health

Implementing effective energy and water metering systems

Guidance Note

The role of metering in managing energy and water consumption

Overview

Understanding how water and energy are used within healthcare facilities is the first step in identifying opportunities to reduce consumption and operating costs. Correctly designed and installed metering systems can accurately monitor the energy and water flows from the campus level down to individual appliances. The information generated by meters can provide real time and historical data that forms the basis for informed decision making with respect to changes to procedures, maintenance regimes, control strategies, tariff optimisation or capital upgrades. Metering data can also be used to communicate building performance to occupants and as an input to external reporting requirements, increasing awareness and engagement and providing the basis for benchmarking.

Energy and water retailer metering is typically at the whole building or precinct level and provides only limited information on consumption. An effective sub-metering network can provide a detailed breakdown of consumption by separating out end uses such as lighting, power, heating and air-conditioning, as well as consumption by floor, building, equipment or department.

An effective metering strategy is one which identifies the appropriate level and configuration of meters necessary to assess system performance. A ‘granular’ metering network, where the metering system is broken down into measuring small uses, can be expensive and complex to analyse; however, a metering network that is too ‘coarse’ can result in data gaps and inadequate information. A balance needs to be found between the two. Meter data that is not monitored is of almost no practical use. A key part of any metering strategy needs to cover how the data is actually going to be used, and making sure there are tools (software) and processes that can turn data into valuable information.

Metering is one component of an integrated data monitoring system that provides the ability to process and combine information in ways that can benefit building performance. Healthcare facilities managers are increasingly utilising metering systems to provide exception notification, activate building management controls, generate consumption reports and drive real time dashboard displays.

This guide provides important information on how to implement energy and water metering within healthcare facilities and is intended for capital project design teams, hospital engineers, facility managers, building service engineers, energy engineers, sustainability officers and project managers.

How does metering benefit healthcare facilities?

A metering system should be designed to provide information that enables healthcare facilities to reduce energy and water consumption without impacting on building performance. Although meters do not directly achieve savings, they are essential for providing information that can result in savings such as highlighting inefficient operational practices, user behaviours and system performance.

Without an active monitoring program poor facility performance can be difficult to detect resulting in significant missed opportunities to implement remedial measures. Metering systems represent a relatively small investment but the savings opportunities can be very significant which is why an effective metering system is considered one of the most cost effective strategies for achieving energy and water efficiency.

Metering can benefit healthcare facilities in the following ways:

- Building tuning: Verification of proper building services operation on a continuous or annual basis.
- Exception reporting: Automated notifications sent as texts or emails to facility management staff (when an element of the system shuts down for example).
- Real time dashboards: Wall displays, websites and hand-held applications which use interactive and easily understood graphical interfaces to engage all building users.
- Management reporting: Weekly, monthly and annual reports which document patterns of consumption and cost.
- Performance benchmarking: Normalisation of energy and water consumption to allow comparison against established benchmarks.
- Energy/water trending: Identifying trends in consumption over time, encouraging proactive maintenance rather than the business-as-usual reactive maintenance.
- Measurement and verification: Confirmation that energy and water savings targets have been met
- Monitoring equipment efficiency: Calculating and monitoring a performance indicator (for example Coefficient of Performance for a cooling system).
- Verifying savings: Determining savings from energy and water saving initiatives implemented in capital projects, or energy efficiency retrofit projects.
- Tenant billing: Where space has been let to third parties, metering can provide an accurate means of billing for energy and water consumption.
- Demand response: Understanding what drives peak demand can highlight opportunities for load shedding to reduce peak electrical demand charges.

A tightening of standards, and advances in metering technology means that metering systems in existing facilities may typically need to be supplemented or replaced to meet current needs. For instance new meters are electronic and can be read remotely, significantly reducing the labour required to read older manual meters.

Given the clear benefits of metering systems, energy and water metering is now considered standard practice for new capital works projects and should be retrofitted into existing facilities whenever possible.

Current practices in health care facilities

Metering is already standard practice in new health care facilities and is frequently being retrofitted into existing facilities. There is now increasing recognition that metering provides information that is essential for managing equipment maintenance, on-going operational efficiency and upgrades to existing buildings and infrastructure.

