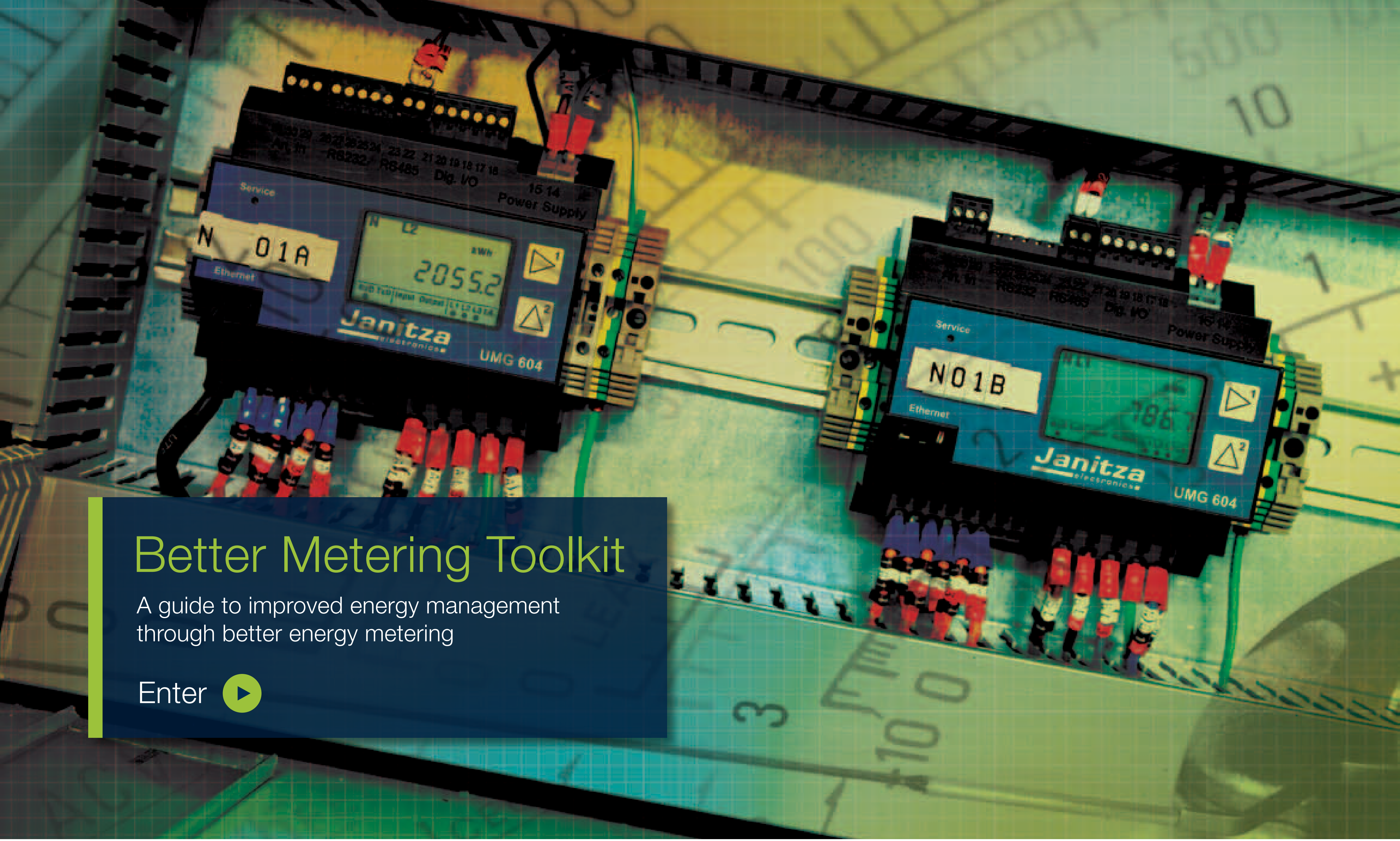


# Better Metering Toolkit

A guide to improved energy management through better energy metering

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BETTER BUILDINGS PARTNERSHIP

# Acknowledgements

The Better Buildings Partnership (BBP) brings together a number of the largest commercial and public property owners in London in one collaborative organisation. All members are working together to improve the sustainability of London's existing commercial building stock and accelerate the reduction in $CO_2$ emissions from these buildings.

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The views expressed in this document are not necessarily those of either the individuals who provided input or their organisations.

# Chairman's Statement

Commercial buildings are responsible for approximately one fifth of the UK's $CO_2$ emissions, however the sector as a whole has historically been profligate in its attitude to energy use. Such energy wastage not only results in unnecessary cost to business, but is fundamentally detrimental to the industry's efforts to drive down $CO_2$ emissions in line with the government's ambitious, but necessary reduction targets. Effective energy management is therefore an essential part of any sustainability strategy.

A critical first step in any energy management programme is the accurate measurement and monitoring of how much energy a building uses. This is by no means an easy process and is an area which Better Building Partnership (BBP) members find extremely challenging.

Appropriate metering systems, installed so as to record consumption throughout a building, are able to provide owners and occupiers with the information necessary in order to take the first steps towards improving the energy efficiency of their buildings. The property industry is becoming increasingly interested in the use of metering systems given their many benefits, including the potential for energy, cost and $CO_2$ savings, as well as the provision of data to support corporate reporting and compliance with increasing environmental legislation such as the CRC Energy Efficiency Scheme. The likely future mandatory roll-out of Display Energy Certificates to commercial buildings is an added driver.

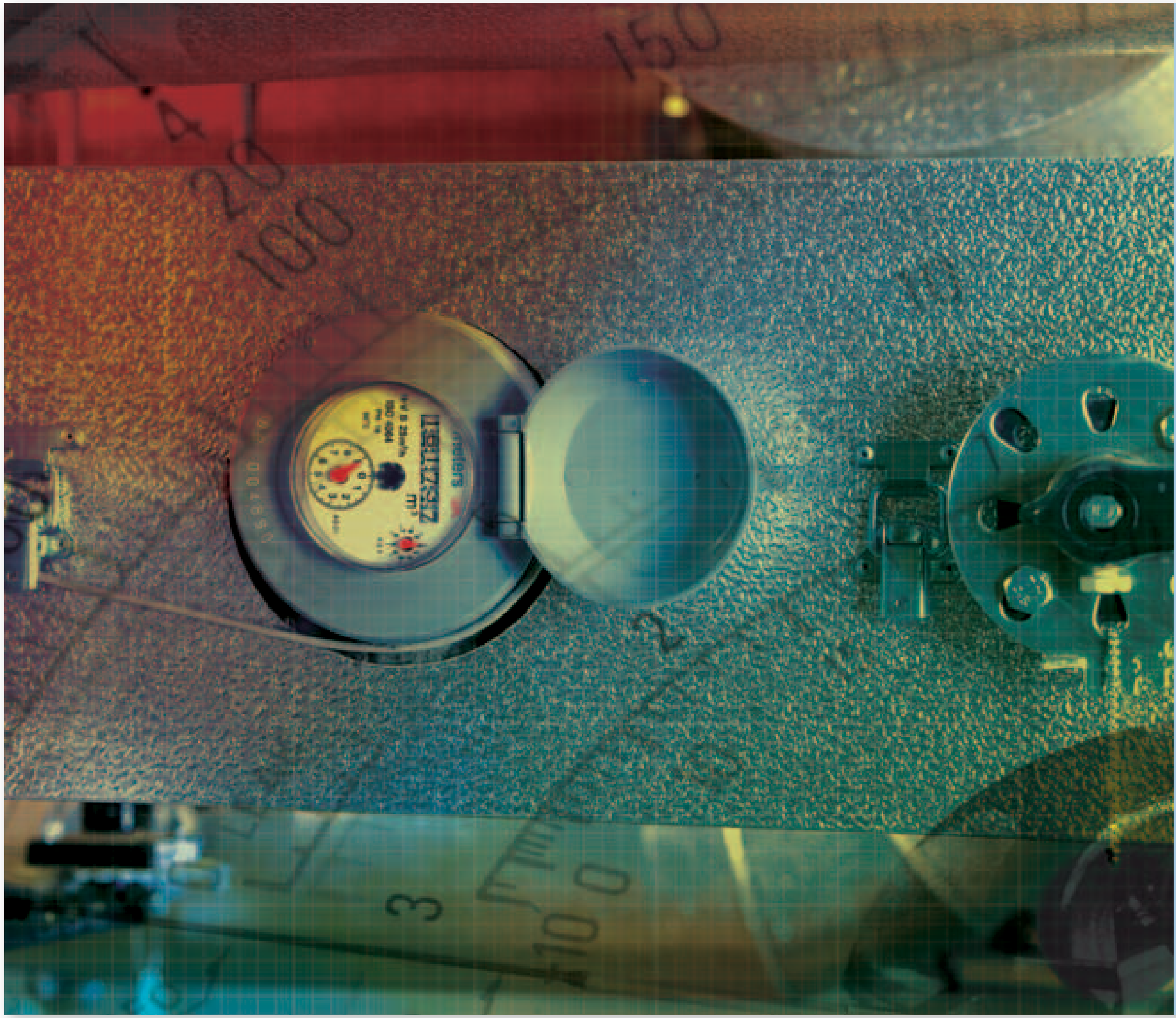
However, the opportunities for confusion are significant. An increasing number of suppliers offering a perplexing variety of different metering systems, coupled with an understandably confusing variety of terms such as 'smart', 'AMR', 'advanced', 'sub', 'fiscal' and 'check' meters, creates potential for a disjointed industry approach to such a key area of environmental management.

The BBP, tasked with developing practical guidance on the subject, has produced this Toolkit. It sets out the metering options currently available for commercial buildings, considers the costs and benefits and provides advice on how metering data can be used to make energy and cost reductions.

I hope that this Toolkit provides a helpful guide for 'non-technical' decision makers and supports both owners and occupiers when engaging with metering system designers, suppliers and utility companies in order to ensure that the most appropriate and effective solutions are implemented in their buildings.

Quinten Babcock
Chairman, Sustainability Benchmarking Working Group

# 1. Introduction



The UK Government has committed to a binding target of reducing carbon emissions by 80% relative to the 1990 levels by 2050.

The absolute level of $CO_2$ emissions has fallen less than 20% since 1990, and so substantial improvements will have to be made over the next 40 years if the target is to be met.

Since 18% of national carbon emissions come from the operation of non-domestic buildings a significant reduction in the amount of energy we use to heat, cool and power buildings will be needed.

As a significant proportion of the building stock that will exist in 2050 is already constructed, carbon emission reductions cannot just come from increasing the efficiency of new buildings. A substantial improvement in energy efficiency will be required from the whole sector – every building and every occupier of every building will have to contribute to delivering the necessary savings.

Continue

# Introduction

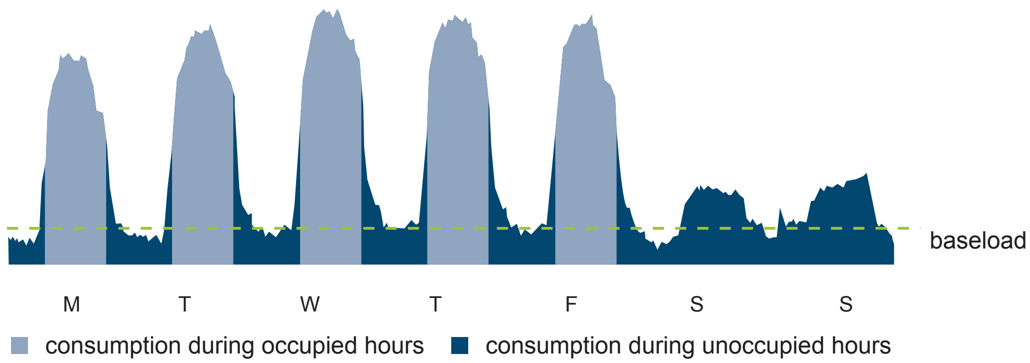
One of the biggest challenges to improving the energy efficiency of commercial buildings is a lack of performance data. Owners and occupiers are generally unaware of how well or badly their building is performing. It is often said that 'if you can't measure it, you can't manage it'. An appropriate energy metering system helps tackle this issue by enabling owners and occupiers to measure how much energy their buildings are consuming on a daily basis. This information can then be used to help deliver energy and cost saving opportunities.

These opportunities fall into two distinct categories:

- **Improved energy management:** these are generally no or low cost actions that better match the operation of the building services to the operational use of the building. Examples include making sure lighting, heating and air conditioning is not being used when the building is un-occupied.
- **Investment in new or enhanced energy efficiency measures:** these can have very short payback periods. In addition, they often improve the comfort and satisfaction of the occupier, and there may be added value in terms of attracting occupiers and increasing retention rates. Choosing where to invest in energy efficiency measures and preparing the appropriate business case should be guided by an understanding of how and where energy is used in a building.

This Toolkit is about 'better energy metering', an approach that offers owners and occupiers energy consumption data at a greater degree of detail than is provided for basic billing purposes. It allows building owners and occupiers to understand how, where and when energy is being used in their building and to identify and assess savings opportunities (see Figure 1). However, it is important to note that better metering does not guarantee savings. Rather it is a tool that enables better understanding of where and how savings can be made. To achieve actual energy and cost savings, someone with the appropriate responsibility and authority to implement an energy saving programme will be required.

**Figure 1: Example weekly half hourly profile of electricity consumption which can be produced through better metering of a commercial building**




The troughs in the graph show the baseload of the building – i.e. the minimum amount of electricity consumed by the building. This occurs overnight when the building is empty. An optimised standard occupancy building operating during normal working hours should have a baseload of between 10 and 15% of peak consumption, with 24/7 operated buildings having approx. 40% baseloads.

