</td></tr>
</table>

Business case results								
Electricity savings MWh p.a.	**Gas savings GJ p.a.**	**Energy cost savings $ p.a.**	**Other cost savings (e.g. maintenance) $ p.a.**	**Total cost savings $ p.a.**	**Capital cost $**	**Payback period (years)**	**Net present value $**	**GHG savings tonnes CO_2 p.a.**
0	10,000	$50,000		$50,000	$80,000	1.6	TBA	TBA

Implementation plan	• Evaluate attached proposal and negotiate contract • Engage consultant and follow process outlined in proposal • Establish management processes (policies, targets, KPIs, procedures, etc.) • Develop measurement and verification plan • Design and implement tracking system • Set boundary conditions • Train operations staff • Implement system • Conduct regular management review of progress • Conduct first year close-out review and determine if extension is justified
Risk management	The key risk associated with this project is the non-realisation of projected savings. There are limited options to reduce the likelihood of this risk occurring, aside from engaging quality consultants and working with genuine intent to achieve the intended outcomes. If the likelihood of this risk occurring is considered to be unacceptably high, one option may be to transfer some of the risk to another party by negotiating a success–fee arrangement with the consultant, which shares the risk. The project will be subject to rigorous M&V using high quality monitoring equipment. Note that this contract arrangement may increase the estimated fee noted above.

Appendix H: Checklist for selecting energy management software

Define and prioritise software needs

All services and aspects of a business can benefit from software; however, it is rare that the software can fulfil all requirements. Therefore, it is important to identify the main beneficiary of the software.

Energy management software has five main categories of capabilities:

1. Utility bill management – Utility bills are entered manually in the software to create a database of energy use. The main benefits are the avoidance of late fees and billing errors. This is typically purchased by Procurement or Sustainability.
2. Sustainability or environment health and safety (EHS) – Utility bill data, EHS or sustainability events are recorded. This reduces costs and risks associated with automated tracking and reporting. EHS, Sustainability, Corporate Energy Management, Finance or Facilities teams are the principal purchasers of this tool.
3. Gas measurement and monitoring-related – These solutions require the measurement and monitoring of certain energy loads to manage energy use in real time or to allocate energy costs to product lines, customers or tenants. The benefits are lower cost because operators can act upon real-time data, or increased revenue from customers or tenants. These solutions are purchased by Operations, Manufacturing, Facility or Real Estate teams.
4. Demand response-related – Increasingly, demand response vendors offer software to track energy use at one or multiple facilities. The main benefit of demand response is financial payment, which is often a useful way to fund the purchase of sub-meters and software. These systems are purchased by Operations or Facilities.
5. Control-related – These solutions are asset-specific (HVAC, lighting, manufacturing line, data centres, refrigeration), require sub-metering and often offer the ability to control assets (either hardware or software-based). The main benefits of these solutions rest with operational reliability, with energy management as an optional and growing feature. These tools are purchased by Operations or Facilities.

Define your needs related to real-time data and time-criticality

In addition to the main categories of capabilities, software products can be divided into three categories:

- Local based solutions – The software is installed on the local server where data are stored and analysed.
- Cloud-based solutions – Data are sent to an online platform where they are analysed by the software.
- Hybrid (local and cloud-based) solutions – Data are firstly stored on a local server and, then are periodically uploaded to an online platform. The data can be analysed by software locally and on the online platform.

Generally, cloud-based solutions offer more capabilities and more value than local solutions. However cloud-based solutions are not recommended for time-critical applications. When real-time control is needed, such as control or demand-response related applications, a local or hybrid solution will be more suitable.

Assess the existing tools and software used within the factory

Businesses use software and platforms to record, manage and share information. Depending on the needs identified above, knowing what software is currently in use and how information can be shared are essential aspects of selecting software.

Moreover, some software providers offer extensions to their main software to integrate energy management capabilities. This represents a significant advantage in terms of ease of implementation, software compatibility and familiarity of staff with the user interface.

Be aware of existing software that might already integrate energy management tools.

Nevertheless, the software should be carefully evaluated prior to its implementation.

Evaluate technical and commercial software offerings

This guide focuses on the technical characteristics of metering-related software. The table below provides a list of some of the characteristics which need to be considered when evaluating software.

Item	Things to consider
Fit for purpose	• Is the software designed for a specific type of building, business or industry? • What are the facilities and energy services you want/need monitored? • Is it a monitoring tool only, or will it need process control capability?
Reporting abilities	• What is the extent of charting and reporting capability? • How flexible is the reporting package? • Are reports available for reporting against regulatory compliance?
Alerting abilities	• Are exception reports available via SMS and/or email? Note: It is not sufficient to detect a problem that has occurred in the past (for example, last week) that cannot now be rectified because too much time has elapsed and operations have moved on to a new ‘mode’. Alerting abilities are essential to allow immediate action when energy consumption reaches a certain threshold.
Remote access	• Is remote access available for collection and viewing of data and reports from mobile devices?
Operating system	• For what operating system is the software designed? • Is it compatible with the existing operating system of the site? • Does it need new hardware or software to be installed?
Adequate capacity of the existing network	• Is the current computer system and network able to run the software?