New capital works projects

Energy and water metering is already a standard practice for new capital works projects and are required by the Building Code of Australia and Department of Health guidelines. The amount of data generated by these metering networks can require significant time and resources necessary to process, interpret and respond to metering data which can be a challenge for some health care services. One of the solutions which is gaining increasing prevalence is the use of advanced data management platforms and interfaces which increase the utility of metering data by making it much easier to analyse and interpret.

Existing facilities

Existing facilities represent a high value opportunity for metering retrofits. In many facilities, particularly those which predate Building Code of Australia 2009 requirements for metering, there is often no metering system or the current metering system is inadequate. Retrofitting meters can be challenging as there can be a lack of information to enable mapping and prioritisation of end use consumption which makes it difficult to identify the number and placement of meters.

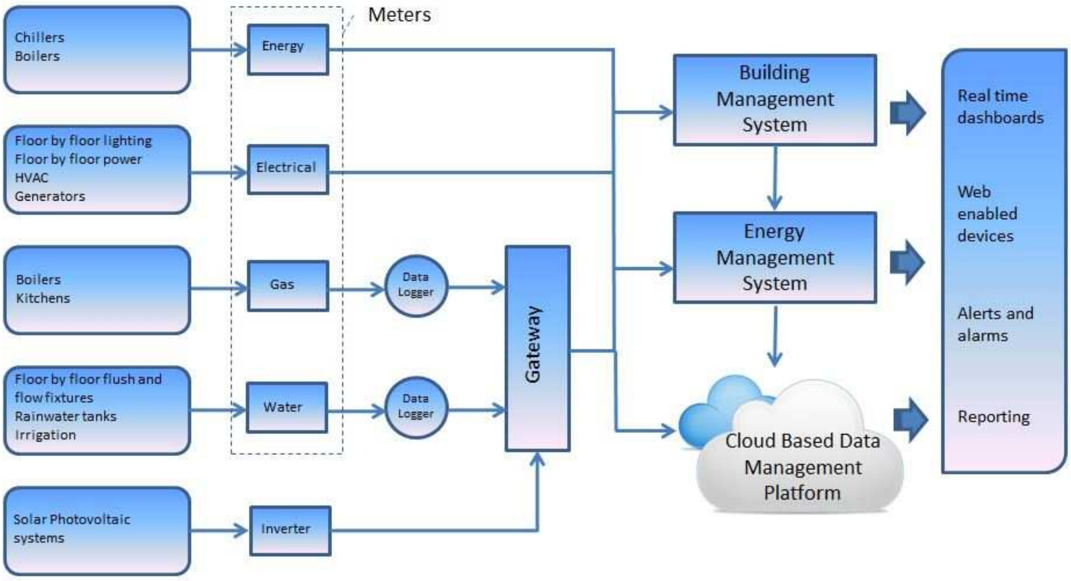
This can be further complicated by complex distribution systems which have evolved over time as a result of facility upgrades and expansion, increasing the number of meters required to provide adequate coverage. Despite these challenges meters are being successfully retrofitted. Expanding metering within existing facilities represents an attractive opportunity for capital upgrades given the potential energy and water savings.

Metering retrofits need to be accompanied by capable data management software and automated meter reading capability. Manually read meters are typically read infrequently do to the burden this places on staff time. Existing software systems are sometimes outdated or not well suited to collecting and reporting meter data. When metering systems are being retrofitted into existing facilities an investment is also being made in the communications and data management capabilities make sure metering information can be used effectively.

Although energy and water costs are rising, some health care services continue to benefit from low cost retailer contracts which can undermine support for meter retrofits. This is despite the fact that many of the opportunities for energy and water savings which can be identified as the result of metering are low or zero cost. This is being realised by an increasing number of healthcare services who are making metering an increasing priority as a means of managing tight operational budgets.

Environmental data management system

Metering has the greatest potential benefit when it is implemented as part of an organisational or facility wide environmental data management system. An integrated system enables the capture and interpretation of environmental performance from a metering network and allows information to be combined to provide context and comparison. For example, this can include comparing the relative performance of similar systems, assessing trends, identifying anomalies and considering the influence of weather, operational profiles and occupant behaviour.



Typical Metering System

The Department of Health is implementing a web-based environmental data management system (EDMS) to provide a standardised platform for the management of environmental and utility data across the Victorian public health portfolio. The system has the capacity to accept sub-metered data and standardised data allows users to monitor and benchmark environmental performance, and improve utility cost management.