This guide is designed to provide a better understanding of energy metering systems, and to inform decision-makers about the choices available when procuring and installing systems. Section 2: Benefits summarises the benefits of better energy metering. A detailed description of the different types of meter is given in Section 3: Meters. Section 4: Systems provides guidance on the current options available when selecting a better energy metering system, including some of the costs and benefits. Section 5: Using Data then illustrates the ways in which the information generated through better metering can be used to improve energy efficiency.

# Contents

## 2. The benefits of better energy metering


There are numerous benefits available to both owners and occupiers from installing better energy metering systems. These are summarised in this section under the following three headings:

- Understanding the energy performance of a building
- Reporting the energy performance of a building
- Improving owner occupier relationships

Continue

Benefits



# 2.1 Understanding the energy performance of a building

Understanding when and where energy is being used is the first and most important step in reducing energy consumption. Most, organisations rely on meter readings provided by the utility company within their bills. However, utility companies typically manually read the meters on an annual basis. Hence, monthly or quarterly bills will be produced on the basis of estimated usage, which may not be an accurate reflection of actual usage, especially if there has been a change in activity in part of the building.

Better metering can provide more timely and detailed information on how energy is being used in a building. It does this by:

- Providing measurements on the amount of energy used during each half-hour period. This enables users to understand how energy demand varies through the day, and can provide instant feedback on performance.
- Providing a disaggregation of the energy demand into its different end uses, such as lighting and small power for individual occupiers, and major plant items such as chillers etc. This is achieved through sub-metering and gives a much enhanced understanding of the patterns of energy demand within a building.
- Providing automated reading and logging of meters. If this is linked into a suitable energy management system, then the data can be analysed and automated reports prepared.
- Checking actual consumption against expected profiles and providing 'out of range' alarms to warn building management that corrective action may be required.

## Reducing costs

Enhanced understanding of when and where energy is being used through automated meter readings allows waste to be identified and suitable corrective measures to be taken (see Section 5: Using Data). This saving of energy leads to reductions in energy bills and carbon emissions. It is for this reason that better energy metering systems are seen by Government as an important tool in reducing UK carbon emissions. It is anticipated that certain types of meters will be required by law for all buildings over time. Further details on the regulatory requirements of different types of meters are provided in Section 3: Meters.

## Bill validation and tariff selection

Automated meter readings allow owners and occupiers to cross check that they are being billed correctly. For example, billing errors can result from inaccurate manual meter readings by the utility company.

Utility companies are also very interested in managing their supply network, and balancing supply and demand. With a detailed understanding of the energy demand profiles of a building, it may be possible to negotiate a more beneficial tariff.

## Maintenance contract fees

Automated meter readings can reduce facilities management costs in a building where regular manual readings take place by reducing the requirement for manual meter inspections. Finding, recording and consolidating meter readings, especially in a large building, can be a time consuming exercise. Automating the meter readings can eliminate this task, and also improve the accuracy of data that is recorded. This saving alone can often pay for the cost of installing the improved metering. However, it is prudent to undertake manual readings in the initial period after installation to validate that the automated system is operating correctly and then occasional readings (e.g. twice per year) to confirm the system is still reporting accurately.

Benefits



# 2.2 Reporting the energy performance of a building

## Corporate Social Responsibility (CSR) reports

Given the increasing public concern over environmental issues, there is growing moral and indeed legal pressure to report environmental performance. Corporate social responsibility demands that building owners and occupiers understand the environmental impact of their business activities and take active steps to reduce it. Energy use and consequent carbon emissions rank high on the environmental agenda, and so understanding and managing energy consumption should be a key part of the management function in every responsible business.

The classic environmental management cycle is:

- Measure and report current performance.
- Compare that performance against appropriate benchmarks.
- Identify areas of improvement and implement an action plan.
- Measure the success of the implementation plan.
- Repeat the cycle.

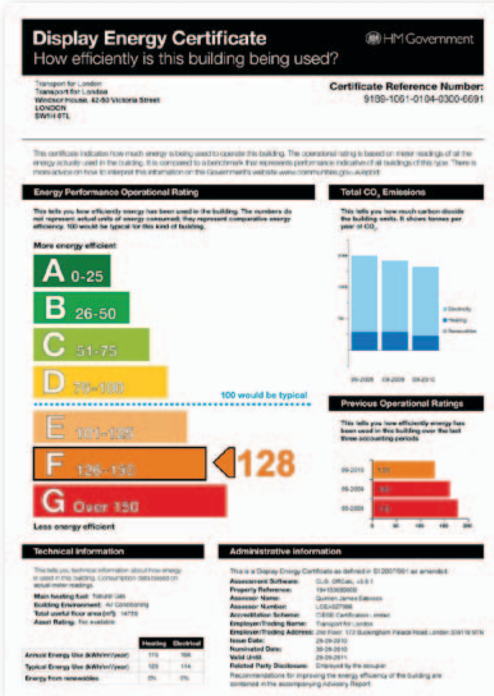
Better metering can support these objectives, as part of a suite of environmental reporting initiatives. The range of environmental reporting possibilities is diverse, from an internal report to senior management through to initiatives such as the Carbon Disclosure Project (CDP).

## Display Energy Certificates

The public display of Display Energy Certificates (DECs) is now a legal requirement in public buildings over 1,000m$^2$ and is likely to be rolled out to the commercial property sector following the publication of the government's Carbon Plan. A DEC includes an energy rating, which indicates how well the building is performing compared to its peers, and how energy performance is changing with time (see Figure 2).

Public perceptions of owner's and occupier's commitment to effective energy management will be influenced by their building's DEC rating. Better metering will help owners and occupiers obtain good quality data that can help improve the energy rating, both through discounting defined 'separable' energy uses (e.g. through sub-metering of regional server rooms or trading floors in offices) and improved energy management. It will also assist building management to prioritise the list of recommended energy efficiency improvements identified by the assessor who produces the certificate.

**Figure 2: Example of a DEC certificate**




Continue

Benefits



# 2.2 Reporting the energy performance of a building *(continued)*

## CRC Energy Efficiency Scheme

The introduction of the Carbon Reduction Commitment Energy Efficiency Scheme for organisations using more than 6,000MWh of electricity per annum is a further incentive to have accurate and timely energy consumption data. The government is currently consulting on the operation and design of the scheme. Ultimately, it is expected to increase the cost of energy consumption and thus encourage energy efficiency.

## Influencing behavioural change

As well as reporting up the management chain, the reporting of energy performance is a powerful motivational tool that can influence the behaviour of all staff. For example, publishing league tables highlighting the out-of-hours energy consumption on different floors of a building can encourage the switching off of equipment at the end of the working day. Figure 3, supplied by Transport for London, illustrates the percentage of energy consumption out of hours (from 19.00-07:00 Mon-Fri and all day Sat-Sun) at Windsor House, which they use to stimulate behavioural change among employees. In addition, the use of an energy dashboard (a visual display of energy consumption e.g. TV screens or online portal) can help to effectively present energy savings data to company staff, management and visitors. An example of an energy dashboard can be viewed on the Department of Energy and Climate Change Homepage.

**Figure 3: Example four weekly league table of out of hours energy consumption at Transport for London's Windsor House**

| Group Name | % Out of hours | Cost | % Change |
|---|---|---|---|
| 6th Floor | 32% | £101 | 4% |
| 13th Floor | 32% | £80 | 9% |
| 7th Floor | 37% | £140 | -7% |
| 8th Floor | 37% | £128 | -6% |
| 5th Floor | 38% | £122 | 0% |
| 10th Floor | 40% | £147 | 2% |
| 15th Floor | 40% | £121 | -4% |
| 17th Floor | 40% | £122 | 7% |
| 9th Floor | 41% | £155 | 0% |
| 11th Floor | 41% | £147 | 1% |
| 14th Floor | 41% | £113 | 4% |
| 12th Floor | 42% | £154 | 2% |
| 16th Floor | 42% | £147 | 5% |
| 18th Floor | 44% | £116 | 12% |
| Ground Floor | 48% | £19 | -34% |
| 3rd Floor | 53% | £108 | -7% |
| 4th Floor | 53% | £150 | 8% |
| 1st Floor | 65% | £13 | 41% |

Benefits



## 2.3 Improving owner occupier relationships

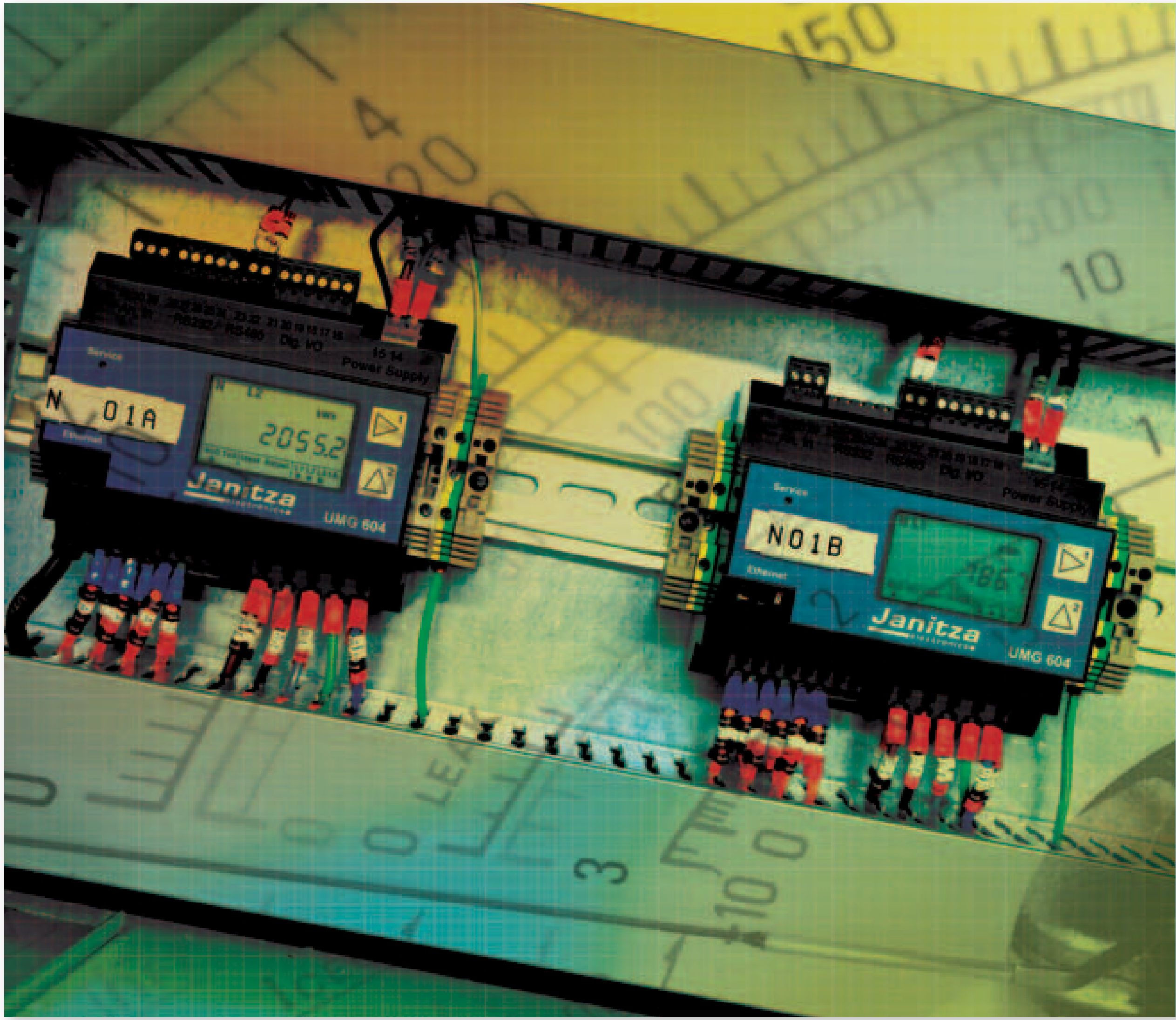
Better metering can deliver improved customer service to occupiers. Currently, many occupiers' bills are simply estimated as a proportion of the total energy bill for the building e.g. pro-rated by occupied floor area. Better metering systems enable a more accurate measurement of energy use by each occupier. It allows owners to itemise actual energy consumption in the service charge, which results in fairer billing and reduced complaints as to the accuracy of bills. Furthermore, because occupiers will then be paying for the energy they actually use, they will have a direct incentive to engage in energy reduction measures within their occupied area.

Offering occupiers a better managed building with a lower total cost of occupancy, and moreover one which aligns with their own carbon reduction and sustainability commitments, can be an attractive proposition. Owners benefit too, because the approach provides an opportunity to increase retention rates and to reduce building obsolescence.

The LES-TER initiative (landlord's energy statement and tenant's energy review) provides a tool for recording, benchmarking and sharing owner and occupier energy consumption data.

Further information on improving owner occupier relationships can be found in the BBP Green Building Management Toolkit.

## 3. What is better energy metering?




This section defines the types of meters that are likely to be present in a building and the options available for better metering which can be installed, covering:

- Main utility meters
- Sub-meters
- AMR, Advanced and Smart meters

Continue

Meters



# 3.1 Main Utility Meters

Many commercial buildings (particularly ones constructed pre-2002 Part L Building Regulations) will only have basic energy metering comprising main utility meters (also known as 'fiscal' meters): one each for gas and electricity (see Figure 4 and 5). These are usually located at the point of entry of the supply to the building and are used by the utility company for billing purposes. These meters are very basic and are similar to those used in domestic buildings. Customers typically receive a monthly or quarterly bill that provides the cumulative energy consumption since the last bill. In many cases, the bill will be based on estimated energy use unless manual (or automatic) meter readings have taken place.

