Energy Saver

Electricity metering and monitoring guide

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Foreword

This publication has been developed through an industry–government partnership between the NSW Office of Environment and Heritage (OEH) and the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH), the Facility Management Association of Australia (FMA) and the National Electrical and Communications Association (NECA).

Bringing together expertise from business, industry and government, OEH helps NSW businesses adopt energy efficiency initiatives and reduce their energy consumption and costs, while enhancing productivity. The OEH energy efficiency team has developed a suite of technology guides like this publication. These guides, which include resources on lighting, industrial refrigeration, compressed air, voltage optimisation, battery storage and cogeneration, are available free to download from the OEH website: energysaver.nsw.gov.au/business/equipment-and-technology-guides.

List of acronyms and abbreviations

ACP	accredited certificate provider
AEMO	Australian Energy Market Operator
AIRAH	Australian Institute of Refrigeration, Air Conditioning and Heating
BEEC	building energy efficiency certificate
BMS	building management system
CT	current transformer
DLF	distribution loss factor
DMA	direct metering agreement
ESCs	energy savings certificates
ESS	Energy Savings Scheme
HVAC	heating, ventilation and air conditioning
kWh	kilowatt hours
MDA	meter data agency
MLF	marginal loss factor
NMI	national metering identifier
NMI	National Measurement Institute
M&V	measurement and verification
NABERS	National Australian Built Environment Rating System
NCC	National Construction Code
OEH	Office of Environment and Heritage
PLC	programmable logic controller
RMRS	remote meter reading system
SCADA	supervisory control and data aquisition
TLA	tenancy lighting assessment
UPS	uninterruptible power supply
VSD	variable speed drive

See also the **Glossary**, page 41.

Contents

About this guide

This guide is for owners, facility managers and operations staff of commercial and industrial facilities.

The advice in this guide is relevant for both large and small facilities including office buildings, industrial buildings and laboratories, health and aged-care buildings, schools and educational facilities, shopping centres, retail buildings, hotels and data centres.

Will metering and monitoring benefit my business?

Metering and monitoring are now an essential part of good facility management, providing valuable insight into facility and equipment performance, and supporting better management of energy use and costs. Proof of improved performance via metering can be the key to unlocking increased property and product value.

Electricity metering and monitoring can help you to:

- operate your facility more effectively
- save energy, money and time
- target opportunities for improvement
- comply with regulations
- track and report your energy performance improvements
- secure funding for energy efficiency upgrades from government-backed energy efficiency schemes and third parties.

What's covered in this guide?

This guide explains how you can effectively procure and implement an electricity metering and monitoring system that will meet your needs and objectives.

- The **seven-step implementation plan**, along with tips and checklists, will help you to set goals, prepare budgets and business cases, define your requirements and successfully install and commission a metering and monitoring system.
- You can use the separate Request for Proposal Template to present your requirements to prospective suppliers and obtain suitable, comparable quotes.

The advice covers electrical meters and other related components that measure power in electrical circuits, log and store energy-use data, present information to the user through monitoring and data visualisation, and provide actionable feedback for facility managers via reports, alerts and control optimisation.

Resources for gas and water monitoring

This guide is not intended to be a resource for measuring and monitoring gas or water, although many of the same principles will apply. If you are considering implementing a metering and monitoring system for gas or water, it makes sense to consider the various systems at the same time.

For facilities with major gas-fired equipment and for industrial processes, guidance on thermal energy consumption, gas flow and temperature measurement and metering systems can be found in the OEH Gas Measurement and Monitoring Guide.

Project partners

- **Australian Institute of Refrigeration, Air Conditioning and Heating** (AIRAH) is an independent, specialist, not-for-profit technical organisation providing leadership in the heating, ventilation, air conditioning and refrigeration (HVAC&R) sector through collaboration, engagement and professional development. AIRAH's mission is to lead, promote, represent and support the HVAC and related services industry and membership. AIRAH has a reach of over 25,000 HVAC&R professionals across Australia and produces a variety of publications, communications and training programs aimed at championing the highest of industry standards. AIRAH encourages world's best practice within the industry and has forged a reputation for developing the competency and skills of industry practitioners at all levels."
- The **Facility Management Association of Australia** (FMA) is the peak national industry body for facilities management, representing and supporting professionals and organisations responsible for the operational management of Australia's built environments. FMA's mission is to inspire, shape and influence the facilities management industry and promote and represent the interests of facilities managers nationally and internationally.
- The **National Electrical and Communications Association** (NECA) is the peak industry body for Australia's electrical and communications contracting industry that employs more than 165,000 workers with an annual turnover in excess of $23 billion. NECA's more than 4800 members operate businesses across the Australian building, infrastructure and commercial construction sectors including the provision of these services to local, state and federal governments. NECA plays a significant role within the industry training sector, maintaining responsibility for the employment, learning and skilling of approximately 4500 apprentices who will develop into future electricians and contractors.

Why electricity metering and monitoring matters

There may be a variety of reasons for tracking and analysing your energy usage, depending on your situation. Your primary reason might be related to running costs, building performance, customer expectations, leasing obligations, production efficiency, continuity of service, sustainability goals or reporting and compliance.

From all of these starting points, accurate, up-to-date and usable information about your energy usage can open the door to a whole range of benefits and improvements relating to energy efficiency.

This section summarises these reasons and the benefits you could gain from electrical metering and monitoring.

Why electricity metering and monitoring matters

Manage your energy use with confidence

Improve energy management practices

- Set and achieve energy performance targets
- Benchmark your site and compare it with other facilities
- Establish an energy baseline and use it to estimate savings from energy-saving measures
- Identify unexpected increases in energy consumption
- Know the impact of each equipment item or area
- Monitor the impact of efficiency measures

Manage costs

- Track your energy expenditure
- Charge tenants for their electricity usage
- Track and report energy consumption for separate business units
- Validate retail energy bills
- Predict energy consumption for different operating profiles, e.g. according to weather conditions or production output
- Be alerted when your facility exceeds expected energy consumption
- Compare day-to-day consumption levels taking into account variables in weather or facility operation
- Mitigate peak demand (e.g. by controlling peak loads) and save costs in network capacity charges
- Build better business cases for your efficiency projects

Report on your energy performance

NABERS

- Collect information for your NABERS reporting

Green Star

- Attain points in the Green Star rating system

Corporate sustainability reporting

- Support participation in carbon abatement schemes and voluntary sustainability reporting schemes and meet corporate social responsibility targets

Energy savings certificates

- Gain a financial advantage – provide data for creation of energy savings certificates under the NSW Energy Savings Scheme

Measurement and verification

- Support measurement and verification using an internationally recognised approach (such as the Efficiency Valuation Organization's International Performance Measurement and Verification Protocol) to quantifying savings from energy efficiency improvements

Support financed solutions and grants

- Measure and verify guaranteed savings for energy performance contracts, building upgrade finance, or similar

Achieve regulatory compliance

Meters for billing or other transactions

- Support compliance with regulations on charging tenants or subtenants for electricity, or for using meters for other transactions

Commercial Building Disclosure Program

- Support your compliance with the Commercial Building Disclosure regulations, which include obtaining a NABERS rating

National Construction Code

- Ensure you comply with the energy efficiency requirements of the Building Code of Australia
- (Energy efficiency provisions [Section J] of the Building Code of Australia now form part of the NCC)

Operate your facility more effectively

Reduce risks and test technology

- Provide data on the impact of changes to facility operation
- Reduce implementation risks
- Accurately monitor and evaluate trials and proof-of-concept tests

Optimal facility operation

- Provide relevant information about your facility's operation
- Focus attention on equipment faults or incorrect operation
- Track the general health of your facility
- Reduce time spent on daily or weekly meter reads

Fault detection and diagnosis

- Detect drift in equipment performance
- Detect component failure
- Optimise equipment maintenance and replacement times

Building management and control systems

- Interface with any existing control and management systems, e.g. BMS, PLC, SCADA
- Expose inefficiencies in control settings and plant operation and extend asset life
- Identify opportunities for new control strategies, improved set points and active feedback

Manage your energy use with confidence

It makes sense to monitor your electricity usage as you would monitor any other input into your business, yet electricity consumption often does not receive the same scrutiny as material or labour costs.

The cost of electricity is a significant cost to many businesses. Environmental issues associated with the production of energy are receiving more attention from government and the public, and some organisations are setting significant energy and greenhouse gas emissions reduction targets irrespective of the actions of regulators. At the same time, the tools, techniques and systems available to businesses to identify waste and increase energy efficiency continue to improve and become more affordable.

Effective management of energy usage and costs is best achieved through an integrated approach, such as adopting an energy management system like *ISO 50001:2018 Energy management systems* (published by the International Organization for Standardization). The ISO 50001 Energy management system is based on a Plan, Do, Check, Act framework, in which metering and monitoring is a critical component:

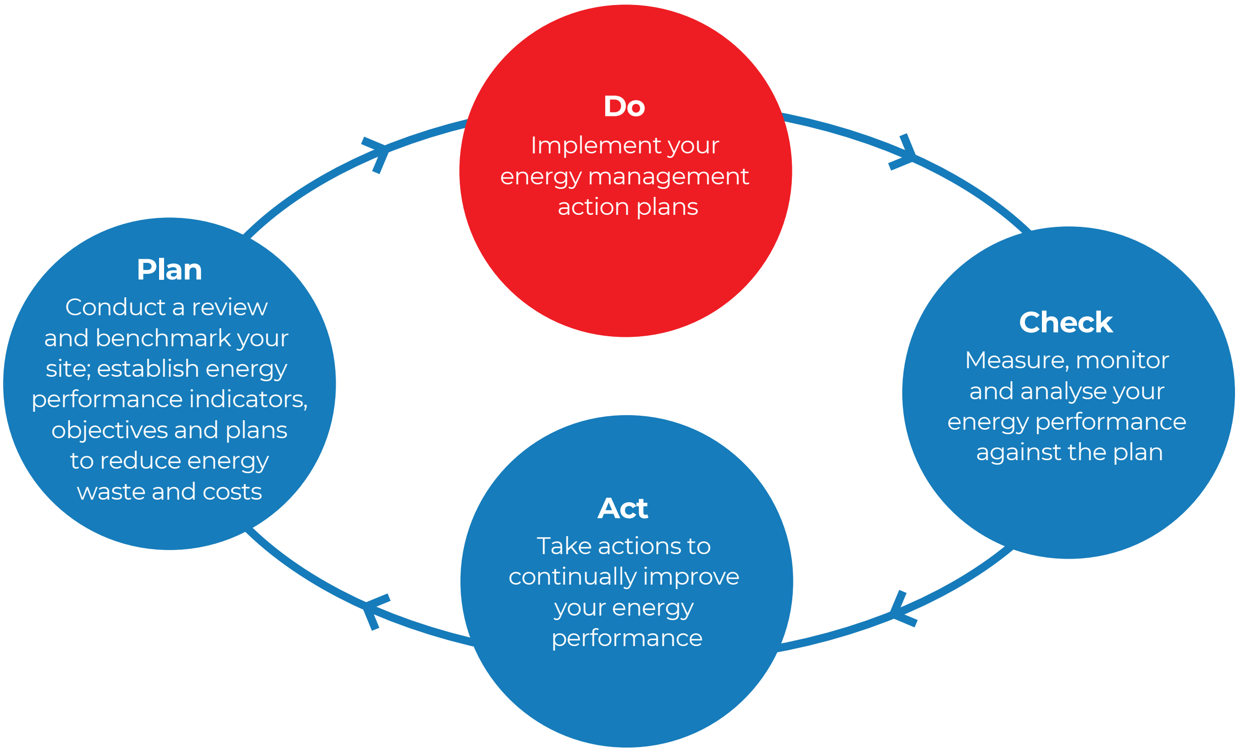


Figure 1: Energy management systems – the Plan, Do, Check, Act framework

Having good data from a metering and monitoring system provides you with the confidence to make the right decisions in your energy management plan and makes your job easier.

Report on your energy performance

National and international rating schemes allow you to compare energy performance across facilities and demonstrate where best practice has been achieved. While metering and monitoring is often not essential for participating in these schemes, it can lead to improved ratings through tracking performance and supplying more accurate information. Likewise, corporate and industry targets motivate businesses and facilities to continuously improve energy performance, and the availability of quality data is invaluable for this. Internal reporting of energy usage per unit of production, attendance, building area, or other metric, allows you to compare a facility's performance over time and against industry benchmarks.

NABERS rating system

NABERS is the National Australian Built Environment Rating System: a system that rates the environmental performance of office buildings and tenancies, shopping centres, hotels, public hospitals, apartment buildings and data centres. NABERS is administered by OEH on behalf of the Australian Government and all Australian state and territory governments.

Under the requirements of the National Commercial Building Disclosure Program, the NABERS performance of any commercial office space over 1000 square metres must be disclosed when it is leased or sold.

NABERS Energy ratings are calculated using various sources of information including energy bill data, revenue (Utility) meter interval data, and non-revenue (Utility) meter interval data (e.g. submeters). There are specific requirements set out in NABERS Rules for Collecting and Using Data that must be followed if data from a non-revenue meter is used for a rating. See **Appendix E** for the metering requirements relating to NABERS ratings.

Green Star rating system

Green Star is a voluntary, internationally recognised sustainability rating system for the design, construction and operation of Australian buildings, fitouts and communities. It is administered by the Green Building Council of Australia.

Green Star uses a 1- to 6-star scale to rate building performance according to a range of environmental impact categories, including energy. The rating system can be used to assess buildings throughout their life cycle, from design and construction to ongoing operation.

Electricity metering and monitoring can help you to gain points towards a higher Green Star rating. To be eligible to gain these points you must have an accessible metering system in place that measures common energy uses, major uses and sources. You can gain one point if you have a basic comprehensive monitoring strategy, and two points if you have a more advanced monitoring strategy. Your metering system must comply with a recognised metering guide, such as the Chartered Institution of Building Services Engineers (CIBSE) *TM39:2009 Building Energy Metering.*

Corporate sustainability reporting

Many organisations are now reporting on energy management practices, specific facility energy performance, or energy savings initiatives. Metering and monitoring systems can help make this reporting easier by collating disparate information from multiple sites, with some systems providing ‘live’ consolidated reports at a group level that are continuously available. Understanding the energy intensity of your facility or production process allows you to track and assess improvements in productivity and efficiency over time.