Metering codes, standards and guidelines

Metering is a regulatory requirement in many instances and is increasingly targeted under voluntary green building certification schemes. New healthcare projects are to comply with the Building Code of Australia (BCA) and Australian Standard requirements as well as complying with Department of Health Guidelines for sustainability in health care capital works. A summary of current relevant metering codes, standards and guidelines are included below. A summary table is also located in Appendix A. Relevant resources and links are further provided in Appendix C.

Building Code of Australia

Section J8.3 “Facilities for energy modelling” under the 2014 Building Code of Australia (BCA) contain requirements for metering which apply to Class 2 through 9 buildings which include residential, hospital and office buildings.

Table 1: 2014 Building Code of Australia metering requirements

Floor area	Requirements
>500m2	Metering required to record consumption of gas and electricity
>2,500m2 including at least 500m2 of common area	Metering required to record individually the energy consumption of: • air-conditioning plant including, where appropriate, heating plant, cooling plant and air handling fans; • artificial lighting; • appliance power; • central hot water supply; • internal transport devices including lifts, escalators where there is more than one serving the building; • other ancillary plant.

There are no requirements for water metering under the 2014 version of the BCA.

Australian Standards

Meters are covered by a number of Australia standards which specify aspects of metering such as accuracy, safety, reliability and testing. The relevant standards are:

- AS 62052: Electricity metering equipment - general requirements, tests and test conditions
- AS 60044: Instrument transformers including current transformers and inductive voltage
- AS 3565: Water meter technical requirements

Department of Health Guidelines for sustainability in health care capital works

The department’s Guidelines require the development of a metering strategy and the installation of energy and water meters as standard practice. These meters are to allow measurement of energy and water from functional areas, concessions, areas of substantive electricity use (greater than 100 kVA) and areas of high water use (such as kitchen, laundry and Central Sterile Service Department). The strategy is to indicate how data would be used to report against targets and benchmarks and influence behavioural change.

Green Star

If an upgrade or new building project is to achieve credit for energy or water metering under Green Star Health Care v1 then meters are to be installed to meet the requirements contained in the Technical Manual.

The credit ENE-2 Energy Sub-metering requires that energy metering be provided to separately monitor lighting and general power consumption for primary functional areas (per floor), these areas include in-patient accommodation and operation theatres, office/administration space; and laboratories. Where the functional area is less than 200m^2(GFA), it may be grouped with an adjacent functional area providing the total area being metered does not exceed 1000m^2. The sub-meters are to be connected to a data collection system and continually demonstrate actual performance against energy benchmarks.

The credit WAT-2 Water meters requires that separate water meters are installed for all major water uses in the project including bathrooms, evaporative heat rejection systems, fire water systems, irrigation systems, rainwater supply, recycled water supply, hot water, hydrotherapy pools, kitchen facilities, laundry facilities and renal dialysis. An effective system is to be in place to collect, record and monitor data from these sub-meters.

International Performance Measurement and Verification Protocol (IPMVP)

The IPMVP defines a methodology for quantifying the energy savings resulting from energy efficiency projects and has been widely adopted internationally as the industry standard approach to measurement and verification. It is commonly used in energy performance contracts where financing is contingent on a robust and objective method for determining the energy and water savings resulting from equipment and facility upgrades. The IPMVP provides a number of options for calculating energy savings which include field measurements of isolated systems, whole facility metering or use of a calibrated energy simulation model.

Overcoming the challenges of implementing metering for existing buildings

Existing facilities, unlike new capital works projects, can pose a number of challenges to the implementation of an effective metering system. The configuration of existing services and a lack of information which identifies the layout of services as a result of successive facility upgrades can increase metering system costs and make separation of some types of energy use consumption more difficult. These challenges can be overcome and the investment is typically justified due to the significant potential for energy and water savings.