These meters provide limited information with which to manage the energy consumption and cost in a building. The energy data can be used to assess the relative energy performance of a building by benchmarking it against similar data from other buildings of a similar type. However, it does not provide information on how, when or where energy is consumed within a building, which makes it difficult to establish why energy performance may be poor and how to improve it.

**BOX 1**

## Check meters

For buildings with over 1MW electrical supply, the utility company provides both the main utility meter and a 'check' meter. The check meter is required for validation purposes and its reading is compared against the main meter's reading to ensure that it is operating correctly. The term 'check' meter is also often used to describe any 'unofficial' sub-meter used to compare against any main utility or sub-meter.

**Figure 4: Main electricity meter**

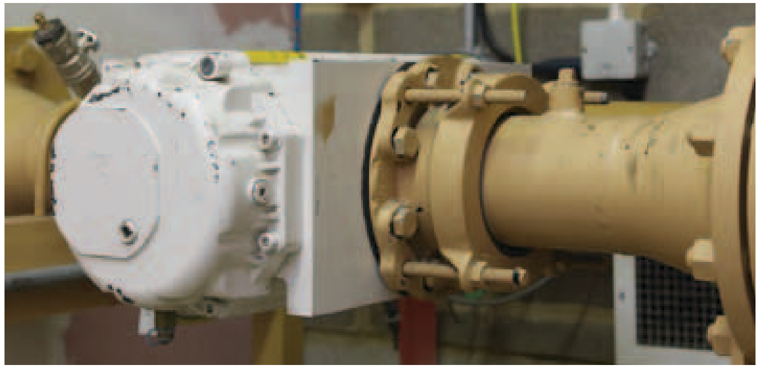


**Figure 5: Main gas meter**

Meters




**Figure 6: Lift sub-meter**

# 3.2 Sub-meters

## What is sub-metering

Sub-metering is used to measure part of the energy load in a building. Depending on the overall metering aims, sub-metering is likely to include a combination of both location based and energy load specific measurements.

- **Location based:** Sub-metering may be installed to separately measure the energy use of each floor or occupier. Such sub-metering helps the building owner determine an occupier's consumption to fairly assign their part of the bill.
- **Energy load specific:** Sub-metering may be installed for different energy loads to measure their consumption (e.g. lighting, power, heating and cooling energy). This helps both building owners and occupiers to better manage their energy consumption (see Figure 6).

For many buildings, there will be no overall sub-metering strategy to fully understand a building's energy use. Although sub-meters may have been installed, the infrastructure required to automatically read and collect the data may not be in place. Therefore, the first stage of any metering strategy should be an audit of each existing meter to document the location, function, type and data collection facilities available.

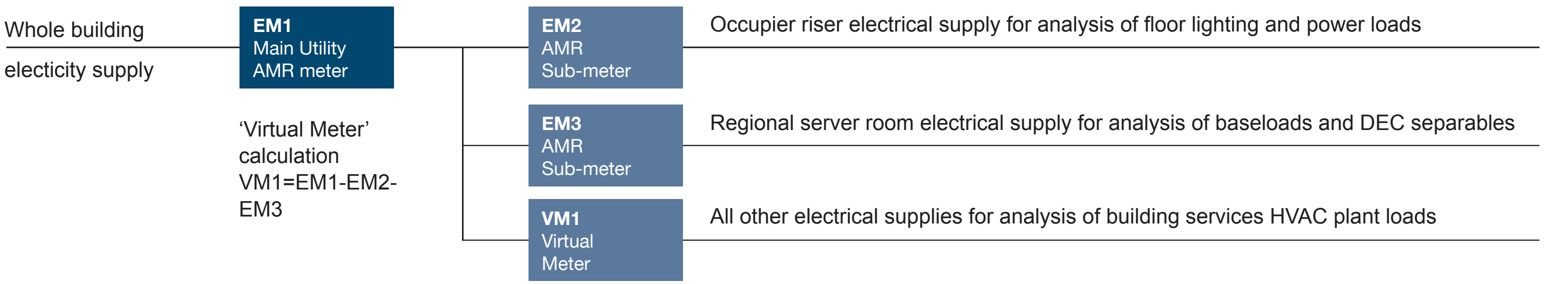
## Developing a sub-metering strategy

A clear sub-metering strategy is an important tool in ensuring costs are minimised when installing a sub-metering system. Some best practise principles include:

1. Use what sub-meters are already installed and upgrade where necessary
2. Minimise the number of sub-meters to install by using 'virtual' meters. See Figure 7 as an example
3. Assess the opportunities to install gas, water, heat and coolth sub-meters rather than just electricity
4. Use the existing Building Management System to collect metering data where feasible
5. Always look to improve the sub-metering capacity when undertaking a refurbishment or an extension to an existing building, or embarking on major HVAC plant renovation/replacement
6. Produce a clear metering schematic which is kept up to date

See CIBSE TM39 for in-depth details on how to design, implement and document sub-metering strategies.

**Figure 7: Example of 'virtual' metering**




By metering whole building supply and sub-metering occupier and server room consumption, the remaining electricity used to power building services and HVAC loads can be calculated using the formula above. This 'virtual' meter therefore reduces the need and cost for additional sub-metering of potentially multiple other supply cables.

Continue ▶

# 3.2 Sub-meters *(continued)*

## Regulations

The provision of sub-metering is also part of the guidance on ways of satisfying Part L of the Building Regulations:

- Sub-metering within new buildings was introduced in Part L 2002.
- Sub-metering of building services provided as part of the work to existing buildings was introduced in Part L 2006.
- Since 2006, for buildings which have a floor area greater than 1000m$^2$, sub-metering should be capable of automatic data reading and collection.

Reasonable provision to comply with Part L is to install metering that enables at least 90% of the energy consumption for each energy type (electricity and gas) to be assigned to its various end uses (e.g. heating, lighting etc.) (see Figure 8).

## Heat and coolth sub-meters

In addition to typical electricity and gas sub-metering, heat and coolth sub-metering can be used to apportion the energy supplied from central heating and cooling systems to the occupiers in a building (see Figure 9).

- 'Heat' sub-meters can separately measure the hot water flow from a central heating system to each occupier and estimate their energy use.
- 'Coolth' sub-meters can be used to separately measure the cold water flow from a central chilled water air conditioning system to each occupier and estimate their energy use.

This type of metering is particularly relevant where there is a disproportionate use of heating or cooling amongst the different occupiers in a building e.g. where there is a large data centre, or 24/7 trading floors. Occupiers can be supplied with more accurate and fairer billing, resulting in fewer complaints and a greater incentive to engage in energy reduction initiatives.

**Figure 8: Gas sub-meter for a Combined Heat and Power (CHP) engine**

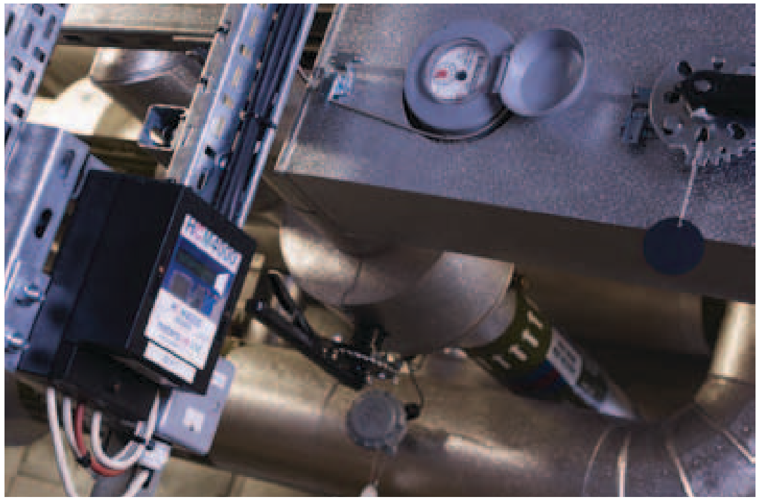


**Figure 9: Heat and coolth sub-meter**

# 3.3 What better energy metering options are available?

Better energy meters are available which provide more useful information on the energy consumption in a building. The most common names for these meters are 'advanced meters', 'automatic meter reading (AMR)' and 'smart meters'.

## Automatic meter reading (AMR) or 'advanced' metering

### What is AMR/advanced metering

AMR technology provides the ability to read a meter remotely, automatically and at frequent intervals. Such meters are also often termed 'advanced'. The technology is applicable to both main utility meters and sub-meters. It is important to note that existing meters can either be replaced with new AMR capable meters or retrofitted with AMR technology (see Section 4: Systems) for more details.

AMR capable main utility meters allow a utility company to remotely access energy consumption data. Energy readings are typically recorded on a half-hourly basis, providing much more accurate and 'up to date' energy usage data (than available through monthly or quarterly bills). This type of meter also reduces the need for manual readings and provides the client access to the information e.g. via internet 'portals'.

### Regulatory requirements

AMR metering is mandatory for large users of energy, as follows:

- Electricity: AMR meters which provide half-hourly interval consumption data are required in situations where the average peak electricity demand over the three months of highest consumption within a year exceeds 100kW.
- Gas: Daily AMR meters are required where gas is supplied to sites where the annual consumption level is 58,600MWh or more.

By 6th April 2014, the following buildings must also have AMR metering.

- Electricity: Non-domestic premises which fall into electricity tarriff profile classes 5, 6, 7 and 8.
- Gas: Non-domestic premises with an annual consumption of more than 732MWh.

For further information see Department of Energy and Climate Change.

### AMR sub-meters

AMR capable sub-meters operate in much the same way as AMR main utility meters. They provide more accurate and 'up-to-date' energy consumption data for a sub-meter which measures a specific location or energy load – storing and transmitting readings typically on a half-hourly basis. Data for these meters is not transmitted to a utility company but is used by building management where performance can by analysed to ensure efficient operation and identify energy reduction opportunities (See Section 5: Using Data for more information).

Continue ▶

# 3.3 What better energy metering options are available? *(continued)*

## 'Smart' metering

### What is a smart meter?

A 'smart' meter allows the utility company to both remotely read and instruct the meter. It therefore provides two-way communication whereas advanced/AMR meters only allow one-way communication. This additional functionality (of a utility company being able to instruct the meter) allows a number of additional operations, which include:

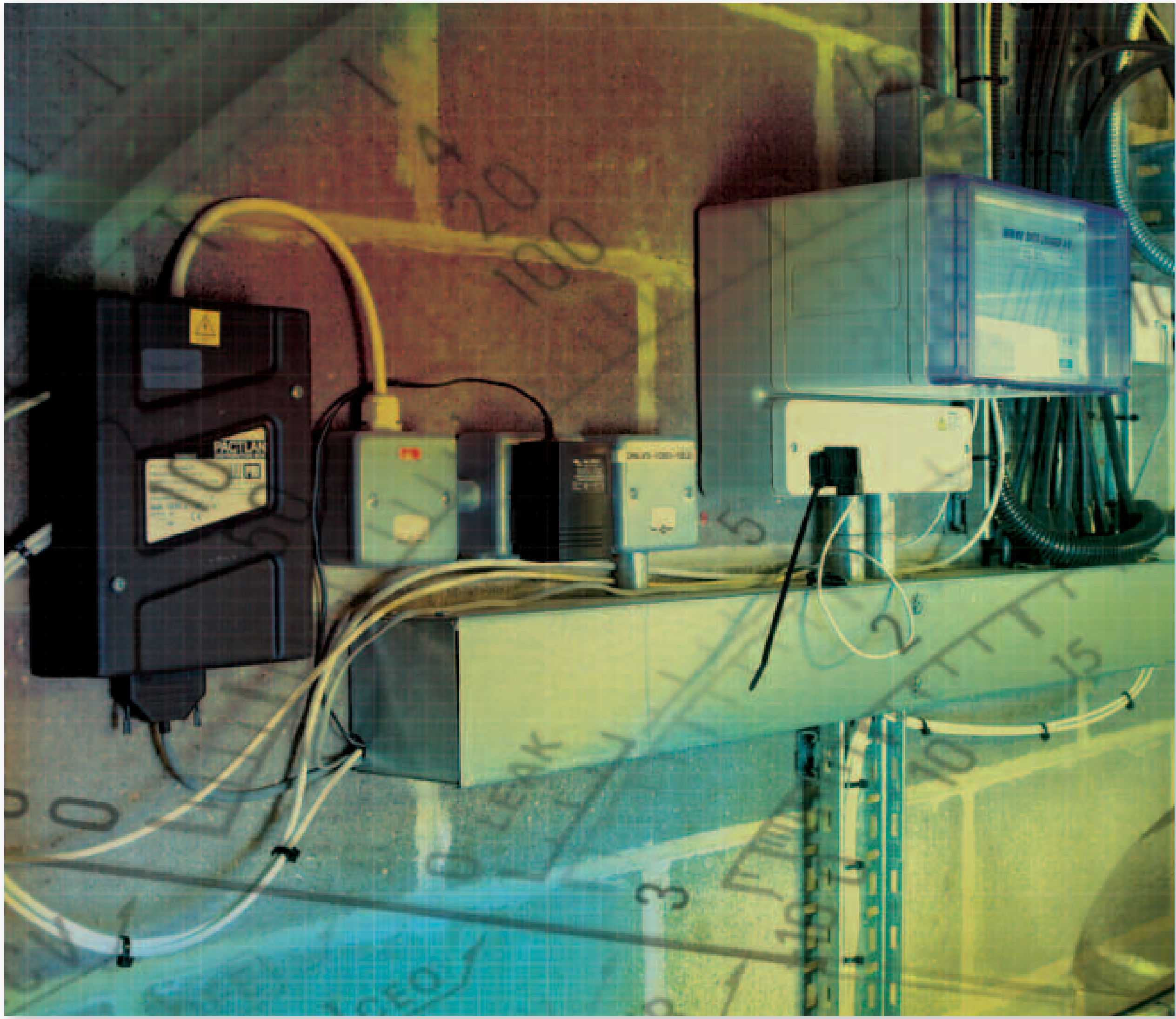
- updating metering software.
- changing the read frequency.
- remotely controlling an agreed portion of a customer's consumption in order to help balance grid electrical generation and demand.
- updating the metering tariff.
- terminating energy use in the event of non-payment.