Voluntary sustainability reporting and benchmarking schemes exist internationally, such as the Australian Carbon Neutral Program, the Dow Jones Sustainability Index, and the Global Real Estate Sustainability Benchmark. Participation in these schemes can enhance your industry standing and brand exposure. Implementing suitable metering and monitoring schemes will help you to supply accurate energy data and improve your ratings with these schemes.

Energy savings certificates

The NSW Government Energy Savings Scheme (ESS) creates financial incentives for organisations to invest in energy savings projects in New South Wales. The scheme is based on a system of energy savings certificates (ESCs) that are created by saving energy, and can then be sold. You can use this to offset the cost of new equipment or upgrades.

To reap the benefits you need to work with an accredited certificate provider (ACP) who will create ESCs on your behalf and then register and trade them. To measure the energy savings you may need to have a system of measurement and monitoring in place. The ACP may require meter data to measure and verify your energy savings.

One ESC is equivalent to one notional megawatt hour of energy saved. The ACP will calculate your energy savings and determine the number of ESCs created. This varies depending on the technology used to save the energy.

The price of an ESC is open to market fluctuations. Typically the ACP will negotiate with you to retain a proportion of this price to cover their expenses. For more information visit the Energy Savings Scheme website (see References and further reading), which includes a list of accredited certificate providers**.**

Achieve regulatory compliance

Several Acts and associated Regulations may require your organisation to provide metering within your facility to a certain standard and configuration. Below are a few of these obligations.

Note: This advice is provided as general information only and is not a substitute for the advice of technical and legal professionals. You should seek appropriate and up-to-date advice when applying this information to your specific needs.

Meters for billing or other transactions

Any meter used for trade purposes (understood to be for a transaction or other billing purpose), must have been granted 'pattern approval' by the National Measurement Institute and must be verified. For example, if you own a facility with a tenant and you charge the tenant for their electricity usage, the energy billed in this transaction requires use of a meter that is pattern-approved and verified. Refer to **Appendix F** for more information on 'pattern approval' and meters for trade purposes. **Appendix F** provides more information on metering requirements for on- and off-market electricity users, including embedded networks.

National Construction Code requirements for energy monitoring

The National Construction Code (NCC) requires that building construction or renovation that requires a construction certificate (except Class 1 Residential and Class 10 non-habitable structures) incorporate facilities for energy monitoring. The requirements range from simply having a facility that records consumption of electricity and gas coming into the building, to separate monitoring of:

- heating, ventilation and air conditioning (HVAC)
- lighting
- appliance power
- hot water
- internal transport devices (lifts, escalators, travelators).

Commercial Building Disclosure Program

The Australian Government Commercial Building Disclosure (CBD) Program requires most sellers and lessors of office space of 1000 square metres or more to obtain a Building Energy Efficiency Certificate (BEEC) before the building goes on the market for sale, lease or sublease.

BEECs include the building's NABERS Energy for offices rating and a Tenancy Lighting Assessment (TLA) of the relevant area of the building.

Some facilities will require submetering to enable an accurate and compliant NABERS rating to be performed. Submetering allows a facility to quantify energy for areas that can be excluded from the rating calculation (non-rated areas), which may improve the NABERS rating.

Under the NABERS rules, meters must be installed, validated and be measuring the correct circuits before metering for exclusion is permitted.

Operate your facility more effectively

Electricity metering and monitoring have additional benefits that can help improve the overall operation of your facility, beyond managing energy usage and costs.

Optimising your building management and control system

Building management systems (BMS) and supervisory control and data acquisition systems (SCADA) are valuable systems for the efficient operation of your facility and processes. Often, they have complex interfaces, and non-routine uses of the system require support from a controls contractor. Some electricity metering and monitoring systems can be configured to extract, track, and report on data from your BMS or SCADA. Done well, this can improve your awareness of overall facility operation and performance. Some energy management platforms offer direct control feedback to a BMS to optimise equipment settings and operational schedules.

An electricity metering and monitoring system has the potential to:

- interface with the BMS and SCADA, and other programmable controllers
- expose inefficiencies in control settings and plant operation
- identify opportunities for new control strategies, improved set points and active feedback
- mitigate peak demand and save costs in network capacity charges.

Optimising facility operation

Correctly implemented and utilised electricity metering and monitoring systems will provide you with targeted information about your facility's operation.

It is widely accepted that real-time or near real-time energy consumption data exposes you to patterns and changes in your facility's performance. Monitoring this information, even at a high level, may alert you to unexpected operation of equipment, plant failures or incorrect equipment settings.

Tracking and reporting on your facility's energy consumption, especially in conjunction with an energy management plan, may alert you to the general operational health of your facility.

Facility staff often spend time conducting daily or weekly meter reads and compiling the information in spreadsheets and reports to management. An electricity metering and monitoring system may replace the need to conduct physical meter reads and automate the process of collecting data and reporting.

Detecting and diagnosing faults

Electricity submeters record a lot of data that can be used as a proxy to detect faults in other equipment. For example, when motor currents are lower or higher than the long-term average, this can indicate motor failure, wear and tear, or some other fault. Excessive energy consumption by a piece of equipment outside operational times may indicate component failure (such as timer controls), or changes in the nature of the operations.

Submeter data can therefore be used to optimise equipment maintenance and replacement, as well as detecting drift in equipment performance

Steps to implementing electricity metering and monitoring at your site

This guide sets out seven simple steps to help you clarify your requirements for electricity metering and monitoring, determine what information you need to review and provide to a supplier, determine what to meter and how, and successfully implement and commission an effective electricity metering and monitoring system. Following these steps, and using the separate Request for Proposal Template, will enable you to provide accurate information to suppliers and evaluate their responses. The seven steps are illustrated in Figure 2.

Step 1 – Set your goals	**Step 5 – Develop a business case**
Step 2 – Understand your current situation	**Step 6 – Implement**
Step 3 – Investigate costs	**Step 7 – Monitor and review performance**
Step 4 – Investigate and choose solutions	

Figure 2: Steps to implementing an electricity metering and monitoring system

Step 1 – Set your goals

Write down your primary goals: what do you want to achieve from electricity metering and monitoring? For example, your goals might be to:

- manage energy costs and wastage
- track and improve your NABERS rating
- understand your costs of operations and production
- better allocate costs to business unit or tenants in a facility
- improve asset management
- identify energy saving opportunities
- evaluate energy savings from an upgrade project (measurement and verification)
- create energy savings certificates for a project.

Being specific will help you determine the success of the project. It will also help you keep the procurement process focused on obtaining a system that meets your needs.

Step 2 – Understand your current situation

Review your annual electricity use and cost

Understanding your annual electricity use and cost is the first step to determining potential savings from better managing energy use. Your potential savings will help you work out how much to invest on an electricity metering and monitoring system. You can start by looking at one year of electricity bills. See **Appendix B** for information about how to read and interpret your bills.

More detailed 15- to 30-minute electricity data is available for large market customers (using more than 160 megawatt hours a year) and some small market customers. This data can be requested directly from your electricity retailer, or by viewing or downloading data through your electricity retailers' web portal.

Check if you already have a direct metering agreement

Before buying an electricity metering and monitoring solution, check whether you are already directly paying a meter data agency (MDA) for data collection and analysis services, and what you are getting for your money. This should be noted in your current electricity contract or recent bills.

If you already have a direct metering agreement (DMA), contact your MDA to find out what services they can offer. Many MDAs install and maintain electricity meters, provide web-hosted platforms that allow you to visualise and download revenue meter data on energy use and peak demand, and some provide data on greenhouse gas emissions for environmental reporting.

If you are currently not paying for this service, a good time to investigate a DMA is when you are negotiating a new retail electricity contract.

TIP 1: Consider entering a direct metering agreement with a meter data agency for the provision of data from your revenue meter.

Identify knowledge gaps

Review your current system for tracking energy expenditure. Write a list of information you would like to have about your facility, and how metering and monitoring could help fill these knowledge gaps.

Review any past energy audits and energy management plans. These can provide valuable insights into where and how energy is being used in your facility and where there are metering gaps. This information can feed into design specifications for a new metering and monitoring system.

Energy audits will also identify opportunities for improving energy efficiency. You may want to consider specific metering and monitoring that will help track savings on current or future projects. For example, an energy audit may identify a major HVAC upgrade for which you want to track the energy savings.

Understand electricity infrastructure

As part of this process, to gain a better understanding of your facility, you should review or update the single-line electrical diagram of your site. A single-line diagram maps out all the major electrical connections in a facility, including transformers, main switchboards.

Locate existing metering equipment

Locate any existing meters and assess their condition, including the site revenue meter (usually located near the incoming supply), switchboard meters and tenancy meters. Review the site's existing BMS and assess whether it can present or export energy consumption data, or be upgraded to do so.

Switchboard meters

Often, newer switchboards and distribution boards will include small multifunction meters in the design. These meters provide real-time display of commonly required parameters, however, they may lack data logging capabilities. The meters may have a communications interface built in that can be integrated into a broader submetering system.

Photo: OEH

Figure 3: Panel meter installed in mechanical switch board

Variable speed drives

Electricity use can be reported from variable speed drives (VSDs) that are often used to run motors on pumps, fans, gas burner fans and lifts. The unit may have a small display which can be configured to display – or output to a BMS – current, frequency, speed or power. Though less accurate than a revenue meter, this can give a reasonable estimate of consumption. You may need to purchase additional parts for your VSD to activate this capability.

Photo: OEH

Figure 4: Navigating VSD menu to access power parameter

Existing BMS or SCADA systems

Larger facilities often have some form of BMS that will monitor and operate air conditioning equipment, lighting, site processes, and other building systems. Historically BMS have been used for engineering and maintenance functions, and typically do not have simple user interfaces for displaying energy consumption data or providing reports, but this is changing. Speak with your control system contractor to get a better understanding of what can be obtained via your existing BMS.

Your facility might have a SCADA system for managing process equipment such as motors, pumps, fans, industrial equipment, etc. As with a BMS, consult with the control system contractor or site operators to see if this system can be cost-effectively configured to read and record electricity consumption from submeters in the equipment, or send data to third-party systems.

It is also valuable to understand what production parameters your control systems can log and export to a monitoring system to enable energy consumption to be viewed in the context of changes to operations.

Photo: Elana Clark Photography/OEH

Figure 5: Accessing metering and other data recorded in Aquatic Centre SCADA system.

Electronic circuit breakers

Electronic circuit breakers are designed to monitor electrical current and cut power when current rises above a pre-set limit to prevent overloading of circuits. Some electronic circuit breakers can be interfaced to a metering system to report this current. The metering system can then be used to monitor and display current over time and infer energy use just like a meter. It is likely they will not be as accurate as a dedicated meter, however, this can give a reasonable estimate of consumption.

Photo: Elana Clark Photography/OEH

Figure 6: Electronic circuit breaker capable of monitoring electric current.

Update your inventory of plant and equipment

Knowing what equipment you have in your facility helps you quantify your total meter requirement, obtain the right meters, and target areas of large energy consumption.

Your facility may already have a complete inventory of plant or schedule of equipment; if this is the case review it to confirm it is up-to-date.

If there isn't an existing inventory or schedule, this should be established as a priority. Document the major energy consuming equipment at your facility, taking care to document the rated capacity, make, model, and age of the device. This information is usually available on the unit's nameplate or in the operations manual.

Consider engaging an expert to conduct an energy audit of your site or conduct an energy balance analysis, demonstrating the relative contribution of each equipment item to overall site consumption.

TIP 2: Temporary meters and data loggers can be a cheaper way to collect data and prioritise capital expenditure before installing a permanent meter. Temporary meters that clamp on existing circuits do not cause any disruption to equipment and can provide reasonable estimates of energy consumption. Depending on the measurement parameter sought and the variability of site operation (e.g. daily and seasonal changes) temporary metering can be conducted over a period of minutes to months. Both permanent and temporary meters and data loggers must be installed by a licensed electrician.

Step 3 – Investigate costs

Budget considerations

Once you have an idea of why you want to implement electricity metering and monitoring, and have gained a better understanding of your current situation, the next step is to consider what the likely costs will be and prepare a preliminary budget. Consider all aspects of meter installation and how the data will be captured and used.

Table 1 summarises the cost items that could be associated with an electricity metering and monitoring system. Of particular interest are the upfront hardware and software costs, and any subscription fees paid over time.

Table 1: Cost considerations for a metering and monitoring system

Costs	Description
Project management	Even if there is a single contract for supply and installation, someone will need to manage the project, manage communications, ensure the supplier meets contract specifications, and the system is fully implemented as planned.

Equipment and installation	• Purchase of the meters and associated equipment • Work needed to physically install the meters and associated components into the system, e.g. meter panels, wiring, CT locations, hazardous material removal or area protection • Disruptions to tenants, operations or production and planning related to the meter installation • Integration with data storage and management systems (data cabling, computers, software licences) • Removal costs if necessary
Maintenance and validation during the life of the meters[1]	• Maintenance (inspection and replacement of components or sensors) • Validation and testing of meters to confirm correct readings
Data collection and storage	• The preferred energy management and monitoring software or service and subscription fees • Storing the data • Making data available for various analysis or reporting systems
Ongoing data analysis and reporting	• Procedures, systems and people to interpret and use the data acquired from the electricity metering and monitoring system
Training and allocation of responsibility	Training is often undervalued, underfunded or, at worst, forgotten. Unless staff receive adequate training on the use of the system, the data may not be used and many of the projected savings may not be realised.

Actual capital costs and subscription fees for an electricity metering and monitoring system will vary depending on the nature of your facility, your needs, and the equipment supplier chosen. See Table 2 for guidance on expected costs for the components of a metering and monitoring system.

Table 2: Indicative costs for a metering and monitoring system

Item cost per unit	Cost range
Basic meter	\$200 – \$800
Power quality meter	\$1000 – \$5000
High accuracy billing meter	\$2000 – \$5000
Solid core current transformer	\$20 – \$500 (size dependent)
Networking equipment (total)	\$2000 – \$10,000
Installation (per meter)	\$500 – \$3000
Software or online platform annual subscription fees (per device	\$100 – \$300
Software or online platform subscription fees (set-up price)	\$1000 – \$2000

1 See Step 6 for more information on maintenance and validation requirements

Step 4 – Investigate and choose solutions

Consider how information will translate into taking action

Metering only has value if the data it provides can translate into meaningful and actionable feedback. Consider how your staff would like to view and interact with the information. This should align with your goals and will influence the type of system you buy.