Mixed lighting and power boards

Mixed light and power switchboards (rather than separate) are very common particularly in older buildings and can make it difficult to segregate lighting and power consumption. In these cases independent metering of lighting and power would require individual sub-meters for each lighting and power circuit, or replacement of the switchboard with a new board. In these cases the most cost effective approach is to meter the complete board and estimate the relative contribution from lighting and power based on an assessment of loads and operational hours. For example, if a particular board is serving an area with 10x T5 fluorescent lights (28W each) that operate for 12 hours daily, the lighting contribution to the switchboard energy may be estimated by calculating the annual lighting consumption (10 x 28W x 12h x 365days). The power component can be estimated by subtracting the lighting consumption from the total energy consumption measured at the switchboard. Another alternative approach may be the proportioning of the total energy of board by Net Lettable Area (NLA) using virtual metering.

Shared central mechanical plant

A healthcare campus may include multiple buildings which are served by a common central mechanical plant meaning that the individual energy consumption by each building is not available. The recommended approach in this situation is to retrofit thermal meters into the chilled water or hot water loops servicing each building. The amount of gas or electricity used to condition each individual area can be apportioned based on an assessment of the average thermal load of the mechanical plant for the studied area as a portion of total thermal load (applied to an estimate of operational hours). The cost of installing a thermal meter is often not justified for smaller buildings with limited heating and cooling demand.

Insufficient as-built information

Successive capital improvements can add considerable complexity to building services infrastructure which is not always adequately represented in as-built services drawings. Documentation may not be up to date or may contain gaps so the services infrastructure may be poorly understood. This is particularly the case with HVAC ductwork and water piping, making it problematic to isolate and meter certain water uses. In these cases on-site investigations, surveys and testing are recommended to confirm the configuration and operation of the network. The layout of water piping can be investigated by observing the impact of opening and closing taps and valves. Additional metering may be necessary to determine the layout of electrical and gas systems however this can be done by using temporary meters to reduce costs.

Setting metering priorities

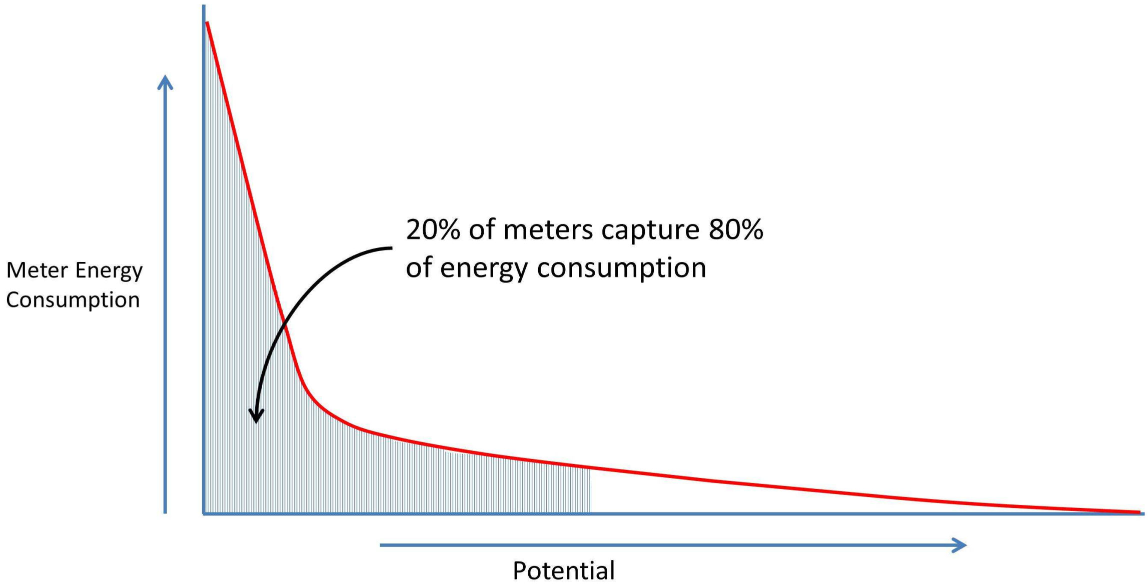
Not every aspect of energy and water systems warrants metering. Metering technologies provide the capability to capture very large data sets however excessive metering can unnecessarily drive up metering costs and can make interpretation and analysis complex and time prohibitive. A metering strategy should be developed early in the design process and should be driven by a clear set of requirements. These requirements typically include BCA compliance, environmental ratings, regulatory reporting and continuous commissioning. Rather than consider what can be metered it is more important to identify what questions need to be answered, such as:

- Who are the key stakeholders and what are their informational needs?
- What level of detail is required to adequately characterise energy or water consumption?
- Are there areas of consumption which can be accurately estimated without the use of meters?
- Are there some areas of consumption which are constant and can be measured using temporary meters?
- What is the tariff structure and does metering provide sufficient ability to understand elements of consumption that impact tariffs, such as time of use, peak load demand or power factor (how effectively the building uses the electricity supplied to the site)?