### Common misconceptions

Within the property industry there is some confusion over the term 'smart meter'. It is often used by trade press, equipment suppliers and others to cover all types of intelligent energy meters, including AMR meters and energy display devices.

In the UK, the government has committed to roll-out of smart electricity and gas fiscal meters to all households and smaller non-domestic premises by 2019. A Smart Metering Prospectus jointly published by DECC and Ofgem in July 2010 set out proposals on the key elements of a smart metering roll-out. A Response to the Consultation was released in March 2010 which sets out the government's conclusions on how the smart metering roll-out will be organised and regulated and provides details on the high-level functionalities and technical specifications of a smart meter. The planned roll-out is expected to start in 2014, however, for smaller non-domestic buildings where AMR metering has previously been installed, these meters will not need to be replaced with smart meters. No proposals have currently been outlined regarding requirements for larger commercial buildings.

# 4. Choosing a better energy metering system



This section provides guidance on the separate components of an AMR metering system. It is not intended to be a fully comprehensive guide and the reader may need additional technical support when selecting the most appropriate system for their building(s). However, this section will help when engaging with system designers, meter system suppliers and utility companies. It outlines the key decisions to be made and the main advantages and disadvantages of options available in the UK today.

Continue ▶

# Overview

BOX 2

## The Enhanced Capital Allowance Scheme

The Enhanced Capital Allowance (ECA) scheme helps reduce the costs of investing in AMR metering systems. It provides tax relief for a range of specified energy saving technologies, including (Automatic Monitoring and Targeting (aM&T) systems). This includes the meters, the meter reading system and the analytical software. The tax relief is not granted on software when using an external service provider, although tax relief can still be gained on the other components of the system. Further details can be found from ECA's web-site: www.eca.gov.uk

As an example, through the ECA scheme, Transport for London (TfL) received a rebate of 19% of their costs for metering and aM&T software systems for their Palestra building in Southwark.

It should be noted that while this section is written principally for a non-technical audience it does provide same detail over and above that which a non-technical reader may wish to know.

Estimated costs of various options are provided (see Cost Table), but it must be emphasised that the costs are illustrative only – actual outturn costs will depend on a number of factors including client needs, the layout of the building, the potential to use existing infrastructure and the ease of installing the new system.

A general schematic of an AMR metering system and its associated benefits is provided (see AMR Schematic). The schematic comprises a number of key components. These are summarised below and are dealt with in more detail later in this section: (see Technical Detail)

## 1. Metering

This includes the main utility meters and any sub-metering. The meters measure the amount of electricity and gas passing through them. Some meters will incorporate memory storage capacity to record half-hourly energy consumption. Other meters will only have the capacity to produce half-hourly 'pulses' related to the units of consumption.

## 2. Transmission to a central point

The half-hourly data needs to be transmitted over a communications network from the meter to a central point for aggregation / consolidation.

## 3. On-site data collection

Data loggers or a central data server can provide this aggregation / consolidation function by storing readings from the various meters within the building. This stage is not necessarily required if all data storage and analysis is being carried out off site.

## 4. External transmission for off-site analysis

In many cases, metering data is transmitted externally from the metered building for central storage. This allows data from a portfolio of buildings to be easily compared and analysed.

## 5. Data storage

The transmitted data is centrally captured and stored.

## 6. Data visualisation and analysis

The data is analysed using automatic Monitoring & Targeting (aM&T) software. It is this element that is vital in developing an understanding of how energy is being used in a building. The data itself has little value; it is the analysis of the data that leads to understanding, which can then drive positive action.

## 7. Energy management

As well as procuring the hardware, it is essential to appoint someone to be responsible for the energy management of a building. They need to review the information provided by the data analysis and then take the necessary action to make appropriate savings. Arguably, the energy manager is the most important part of the system, and appointing someone with the appropriate skills and authority should be an integral part of the process.

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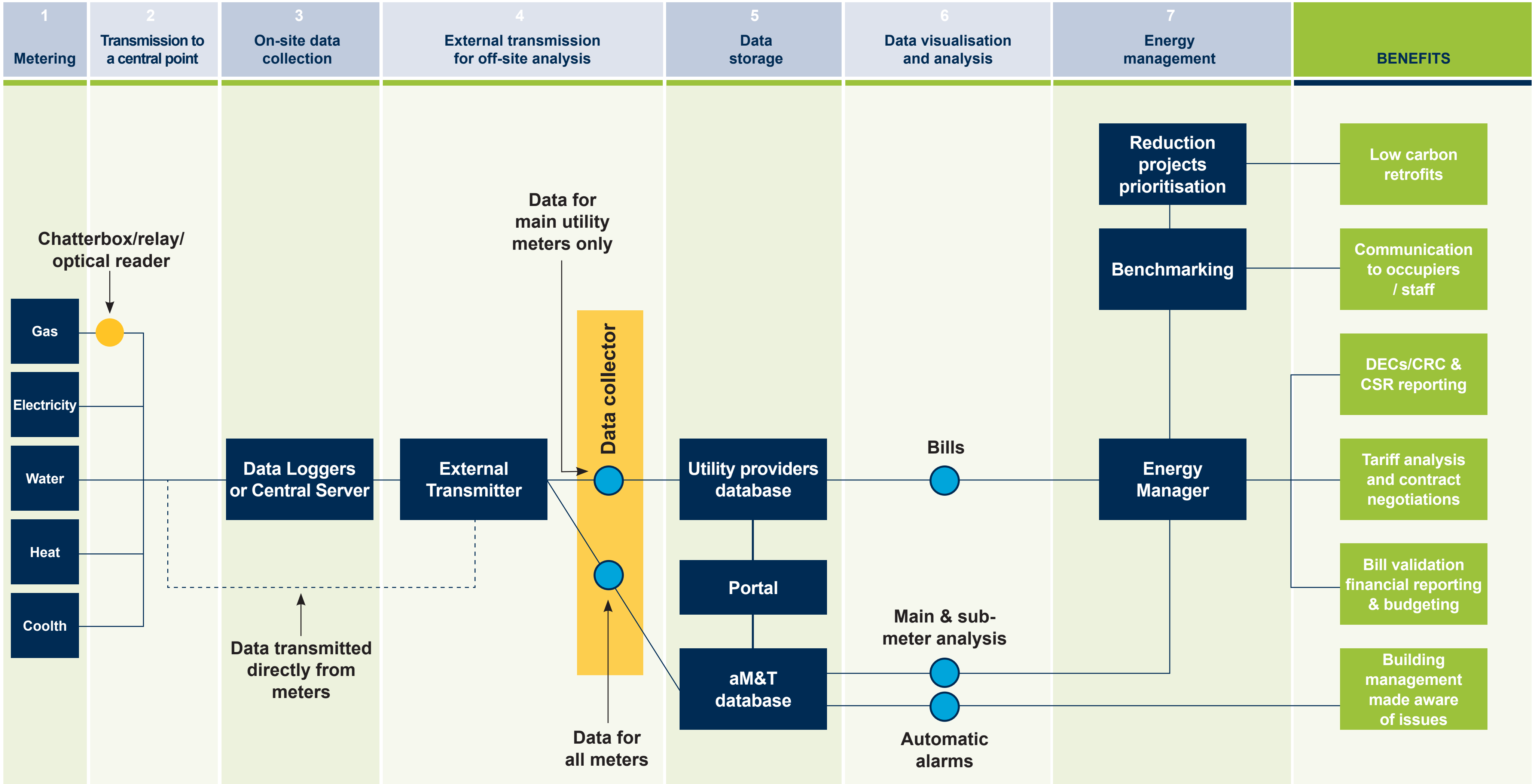
# AMR Schematic

**General schematic of an AMR metering system and its associated benefits**



# Cost Table

| Component | Option | Initial cost (capital + installation) | On-going cost | Comments |
|---|---|---|---|---|
| Meter | Enabling existing main utility AMR meter | £100-£500 per meter | See relevant box below for installing a new main electricity or gas AMR meter | |
| | Installing a new main electricity AMR meter | £300-£500 per meter | Meter maintenance costs typically met by the meter operator. Their data collection and support costs would be £50-340 per annum depending on external transmission method | Initial costs assume that there are existing current transformers in electrical switch gear panels |
| | Installing a new main gas AMR meter | £600-£5000+ per meter | Meter maintenance costs typically met by the meter asset manager. Their data collection and support costs would be £50-180 per annum depending on external transmission method | Initial cost example: fitting a new 80mm rotary meter including new pipe work will be £3,000 - £3,500, but in existing metering pipe work it would be £2,000. Then add £800 for provision of gas logger and ancillaries. The higher costs of data collection may include some elements of external analysis. Initial costs can potentially be free if utility provider can take over meter asset manager role from national grid, but this will tie the client to their data collection contract |
| | Retrofitting a gas or electricity meter | £300-£600 per meter | See relevant main utility or sub-meter costs as appropriate | |
| | Installing an electricity or gas AMR sub-meter | £200-400 per electricity sub-meter<br>£600-2,000 per gas sub-meter | See data collection and storage | Initial costs assume that there are existing current transformers in electrical switch gear panels |

Continue

# Cost Table *(continued)*

| Component | Option | Initial cost (capital + installation) | On-going cost | Comments |
|---|---|---|---|---|
| Internal transmission | Hard-wire | £60 per 100 metre of cable | See data collection and storage | This is the capital cost of the cable. The installation costs should be small during a refurbishment but potentially prohibitively expensive during other times |
| | Wireless | £175-300 per meter | See data collection and storage | Installation costs not included |
| On-site data collection | Bespoke data-logger | £30-50 per meter channel, stand alone GSM data logger equipment cost £600 | See data collection and storage | |
| | BMS (already present) | £600 per day for commissioning | See data collection and storage | It should be possible to commission up to 10-20 meters per day if located in close proximity |
| | Data Server | £1,000-2,000, plus £600 per day for commissioning | See data collection and storage | It should be possible to commission up to 10-20 meters per day if located in close proximity |
| External transmission | Cellular wireless transmitter | £100-300 per meter | £35-50 per annum | On-going costs are for data transmission only |
| | Landline | £150-200 per landline | £150-£200 per year | On-going costs are for data transmission only |

Continue

# Cost Table *(continued)*

| Component | Option | Initial cost (capital + installation) | On-going cost | Comments |
|---|---|---|---|---|
| Data collection and storage | Data collection by third party | | (i) £20-50 per meter per year for daily data transmission<br>(ii) £10-20 per meter per year for weekly data transmission | On-going costs are for data collection only |
| | Self-collection | | £0-180 per year | On-going costs depend on transmission solution (e.g. Ethernet vs. phone line costs) |
| Data visualisation and analysis | aM&T software | £2,000-£50,000 | Yearly license and maintenance typically 12.5% of original acquisition cost | Cost will depend on functionality required from software |
| | External analysis | | £100-200 per meter per year | Costs assume basic consumption reporting and alerts. The external provider may provide additional services such as acting as a virtual energy manager |

# 1. Metering

The first component in the system is the meter, which measures the amount of energy being consumed. This section discusses the key decisions necessary in procuring:

- main utility meters to measure the total energy use in a building
- sub-meters to measure energy used by specific areas of the building or particular end-uses (e.g. the chiller).

## Main Utility Electricity Meters

Every building will already have a main utility electricity meter (see Figure 10). It is necessary to check whether it is a half-hourly capable meter (i.e. has AMR capability). If not, the meter will need to be either replaced or retrofitted to provide AMR capability. The three typical scenarios are discussed below.

**Figure 10: Main electricity meter**

### Electricity meter with enabled AMR capability

If the existing meter already has enabled AMR capability, the data will already be automatically collected and transmitted to a utility company for billing purposes at half-hourly intervals. If so, there is no need for any changes to be made to the meter. All that is required is to gain access to the data. There are three options for obtaining the data:

- Request that the utility company provides the data, either by providing access via a web-portal, or by emailing the data.
- Appoint a licensed Data Collector to collect the metering data for both the utility company and the owner / occupier (see Data Storage).
- Request that the utility company fit a Customer Access Terminal box ('CAT box') to enable access to the data feed for an onsite data logger or central server.

### Electricity meter with un-enabled AMR capability

The meter may have the capability of producing half hourly data but it is not currently being remotely accessed for billing purposes. In this instance, retrieving data from the meter should be relatively straightforward by either:

- Installing an external transmitter direct to the meter
- Requesting that the utility company fit a 'CAT box' to enable access to the data feed for collection by a data logger or central server.

The cost will typically range from £100 to £500 depending on what type of device is fitted.

Continue ▶

Detail



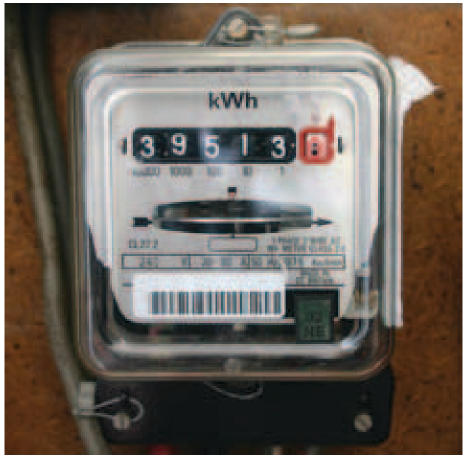



**Figure 11: Non-AMR meter**

# 1. Metering *(continued)*

## Non-AMR capable electricity meter

If the current electricity meter does not have AMR capability (see Figure 11), in order to automatically collect meter readings, the meter must either be replaced or retrofitted.