Data presentation formats include:

- online portals
- real-time data feed
- daily and monthly email reports
- email and phone alerts
- web and mobile application notifications
- interval data exports (e.g. as comma-separated value [CSV] or Microsoft Excel [XLS] files).

The installation of more meters may not be the best way to solve a lack of information about energy consumption. Instead, it might be more effective to implement a simple monitoring and reporting system using existing data.

Figure 7 presents the necessary hierarchy of information whereby data is transformed into information, insight and then taking action.

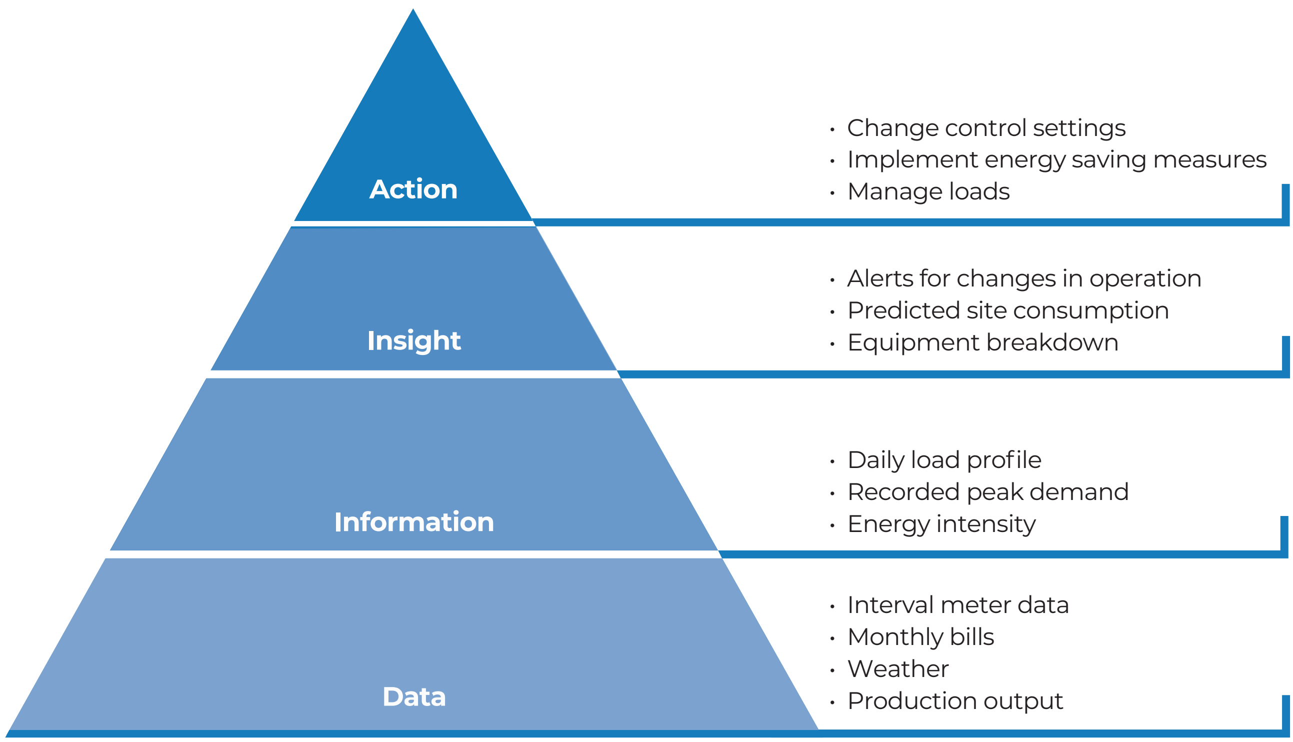


Figure 7: Hierarchy of information, from metering and monitoring to taking action

Review energy management and monitoring platforms

Energy management and monitoring platforms range from the very simple to the very complex. While the idea of 'big data' and 'intelligent' systems might be attractive, in practice your need might be for a simple online portal, or an email or SMS alarm or reporting system. The options for managing and monitoring data include:

- **User-implemented systems:** At the most basic level you can choose to collect data from a logger or hub and store the data in your own database. Data can be viewed in real or near-real time.
- **Third-party meter data collection and visualisation systems:** At a slightly more complex level, providers of metering hardware or meter data agents can offer basic 'off-the-shelf' software which you can use to interpret and monitor electricity usage. Sometimes this is real-time, but often it is at least day-old data.
- **Energy intelligence platforms**: At the most complex level, dedicated energy intelligence and analytics service providers offer platforms which capture data across multiple sources, including metering devices, temperature sources, other sensors and billing data; present the data with real-time monitoring, visualisation and reporting; interpret data in analytics engines; and even provide active control and system optimisation.

Use the Request for Proposal Template to help decide which energy management software or energy intelligence platform is right for you.

TIP 3: At a minimum, look for energy management software or an energy intelligence platform that has the following features:

- a tracked historical record of consumption
- a portal and graphical user interface for quickly visualising energy data
- automated basic reports of energy usage, at a manageable resolution, e.g. daily.

Compare data storage options

Over time, metering devices generate a significant amount of data that needs to be collected and stored in a database. For energy management, data covering several years are a valuable source of information. As such, ongoing data management is an important part of a metering system and your overall energy management practices. The database can be stored in a computer or data centre that may be on or off site.

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

- **storage on site** – data and hardware are located within the facility
- **storage off site** – data is stored in a dedicated facility, e.g. data centre
- **storage in the 'cloud'** – data is stored on a hosted cloud service; everything is outsourced to a third-party data centre provider (the actual data centre can be virtually anywhere)
- **energy management service provider stored and managed** – responsibility for data collection and storage is given to an energy management service provider, who will either store data on a local server or a remote server, or use a cloud service. Typically, an energy intelligence platform will include data handling by the service provider, who will aggregate and store data in a remote server. Interval data can be exported from their system when needed.

TIP 4: If using a third-party service to store and manage your data, ensure you are comfortable with the data ownership arrangement and you are able to retrieve a complete archive of your interval data.

Set a boundary

To help define the scope of your project, draw a boundary around the services, facility, campus or portfolio of facilities you wish to meter using a single-line diagram, or plan layout of the facility. Consider what equipment exists within this boundary and the energy flows imported and exported across this boundary. This will help you to review the information you collected at **Step 2**.

Using this boundary and your goals and requirements, decide how many new meters you require and where these should be located.

Specify your metering and monitoring system

Figure 8 illustrates the typical components of an electricity metering and monitoring system.

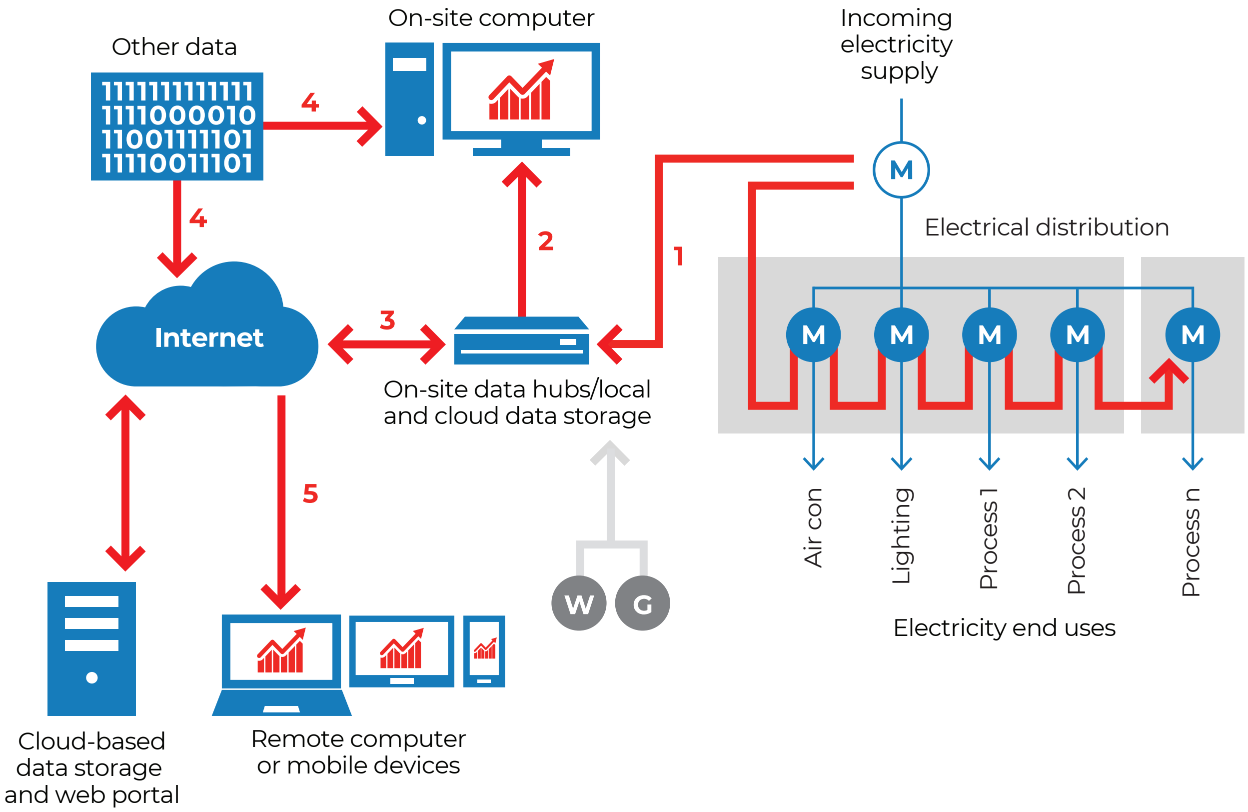


Figure 8: Typical components of an electricity metering and monitoring system

Legend:

M	Electrical utility meter – used by the electricity retailer for billing. In many instances electricity consumption data can be extracted directly from the existing utility meter to give an overall picture of site electricity usage. Additional hardware may be required to enable this.
M	Submeter – a device that physically attaches to an electrical circuit directly or via current transformer to permit the energy consumption of individual subsystems and equipment to be monitored. These are typically solid-state meters (see **Appendix C** for definition) with no moving parts, have a digital display, and an interface for electronic communication.
→	Site electrical distribution infrastructure (i.e. cables and switchboards)
→	Electronic communications link:

1 Industrial communication wiring and protocals (e.g. Modbus over RS485) can connect a number of meters to a hub where the data is aggregated. Wireless technology may also be used (e.g. wifi and Zigbee). Utility meters provide a signal in the form of electrical pulses. Each pulse indicates a predefined quantity of electrical energy (e.g. 1 pulse = 0.1kWh). Additional hardware is required to transform these pulses into a form suitable for communication over the submetering communications network. Approvals may be required from the electrical network operator to connect the utility meter to the submetering communications network.

2 Ethernet/wifi computer network allows the submeter data to be accessed by any computer connected to this network. An existing network can be used or a dedicated network established. The software installed on a connected computer may be used to process the data for viewing and analysis.

3 Telecommunications carrier link (wired, mobile wireless) to allow the data to be communicated over the internet. An existing telecommunications link may be used or a dedicated link established.

4 Other information from a variety of sources can be integrated into the metering and monitoring system to assist with analysis. Common sources of additional information include weather (i.e. temperature, humidity), status of plant and equipment and production/service level metrics).

5 Specialist providers offer a variety of cloud-based analytical and data management services. The services are accessed via a web portal.

W G	Water and gas meters are frequently included with electricity meters (water and gas metering is outside the scope of this guide).

Choose meters and measurement parameters

Choose the meter systems that are appropriate for your needs. Meters can be grouped into the following categories:

- **Electricity billing meters** – meters that are pattern-approved by the Australian Government National Measurement Institute for trade use. They are used by utility companies to record your site or facility's electricity consumption. Their accuracy can vary depending on the application, and this influences the cost of the unit.

Photo: OEH/North Sydney council

Figure 9: A utility meter

- **Basic power meters** – cost-effective multifunction electronic meters with a digital display and the ability to output data to a logger.

Photo: OEH/North Sydney council

Figure 10: An electrical meter

- **Power quality meters** – high-end meters that can analyse power events and store this information for future reference. They have onboard data logging capability and are highly accurate.
- **Soft meters** – equipment sensors, such as chilled water temperature and fan speeds, controlled in a BMS, can be read by an energy management platform and translated into electricity consumption data using known information about the equipment. Soft meters tend to be less accurate than a physical meter, but do not require additional capital cost.
- **Virtual meters** – energy flows in one circuit can be determined without the use of physical metering in that circuit. These flows are calculated from flows in upstream and adjacent circuits. Figure 11 shows that energy flow at the virtual meter **D** can be calculated subtracting the energy flow at meter **A** by the energy flow at meters **B** and **C**.

  In a metering system, the results of this calculation are represented as being reported by a 'virtual meter'. Virtual meters reduce the number of physical meters in an installation, therefore reducing installation costs. However, all meters used in the calculations must be accurate and functioning correctly for the virtual meter to operate correctly. Identifying malfunctioning meters is difficult when virtual meters are used, as reconciling downstream meters with a parent meter upstream is not possible.

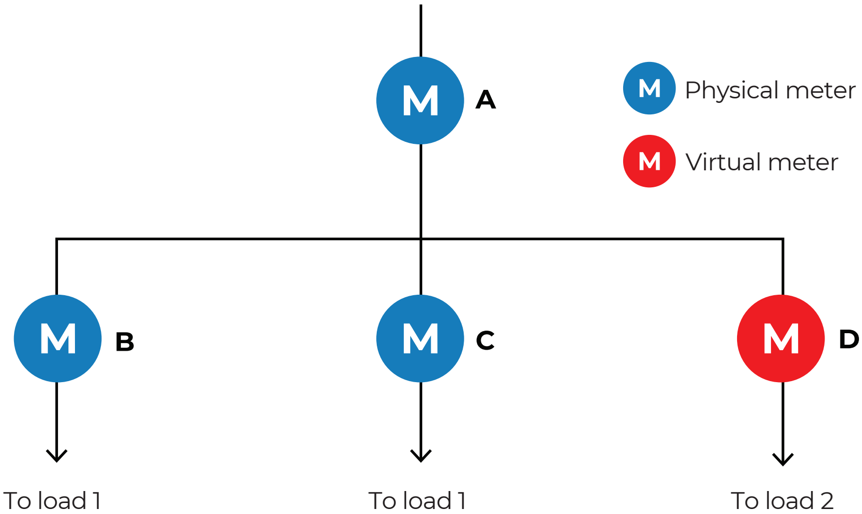


Figure 11: Single-line diagram noting physical and virtual meters

Advice on precisely what to meter and how is outside the scope of this guide. A metering solution should be tailored to organisational goals, available resources and the nature of the facility to be monitored. Table 3 outlines a few scenarios as examples and indicates what types of metering and monitoring systems may be appropriate for each.