A minimum level of metering should provide a floor by floor breakdown of lighting, power and water, building level metering of natural gas and metering for substantive electricity uses (greater than 100 kVA) and areas of high water use. To provide guidance on the various end uses that can be considered a summary of metering applications is included in Appendix A. An example of a simple electrical metering diagram can be found in Appendix B.

In order to avoid unnecessary expenditure and complexity, electrical metering should be limited to end uses which represent at least 20kVA* or 5 per cent of the total demand as loads smaller than this are likely to represent a small percentage of total building energy consumption. At 2014 rates the energy expenditure at 20kVA load operating during business hours would be approximately $5,000 per annum. A rule of thumb is that typically 20 per cent of the total number of meters which can be installed would capture 80 per cent of the energy consumption.

Figure 1: Meter capture vs energy consumption



Diminishing Returns of Excessive Meter Installation

Metering technologies and communication protocols

Meters are not a new technology however they are becoming increasingly sophisticated to improve accuracy, remote access, reliability and to integrate with real time tracking and reporting software platforms.

Technologies

The common types of meters are electricity, gas, water and thermal energy. Thermal energy meters provide flow and temperature differential measurement and are often used on chillers and boilers to monitor efficiency.

Examples of typical meters

Electricity Meter
Source: Schneider

Water Meter
Source: Spiremt

Gas Meter
Source: Accutherm

Thermal Mass Flow Meter
Source ABB

Accuracy

Meters should be specified to provide a level of accuracy appropriate to the application. If data results in ‘money changing hands’ (i.e. a health facility tenant is being billed) meters must be a “Patent” approved meter under the National Measurement Institute (NMI). Where energy consumption is up to 2 GWh per annum an overall error of 1.5 per cent (Class 1.5) is allowed. The 1.5 per cent error would be a combination of 0.5 per cent (or Class 0.5) for Current Transformer and 1.0 per cent (or Class 1.0) for the Meter. For non-billing meters a Class 1 meter (accuracy of 1 per cent) would be acceptable which is the case for most commercial grade meters.

Communication protocols

Meters need to be connected to a data collection device to enable automated meter reading and reporting. Individual “stand-alone” or manually read meters are not supported by the Department of Health due to the time required to read the meters on a regular basis and the potential for erroneous readings and reporting. The value of automatic metering reading over manual reading is not just around saving time and improving accuracy. A meter read monthly does not provide much value in terms of managing performance, as functions are limited to tracking trends. However, regular interval data can produce profiles that provide valuable feedback information such as the influence of the time of day on usage. A number of standardised metering communications protocols have been widely adopted by industry. In some cases these protocols are entirely open source, in other cases some portions of the protocol are proprietary. The most common protocols include:

- pulse
- Modbus RS485
- BACNet
- ethernet,
- GSM (i.e. via a Telco mobile network)
- low powered radio mesh.

Open protocols are recommended to avoid reliance on a particular system or supplier.

Electricity meters can be sourced with any of the above communication protocols. The recommended protocol in most cases is Modbus RS485 as this is still the most widely supported within the buildings and control industry.

Water and gas meters are typically less sophisticated and provide only a pulse output. Careful attention to setting up a pulse data collection system is required. The pulse “shape” needs to be clearly read by the collection system and the pulsing frequency should provide an adjustable and appropriate level of accuracy and resolution (fewer pulses per minute means a lower level of data resolution).

Thermal meters generally use an electronic device to convert their specific communication protocol (Mbus) to Modbus, which enables them to ‘talk’ in the same language as the rest of the meters.

Data storage provides an important means of preserving metering data when communications are interrupted. Electricity meters can be specified with on-board memory storage however pulse meters require a separate data logger with storage capability.