### Replacing a non-AMR capable electricity meter

If choosing to replace a meter, one option is to contact the utility company to request that the meter be upgraded. The upgrade might be provided by the utility company at no charge, but if not, they will usually agree that the meter be replaced at the organisation's cost, subject to using a licensed meter operator (who is responsible for installing and maintaining electricity meters).

For further information on the key players within the electricity and gas markets and their respective rules see Carbon Trust CTV027.

The main advantages of replacing the meter are that the newly-installed meter will be designed for AMR-use, be based on latest technology and have greater functionality.

The main disadvantage of replacing the meter is that there may need to be a total or partial electricity shutdown of the building which can raise several issues:

- Planning an electrical shut-down for, e.g. a commercial office building is a complex process and may involve shutting down occupier's server rooms (which may be serving a wider national or international area) and other plant. This may often need to be undertaken outside of normal working hours, which raises both the cost and complexity of planning involved.
- Once equipment is turned off, it may not start again. This could happen, for example, with services which are approaching the end of their life.

The cost for the supply and fitting of a meter is around £300-£500 per meter. This is likely to be higher if installed outside of normal working hours.

An alternative solution which does not involve shutting down the electricity supply of the building is to install a new AMR 'sub' meter just downstream of the main utility meter, using split current transformers (CTs) clamped around the mains supply. This provides the same information as if the main utility meter was AMR capable (i.e. total energy consumption in the building) but instead there is simply an additional AMR capable meter alongside.

### Retrofitting a non-AMR capable electricity meter

Rather than replacing the existing meter, it can be modified to allow AMR capability. The key component is a reading device to transform the analogue meter reading to a data output which expresses energy consumption on a half hourly basis. For example, an optical reader can be fixed to the front of the existing meter which 'watches' the rotation of the meter dials and converts this information into data outputs (see Figure 13).

The main advantage of this option is that it is simpler to install than replacing the meter and does not require a building shut down. However, the cost can be similar to replacing the existing meter (around £300-£600 per meter) when allowance is made for commissioning the retrofitted meter.

The disadvantage of retrofitting is that many older meters do not have bespoke optical readers available on the market and therefore generic ones need to be attached, often using glue or sticky tape. This can lead to reliability problems e.g. the reading device can come loose or knocked out of place (particularly when manually read by the utility provider). This is likely to result in the loss of data and the additional expense of re-commissioning the system.

Continue ▶

Detail



**BOX 3**

### Gas safety issues

It is important to note that to obtain half-hourly data from a gas meter it must not be connected directly to an electrical supply for safety reasons. Therefore, a battery powered pulse relay switch (often called a 'chatterbox'), or an optical reader will be required prior to connection and collection of data by a data logger or central server.

# 1. Metering *(continued)*

## Main Utility Gas Meters

As with main utility electricity meters, the first thing to check is whether the current main gas meter (see Figure 12 is being remotely read by the utility company. This will typically not be the case for a small to medium-sized commercial building due to its relatively small energy demand compared to the current mandatory requirements for an AMR meter. In this situation, the meter will need to be either replaced or retrofitted to provide AMR capability. The three typical scenarios are discussed below.

### Gas meter with enabled AMR capability

In this case, a meter may be installed where the data is already being automatically collected and transmitted to the utility company. However it will probably be recording daily or monthly totals only (not half-hourly). Whilst useful for billing purposes, it is far less useful for energy management. If the utility company is not prepared to provide the data direct on a half-hourly basis then a pulsed repeat - termed Meter Pulse replication Unit (MPU) - can be requested instead for connection and collection of data by an on-site data logger or central server. The cost of supplying and fitting such a device is in the order of £400.

### Gas meter with un-enabled AMR capability

In situations where a meter is not currently being remotely accessed but can produce half-hourly data, it should be relatively straightforward to fit a chatter box (see Box 3) for the collection of data by an on-site data logger or central server. The cost of supplying and fitting such a device is in the order of £100-500.

### Non-AMR capable gas meter

If the current gas meter does not have AMR capability, in order to automatically collect meter readings, the meter must either be replaced or retrofitted.

**Figure 12: Main gas meter**


**Figure 13: Optical reader** (courtesy of PA Energy)

Continue ▶

Detail



**Figure 14: AMR capable water sub-meter**

# 1. Metering *(continued)*

**Replacing a non-AMR capable gas meter**

The cost of fitting a replacement gas meter is more variable than for an electricity meter.

- For a small domestic style gas meter, the cost is around £600-£800 for full AMR capability.
- When replacing a larger gas meter, the cost can be in the region of £5,000 due to the greater amount of installation work involved.

It is always worth checking whether the utility company will upgrade the gas meter free of charge. However, there are costs associated with this upgrade as the utility company will now become the meter asset manager for the 'free' upgrade. It is usually necessary to sign up to the utility company's AMR contract with annual costs of circa £200 per year.

For further information on the key players within the electricity and gas markets and their respective rules see Carbon Trust CTV027.

To be able to measure the gas flow, gas meters are always fitted in-line. Therefore, adding or changing a meter requires disruption to the gas feed. Whilst this requires greater installation effort than for an electricity meter (pipes need to be emptied, purged, cut, re-sealed and tested prior to re-commissioning) it may well be less disruptive to the organisation e.g. it will not affect the operation of vital IT services. Installation can be carried out outside normal working hours or during the summer months when no space heating is required.

Gas meters may also impose a significant pressure drop. Since gas appliances usually require a minimum supply pressure, installing a new meter may require a re-commissioning exercise, with consequent cost and business disruption. There are various options for replacement metering systems and it is worth discussing with potential meter providers any solutions that might be available to minimise disruption.

**Retrofitting a non-AMR capable gas meter**

As with a non-AMR electricity meter, the existing gas meter can be similarly modified to be read remotely by coupling it with a reading device to provide a pulse output e.g. optical reader. The cost of retrofitting an existing meter is similar to retrofitting an electricity meter (£300-£600). Hence, particularly for larger gas installations, retrofitting can be an attractive option. Note the same issues for retrofitting electricity meters also apply to gas meters. (See Retrofitting a non-AMR capable electricity meter).

It is important that all bolt-on retrofit devices fitted to utility meters are registered with the utility provider or they are likely to be removed when the meter is next read manually.

**BOX 4**

### AMR Water Metering

It may be beneficial to implement an AMR water metering strategy. Main water meters can be replaced or retro-fitted, and sub-meters can be installed, to provide more detailed information on water consumption (see Figure 14). Such a strategy can used to deliver improved water management and occupier billing, comparable to energy metering. AMR water meters act in a similar manner to gas metering in that they measure the flow (in this case of water) and produce pulsed outputs related to units of consumption. This data can be used to identify normal and abnormal flow rates which help identify leaks and potential efficiency improvements. Many of the issues related to the installation of an AMR water metering system are similar to those outlined here for gas, however it is important to seek specialist advice for water metering.

Continue

Detail



# 1. Metering *(continued)*

## Sub-metering

Section 3: Meters described how sub-metering can be used to measure part of the energy load in a building. The key decisions to be made are whether to sub-meter the building and, if so, the sub-metering strategy to be adopted i.e. what areas or part-loads to sub-meter.

### Do you need to sub-meter your building?

The decision as to whether to sub-meter a building depends on the reasons for installing the new metering system.

- **To improve energy management:** In buildings that are not complex e.g. a single HVAC system, quick and large wins can often be made by initially focussing on analysing the main utility meter readings (see GE Capital Real Estate case study). Sub-metering is particularly helpful for buildings with more complex building services systems and for investigating power load issues that cannot be resolved from the main meter readings. By knowing the expected power loads of the specific energy consuming appliances (e.g. chillers and or handling units) and the times that they should be operating, a quick check can be made to see if they are operating as intended.
- **To improve occupier billing:** in this case, sub-meters should be installed to separately measure the energy use of each occupier.

### What to sub-meter in a building

Most sub-metering systems solely measure electricity consumption within the building. Sub-metering for gas is less common as, for many office buildings, the gas supply principally feeds a single heating system and there are no other significant loads to measure. However, it can be relevant where there are multiple heating systems (e.g. a hotel or large office may have separate space and hot water heating systems) or there is a significant use of gas other than for heating (e.g. a building includes a large catering facility).

**Figure 15: Electricity sub-metering of a photovoltaic array**


Renewables and low carbon technologies (e.g. photovoltaics, solar thermal, wind turbines and Combined Heat and Power (CHP) plant can also be sub-metered and monitored to ensure the technology is performing according to expectations, as well as for reporting purposes (see Figure 15).

For the purposes of improving energy management, the recommended approach is to only install meters where the potential cost saving from reduced energy consumption is likely to outweigh the cost of the metering point (see Box 6). As a guide, action taken as the result of installing a meter can save a minimum of between 5-10% of the energy flowing through it. For more information CIBSE TM39 provides detailed explanations on location based sub-metering

The cost of the supply and installation of an electricity sub-meter with AMR capability is similar to the cost of a main utility meter (£200 to £400). In addition, there will be an on-going cost for maintenance. The number of sub-meters installed will depend on the overall metering strategy.

Continue ▶

Detail



BOX 5

### Portable sub-meters

Portable meters with a data logging capability can be a cost-effective alternative to identify energy wastage in areas where fixed, permanent sub-metering cannot be justified financially. Once any inefficiencies are identified and corrected, the portable sub-meter can easily be removed and, if required, redeployed elsewhere. However, specialist knowledge is required to connect the portable sub-meter safely and access the data for analysis using the device's bespoke software application.

# 1. Metering *(continued)*

**Challenges to sub-metering**

There are some practical issues associated with sub-metering that need to be considered at the procurement stage as they could affect the cost and appropriateness of a sub-metering system.

- In existing buildings, a major problem with installing electricity sub-metering is the lack of accurate schematics. These are needed in order to accurately associate the meter with the various loads connected to it. Often, distribution board schedules are inaccurately labelled or not labelled at all! Tracing the circuits can take considerable time, effort and cost.
- Services in most existing buildings were not designed with sub-metering in mind. For example, lighting and power circuits may both have been originally served from the same distribution board. New loads may be added to existing electrical circuits in the most convenient and cost-effective way. This can make it challenging to separate and measure the desired energy loads.
- Some non-AMR sub-metering may already be present in a building. In this case, there are similar issues as main utility meters when considering whether to replace or retrofit. It is quite possible that sub-metering is present, but no record of where the meters are located and what they are measuring.

Installing sub-metering when unsure of the connected loads is unlikely to deliver meaningful information. Therefore it is recommended that the first step must be a survey of the existing infrastructure (including 'clamp on' load surveys) so that the metering strategy and subsequent energy management actions are based on reliable information.

BOX 6

### Cost of sub-metering

This example evaluates whether it is cost-effective to install a lighting sub-meter in a building. A similar calculation could be applied to the sub-metering of any energy load.

In an office having a floor area of 500m$^2$, with a lighting load of 12W/m$^2$, intended to be operating for 10 hours per day on weekdays only, the running cost of the lighting, at 10p/kWh, is of the order of £1,500 per year.

To evaluate whether it is cost-effective to install a lighting sub-meter, the cost of the meter should be compared with the cost of the additional energy that would be used if the lighting were left on longer than intended as, without the meter, the building operator would probably not be aware of this wastage. If the lights were needlessly left on for an additional 2 hours per day, this would equate to an extra £300 per year spent on electricity. If having the sub-meter helped to ensure that the lights were switched off when not required, then the simple payback period for the sub-meter would probably be very short, and installation of the meter would be considered cost-effective.

The ease with which data from the sub-meter can be used by the building operator should also be considered, as well as the building operator's willingness to act on this information to keep the lights switched off when they are not required.

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Continue

# 1. Metering *(continued)*

### Heat and coolth sub-meters

As mentioned in Section 3: Meters, heat and coolth sub-metering can be used to apportion the energy supplied from central heating and cooling systems to the occupiers in the building.

Heat and coolth sub-meters both comprise of two key components:

- A flow meter to measure the volume of water flowing through the pipe-work
- Two temperature sensors to measure the temperature difference between the flow and the return pipe-work.

The flow meter and temperature sensors can be locally connected to a heat calculator which determines the energy used by the specific energy load e.g. individual occupier heating or cooling (see Figure 16). The heat calculators then output data related to units of energy consumption via pulse cable connection or via 'data packages' over Ethernet connections. As an alternative, the flow meter and temperature sensors can be hard-wired to a Building Management System (BMS). The BMS calculates the energy consumption of each occupier.

There may be practical issues in installing the meters. For example:

- Space is required to access the pipe work and install the meter. This can be difficult where there are other building services co-located in the same area.
- There will need to be disruption to the heating or cooling system to install an in-line flow meter. This can be effectively managed by undertaking the necessary work during summer or winter months as appropriate.

As with all water flow sub-metering a non-intrusive alternative to in-line metering is to use an ultrasonic flow meter that clamps on to existing pipe work and measures temperature change and flow rate. However, this form of metering is less accurate and will also require a permanent power supply which may not be available in the required location.

### Owner sub-metering for occupier billing

In buildings where an owner has responsibility for the main utility supplies to the building and on floor lighting & power consumed within the occupier's demise is recharged to occupiers through the use of occupier billing sub-meters, under the Electricity Act 1989 the owner is 'on-selling' electricity and for this reason the meters must be Ofgem certified. By 2016 all new occupier meters used for billing purposes must conform with the EU Measuring Instruments Directive (MID). Typical costs vary from £200-£500 (not including installation and commissioning), however on-selling electricity meters can require recalibration or replacement every 10 years.