Table 3: Which metering solution is right for you?

Your situation	Suggested metering hardware	Data platform and monitoring service
Small business (electricity use less than 10,000kWh/month)	Contact your electricity retailer to see if you can access the interval data that your site's electricity meter may be collecting. If not, ask if your utility meter can be upgraded to support the recording of interval data. Request access to this data via the retailer's online portal. Consider installing temporary clamp-on meters to dedicated circuits and monitoring usage. Licenced electrician must install temporary clamp-on meters.	Self-monitor or access a basic retailer or meter data agency online portal.
Large business (electricity use greater than 10,000kWh/month) with one or two buildings and multiple items of plant equipment	Basic power meters at distribution and subsystem level, with a data logger and local or remote storage. Consider integrating soft meters from your BMS or SCADA.	Use energy management software or an online service to view high-level aggregated metrics (e.g. daily, monthly total and sublevel consumption) and export more detailed data for further analysis.
Single facility with separate cost centres or tenants that are billed for consumption[2]	Revenue-grade, pattern-approved meters at point of supply to tenant. See **Appendix F**: Meters for billing purposes.	Engage a meter data agency or other suitable service provider to produce monthly billing reports, or access data from energy management software and generate your own billing information.
Large commercial or industrial building with multiple sensitive equipment critical to functioning of the facility, and integrated building management systems	Power quality meters at equipment level, with a dedicated energy management system, or upgraded BMS.	Engage an energy intelligence platform provider or other suitable service provider to analyse and report on performance, identify opportunities for efficiency improvements and implement solutions.
Organisation with a large portfolio of buildings under management (e.g. local government, multi-site commercial property owner)	Basic power meters at site level, distribution and subsystem level, with data logger and local or remote storage for the larger facilities. If you will be charging tenants for energy use, see **Appendix F**: Meters for billing purposes.	At a basic level, use your own or third-party energy management software or online portal to view high-level aggregated metrics (e.g. daily, monthly total and sublevel consumption). For large portfolios, engage an energy intelligence platform provider or energy management company to analyse and report on performance, identify opportunities for improving efficiency and implement solutions.

2 Embedded networks (i.e. where tenants buy power directly from an embedded network manager) have additional regulatory requirements.

See **Appendix C** for more information about types of electricity meters, and meter accuracy classes. You need to choose a meter accuracy level that is appropriate for your needs.

See **Appendix D** for general guidance on what to meter when the primary goal is to identify wastage and improve energy efficiency.

Tip 5: Specify a meter that complies with Australian Standards (see **Appendix A**).

Electricity supplied to a facility may be single-phase (230 volts) or three-phase (400 volts) power. Measuring single-phase power will require a single-phase meter and measuring three-phase power will require a three-phase meter.

For high-load circuits, a meter operated by a current transformer (CT) may be more appropriate. Meter providers may need to access parts of the switchboard to install solid-core CTs, or install lower cost, lower accuracy split CTs.

Photo: OEH/North Sydney council

Figure 12: Solid Core CTs around bus bar

Electricity meters used for assessing energy savings or quantifying total energy use should include a voltage reference to ensure that both voltage and current are measured. Meters that do not include voltage measurement, i.e. use an assumed voltage, may not provide accurate consumption measurements for equipment where the voltage varies from the presumed value.

Consider what information you require from your metering system, including the resolution of the data. For practical reasons (storage and resolution needs), a meter capable of producing interval data at 15 and 30 minute resolution should be sufficient. However, if you are planning to implement demand response, load management or real-time fault detection, you will need a meter capable of generating higher resolution data.

Submeters should have some onboard storage for data logging, in addition to the local or remote data storage hub, to avoid data loss in the case of temporary communications failures or outages.

Connectivity options

Meters will typically transmit data via a pulse or serial output, either by cable or wirelessly. The best solution will be customised to each site and each location within the site.

Meters using widely supported communications protocol such as BACnet and Modbus are often preferred by specifiers as they allow the meters to be interfaced to a wide variety of third-party equipment and systems.

See **Appendix C** for more information about network communication protocols and connectivity options.

Tip 6: Specifying the use of meters that support the popular BACnet or Modbus communication protocols will allow a wide variety of third-party devices to interface directly with the metering system.

Step 5 – Develop a business case

Formulating a compelling business case that sets out the costs, benefits and risks of an electricity metering and monitoring system is often the key to winning support for the system from senior management and other stakeholders.

When preparing your internal business case, think about:

- your initial budget – revise the proposed metering and monitoring solution if required
- whether you have clearly defined your goals and needs, using the steps in this guide
- who in the organisation is going to approve the electricity metering and monitoring plan (stakeholders)
- who will benefit from its implementation (allies)
- what reporting will be required (e.g. will you need exception-based or continuous alarming when parameters drift out of pre-set boundaries)
- who will be responsible for the monitoring
- who will act if energy use is higher than expected
- the value of the investment and savings expected.

Tip 7: Undertaking a trial period of a monitoring platform or installing a small number of meters as a test case, before a larger roll out, can provide concrete evidence of the system value and potential savings. This can be used to develop a more robust business case and justify more comprehensive metering and monitoring systems.

Quantify potential savings

Estimating the potential savings from the proposed electricity metering and monitoring system can be difficult as there are so many variables that are site-dependent. However, there is some industry research that can help your business case:

- The *Low Energy High Rise Building Research Study*, conducted by the Warren Centre in 2009, found that buildings with energy metering and monitoring, personnel training, and better knowledge of and reporting on energy usage, could achieve a NABERS energy rating improvement of between 0.5 and 4 stars, leading to total performance improvement of between 10 to 30%.
- Research presented in the *Zero Carbon Australia Buildings Plan*, published by Beyond Zero Emissions in 2013, indicated that the introduction of energy metering and management, coupled with appropriate training and guidance, could lead to average improvements of between 5 to 15%, and in some cases 40% savings.
- The 2006 US Department of Energy Federal Energy Management Program provided guidance on potential savings from energy metering.

Information from the above sources has been adapted for this guide in Table 4.

Table 4: Indicative savings from implementing electricity metering and monitoring

Action	Typical energy savings	Savings mechanism
Installation of meters only	0 to 2%	Awareness that consumption is being monitored; savings not likely to persist
Enhanced billing and allocation	2 to 5%	Improved awareness, ongoing
Feedback on consumption and facility tune-up	5 to 15%	Improved awareness, and identification of opportunities for simple operational and maintenance improvements
Real-time feedback and continuous commissioning	15 to 30+%	Improved awareness, identification of opportunities for simple operational and maintenance improvements, implementation of energy efficiency projects with verified results, continuing management attention

There are other beneficial cost reductions from implementing your metering and monitoring system that should also be considered, including:

- reduced staff time identifying and diagnosing faults
- reduced maintenance costs
- potential creation of energy savings certificates for efficiency projects
- cost recovery from charging tenants for electricity
- reduced maximum demand and peak capacity charges
- reduced staff time undertaking manual reads of meters for reporting or billing purposes.

Step 6 – Implement your new measurement and monitoring system

Procurement

Use the separate Request for Proposal Template provided with this guide to develop a technical specification suitable for requesting offers from suppliers. You may need additional advice from a technical expert.

Include photos of main switchboards and any equipment you wish to meter, as well as single-line diagrams for your site.

Check that equipment warranty terms are provided in the proposal responses. Consider also how you would like hardware maintenance to be handled, and whether you want this to be included in the service provision contract.

Installation

Develop an installation plan which considers:

- **Procedures** – What procedures need to be followed in this installation? Are all subcontractors inducted and permitted on the site?
- **Schedule** – Installing meters will require the shutdown of electrical supplies. Determine the most suitable time for this to occur so that disruption to business activities is minimised. Will this incur penalty rates for installers? Are there any periods when installation can or can't occur, e.g. scheduled plant shutdowns?
- **Ancillary works** – Consider additional electrical works that need to be undertaken before metering can proceed, such as installation of new meter panels, modification of switchboards to ensure compliance with Australian Standards, installation of meter current transformers and voltage transformers (for high-voltage metering applications), and installation of data cables to transmit metering data.
- **Supervision and inspection** – Establish who will be responsible for supervising installation works and ensuring major milestones are met and sighted.
- **Safety and compliance** – How will the installation be completed safely? Request evidence of a work health and safety management system and ensure contractors complete safety induction for the site. Ensure that appropriate certificates are sited and recorded, e.g. licenced electrical contractors, construction white card. SafeWork NSW has tools and resources to help small **and** large businesses manage work health and safety.
- **Documentation** – How do you want the installed system to be documented? What information will you require from the metering and monitoring supplier and installer? Typical documents include electrical drawings, specification sheets, network diagrams and manuals.

In addition to the above safety considerations there are some specific safety considerations for metering electrical connections. These are:

- **Current transformers (CTs)** – these are coils of copper that, due to their physical design, store significant electrical energy. When being disconnected from the metering circuit this energy needs to be discharged in a controlled manner to avoid an electric arc that can cause injury or equipment damage. This is commonly achieved using special CT terminals which allow the CT to be manually discharged with a shorting bridge before electrical disconnection. The use of split-core CTs allows the installation or replacement of these CTs without the need to disconnect the mains cables or cut bus bars.
- **Installation** – all voltage connections should be fuse-protected to allow isolation.

Tip 8: 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 and any required electrical shutdowns agreed to and scheduled), will help you to develop a realistic schedule. A Gantt chart is one way to visualise how the tasks link together and produce a probable timeframe for final delivery of the project.

Requirements emerging from this installation plan should be included in the contract conditions and brought to attention of the successful contractor in the initial project briefing meeting.

Commissioning

Commissioning is critical to ensuring the successful implementation of your metering and monitoring system. Inadequately commissioned systems can lead to errors that aren't discovered until months following installation, such as CTs being installed in reverse direction leading to incorrect current readings.

Before equipment and switchboards with meters are re-energised, the contractor must carry out commissioning tests in accordance with AS/NZS 3000 Wiring Rules and any other relevant codes. A certificate of compliance for electrical work for the installation must be provided by the contractor. See **Appendix G**: Installation and commissioning tests and checklist.

Staff training should be provided by the successful contractor, including operating and safety procedures. As-built hardware (including operation and maintenance) manuals should be provided, and electrical drawings including updated single-line diagrams where relevant.

You also need to consider how the metering and monitoring system performance will be validated post-commissioning, and make allowance in the contract for fine-tuning.

Photo: Shutterstock

Figure 13: Verifying voltage readings

Tip 9: The following information should be provided by the metering company and stored for safekeeping in your facility records:

- meter accuracy class
- meter K factor
- CT ratios and type (solid- or split-core)
- meter location, metered circuit, meter model and serial number, and static IP address if networked.

Operation

Introduce energy management into the position description of an existing or new staff member and make it their responsibility to monitor the information from the electricity metering and monitoring system. Ensure they have access to a technical support person from the electricity metering and monitoring system provider, and receive ongoing training when any system updates take place. See **Appendix H**: Operations checklist.

Develop the required reports and alarms from the system and ensure these continue to be sent to your facility in the advent of staff changes.

Testing and validation of your metering system depends on the type of meter and usage:

- Revenue meters used in the supply of electricity in the national electricity market need to be retested and inspected at a maximum interval of five years.
- For non-trade use meters, testing and validation of the metering system should be conducted at established intervals over the meter lifetime.

Modern solid-state electricity meters built to the Australian Standard maintain their accuracy over time and generally do not need to be re-calibrated**.**

Tip 10: Ongoing testing and validation should occur whenever metering systems are altered or otherwise at a maximum interval of 10 years for meters for non-trade use and five years for billing meters. The NABERS Rules for Collecting and Using Data contains a good approach for checking accuracy and correctness of non-trade metering systems.

Step 7 – Monitor and review performance

An electricity metering and monitoring system can assist greatly with the process of creating an energy management plan or energy management system for your facility.

At a minimum:

- Develop an energy management plan that:
  - identifies the main energy consuming equipment and lists key information about it
  - lists energy-related responsibilities of staff
  - presents known issues or desired efficiency upgrades
  - sets out a framework and plan for improving energy performance.
- Implement simple, trackable key energy performance indicators (EnPIs).
- Introduce an energy management position into the company, either as a dedicated employee or by amending the position description of an existing staff member and making them accountable for EnPIs.
- Monitor and report on progress at regular intervals to senior management.

The implementation of an energy management plan, or the formal adoption of the ISO 50001 system, will help you to develop a framework of continuous improvement for your facility. Continuous improvement can mitigate against drift in performance caused by ageing equipment, suboptimal set points, sensor inaccuracy and changes in facility operation. It will also help you to identify and prioritise new capital expenditure on major equipment.

Tip 11: Use data from your energy metering and monitoring system to predict the savings impact from purchasing new, more-efficient equipment such as chillers, pumps and lights, and use this information to produce winning business cases that will secure investment in this equipment.

Managing the data and driving performance

Once your metering system is in place, what you do with the data is what really matters. You need to make sense of the data and turn it into valuable, actionable information.

Software-driven 'energy intelligence' platforms are becoming increasingly available. These can help you to minimise the task of interpreting data, so you can focus on taking action.

Data management can also be outsourced to energy management companies and consultancies. They may use energy intelligence platforms to directly monitor data, or extract raw data for analysis and to provide recommendations.

System security: protecting your information

A well-designed metering and monitoring system can give useful information and insights into your organisation's internal operations, such as staff routines and production metrics. This information may also be valuable to your competitors or others with malicious intent. Consider how the access to this information might compromise your business if it fell into the wrong hands. Could it compromise the physical security of your staff or facility? Could your competitors use this information to their advantage?

Metering and monitoring systems often share infrastructure with information technology, building management systems and telecommunications equipment, potentially exposing these systems to unauthorised access too.

Consider conducting a risk assessment and seeking advice from a suitable IT security specialist in relation to how to best secure your information and systems.

Analysing the data

Detailed analysis of energy data is beyond the scope of this guide, and you may choose to use third-party companies and services for this. However, this section sets out some common ways you can visualise the data and understand the information it provides.