Cost Effectiveness

Although metering systems represent an additional cost, they provide the information necessary to improve the energy performance of new and existing buildings. Monitoring-based commissioning, which relies on the use of meters to allow for continuous tracking of energy data for maintaining and improving facility energy performance, has been demonstrated to be highly cost effective. A 2009 California study on monitoring-based commissioning in 24 buildings revealed median electricity savings of 9 per cent, median peak electricity demand savings of 4 cent and a median simple payback of 2.5 years[1]. Office buildings which achieve a NABERS (National Australian Built Environment Rating System) energy rating based on metered energy consumption have been found to achieve continuous improvement in energy performance. By the time buildings had achieved their eighth consecutive NABERS energy rating the average improvement in energy performance was found to be 29 per cent. These results indicate that metering can be instrumental in achieving significant and cost-effective energy savings and that those savings can be sustained and improved over time.

The costs of purchasing a meter can range significantly depending on the type and quality of the meter and are outlined in Table 2.

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[1] Evan Mills, Paul Mathew, Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU projects, Lawrence Berkeley National Laboratory, Berkeley, California, June 2009

Table 2: Energy metering costs

Meter type	Capacity	Approximate cost (hardware only)
Electricity	CT up to 300A/phase	$300 - $2,000
Gas	400 MJ/hr	$1000
	1,000 MJ/hr	$3,000
Water	20mm pipe	$200
	150mm pipe	$2,000
Thermal	Strap on ultrasonic meter	$4,000
	Magnetic flow meters	$8,000

Data Collection Systems

Data collection systems for metering networks can be hosted via on-site computers or within a remote cloud based computing network. On-site systems include building management systems and energy/water monitoring systems are standard practice. Cloud based systems are relatively new but are likely to become increasingly common due to the greater security capacity and utility they provide with respect to data management.

Building Management System (BMS)

Most existing buildings rely on some type of BMS and this can be expanded to collect the data from meters and facilitate the generation of reports and spreadsheets. The disadvantage of using a BMS for this task is the lack of price competitiveness when purchasing expansions to an existing BMS / increased functionality. The features offered by the existing BMS may also not be best in class. Other disadvantages include restrictions on access, expensive user-based licensing models or inability to pull in other data to provide context to metering, such as local weather.

BMS is typically good for control (as per the original intent of the BMS) but it is not so good for data visualisation and analysis, so capabilities and limitations should be identified for each project. It is good practice for cloud-based environmental data management systems and the BMS to work in partnership rather than one replacing the other.

Energy/water monitoring system

This is effectively a simplified BMS that is solely designed for energy/water monitoring including reporting functionality, alarm notification and user interface. There are multiple vendors offering these systems.

Web/cloud based system

These systems include some hardware to collect the data delivered by meters and upload it to the “cloud”. Software then converts the data into graphical information that is viewed via an IP address using any web browser (access via log in and password). The web site also allows users to download metering data in a “flat file format” (typically .xls or .csv) for further analysis. Cloud based systems can provide a higher degree of flexibility as they are often designed to be “technology agnostic” meaning that they can incorporate data from different types of proprietary BMS as well as other types of sustainability metrics such as waste generation or paper consumption. A cloud based system is well suited to situations where there are multiple buildings or campuses which need to be integrated into a single reporting system.

The department’s environmental data management system for the health portfolio is a web-based system.

Data from utility smart meters

Electricity utility smart metering data can be read by Metering Data Agencies, using wireless “Radio Frequency” technology. The metering data can then be exported into a software platform to provide a site-wide platform that contains utility and sub-metering data.

Virtual Metering

Virtual metering allows combination of data from multiple meters of the same type (electric, gas or water) to create an aggregate total and assign the values to a virtual meter. The ability to create Virtual Meters can be especially beneficial where there is a need to aggregate data for groups of meters for different uses, floors or locations, or where aggregation is not possible due to existing building configuration.

Commissioning

Metering systems should always be properly commissioned to validate correct installation and operation. Metering problems can easily go undetected for long periods of time when commissioning is not performed. Meters in new capital works projects are included in the normal commissioning process however the use of a commissioning agent to oversee the commissioning process is recommended. A commissioning agent should be engaged during the schematic design process to review the metering strategy and confirm that the metering locations are appropriate and all components of the metering systems have been correctly specified. It is also recommended to engage professionals with the right metering skills as the communication systems are still poorly understood by many electrical contractors.