For further information see the National Measurement Office


**Figure 16: Heat/Coolth calculator**

Detail



# 2. Data transmission to a central point

Once a meter reading has been taken the data needs to be transmitted to a central point for storage. This may be a multi-staged approach depending on the complexity of the situation. For example:

- In a single building, the metering data may simply be internally transmitted to a central server within the building. This may be via a direct connection from the meters to the server or via data loggers connected to the server.
- For a multi-building portfolio, it is likely to be a combination of internal and external transmission using both data loggers and external transmitters.

This section first deals with internal transmission options for connecting meters to data loggers, central servers or external transmitters. There are many possible means of internal data transmission. Some common options are outlined here, but the list is not exhaustive.

## Wireless transmission

Wireless transmission is communication without the use of physical wires. Data is transmitted through the use of a transmitter and receiver at the two connected locations.

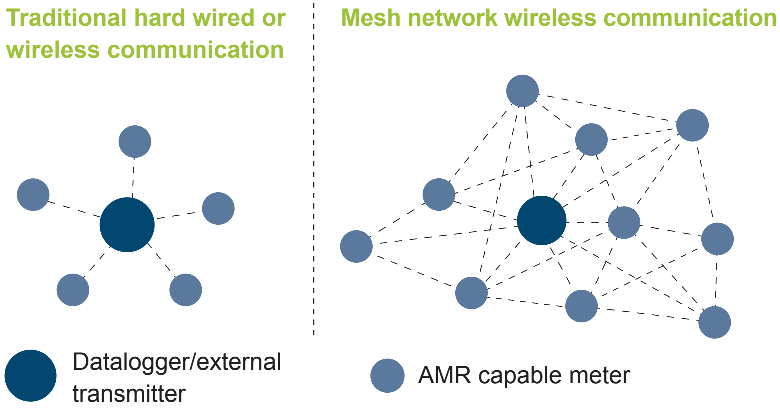
An internal wireless network has a number of advantages for existing buildings where installation of a wired network is prohibitive. In particular,

- It allows different components of the system to be located anywhere in the building.
- It is simple to expand the capacity of the network – new components can be added without the need to install new cabling.
- It is less expensive when connecting over long distances where cabling becomes difficult or transmission of data weakens.
- In a building where there are no risers or containment options e.g. shopping centres

There may however, be issues of signal strength for internal wireless communication depending on the relative location of the meters and main transmitter. An alternative is to use a mesh network (e.g. using the Zigbee communications standard) whereby all of the meters communicate wirelessly with each other, which effectively boosts each meter's signal strength to the main transmitter (see Figure 17).

As a rule, wireless communication, no matter how advanced, is prone to data gaps if there is a break in communication. However, this is only an issue if a major spike in consumption occurs that requires analysis within the specific half-hour period of data that has been lost.

**Figure 17: Comparison between traditional and mesh network communications**




Continue

# 2. Data transmission to a central point *(continued)*

## Hard wired cabling

In this case, data cables are installed within a building (see Figure 18). The main advantages of this approach are that it is a very reliable form of communication and provides fast transmission speeds. This could be via 'twisted pair' pulse cables or Ethernet cables depending on the meters' data output capabilities.

Hard wired cabling is a practical option when connecting components located close to each other. However, if components need to be connected over a long distance e.g. to a central server, installation of a new cabled communication network in an existing building can be disruptive and expensive. The cabling routes must fit within the existing building structure, potentially involving routing channels in the fabric of the building or accessing cramped and confined spaces.

## Other options

A building's data telecommunication network could be utilised. However, this is subject to:

- agreement from the IT team who for security reasons may not wish to include additional devices on the IT system; and
- adequate capacity being available near meter locations (which are usually in the plant room away from IT infrastructure).

Another option which exists is to use the building's electrical wiring network to transmit data (i.e. Ethernet over power). Any meter or data logger with Ethernet output can use this communication facility. However, power outlets and proprietary products are required to deliver this approach and it is not possible to transmit between sites or areas of a building wired on different phases or incoming supplies.


**Figure 18: Hard wired cabling installation for internal transmission of main water meter pulses**

# 3. On-site data collection

Each data output from an AMR meter corresponds to a fixed amount of energy consumption, expressed as pulses per kWh or 'packages' of data depending on the type of meter that is installed:

- Standard electricity AMR meters will produce pulse outputs, while more high-end electricity meters (meters with greater functionality) can send 'data packages' via ethernet connections. These data packages can contain a number of additional electrical parameters which may be of interest to building management to understand the power consumption and base loads of specific equipment e.g. a chiller, however these meters are more expensive.
- Gas and water meters only have the ability to produce pulse outputs.

In which ever form data is sent from the meter, the information needs to be captured by a storage device before the information can be analysed. Typically, such storage devices count and store data emitted by the meters in each half-hourly period and then convert this into half-hourly energy or water consumption. This may be either:

- Temporary data collection via a data logger prior to on-going e.g. daily or weekly data transmission to an internal or external central server. Data loggers can generally only store pulse data outputs
- Central storage via a central metering server or BMS. These can store pulse data outputs as well as data packages from high-end electricity meters.

## Data logger

Traditionally, a data logger (see Figure 19) is separate to the meter. The logger has one or multiple input channels, with each one being able to be connected to a different meter to collect pulse outputs. The logger will also have one or more output channels to allow on-going data transmission e.g. connecting multiple data loggers in a row (often referred to as daisy chaining) to one central server or external transmitter.

There are a wide variety of data loggers, however most operate with a proprietary data collection application and it may be necessary to seek specialist advice on the most appropriate technology.


**Figure 19: Data logger**

Continue

# 3. On-site data collection *(continued)*

## Central metering server

It is possible to set up a bespoke central metering server to store the captured metering data. Central servers can receive data via data loggers or direct from the AMR meters themselves. Whilst costing significantly more and possibly requiring the setting up of additional communication structure in a building, this option may be selected for the following reasons:

- Central storage for on-site data analysis.
- Central storage before external transmission for analysis.
- To receive 'data packages' containing additional electrical parameters from high-end electricity meters which traditionally data loggers are unable to receive.

## Building Management System (BMS)

In a similar way to having a central server, it may be possible to use the existing BMS to store the captured metering data. This option can achieve significant cost savings, since the communication infrastructure and data storage is already in place.

However, it is important that the BMS is assessed thoroughly to make sure it has the capability to deliver the proposed additional functionality. For example:

- The BMS may not be designed for, or have the capacity for the continuous acquisition of data from multiple meters.
- There may be insufficient hard-wire connection points on the BMS out-stations to connect the sub-meters.
- Careful commissioning will be required to ensure the BMS is recording accurate data. This is particularly true for calculated meters such as heat and coolth meters
- Specific data logging and scheduling standards will need setting out in order to capture data consistently for any onward transmission.

**BOX 7**

### Combined AMR meters

AMR meters can be supplied with a combined meter, logger and transmitter all in one box. This option is most common for new main electricity meters. The unit may have multiple input channels e.g. it may be possible to use an electricity meter with an integral data logger to capture data from the main gas and water meters and thus provide a simple solution for whole building multi-utility AMR monitoring. This integral unit may be an attractive option as it avoids the need to separately purchase and connect multiple components, although it is then not possible to change one component in isolation. The cost for this option is in the region of £400-£600 per meter.

# 4. External transmission for off-site analysis

In many cases, metering data is transmitted externally from the metered building prior to being provided to the end user. This can occur in instances when:

- The owner or occupier has a portfolio of properties and the metering data from these buildings is externally transmitted to a central storage centre.
- The owner or occupier has contracted an external data collection service which collects the metering data on the organisation's behalf. The cost of data transfer and collection by a data bureau service is typically £20-60 per year per meter (assuming daily transmission of data).
- The utility company is collecting the AMR data from main utility meters for billing purposes.

There are many possible means of external data transmission. Some common options are outlined here, but the list is not exhaustive.

## Use of cellular wireless technology

As well as for internal communication, wireless technology can also be used for longer range external communication using cellular technology (GSM). SMS messages are transmitted periodically (e.g. daily) from each data logger or central server comprising all half-hourly readings since the previous transmission.

The main problem with cellelar wireless communication is signal strength. Meters are often located in areas of a building with either a significant amount of electrical interference or in basements with structural barriers. As a result, cellular signals may be very weak. When setting up the system, the signal strength from various mobile phone operators can be checked and a SIM card installed for the operator with the best signal. Alternatively, a remote antenna can be installed to link the metering point to an area of the building where a better signal can be found.

In terms of cost, it is advisable for an owner or occupier to check their SMS mobile tariff. Mobile tariffs exist with unlimited SMS messages but are rarely selected on business contracts. Tariffs with free SMS messages will significantly reduce costs of data transmission.

## Landline communications

An alternative option is to use landline communications where an analogue telephone line is reserved for the transmission of metering data.

This is a very reliable communication method and avoids problems of poor signal strength that can be associated with wireless communication. As an example, a conventional telephone line is the normal method of communicating with a half-hourly utility billing electricity meter. It can also be used to transmit data from other main utility meters or sub-meters (see Transport for London case study as an example).

This method of communication can be more expensive than the wireless option, as there are additional costs of procuring the line and paying a line rental charge (circa £150 per phone line). However for many large organisations, there may be no charge if transmitting data between their own buildings. This may be relevant if, for example, an owner or occupier is transmitting data from multiple buildings to a central server located in, say, their headquarters building.

Continue ▶

# 4. External transmission for off-site analysis *(continued)*

## Other communication options

There are many other communication options, which include:

- 'Walk by' meter readings whereby a handheld meter reader with a built-in or attached receiver/transceiver (radio frequency or touch) is used to collect meter readings from an AMR capable meter. This is a simple option to set-up as it only requires a meter reader to pass each meter on a meter reading route, however, it is likely to be a more labour intensive (and costly) solution for the energy management of a large building portfolio where there may be a requirement for frequent data collection from hundreds of meters.
- A computer network and internet connection. However, this will be subject to approval of corporate IT teams who may have concerns with connecting devices to their networks and especially external parties accessing devices on that network from outside a corporate firewall.
- Power Line Communications (PLC) where metering data is transmitted over electricity power lines. While not a common transmission option in the UK, it may be used more extensively in the future. Utility companies are working towards the development of this transmission option as it will be an attractive communication method considering the government's plans for the roll-out of smart meters and development of 'smart grids'.

## Frequency of transmission

Once a decision on how data will be transmitted externally has been made, a further decision on the frequency of data transmission is required.

The decision will depend on the benefits gained from having data provided more frequently. As a general rule, the more frequent the transmission, the greater the cost e.g. the cost of additional phone calls or SMS messages. The main benefit of high frequency data transmission is through the use of automated alerts which tell the building management that energy consumption has gone outside a pre-defined tolerance range, allowing quick remedial action to be initiated.

In most cases, receiving 'live' data is unlikely to be worthwhile. The cost of having someone constantly available to take action, and the associated transmission costs of live data, are likely to outweigh the benefits of being able to take immediate action.

More common is the transmission of data on a day-to-day or weekly basis. Whereby data is transmitted overnight (daily) or over a weekend (weekly) and the building management receives the information when they next log in.

The main issues with longer transmission frequencies are:

- As periods get less frequent, the longer the time before the building management is alerted to an issue and is able to take appropriate remedial action.
- If the identified issue is a transient one, it will be more difficult to find out what was occurring at a given point in time, particularly if significant time has passed since the issue occured.
- There is greater chance of data loss if a communication problem develops during a longer period between data transmissions.

Longer data transmission periods (e.g. monthly) are more appropriate when the focus of a AMR system is simply to provide more accurate occupier billing. Note that the data logged is still half-hourly but the data is transmitted at differing intervals e.g. 48 readings are sent per day, or 336 readings per week etc.

# 5. Data storage

Externally transmitted data is received and stored in a central storage unit. The organisation receiving the data might be:

- The utility company, who then make the data available to the building owner and/or occupier via web access or e-mail. This is most likely for single buildings, where sub-metering is not required.
- The organisation that manages the building: This is most likely where an owner, occupier or managing agent is responsible for a portfolio of buildings. Assembling the data across the portfolio allows a consistent approach to data analysis and reporting, and facilitates comparison of performance between buildings of similar type/use.
- A specialist data collection service, which may additionally provide data analysis and reporting services. This is most likely for large and/or complex portfolios of buildings.

## Main utility meter providing half-hourly data to utility company

Where the main utility meter data is being transmitted to the utility company at half-hourly intervals, there are two options, depending on the electricity supply contract in place:

- For half-hourly contracted buildings, request that the utility company provides the data, either by providing access via a web-portal, or by emailing the data.
- For non-half hourly contracted buildings appoint a licensed Data Collector to collect the metering data for both the utility company and the organisation.

There is likely to be a small fee for the second option e.g. a daily read over GSM could cost between £20-£50 per meter per year whereas the cost of a weekly read could be around £10-£20 per meter per year, however, it does provide data tailored for the organisation's use whereby:

- Data can be put into an appropriate format to aid input to an aM&T system (see Section 5: Using Data).
- Data will be unprocessed and can be reviewed to identify any missing information. This can highlight any data transmission and collection problems.

Where an existing main utility meter has been enabled by an owner or occupier to provide AMR data (i.e. the meter had not previously been enabled to provide AMR data to the utility company), there is an advantage in using a licensed Data Collector to collect this data as they are able to make the data available to the utility company. The utility company can then produce a customer read bill in place of an estimated bill which will result in more accurate monthly/quarterly bills than a large reconciliation when the meter is only read manually once a year.