Hourly load profile

Using 15-minute, 30-minute, or hourly data, it is easy to produce graphs showing the energy consumption from a site in a 24-hour period. This can be conducted via the energy management software, or by obtaining interval data for the selected period and creating charts in a spreadsheet.

Figure 14 shows an example load profile for a building. The load profile will differ depending on the industry type, but generally gives a picture of overall energy consumption in a day, with overnight consumption lower where the facility is not operating, increasing during facility operation and falling as the workday ends. Understanding the energy consumption during periods when the facility is not operational helps identify a site's baseload consumption and any unnecessary load, such as lights being left on overnight.

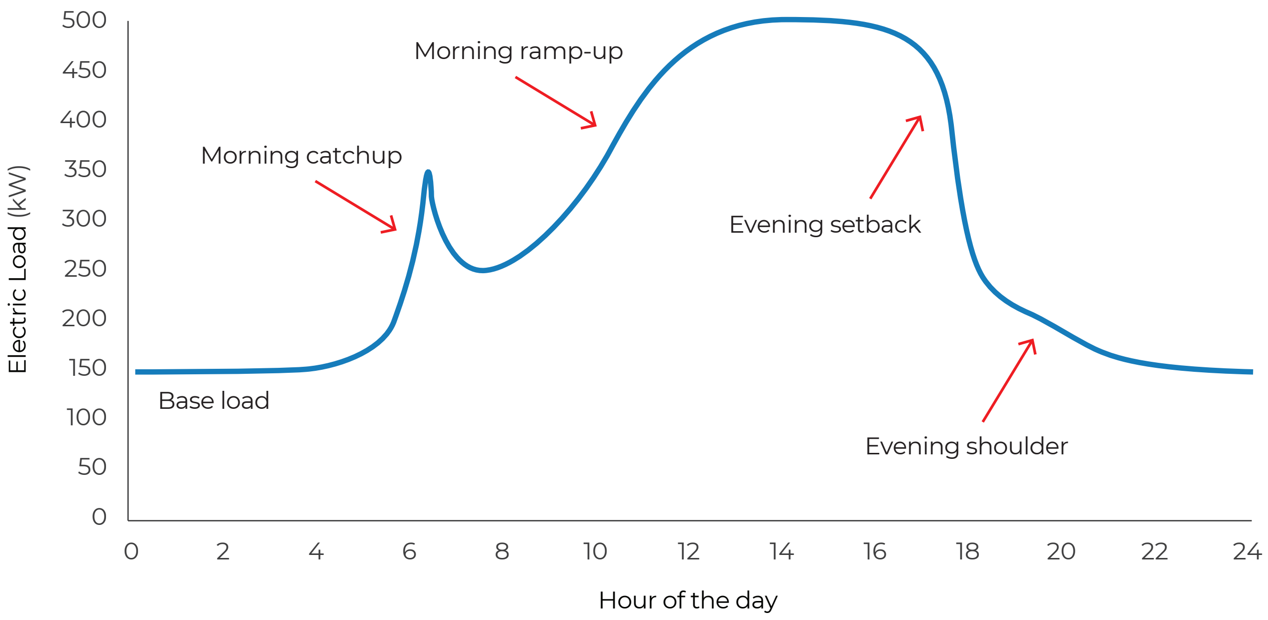


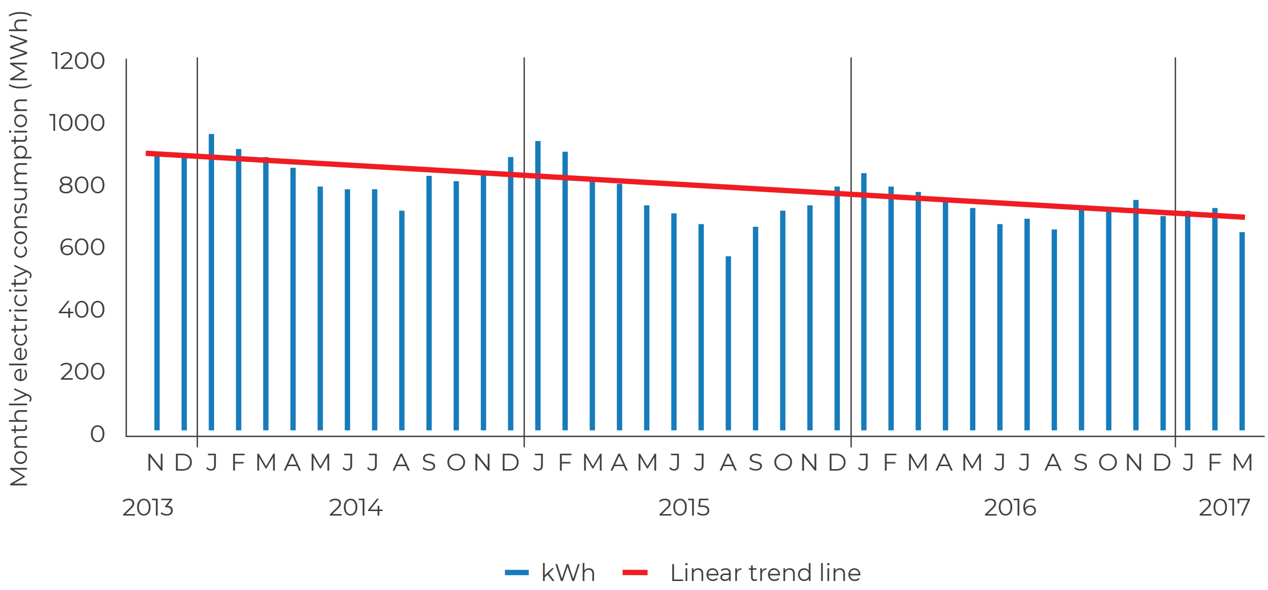
Figure 14: Stylised load shape for a typical office building in summer

Source: *Methods for Analyzing Electric Load Shape and its Variability*, Price PN 2010, Lawrence Berkeley National Laboratory, California Energy Commission

Seasonal, monthly, and daily variation

Comparing day-to-day and month-to-month energy usage helps to build a picture of current performance of the facility and the trends in consumption over time.

Graphing hourly interval data over a weekly period shows changes in consumption from day to day, including lower weekend consumption levels where sites don't operate on weekends. This can identify inefficient load start-up schedules, and equipment unnecessarily operating on weekends. Similarly, total energy consumption each month can be compared with past months for a full 12-month or multi-year period to identify seasonal variations and longer upward or downward trends in energy usage over time.



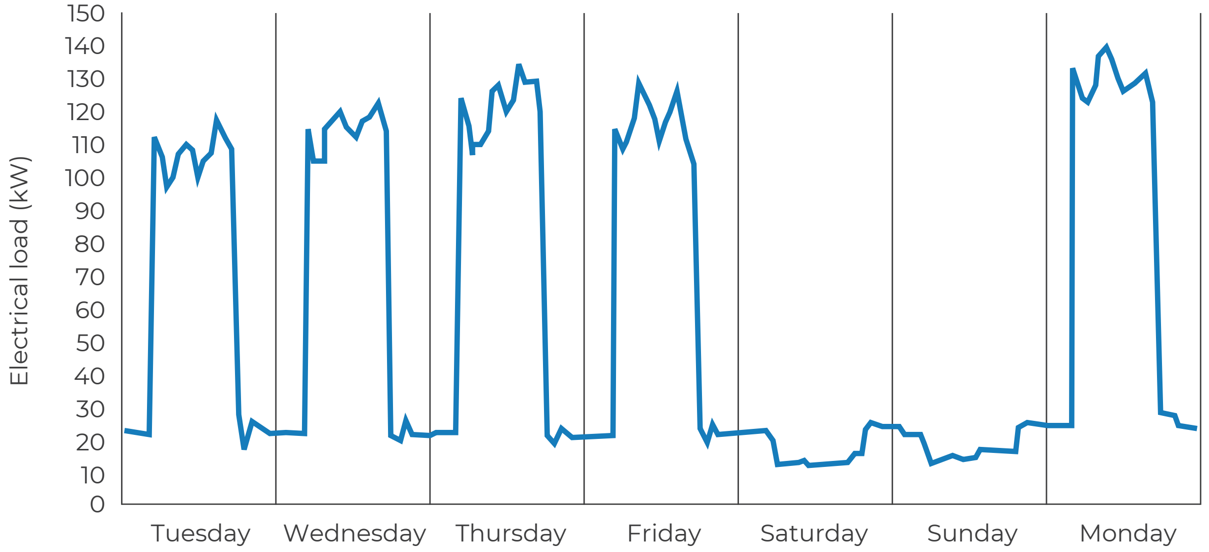
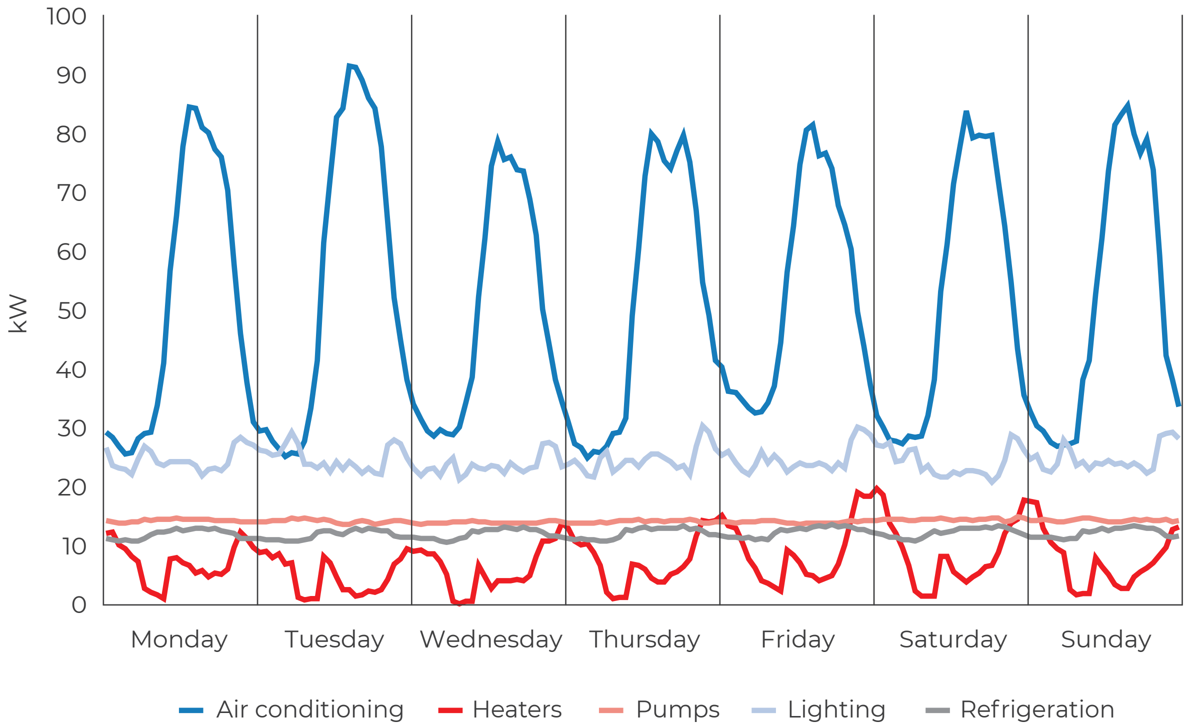


Figure 15: Seasonal and weekly profile graphs

Equipment and circuit-level monitoring

Installing meters on individual equipment and circuits on distribution boards allows separate data from each equipment item to be analysed and its contribution to the total site consumption understood. For example, a meter on a chiller power consumption can demonstrate periods of high cooling demand, and when coupled with meteorological (temperature and humidity) data it can identify performance inefficiencies. A metering and monitoring system with this capability can send alarms to facility managers when major energy-consuming equipment begins operating outside defined thresholds.



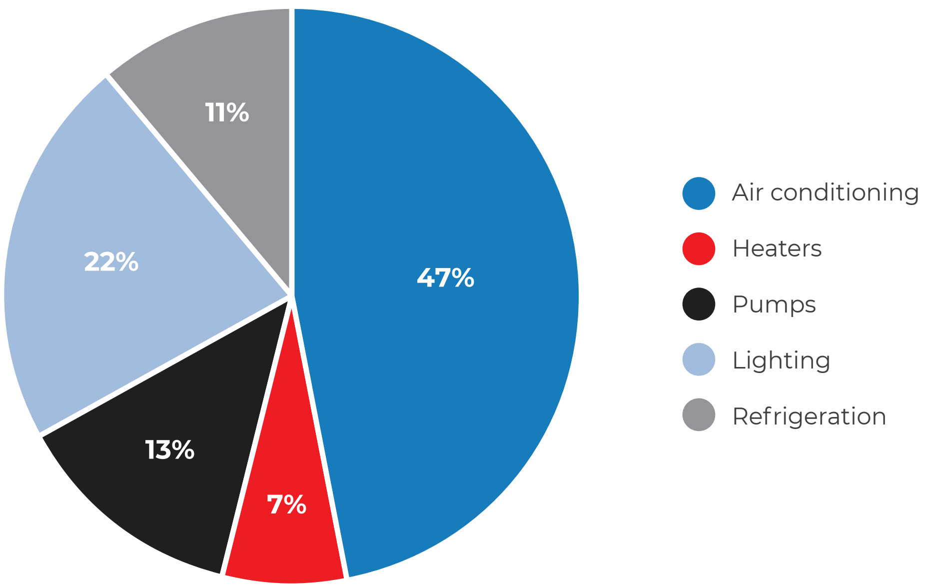


Figure 16: Equipment-level monitoring breakdown

Regression analysis

Regression analysis involves creating a statistical model that can be used to predict your electricity consumption based on internal operating conditions and external factors such as weather characteristics, staff numbers, production output, etc. This can help you to better determine actual savings from implemented energy savings measures. This information can also be used to fine-tune the performance of your facility.

The NSW Government Energy Savings Scheme (ESS) incorporates regression analysis into some of its methods. In some instances, the analysis, along with other information, is used to determine access to the scheme and the quantity of energy savings certificates (ESCs) that should be attributed to a project.