Validation of meters should be performed upon initial installation and then whenever the metering system is altered or at a maximum interval of every 10 years. To assist with this validation a metering management plan should be established which should:

- uniquely identify each applicable metering system
- show the details of the last validation check for that metering system, if any
- nominate the date by which the next regular validation check for that metering system should be completed,
- record the validation of any altered metering systems
- type of area the meter is connected to.

The recommended process for validating meter readings is the National Australian Built Environment Rating System (NABERS) Energy and Water for offices, Rules for Collecting and using data, Appendix D – Guide to non-utility metering system validation.

As part of the commissioning and validation process, it is recommended that the facility manager should have all single-line diagrams and metering schematics updated and verified to reflect the current meter coverage locations. These should be updated during any future upgrade works.

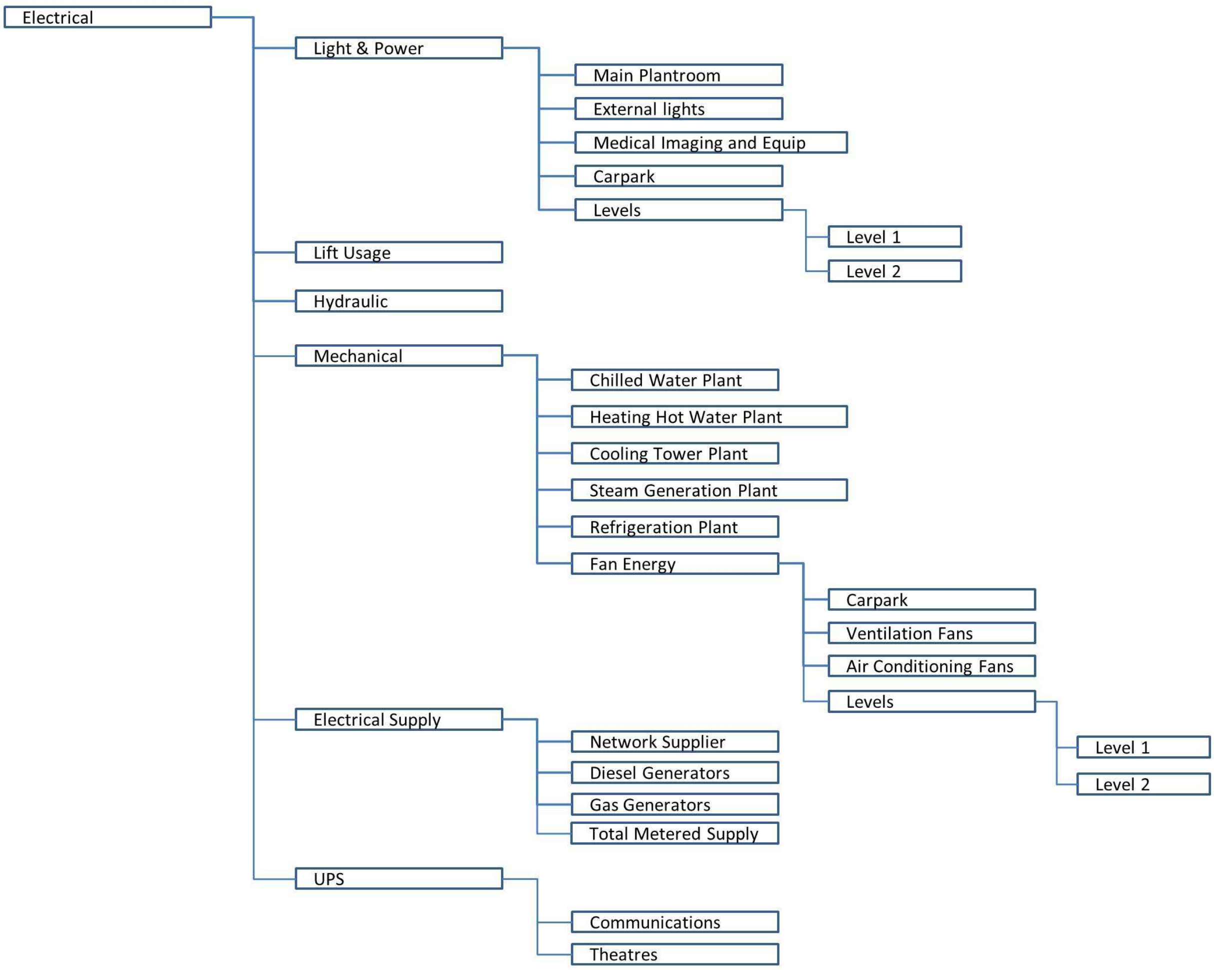
Appendix A – Metering applications

Summary of metering requirements

Metering Scope	BCA	DH Guidelines	Green Star	Good Practice	Recommendations
Energy including peak demand					
General lighting	✔	✔	✔	✔	Floor by floor unless there is a specific project requirement.
Appliance power	✔	✔	✔	✔	Floor by floor with additional metering for equipment uses that exceed 100kVA
Air handling system	✔		✔	✔	Air handling plant – meter as a whole Fan coil systems – meter at each switchboard
Lifts, hoists and escalators	✔			✔	Group the lifts under a common meter.
Carpark (ventilation, power and lighting)		✔		✔	Limit metering to carparks with at least 20 car spaces.
Chilled Water Plant	✔		✔	✔	Separately meter chillers and cooling towers / heat rejection plant. Meter pumps which exceed 20kVA.
Heating Hot Water Plant	✔		✔	✔	Separately meter boilers. Meter pumps which exceed 20kVA.
Domestic hot water plant	✔		✔	✔	Separately meter boilers. Meter pumps which exceed 20kVA.
Energy generation plant such as diesel generators, solar PV, etc				✔	Separately meter each generation plant.
Large energy intensive uses (higher than 100kVA)		✔	✔	✔	Meter all end uses which exceed 100kVA
Communication Room/ Data centre power		✔	✔	✔	Separately meter communication rooms or data centres which exceed 20kVA