Continue ▶

# 5. Data Storage *(continued)*

## Sub-meters

There are two main options for the collection and storage of sub-metering data:

- **Data collection service:** A third-party accesses and stores the data on an owner or occupier's behalf, which the organisation may wish to subsequently download (see British Land, GE Capital Real Estate and Land Securities case studies).
- **Self-collection:** The owner or occupier accesses and stores the metering data via a modem or IT network (see Transport for London case study).

The main advantage of selecting a data collection service over self-collection is that it can greatly increase the ease and cost effectiveness of data collection and storage when collecting data for a number of buildings. For example, a building owner may have a large portfolio of buildings which has been acquired over time. Each building has its own separate AMR metering system and the owner wishes to collect all the metering data onto one central database. Each metering system has different communication protocols and therefore requires separate approaches to communicate with each building, making it a complex and costly exercise to buy all the necessary equipment if a self-dialled option is chosen. By selecting a data collection service, a third party who already has the specialist knowledge and necessary communication equipment required to collect all the data, can collect and provide the data to the owner in the desired format, removing the burden from the owner.

BOX 8

### Selecting the right aM&T software package

It is recommended that the building management request a trial before purchasing an aM&T software package. The supplier should be asked to populate the software with some data relevant to the owner / occupier which will allow for appropriate testing and ensure the chosen software package has the desired reporting functionality.

# 6. Data visualisation and analysis

Once data has been collected, this information needs to be analysed to understand how energy is being consumed in a building. This will help the owner/occupiers realise the benefits outlined in Section 2: Benefits, e.g. ensuring efficient operation and identifing energy saving opportunities. This analysis is carried out by automatic Monitoring and Targeting (aM&T) software. There are a number of different packages on the market that provide a variety of services depending on the owner's / occupier's requirements e.g. bill validation and alert functions.

## Who analyses the data?

There are two main options for how data can be analysed:

- The building management can access the information stored directly or via a data collector and download it into a software package. The software could be on their PC, on their company server or on a web-server usually hosted by the owner of the software. A key advantage of the latter option is that it can be accessed from anywhere by anyone who needs to analyse or review the data. It is possible to undertake analysis using a spread sheet or software tools that are freely available, but this is unlikely to be sufficient for a commercial property owner or occupier with a large portfolio and multiple meters in each building. The cost of dedicated aM&T software ranges from £2,000 to upwards of £50,000 depending on the capabilities required. In addition, there may be an annual license fee and a maintenance contract for technical support.
- An external service provider undertakes the analysis, with the information being accessed via the internet. The cost is typically £100-200 per year for a main utility meter, often less for each sub-meter. This provides basic periodic reporting of energy consumption, and automatic alerts if the energy consumption goes outside a pre-defined tolerence range. The cost would increase if additional services were required. As an example, the service provider can additionally act as a 'virtual' energy manager, providing bespoke advice to reduce consumption. The cost of such services obviously depends on the size of the building portfolio. Some providers guarantee an agreed level of energy savings from using their energy management service (See British Land case study).

The choice between these two options will depend on a number of factors, including the number of meters in the system, the level of flexibility required from the software and the availability of in-house staff to run software on their PC. It should be noted that in the former option, there may be significant manual effort in transferring the data into the software package.

## Software options

Whichever of the two options is selected, a further decision needs to be made as to which software package to select.

- In the first option, the owner / occupier will be able to choose from all of the available software packages and the different alternatives within these packages (e.g. a basic version or a more expensive version with enhanced functionality).
- A data collection service will have already produced or purchased their software. The owner / occupier will need to decide which of the available analysis and reporting functions they wish to pay for.

Continue ▶

# 6. Data visualisation and analysis *(continued)*

aM&T software packages may include one or more of the following features:

- Energy management – consumption reporting, exception alerts
- Occupier billing – to manage the process of creating invoices for sub-metered occupiers
- Invoice validation – to identify billing errors and help reclaim overcharges
- Financial forecasting – future energy consumption and costs
- Energy procurement – to help select and negotiate the best tariff
- Statutory reporting – production of DECs or CRC compliance reports (see Section 2: Benefits).

The requirements set by Transport for London in a tendering exercise to select an aM&T software package that fully integrated the capture, analysis and reporting is provided in Box 9. Half hourly data from AMR meters is referred to as High Frequency (HF) data, while weekly manual meter reads and invoice based data is referred to as Low Frequency (LF) data.

**BOX 9**

## aM&T software requirements for Transport for London

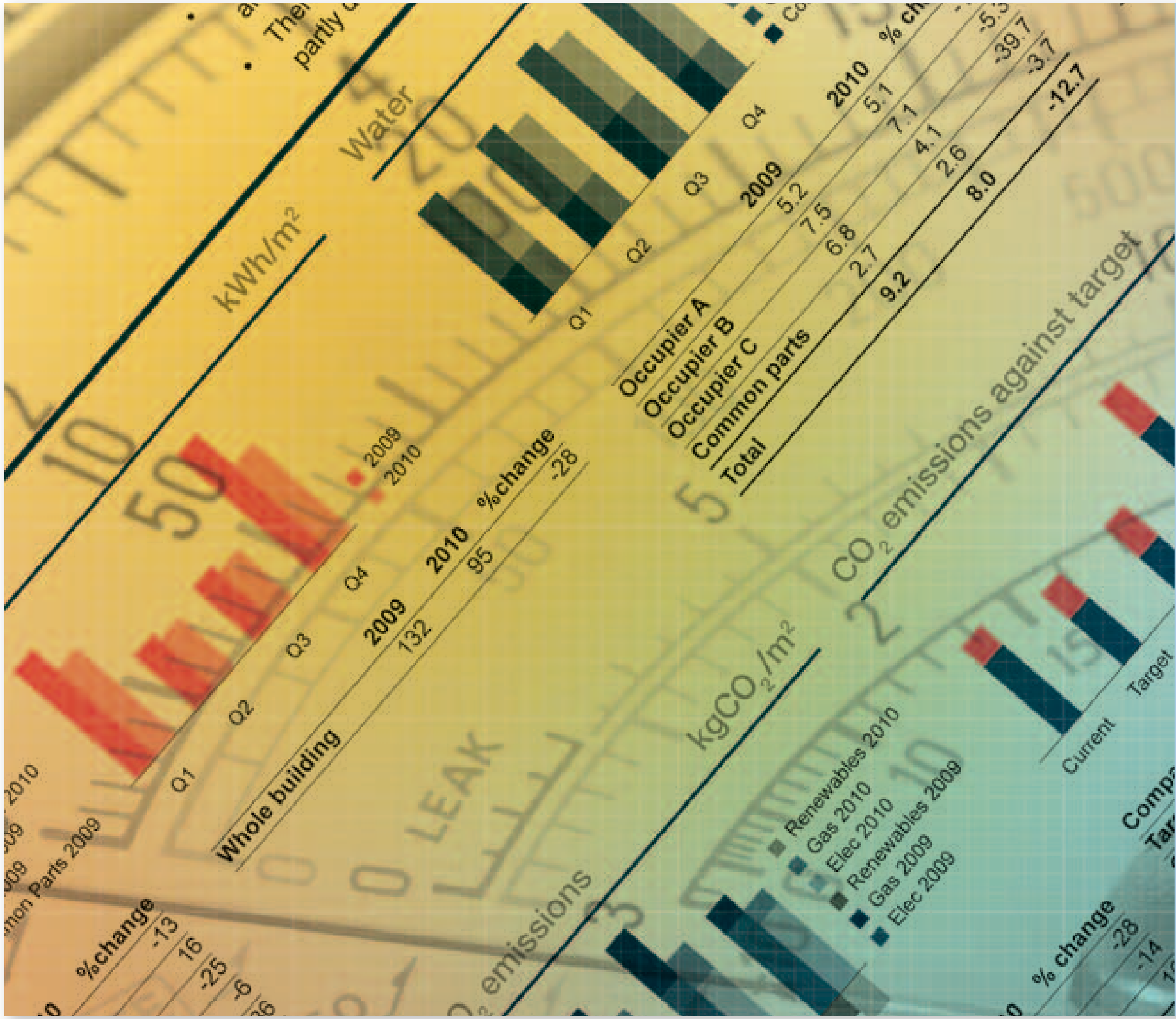
**Low frequency (LF) data**

- Manual invoice data entry
- Electronic data entry and compatibility with different supplier formats
- Invoice validation – user readings or HF data based
- Management of invoice queries
- Invoice audit trails
- Accrual management
- Target setting
- Regression analysis
- Forecasting
- Compatibility with TfL's finance systems
- Integration with HF data handling
- Standard reports
- User defined reports
- Occupier 'off charging' report development
- Four weekly 'Performance Analysis' Reports and link to TfL intranet

**High frequency (HF) data**

- Import of data – supplier and bureau based
- Data validation
- Data management
- Standard reporting capability
- User defined reporting
- Profile targeting
- Production of 'out of hours' Energy League Table
- Conversion of HF to LF data for 'Occupier on-selling'
- Cost Centre Accounting
- Adverse trend identification

# 5. Using Data




This section provides an outline of the various techniques that can be used to analyse and manage energy performance. Each have their advantages and limitations and the different options available will depend on the extent and type of metering installed.

Continue

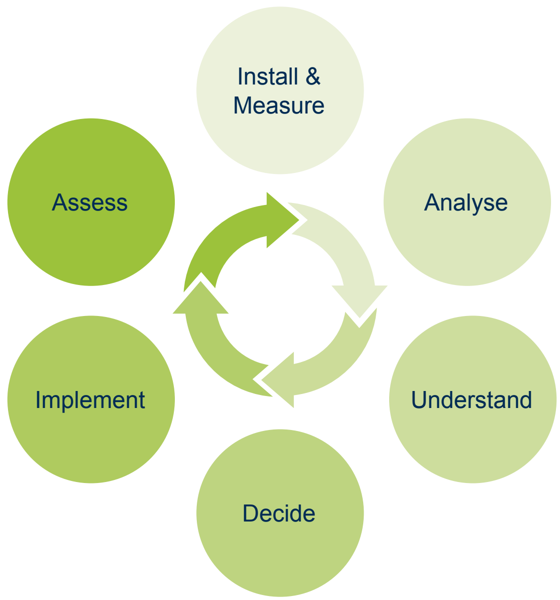
## How to use the data



# 1. Overview

Installing meters is only the first stage in the energy management process (see Figure 20). Meters generate data on utility consumption, but raw data has to be analysed to turn it into useful information. This information then has to be interpreted and understood. Understanding can then be used to make decisions. Decisions prompt appropriate actions, and it is the results of these actions that will deliver energy, cost and carbon savings.

**Figure 20: Energy management process**




It is also important to realise that effective energy management is not a one off process but something that has to be undertaken on a continuing basis. The way a building is used changes with time, as new occupiers take space, as different working practices are adopted, or as bad habits creep back in. For example, one of the most frequent causes of energy wastage is where the building systems have been set up to service the way the building was being used by previous occupiers, but have never been adjusted to the meet the different needs of the current occupiers. This can result in plant running longer than necessary in all or parts of the building. Even routine events like the change to/from summer time can mean that plant operating hours can be out of synchronisation with occupancy patterns.

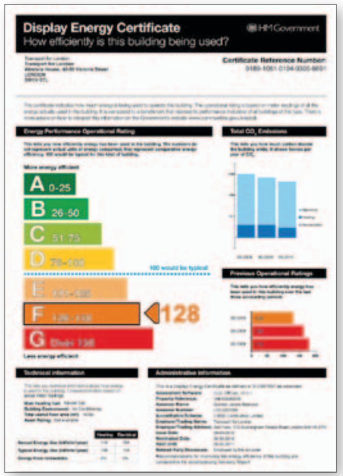
A well considered metering strategy, coupled with analysis and interpretation of the data will allow an owner or occupier to identify such wastage. This will not only save energy, it may increase the life of plant, and may improve the comfort and satisfaction of occupiers.

Continue

## How to use the data



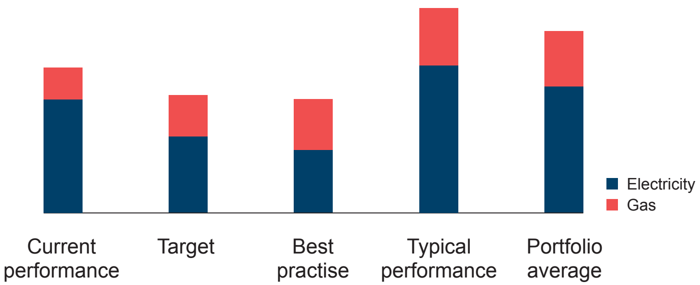
**Figure 21: Example of a DEC certificate**




# 2. Comparing a building with other, similar buildings

If there is no AMR metering in a building providing half-hourly data then the most appropriate analysis is to compare the annual energy performance with other similar buildings (see Figure 22). This assessment will be based on manual readings of the main utility meters. It is important to use actual readings and not estimated usage as provided by the utility company. This is the approach adopted for the Display Energy Certificate (DEC), which generates an energy label for a building. Although only required for public buildings over 1,000m², private owners and occupiers can voluntarily choose to produce a DEC. The underpinning methodology provides a very useful starting point in understanding a building's energy performance. The Operational Rating that is displayed on the DEC will indicate how well a building is performing relative to the national stock of similar buildings (see Figure 21). Clearly, some buildings would be expected to perform better than the national stock average by virtue of the progressive improvement in energy efficiency standards imposed by successive revisions of Part L of the Building Regulations. Therefore a newly constructed building that achieves an E-rating is more likely to be wasting energy than a twenty-five year old building with the same E-rating. The owner of the new building should therefore give particular attention to improved energy management. The older building should not neglect energy management, but should also consider how the fabric or services might be improved to reduce energy demand.