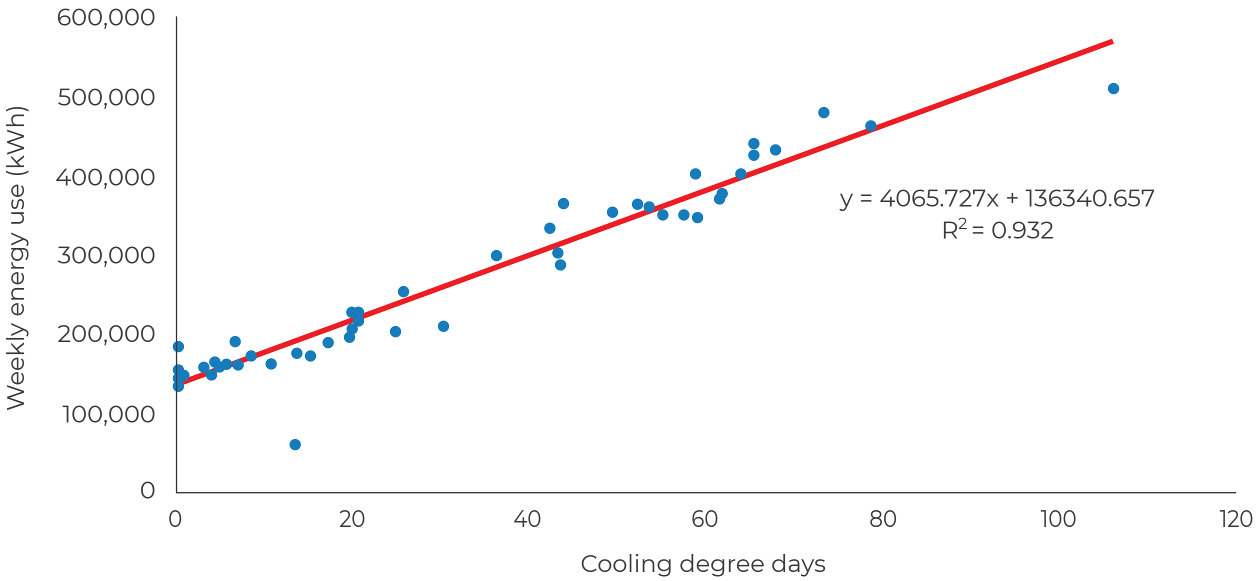


Figure 17: Example of regression analysis showing a correlation between temperature (expressed in cooling degree days) and energy use

Source: *Measurement and Verification Operational Guide*, Office of Environment and Heritage

People and responsibilities

Good control and management of equipment, processes or buildings relies on access to good information, and having trained and capable people available to review outputs, analyse data and take appropriate action. The cornerstone of any successful implementation is the selection of the most appropriate metering and monitoring system and making sure the integrity of outputs is maintained.

The cost of installing and maintaining your metering and monitoring system will only yield positive benefits if your organisation and staff receive and act on information provided by the system. Table 5 gives some examples of success and failure in using energy data.

Table 5: Metering and monitoring users and examples of successes and failures

Application	Potential users	Good results	Poor results
Energy meter billing reports	• Building manager • Facilities manager • Financial officer	• Thorough, shared understanding of usage • Appropriate allocation of energy usage • Accurate energy performance estimates • Appropriate allocation of costs	• No faith in energy allocations • Disputes about cost allocation • Energy performance measures ignored
Analytics and diagnostics and fault detection	• Building manager • Process operator	• Tight control of operations • Effective energy management • Improved throughput and quality • Faults and divergence from expectations identified	• Excessive alerts or alarms • Alerts and alarms ignored or overridden, leading to inefficiencies in operations
Automated measurement and verification (M&V) for ESC creation	• Facilities manager • Process operator • External consultant • Accredited certificate provider	• Correctly applied statistical models • Baseline models for project implementation • Reduced consultant time in collecting data and performing analyses	• Model doesn't conform to statistical requirements • Consultant needs to re-do baseline model • Incorrect data recorded and used in M&V analysis
Corporate sustainability reporting	• Company director • Sustainability officers	• Automated reports, easily inserted into annual reports • Relevant information presented in a clear and timely manner • Attention focused on key sustainability performance indicators	• Inaccurate data in reports • Reports need to be reproduced • Difficulty tracking performance

The use of information from an electricity metering and monitoring system can vary widely across facilities and within industry sectors, and it can be difficult to define all the potential levels of ownership and responsibility. However, your organisation will benefit from having a coordinated approach to implementing metering and monitoring, and this will help to ensure that all associated activities are optimised, e.g. metering selection, analysis of data and reporting, etc.

For example, in an industrial or large commercial office context, the management of the metering and monitoring system could be guided by a multi-disciplinary group, or by an individual with access to the necessary specialty support groups, as illustrated in Figure 18.

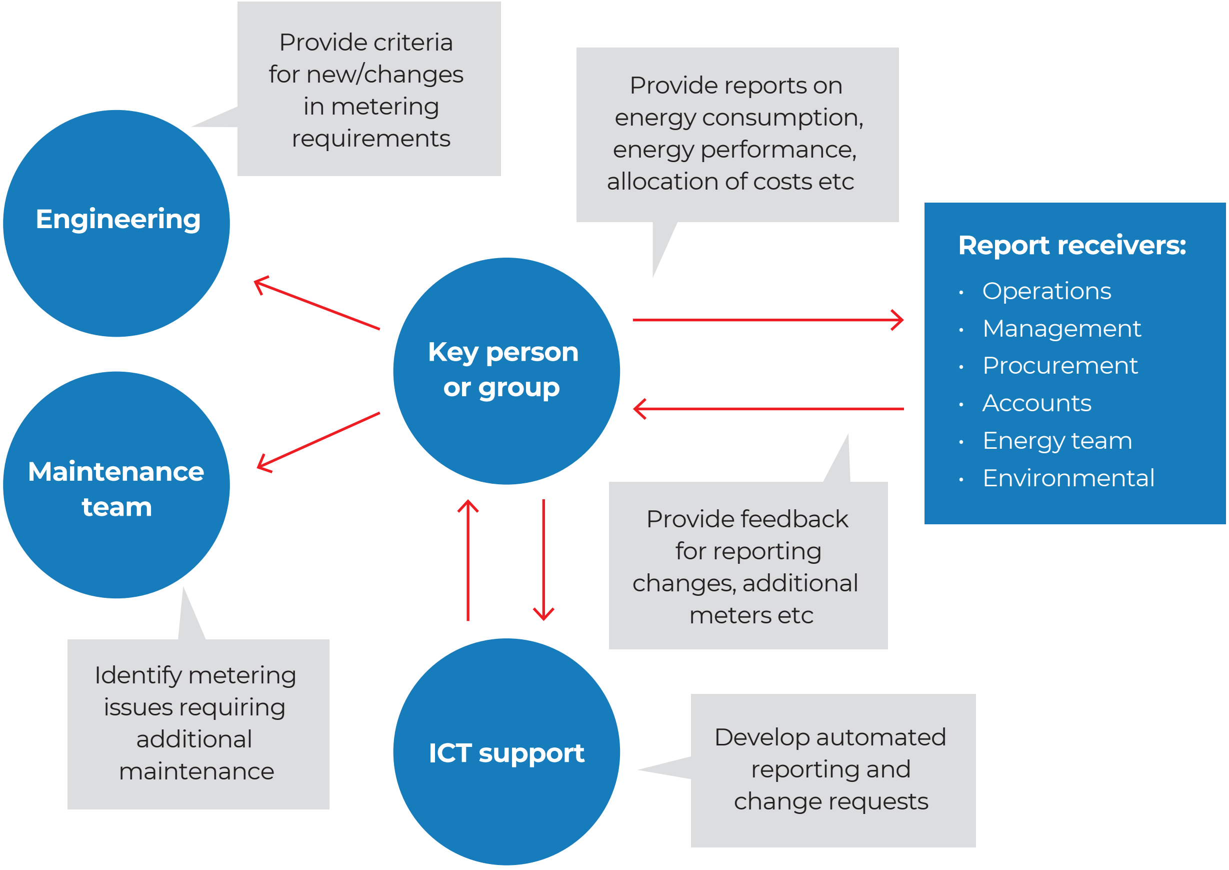


Figure 18: Example responsibility plan for your metering and monitoring system

In this example, the key person or group manages and facilitates the selection, allocation and reporting of metering and associated data with support from specialist departments (Engineering, Maintenance, and Information Communications and Technology). These specialist departments are responsible for reviewing the requests and responding to them in an agreed timeframe.

Their 'clients' are the report receivers who rely on the information provided in order to make the operational decisions needed to run the facility, and have responsibility for taking action and providing feedback.

The key person or group should also maintain good records of the process adopted, documentation of changes, etc. and ensure that a smooth transition occurs should there be staff changes or restructuring.

Glossary

Term	Meaning
BACnet	building automation and control (BAC) network is a data communication protocol for building automation and control infrastructure. It is an open communications protocol.
Baseline	the energy consumption and profile of a building under normal operating conditions, usually established before an energy-saving measure is implemented.
Building management system (also known as building automation system and building management and control system)	a computer-based control system that networks equipment sensors and actuators for managing and monitoring the operation of a building's mechanical and electrical equipment.
Bus bar	a metal bar housed inside a switchboard or electrical distribution enclosure, to distribute power from an incoming electricity supply to multiple uses.
Cooling degree day	a measure of the level of cooling required to maintain thermal comfort in conditioned spaces. The specific value is determined by the number of degrees a day's temperature is above a base temperature (commonly 24 degrees).
CSV	comma-separated variable is a standard file format for large data files, commonly read in spreadsheet programs.
Current transformer	a static device that produces a proportional but lower and more manageable secondary current (or voltage) output for use by an electricity meter.
Direct-connected meter (otherwise known as 'whole current' meter)	a meter intended for use without instrument transformers (such as current transformers), i.e. they are directly connected to the electrical circuit to be monitored.
Direct metering agreement	large market customers (sites using more than 160 megawatt hours a year) are entitled to enter a direct metering agreement (DMA) with a meter data agency. Customers who don't have a DMA have a meter assigned to them by their retailer and a metering charge on their monthly bills.
Ethernet	a network protocol that governs how data is transmitted in a local area network (LAN).
Interval data	any set of electricity, gas or water data, metered and stored at regular intervals for billing purposes or data analysis. Typical intervals are 15 and 30 minutes.
Interval meter (also known as a 'time of use' meter)	an electronic meter that enables the recording of electricity, gas or water data at regular intervals for billing purposes or data analysis. Typical intervals are 15 and 30 minutes.
K factor	the ratio of the energy registered by the meter and the actual human readable output. For solid-state meters this is generally the number of pulses per kilowatt hour.

Term	Meaning
Kilovolt amp reactive (kVAr)	a unit of the amount of electrical energy supplied to a site, which does not produce meaningful work, but services induction loads (e.g. magnetic field in a motor).
Kilowatt hour (kWh)	a unit of the amount of electrical energy supplied to do work.
Maximum demand (also known as peak demand)	the highest recorded consumption (demand) within a defined interval (e.g. 30 minutes) for the preceding measurement period, which is used in calculating peak capacity network charges. The measurement period can be monthly, annually or the entire preceding life of the facility.
Meter data agencies (also called 'registered metering providers' in the National Energy Retail Rules)	companies that specialise in reading meters and collecting data. They have specific functions in relation to the energy market, including the registering of national metering identifiers (NMI) with the Australian Energy Market Operator.
Modbus	a serial communication protocol for transmitting information over serial lines between electronic devices. It is a widely supported and used open standard for control systems.
Pattern-approved meter	the National Measurement Institute (NMI) evaluates electricity meters to check they meet specific Australian Standards and requirements for approval as an energy billing meter. When an instrument is successfully submitted for approval, that particular 'pattern' or type is approved and a certificate of approval is issued.
Programmable logic controller (PLC)	a specialised computer, comprising a microprocessor and input and output circuits, used to control machinery and processes, typically in industrial settings.
RS232	the standard serial port used in computers and a form of serial communication over data cables.
RS485	a standard for transmitting data serially from multiple sources on the same cable.
Soft meters	software-derived energy meters for plant equipment that combine performance specifications with actual operating data from BMS to calculate energy demand and consumption in real time.
Supervisory control and data acquisition (SCADA)	a control system architecture incorporating equipment sensors and meters, PLC devices and other controllers, computers, and software for the operation of industrial equipment and processes.
Programmable logic controller (PLC)	a specialised computer, comprising a microprocessor and input and output circuits, used to control machinery and processes, typically in industrial settings.
RS232	the standard serial port used in computers and a form of serial communication over data cables.
RS485	a standard for transmitting data serially from multiple sources on the same cable.
Soft meters	software-derived energy meters for plant equipment that combine performance specifications with actual operating data from BMS to calculate energy demand and consumption in real time.

Term	Meaning
Supervisory control and data acquisition (SCADA)	a control system architecture incorporating equipment sensors and meters, PLC devices and other controllers, computers, and software for the operation of industrial equipment and processes.
Submetering	electricity metering at a subsystem or equipment level.
Utility (or revenue) meter	a meter used in conjunction with the supply of electricity from the national electricity market by an electricity retailer.
Wireless	a wireless computer network to transfer data between two or more devices using the Institute of Electrical and Electronics Engineers (IEEE) Standard 802.11x.
Zigbee	a proprietary specification for a suite of communication protocols that use low-power wireless networks. Data is transferred across Zigbee networks with the aid of a mesh framework that allows each Zigbee device to amplify the network signal strength.

Appendix A:
Australian Standards for metering

The primary standards for metering systems are:

- AS 1284.1-2004: Electricity metering – General purpose induction watthour meters
- AS 62052.11-2005 (R2016): Electricity metering equipment (AC) – General requirements, tests and test conditions – Metering equipment
- AS 62052.21-2006 (R2016): Electricity metering equipment (AC) – General requirements, tests and test conditions – Tariff and load control equipment
- AS 62053.21-2005 (R2016): Electricity metering equipment (AC) – Particular requirements – Static meters for active energy (classes 1 and 2)[3]
- AS 62053.22-2005 (R2016): Electricity metering equipment (AC) – Particular requirements – Static meters for active energy (classes 0.2 S and 0.5 S)
- AS 62053.23-2006 (R2016): Electricity metering equipment (ac) – Particular requirements – Static meters for reactive energy (classes 2 and 3)
- AS 60044.1-2007 (R2016): Instrument Transformers – Part 1 Current transformers (IEC 60044-1 Ed.1.2 (2003) MOD)
- AS 60044.2-2007 (R2016): Instrument Transformers – Part 2 Inductive voltage transformers (IEC 60044-2:Ed.1.2 (2003) MOD).