Item	Things to consider
Compatibility with other software and platforms	The integration between the software and other software can be a requirement. • Can the supplier conduct a detailed configuration study to make sure the software and hardware platforms can communicate? The risk of integration failure must be assessed and controlled.
Robust scalable platform	• How many meters or systems can be configured with the software? • Under what circumstances will the system become unstable?
Compatibility with routers and sensors	• Are the existing or proposed meters and routers able to communicate with the software?
Data storage	• Where will data be stored? • What are the space requirements? • What will be the need in the future? • Is exporting data off site worth considering?
Additional features such as: • identifies energy waste • identifies billing errors • suggests energy use improvement • offers process controls • anticipates energy usage • has capacity to report faults and events • makes seasonal, weekly, daily or hourly adjustments	According to the needs specified, will the software meet all minimum requirements?
User interface	• How intuitive and user friendly is the interface? • Can user access be provided for different levels of access?
Training	• What initial training is provided? • What ongoing training for existing and new users is provided? • Is there online training that can be accessed at any time?
Maintenance	• What are the maintenance requirements? • How often does the software need to be updated? • Does maintenance impact the operations of the software?

Item	Things to consider
Support services	• What is the stability of the tool? • What is the responsiveness of the support services? • Are support services local? • What is the experience of the support staff?
Security	• What are the protection systems of the software/hardware against viruses and malware? • Is there any record of hacking and software shutdown due to cyber attack?
Experience and reviews	• Can customer references be provided?
Extension of software capabilities	As your business grows, new capabilities might be useful. • Are extensions possible?
Data integration	• Can you add data from other software or older data from another database into the software? • Can utility-provided data be imported?
Data extraction	• Can you extract data from the software? • What is the flexibility of the data extraction system (can it be in a CSV file, or only PDF reports)?
Long-term commitment	• What is the operating history of the software service provider and how is support and maintenance assured for the years to come?

Appendix I: Checklist for selecting a data management solution

As outlined in Section 4.3, the three main technical options for a data management solution are:

A. storage on site
B. storage off site in a dedicated facility
C. cloud computing.

Use this form to conduct a comparison of the different technical options across some common areas.

Consideration	**Explanation**	**Option suitability**		
		A	B	C
Human and technical resources	Human and technical resources with specific abilities and knowledge are available to build, maintain and expand a robust data centre solution			
Data criticality	Solution addresses the risks for the business in case the data is unavailable or lost			
Location	Risks associated with natural or technological hazards are managed			
Ease of access	IT staff (either internal or external) are able to access the data centre to work on the software and hardware			
Physical protection	The data centre is protected against intrusion			
Redundant power	In case of power supply failure, the data centre has appropriate resources to secure the data (e.g. uninterruptible power supply)			
Efficient cooling	Cooling and a backup system is sufficient for extreme weather conditions			
Mechanical protection	The data centre is suitably protected against dust, humidity			
Technical considerations				
Data availability	The data is available at the desired frequency and in the required timeframes			
Storage volume	There is sufficient storage volume			
Bandwidth	There is sufficient bandwidth to handle the data flows for now and the future			

Consideration	Explanation	Option suitability		
		A	B	C
Software compatibility	The data storage system is compatible with software that will be used to send and extract data from the database			
Computer security	The data centre has suitable protection against viruses, hacking, spyware and other malware			
Service provider evaluation – selecting a data centre service provider may be a long-term commitment and can be critical according to the importance of the data stored				
Insurance	The service provider has sufficient insurances			
Experience, qualifications and references	The service provider has the human and technical resources to deal with all the aspects of a data centre			
Solid business continuity plans	The service provider is financially stable for the medium and long term			
Certification	The service provider has appropriate certifications to ensure the quality of management and security of the data centre			
Disaster recovery guarantee and process	Disaster recovery plans exist, are practised, and recovery guarantees are in place			
Response time	In case of failure, the response time is guaranteed			
Expansion capabilities	The data centre and service provider are able to manage the projected increase in storage needs			
Customer service	The service provider has a proven history of high quality customer service			
Contract considerations – for any involvement of third parties in the management and maintenance of the data centre				
Guarantees on service levels	Conditions and any guarantees on service provision are acceptable			
Agreement on penalties	The service provider accepts penalties if they do not reach the level of services stated in the contract			
Privacy policy	The service provider conditions regarding the protection of data are acceptable			

Appendix J: Process for applying for direct connection to a utility gas meter

The following process sets out how to request a data connection point at your utility gas meter on the Jemena Gas Networks (JGN) assets.

1. An end-customer requiring a connection should apply through their gas retailer (retailer='User').

2. The process for a User to apply for a connection is:

   2.1. The User initiates an application by completing and returning a document to JGN.

   2.2. The User provides to JGN a copy of its detailed design of the data acquisition equipment, connection components and other equipment to be installed proximate to the JGN meter set (Customer Interface). The detailed design must include an electrical schematic and general layout diagrams.

   2.3. The User provides to JGN four photos of the existing meter where pulse output is requested (front, back and side views of the meter installation with the photos provided in pdf format).

   2.4. After reviewing the detailed design of the Customer Interface, JGN will notify the User whether it is prepared to provide a connection between the JGN meter and the Customer Equipment. In the event that JGN is not prepared to provide a connection, JGN will provide an explanation for its decision.

   2.5. JGN invoices the User for the application and connection charge as a charge under the relevant transportation agreement.

   2.6. In the event that JGN is prepared to provide a connection, the User and JGN will agree on a time for JGN to attend the site to complete the connection. JGN will not attend the site unless the User notifies JGN that the Customer Interface has been installed and is ready for connection with the JGN meter.

   2.7. JGN will attend the site at the agreed time, verify that the Customer Interface complies with the detailed design, and make the connection with the JGN meter set. JGN will make the physical connection using the cable provided by the User from the input side of the intrinsic safety barrier to pulse-output. The User or end-customer must not touch or otherwise interfere with the JGN meter set.

   2.8. JGN will provide to the User with the value and units of each pulse after completion of the pulse output connection. [11]

[11] JGN Request for Demand Pulse Output Connection form 2014

Appendix K: Further reading

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