Steam system				✔	Separately meter to facilitate identification of system leaks.
Technical compressed air system				✔	Separately meter to facilitate identification of system leaks.
Small energy uses (i.e security, fire boards, sump pumps, etc)					Avoid meter end uses which are less than 20kVA unless there is a project specific reason.
Electrical reheat					Avoid meter end uses which are less than 20kVA unless there is a project specific reason.
Water					
Rainwater reuse			✔	✔	Meter rainwater reuse for tanks larger than 10kL
Recycled water (grey/black water treatment)			✔	✔	Separately meter all treatment systems
Fittings and fixtures		✔	✔	✔	Floor by floor unless there is a specific project requirement.
Heat rejection system / Cooling tower system		✔	✔	✔	Meter make up water use for the heat rejection / cooling tower system

Metering Scope	BCA	DH Guidelines	Green Star	Good Practice	Recommendations
Laundry facilities		✔	✔	✔	Meter all laundry facilities
Renal dialysis		✔	✔	✔	Meter all end uses
Fire system water			✔		Meter all fire systems that contain a fire pump room
Hydrotherapy Pools			✔		Meter the make-up water consumption
Irrigation			✔		Meter only where there is a large areas of landscaping requiring irrigation
Solar domestic hot water					Do not meter unless there is a specific project requirement
Kitchenettes					Do not meter unless there is a specific project requirement
Co-generation / tri-generation systems					
Fuel consumption				✔	Meter gas, electricity, heating hot water and Chilled Water (CHW) in the case of tri-generation to estimate plant efficiency
Ancillary plant energy consumption (e.g. heat rejection system, plant ventilation)				✔	
Generated electricity			✔	✔	
Generated heating hot water			✔	✔	
Generated chilled water (Trigeneration only)				✔	

Appendix B – Example Electrical Metering Diagram



Appendix C – Resources & Links

- Building Code of Australia 2013
  http://www.abcb.gov.au/
- Australian Standards (AS 62052, AS 60044, AS 3565)
  http://www.standards.org.au/
- Department of Health Guidelines for sustainability in health care capital works
  http://www.capital.health.vic.gov.au/sustainability/
- Green Star Health Care v1
  http://www.gbca.org.au/green-star/rating-tools/green-star-healthcare-v1/
- International Performance Measurement and Verification Protocol (IPMVP)
  http://www.evo-world.org
- NABERS EW (Energy & Water) rules
  http://www.nabers.gov.au/public/WebPages/DocumentHandler.ashx?docType=2&id=44&attId=0