In addition to these metering standards, installations of metering systems must comply with *AS/NZS 3000:2018 Electrical installations* (known as the Australian/New Zealand Wiring Rules). Installation of some metering equipment, such as meter panels and CTs, may need to comply with the NSW Government *Service and Installation Rules of New South Wales*.

3 Note this supersedes AS 1284.5-2000: Electricity metering - General purpose electronic watthour meters

Appendix B:
Understanding your electricity bill

Summary electricity consumption data, maximum demand and the various types of charges are set out on your monthly electricity bills. Table 6 explains the type of charges and how they are calculated.

Table 6: Electricity bill components

Category	Name	Calculation	Description
Energy charges	Peak energy	Total energy consumed during peak time during the month x peak time tariff per kWh x DLF x MLF	Cost per unit of energy consumed, measured in kilowatt hours (kWh) from the meter, and charged at peak, shoulder and off-peak rates. These charges reflect the costs (including retailer margin) of trading electricity on the wholesale market. Your retail contract primarily addresses these charges. Energy charges take into account the distribution loss factor (DLF) and the marginal loss factor (MLF). These two factors are calculated by the network service provider and published annually by the Australian Energy Market Operator (AEMO).
	Shoulder energy	Total energy consumed during shoulder time during the month x shoulder time tariff per kWh x DLF x MLF	
	Off-peak energy	Total energy consumed during off-peak time during the month x off-peak time tariff per kWh x DLF x MLF	
Market charges	Participant charge	Total energy consumed during the month x DLF x participant charge	An AEMO charge for participating in the national electricity market.
	Ancillary services charge	Total energy consumed during the month x DLF x ancillary services charge	The ancillary services charge is a cost passed through from AEMO to recover the cost of managing the national electricity market. This charge varies month to month depending on AEMO's cost to maintain the network.
Metering charges	Meter charge	Daily rate	The cost of provisioning a meter where this service is provided by a retailer, not by a meter data agency. Note: even with a DMA, the retailer may still impose some metering charges.

Category	Name	Calculation	Description
Environmental charges	These are costs passed on to consumers by retailers for their obligations under state and Australian Government renewable energy and emissions abatement schemes.		
	Small-scale Renewable Energy Scheme (SRES) charge	Total energy consumed during the month x DLF x SRES charge	This relates to the scheme to fund small-scale residential solar power and hot water systems. This cost varies over time and between retailers.
	NSW Energy Savings Scheme (ESS)	Total energy consumed during the month x DLF x NSW ESS charge	Charge related to the NSW Energy Savings Scheme. This cost varies over time and between retailers.
	Large-scale Renewable Energy Target (LRET) charge	Total energy consumed during the month x DLF x LRET charge	This relates to the scheme to fund large-scale renewable energy projects such as wind farms. This cost varies over time and between retailers.
Network charges	Peak energy	Total energy consumed during peak time during the month x peak time tariff per kWh	Network charges reflect the regulated network costs of transmitting and distributing electricity to your site. These are the variable components (calculated per unit of energy consumed measured in kWh from the meter, and charged at peak, shoulder and off-peak rates). The tariffs are set by the network service provider (Ausgrid, Essential Energy, Endeavour Energy). The tariff is public and available on the provider's website.
	Shoulder energy	Total energy consumed during shoulder time during the month x shoulder time tariff per kWh	
	Off-peak energy	Total energy consumed during off-peak time during the month x off-peak time tariff per kWh	
	Peak capacity/ peak demand	Highest kVA (maximum demand) within the past 12 months or past month (depending on the tariff) x demand charge x number of days in the month	This tariff component is a network charge applied to the maximum demand recorded – kVA or kW. The maximum demand is typically charged on the highest recorded demand within a 30-minute interval for the preceding recording period (in some cases this is monthly, annually, or doesn't reset at all).
	Fixed charge/ network access charge	Daily rate per access point	This is the fixed service charge applied to each point of network connection. A separate network access charge will apply to each revenue meter with an NMI.

Appendix C: Types of electricity metering systems

Electricity metering can apply at various levels: portfolio, facility, building, circuit or equipment/ appliance levels.

Types of meters

Broadly there are three meter types:

- **mechanical meters** – these contain a mechanical dial which records accumulative electricity consumption. Currents are induced in the conducting element (spinning dial) which causes it to move in proportion to the energy used. Mechanical counters are displayed that are designed to be read in person at periodic intervals.

Photo: OEH/North Sydney council

- **electro-mechanical meters** – these are generally the same as mechanical meters but include an optical encoder measuring electricity use via an electronic or pulse output. They generally lack data-logging facilities.
- **Solid-state electric (static) meters** – these are advanced metering devices in which current and voltage act on solid-state electronic elements to produce an output proportional to the energy measured. They have no moving parts and can have data-logging capabilities. They can also have the capability to measure and record interval data, and communicate the data to a remote location. They can measure and log many more parameters than mechanical and electro-mechanical meters. In most cases a solid-state meter will be the preferred type.

There are two main types of solid-state meters:

- **transformer-operated meters** – use current transformers (CTs) and voltage transformers (for high-voltage connections) to supply a lower, more manageable power supply in fixed ratio to the current and voltage in the meter circuit. Current transformers typically have a secondary supply current of 5 amperes (amps) and the ratio of the primary current (the rating on the circuit or busbar) compared to this secondary current is known as the CT ratio.

Photo: SATEC/OEH

- **direct-connected (whole current) meters** – are directly connected to electrical circuits, with a rated capacity up to 100 amps, which is passed through the meter without a CT.

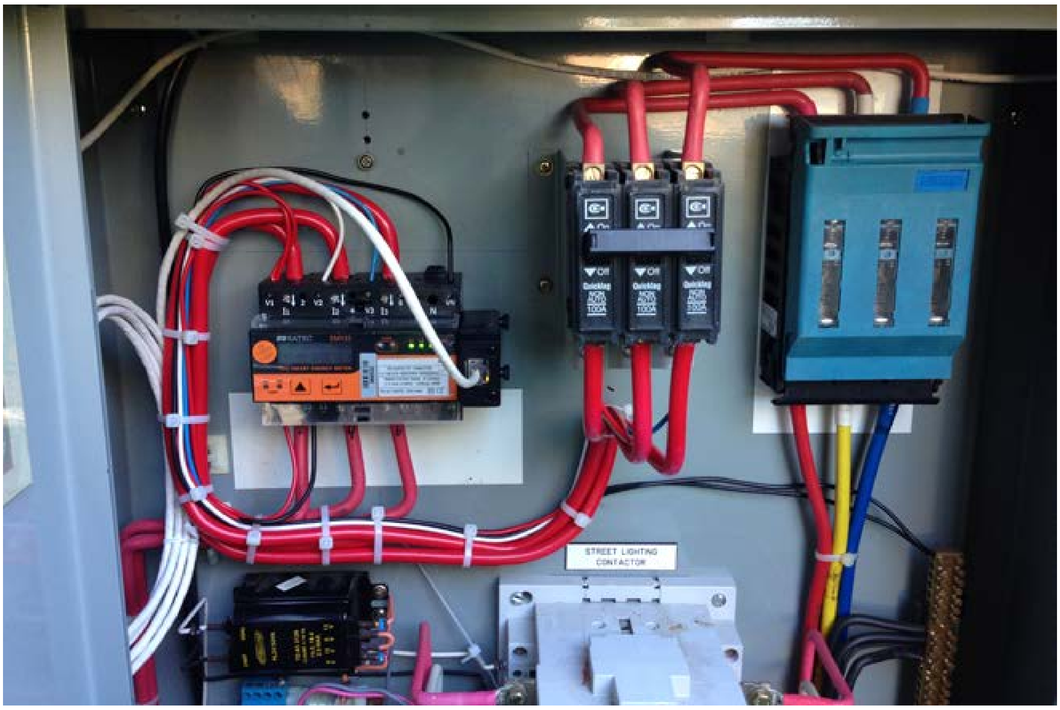


Photo: SATEC/OEH

Meters have a constant known as the K factor, which represents the ratio of the energy registered by the meter and the actual human readable output. For solid-state meters this is generally the number of pulses per kilowatt hour.

Measurement parameters

Solid-state electricity meters can measure some or all of the following parameters:

- active energy (watt hours or kilowatt hours) – the amount of electrical energy supplied to do work
- reactive energy (VArh or kVArh) – the amount of electrical energy supplied which doesn't produce meaningful work but services induction loads (e.g. magnetic field in a motor)
- apparent energy (volt ampere hours [VAh] or kilovolt ampere hours [kVAh]) – the total amount of electrical energy supplied: active energy + reactive energy
- active power (watts or kilowatts) – the rate of active energy supplied
- reactive power (VAr or kVAr) – the rate of reactive energy supplied
- apparent power (VA or kVA) – the rate of apparent energy supplied
- power factor – active power divided by apparent power. This is an important measure of the amount of power delivered to the site which results in meaningful work
- voltage – volts (V)
- current – amps (short for ampere) (A)
- harmonic distortion.

Time clocks and time stamps

Permanent metering systems should have an internal clock tracking national electricity market standard time, which is Australian Eastern Standard Time, and synchronised or calibrated time clocks. This avoids mismatch in time intervals and misinterpretation of time and date stamp data.

Meter accuracy classes

The National Measurement Institute *NMI M 6-1 Electricity Meters – Part 1 Metrological and Technical Requirements,* and Australian Standards AS 1284.1, AS 62053.21, AS 62053.22, set out meter accuracy classes and specify the permissible errors for each class.

Instrument transformer accuracy classes are set out in *AS 60044.1-2007 Instrument Transformers – Part 1 Current transformers (IEC 60044-1 Ed.1.2 (2003) MOD).* (See **Appendix A** for a list of Australian Standards that apply to metering.)

These accuracy classes are named as 0.2s, 0.5s, 0.5, 1, 1.5 (also known as general purpose), 2 and 3. Meters of accuracy class 0.2s and 0.5s conform to a higher accuracy standard which requires more consistent accuracy levels over a range of load conditions.

Consider the meter accuracy level that is appropriate for your needs. For example, if you will be billing tenants for electricity usage, or operating an embedded network, a Class 0.2s or 0.5s meter may be necessary. If you are seeking just a broad picture of energy consumption across different equipment, and data to assist business case development, a Class 1 or 2 meter may be sufficient. For measurement and verification applications a Class 0.5 meter may be suitable.

Table 7: Accuracy classes – static meters for active energy

Class	Accuracy at normal load	Use	Australian Standard
0.2s	+/- 0.3%	High accuracy revenue-grade applications	AS 62053.22-2005
0.5s	+/- 0.6%	Medium accuracy revenue-grade applications	AS 62053.22-2005
0.5	+/- 0.8%	Large business revenue-grade and accurate submetering applications	AS 62052.11-2005
1	+/- 1.0%	Medium accuracy submetering applications	AS 62052.11-2005
1.5	+/- 1.5%	General purpose accumulative metering applications	AS 1284.1-2004
2	+/- 2%	Low accuracy submetering applications	AS 62052.11-2005

Note that the overall meter system accuracy will be lower than that provided above for transformer-connected meters. Similar accuracy classes exist for current transformers. The overall system accuracy will need to take the error of the CT into account.

Communication protocols and connectivity options

Pulse output

Historically the most common data output format has been pulses that are calibrated to kWh usage. Some also give reactive energy (kVArh) pulse outputs; this allows easy calculation of the power factor. Basic meters do not store the pulse data but do provide a cumulative kWh reading via dials or an odometer-style register. Solid-state meters have a built-in data logger which time and date stamps the data at set intervals then stores it. Pulse output is an electronic signal that is generated for every user-defined unit of energy, for example one pulse might represent one kWh.

Analogue output

Most meters provide an analogue power output (typically 4–20 milli amps or 0–10 volts direct current [DC]), where the value is proportional to that of the parameter being measured. This is used for single-meter installations where the output can be read by a programmable logic controller or BMS. This output allows only a single measurement parameter to be transmitted.

Serial output

Serial output is used in networked meter installations, and allows a meter to output multiple parameters from a single data channel, and for multiple meters to supply data to a single network master host (networked data hub). Solid-state meters with built-in data loggers record the value of each required measurement parameter, and transmit encoded data one bit (binary digit) at a time (serially) over cable.

Digital output

Most meters provide a configurable relay or solid-state output to signal alarms, or for load control, for example.

Network communication protocols

Several protocols are used for serial communications, and some meters provide protocol options either at the time of order or via retrofitted plug-in modules.

Some devices use a proprietary protocol, such as Schneider's Ion Protocol. These are capable and easy to work with and may be suitable for your situation. Meters accessible using open protocols, such as BACnet and Modbus, may allow a greater range of services and devices to interface with your meter. BACnet is an application interface protocol used in BMS. Specifying BACnet protocol compatibility will enable meters to be read and monitored by the existing BMS.

The most commonly used protocol is Modbus and this has the advantage that it is used by many devices (e.g. motor variable speed drives, equipment programmable logic controllers) and is well-understood by commercial and industrial technicians. Interfaces are available that allow data to be converted to different protocols.

Connectivity options

Digital output signals from a meter can be transmitted via:

- data cables – RS485, RS232
- wireless – IEEE 802.11 standard and Zigbee (see **Glossary**)
- ethernet
- wireless mobile, typically 3G.

Typically a system of meters will communicate and aggregate data to a central hub or data logger on site, using data cables or Zigbee wireless, with aggregated data exported to an external data management system via wireless mobile or ethernet. Many systems use two or more connectivity options.

Appendix D: Metering to improve energy efficiency

When the aim of the metering and monitoring system is to improve energy efficiency, then 'metering should provide sufficient "evidence" to pinpoint avoidable wastage without requiring expensive and time-consuming detective work.'[4]

A facility can be viewed as a combination of various energy consuming systems working together. Furthermore, each system can be viewed as a combination of subsystems.

Metering at the **facility level** may be sufficient for small facilities, with only a few items of equipment, and relatively well understood loads.

Metering at the **system level** may be sufficient to capture general trends and understand the relevant contribution to energy consumption of each system, e.g. heating, ventilation and air conditioning, lighting, water services. Not all equipment types will be connected to a common distribution board, and as such there is a risk that the information provided is only of limited accuracy.

Metering at the **subsystem level** i.e. direct metering on equipment, gives the greatest level of insight into a facility's energy consumption reducing the 'detective' work to a minimum.

Submetering of significant loads should be prioritised. For example, the Green Building Council of Australia suggests metering individual loads that exceed 20kVA (19kW at 0.95 power factor). An alternative approach is to focus on the equipment which consumes more than 10% of the total energy consumption, which is in line with the approach taken for constructing an energy end-use breakdown in the Australian Standards for energy audits (AS/NZS 3598.1:2014 and AS/NZS 3598.2:2014).

To help identify which items of equipment contribute the most to energy consumption and the number of meters to use, consider seeking advice from suitably qualified professionals. A suitable professional would most likely be active in the energy management or energy metering and monitoring industries. They should also be able to demonstrate experience successfully implementing metering and monitoring strategies for your facility type.

Figure 16 is an example commercial building 'energy tree'. This example highlights the typical system and subsystem components and includes comments on how these components might be treated for the purposes of metering and monitoring.

4 Chartered Institution of Building Services Engineers 2009, TM39: *Building Energy Metering*

Facility	System	Subsystem	Comments
Electricity	HVAC	Chillers Pumps Air handling unit Fans De-humidification Cooling tower	Typically, HVAC accounts for about 40% of total office building energy use and 70% of base building (i.e. landlord) energy use. Given the large proportion of overall energy use, submetering at the system and subsystem level is likely to be beneficial.
	Lighting	Carpark Floor by floor Tenancy Common area	Typically, lighting accounts for about 25% of total office building energy use. Metering of lighting circuits for major areas, such as tenancies, floors, carparks and common areas can help identify inefficient operation.
	Water services	Domestic hot water Pumps	Typically, water services account for a relatively small proportion (1%) of total office building energy use. The benefit of submetering this system and its subsystems may be relatively low.
	Transportation	Lifts Escalators	Typically, transportation services account for a relatively small proportion (4%) of total office building energy use. The benefit of submetering this system and its subsystems may be relatively low.
	Appliances	Floor by floor Tenancy Common area	Submetering of other major items of equipment, such as air compressors should be considered. Plugin loads in some circumstances can be submetered as a group at the relevant distribution board.
	On-site generation		Metering on-site power generation (most commonly cogeneration or photovoltaics) can help to identify these systems are operating as expected and the confirm the actual energy and cost savings related to the deployment of these system.

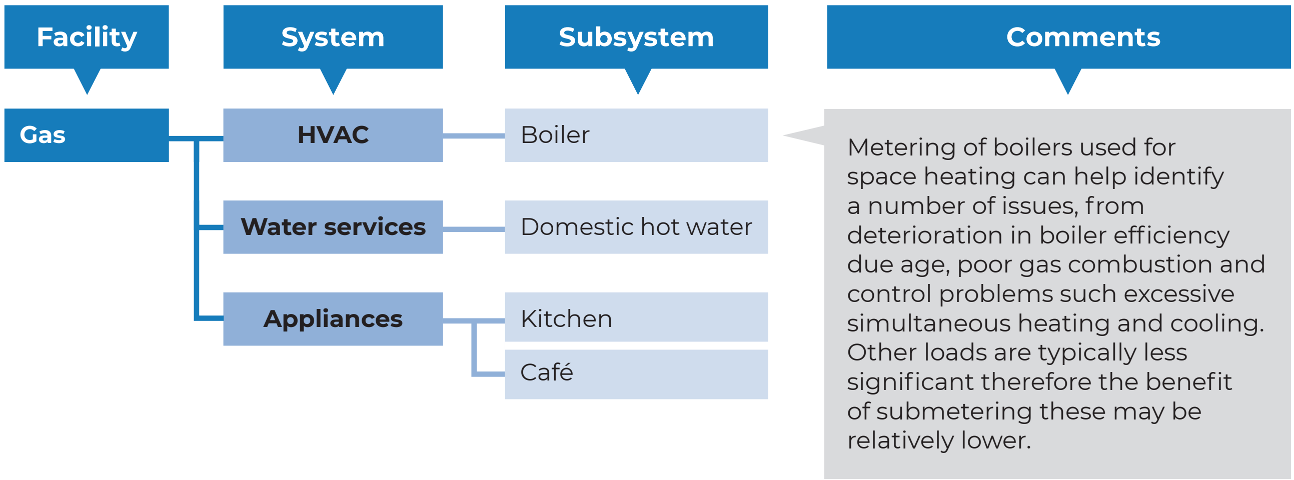


Figure 16: Example energy tree for a commercial building facility showing potential metering applications

Appendix E: NABERS metering issues

In preparing a NABERS Energy rating, an assessor needs to determine the energy consumption of the facility undergoing the rating. Energy consumption data is collected in the form of monthly energy bills for a 12 month period immediately prior to the assessment. Alternatively, interval data obtained from a revenue (utility) meter or non-revenue (non-utility) meter can be used. However, if the data is from a non-revenue (non-utility) meter it must meet the requirements set out in the NABERS Rules for Collecting and Using Data and undergo a validation.

Further clarification on the NABERS metering requirements can be sought by contacting the NABERS team or an accredited assessor – see www.nabers.gov.au.

Cumulative v. instantaneous metering

Total energy consumed is a key factor in determining a NABERS Energy rating. The rating requires meters that can record and display or transmit a running total of energy consumed: cumulative metering. Cumulative meters typically provide better accuracy because energy consumed is determined within the meter rather than being interpolated from transmitted instantaneous meter readings in a separate system. Cumulative meters are also resilient to failures in data collection systems because they will continue to track total energy consumed until the data collection system is restored.

Meters that report instantaneous use without registering a running total (instantaneous metering) cannot be used for NABERS ratings. A stream of instantaneous readings is susceptible to being compromised by failures in data collection systems. Loss of an even a small fraction of instantaneous readings may result in further inaccuracy in the calculation of total energy use.

Cumulative meters are also required for a NABERS Water rating as the same principles apply.

Metering validation

Electricity meters with a current transformer require validation to determine if they are reading correctly. Direct-connected meters that have an onboard counting mechanism and no remote meter reading system do not require validation.

The NABERS rules require:

- initial validation of all meters on the premises within three years
- ongoing validation of all meters on the premises at least every 10 years.

The NABERS rules require a random sample of 10% of meters be validated each year. This means a different 10% is done each year to reach the 10-year ongoing validation goal. Not validating meters according to the rules results in delaying the rating certification until compliance with the validation requirement can be demonstrated.

Current transformer ratios

As part of validating non-revenue (non-utility) metering systems, it is important the correct CT ratio is determined and recorded for the meter.

CT ratios can vary dramatically, from 25 to 400, or more. Error in determining or recording the CT ratio can lead to large discrepancies in the data. A wayward 0 can mean the annual consumption is out by a factor of 10!

Frequency of reads

NABERS requires non-revenue (non-utility) meters to be read at least as often as revenue (utility) meters. This ensures that data can be correlated and analysed to ensure it makes sense.

Remote meter reading systems

Remote meter reading systems (RMRS) must be properly configured and periodically checked to confirm the system interprets and reports the meter data correctly. The NABERS metering validation process requires that cumulative meter readings reported by the RMRS over a nominal period corresponds to cumulative meter readings directly at the meter.

Meter accuracy for NABERS

NABERS does not specify an accuracy class for meters, nor does it recommend or certify products. Claims that meters are NABERS-compliant are self-made and not verified by NABERS. NABERS does require metering systems to be checked, corrected and recalibrated when the NABERS metering validation process reveals a disparity of 10% or more.

Appendix F: Meters for billing purposes

Electricity regulation differs depending on whether a meter is used for trade or non-trade purposes.

Meters for trade use

Any meter used for trade purposes (understood to be for a transaction or other billing purpose) must have been granted 'pattern approval' by the National Measurement Institute of Australia and must be verified.

Pattern approval determines the quality of a measuring instrument. It is a process whereby an impartial body examines the pattern (design) of an instrument prototype against a published national standard. This determines whether the instrument can retain its calibration over a range of environmental and operating conditions, and whether it has measures to prevent tampering that reduce the likelihood of it being used to facilitate fraud.

Verification is the process of testing that an actual meter unit conforms with the approved pattern and is calibrated to perform with errors within a permissible range.

The National Measurement Institute evaluates measuring instruments to check they meet specific Australian Standards. When an instrument is successfully submitted for approval, that particular pattern or type is approved and a certificate of approval is issued.

On-market revenue metering

The national electricity market is governed by the Australian Energy Market Commission *National Electricity Rules* (NER). Electricity metering used by a customer participating in the national electricity market for the supply of electricity to a facility, defined as 'revenue metering', must conform with the requirements set out in the National Electricity Rules: Chapter 7 – Metering. The National Electricity Rules set out seven different metering installation types depending on the volume of electricity consumed and the features of the system required. Requirements and obligations of metering installations on network connection points are the responsibility of the Australian Energy Market Operator (AEMO) and are set out in the AEMO *Metrology Procedure:* Parts A and B.

Off-market trade-use metering

Situations where tenants are billed for energy consumption as a separate line item on monthly lease fees are considered 'off-market' because the tenants aren't direct participants in the national electricity market. However, because a transaction for energy use occurs, the transaction is still required to be metered with a pattern-approved meter.

Embedded networks

An embedded network is a private electricity network serving multiple premises, which is located within, and connected to, a distribution network. These include shopping centres, office buildings, universities and multi-residential apartments. The owner of the embedded network manages the distribution of power, energy market functions and retailing of energy to customers.

Changes in electricity regulations are being introduced for embedded networks. These are aimed at facilitating greater choice for participants in an embedded network, particularly those who are 'on-market' customers. One of these changes is a requirement to establish an Embedded Network Manager, whose responsibility it is to provide the embedded network customer with access to the market, e.g. by establishing a National Metering Identifier for each customer meter in the network, and transferring metering consumption data to the Australian Energy Market Operator. This change will allow embedded network customers to freely choose an alternative electricity retailer, while remaining within the embedded network. The new rules commenced from 1 December 2017.

Meters for non-trade use (general purpose submetering)

Meters for non-trade or revenue purposes, i.e. subcircuit metering, do not require pattern approval or verification and do not need to comply with the National Electricity Rules nor the Metrology Procedure. However, meters for non-trade use should comply with the relevant Australian Standards, have an appropriate accuracy class and have the technical attributes outlined in this section, i.e. be of a recognised type, have a published K factor, and use standard date–time formats.

Appendix G: Installation and commissioning tests and checklist

Metering systems can be highly complex. This list contains some general checks to help prevent some of the more common problems that can arise. The actual tests required may vary depending on the meter installation.

Commissioning tests

The following commissioning tests need to be completed by the metering supplier or contractor to ensure the metering system is installed correctly:

1. Perform a visual inspection of the hardware, including the installed CTs and meter wiring.
2. Configure meter identifier and IP address.
3. Confirm voltage on correct sequence: V1-Red, V2-White, V3-Blue, VN-Black.
4. Confirm the CTs are of the correct ratio and polarity, and correctly located to record the required power flow:
   i. Confirm the loads on any CTs are within the correct limits.
   ii. CT on correct phase: I1-Red, I2-White, I3-Blue.
   iii. CT on correct direction: arrow pointing to the load.
   iv. For split core CTs check for proper closing position.
5. Configure the CT settings in the meter and confirm they match the installed CTs.
6. Check the meter date and time settings.
7. Apply a known load to the circuit and record and confirm:
   phase voltages
   i. phase currents
   ii. phase power factor
   ii. active, reactive, and apparent power.
8. For multi-phase installations, confirm the relationships between voltages and currents are correct and that phase rotation is standard at the meter terminals.
9. Verify the energy management and monitoring system is correctly reading energy usage data from the meter.
10. Re-seal any tamper-proof seals on energy billing meters post-commissioning.

Commissioning checklist

The metering supplier or contractor should have their own comprehensive commissioning checklist, which they should use to validate successful installation of each meter. Following is an example of a meter validation and commissioning checklist.

Meter validation and commissioning checklist

Meter ID	Meter location	Make/Model	K factor	CT ratio

Test	Completed	Result	Notes
Visual inspection	☐		
Configure meter ID	☐		
Confirm voltage connections	☐		
Confirm CTs correctly sized and installed	☐		
Configure CT settings in meter	☐		
CT wire less than maximum permitted length	☐		
Meter date and time setting	☐		
Apply known load to circuit and record and verify the following:			
Voltage phase A	☐		
Voltage phase B	☐		
Voltage phase C	☐		
Current phase A	☐		
Current phase B	☐		
Current phase C	☐		
Power factor phase A	☐		

Test	Completed	Result	Notes
Power factor phase B	☐		
Power factor phase C	☐		
Meter kW reading	☐		
Meter kVA reading	☐		
Meter kVAr reading	☐		
Verify energy management and monitoring system is correctly reading meter:			
Energy management and monitoring system kW reading	☐		
Energy management and monitoring system kVAr reading	☐		
Energy management and monitoring system kVA reading	☐		
Device Pass/Fail		**Meter re-sealed** ☐	
Date			
Signed			

Appendix H: Operations checklist

Use this checklist at any stage during the implementation and operation of your electricity metering and monitoring system, and review and update it over time.

Tasks		Completed?	Further details
Energy management plan	Implemented energy management plan	☐	*Locations records kept*
	Energy performance indicators established	☐	*Locations records kept*
	Site consumption benchmarked	☐	*Locations records kept*
Allocation of responsibilities	Energy management position established	☐	*List job title*
	Responsibility for operation of metering system allocated	☐	*List job title*
	Organisational structure for monitoring and reporting on performance established	☐	*Locations records kept*
	Permanent email address for receiving data and reports set up	☐	*List email addresses*
Maintenance and validation	Date of last validation	☐	*Locations records kept*
	Next validation date	☐	*Locations records kept*
	Has meter validation record been completed?	☐	*Yes/No*

Appendix I: Meter validation and testing template

This example validation record can be adapted and used for recording the results of meter validation tests.

Meter ID	Meter description	Meter wiring checked?	Meter readings				CT ratio*	Meter multiplier; K factor	Temporary power meter check (kWh)**
			Time A		Time B				
			Remote reading from meter system	*Manual reading from meter face*	*Remote reading from meter system*	*Manual reading from meter face*			
M1	(Example)	Yes	Time A: 12.25		Time B: 12.32		300:5	60	1600kWh
			12357.90	12357.90	18256.31	18256.31			
			Time A:		Time B:				
			Time A:		Time B:				
			Time A:		Time B:				
			Time A:		Time B:				
			Time A:		Time B:				
			Time A:		Time B:				

Source: NABERS *Rules for Collecting and Using Data*, Office of Environment and Heritage 2013

* Applicable for CT-type meters only ** Verification using a temporary meter is recommended as part of the validation

References and further reading

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