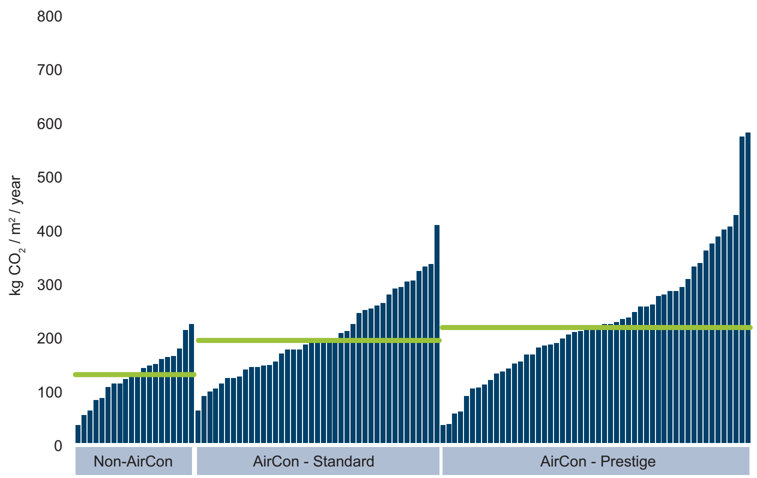
**Figure 22: Example comparison of a building's annual energy consumption against a set of pre-determined benchmarks**




If an organisation occupies several buildings, it can be particularly helpful to also compare a building with others similar in the portfolio (see Figure 23). By identifying good and poor performers in a portfolio, it may be possible to identify trends that allow the application of lessons from the good performers to the poorer ones. There can also be a useful motivational spin-off from this peer benchmarking process. A key requirement for improved energy performance is enthusiastic buy-in from staff. Healthy competition can often provide the incentive that repeated exhortation fails to deliver!

For more information on sustainability benchmarking see BBP Sustainability Benchmarking Toolkit for Commercial Buldings. For further examples of how to report environmental performance see BBP Green Building Management Toolkit.

**Figure 23: Example $CO_2$ intensity benchmarking of a portfolio of office buildings**




The chart represents over 100 office buildings ordered in terms of carbon intensity by floor area ($kgCO_2/m^2$/year), categorised into three bands based on the type of installed HVAC system (provided by ECON 19). The green line (based on the median value) provides a benchmark which individual buildings can be compared against.

How to use the data



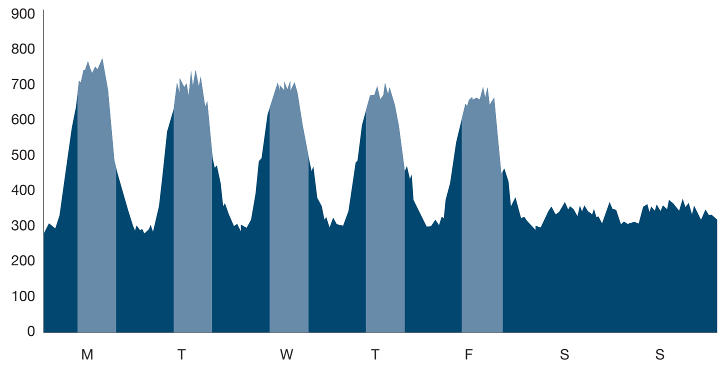
# 3. Comparing how the demand for energy varies with time

A more detailed understanding can be gained if information is available on how the energy demand of a building varies with time. This is possible if AMR metering is installed, since as well as measuring annual consumption, it is possible to consider how the energy demand varies through the year, the week and even through the day.

By comparing the energy demand during different periods (day/night, weekday/weekend etc.), it is possible to identify energy wastage e.g. office equipment being left on, plant running over bank holidays etc. It is also useful to compare performance during different weekdays – if there are significant differences, this may be a sign of waste. One example is to use energy demand time profiles from the use of office equipment to fine tune HVAC operating hours. Another example of this is where early morning cleaners come in three days per week and leave lights on when they leave. On mornings when the cleaning service is not operating, staff arriving later accept the natural light levels as being satisfactory and so do not switch the lights on. A simple instruction to cleaners to turn non-essential lights off when they finish can deliver real savings at no cost.

Figure 24 shows the time profile of the energy consumption of a building over a week, with shades of blue indicating occupied and unoccupied operational hours. It is clear that significant energy use occurs outside of occupied hours, both during the weekend period and during weekdays both prior to and after occupancy. It is important to understand the energy uses during the non-occupied hours to determine if they can be reduced.

**Figure 24: Example weekly half-hourly profile of electricity consumption of a commercial office building**




The troughs in the graph show the baseload of the building – i.e. the minimum amount of electricity consumed by the building. This occurs overnight when the building is empty. An optimised standard occupancy building operating during normal working hours should have a baseload of between 10 and 15% of peak consumption, with 24/7 operated buildings having approx. 40% baseloads.

Occupied    Unoccupied

Familiarity with the usual demand profiles can also be helpful in diagnosing problems more quickly. Any significant change in the profile of energy demand must be caused by a change in the building, either in the way it is used, or in the operating regime of the plant. If the change cannot be explained by known alterations to the use of the building, then this signals a possible failure in the way the plant is operating. Quick identification and rectification of the issue will save money and provide more confortable conditions for occupier's / staff.

## How to use the data



# 4. Comparing different areas of a building

If sub-meters are installed, it is possible to extend the benchmarking process to different parts of the same building. This eliminates a further variable that causes differences in energy performance, i.e. the age and design of the building itself. Comparing the energy demand of different areas can help identify significant areas of waste.

The following charts provide examples of the type of analysis which can be undertaken using aM&T software to analyse sub-metering data in a building. Figure 25 shows how a building's sub-systems (the blue bars) compare with industry benchmarks (the green areas). The left edge of the green area represents good practice – anything under this is good. The right edge of the green area represents typical practice – anything over this is poor. Figure 26 shows the weekly half-hourly profile of a building with separated server and lighting loads. Analysis of individual systems over time such as this can make it easier to locate areas of potential energy wastage within a building. Figure 27 shows how a building owner can compare individual occupier energy consumption in a multi-occupied building over a 24 hour period. This type of analysis can be used to support the engagement process with occupiers when discuss energy efficiency opportunities.

**Figure 25: $CO_2$ emissions breakdown of a buildings sub-systems compared to industry standards**

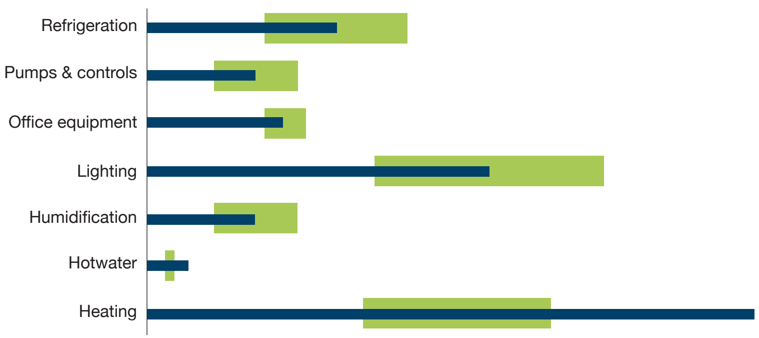



**Figure 26: Example of weekly half-hourly profile of electricty consumption with sepaerated server and floor lighting loads**

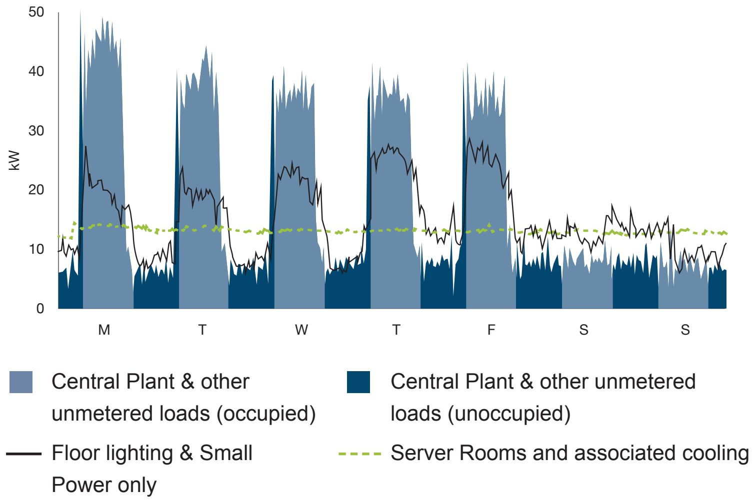



**Figure 27: Example single day comparison of occupier electricty consumption in a multi-occupied office**

## How to use the data



# 5. Comparing how the demand for energy varies with the weather

Some aspects of energy demand are weather dependent, heating and cooling being the main examples. Techniques are available to analyse the weather dependency of the building's energy use. Such techniques are often integrated within aM&T packages and can provide a real insight into the efficiency with which the building is being used. The most common technique is based on the concept of 'degree-days', a measure of the severity and duration of cold weather. The Figure 28 shows a correlation of heating fuel usage against degree days. Poor energy management is identifiable where the general shapes of the two datasets do not match e.g. July as shown. More detailed analysis is possible using regression statistical techniques (see Figure 29). A consistent summer load can indicate a baseline demand for heat (usually the demand for hot water and catering services). This hot water demand can then be compared with established norms to assess the efficiency of hot water generation and use.

More sophisticated techniques can be applied to on-going monitoring, by highlighting when there is a significant deviation from a long established pattern of performance. This can be used to identify emerging faults, but also to confirm expected savings have been achieved following an investment in an energy efficiency measure. The Carbon Trust Guide CTG004, Degree days for energy management provides an overview of these more detailed techniques.

**Figure 28: Correlation of heating fuel use against degree days**

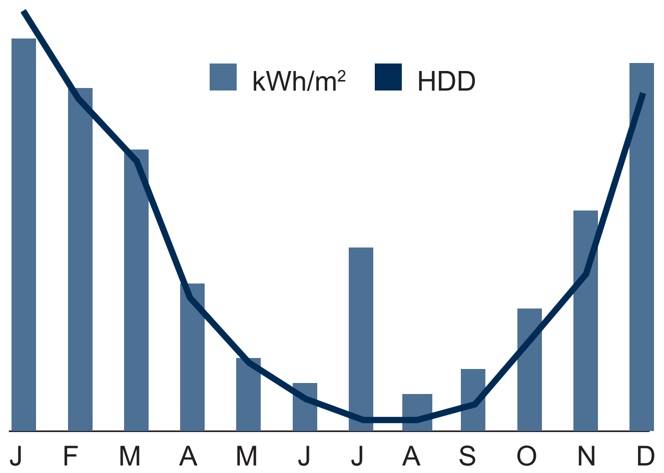
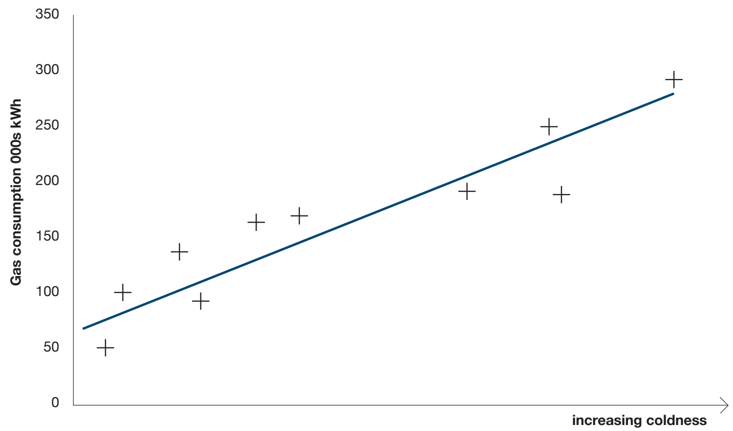



**Figure 29: Correlation of gas consumption against increasing coldness**




The graph shows how gas consumption varies with the external temperature. The horizontal axis shows increasing coldness towards the right, the vertical axis shows how much gas was consumed in the building. Where the blue line meets the vertical axis shows the theoretical gas baseload of the building. The closeness of the points to the line (r2) show how well controlled the building's heating system is. A perfectly controlled building will have an r2 value of 1.00.

How to use the data



## 6. Maintain good records

In order for any energy management strategy to be effective, it is important to document:

- how any new meters fit in with the overall metering strategy for the building.
- changes made to the way the building systems are managed or operated to ensure understanding of what has been done and why.
- any energy efficiency measures and monitor their effectiveness to aid learning for future opportunities and replication across other buildings.

A building log-book is the appropriate place to store this information, so that is preserved in a consistent and readily accessible format for subsequent owners/occupiers. For more information on building log books see CIBSE TM31 Building Logbook Toolkit.

# 6. Case Studies

The following case studies showcase examples of where a number of BBP member organisations have installed new AMR metering systems into existing operational commercial buildings.

Continue ▶

York House, British Land

British Land

## Implementation of AMR metering within British Land's Head Office

In August 2009 British Land's trialled an AMR metering system at its Head Office, York House, which is situated in London's West End. The building offers over 8,400m$^2$ of office space, of which British Land occupy 3,700m$^2$. An important aspect of the project was to learn from the experience and assess the potential for a wider roll-out across its property portfolio.

The main aims of the AMR metering solution were to achieve more accurate utility billing and occupier on-selling, as well as improving energy management to help reduce $CO_2$ emissions from the building. As a result, British Land developed a metering strategy which included the replacement of the main utility electricity meters and installation of an additional 6 sub-meters, including the re-commissioning and connection of approximately 50 sub-meters pre-existing sub-meters to an AMR systems. The sub-metering comprised:

- Sub-metering of each occupier's demise. This measures the total amount of lighting and small power to each occupier's demise
- Sub-metering of common services: heating, ventilation and air-conditioning
- Sub-metering of common parts: lighting and small power.
- In addition the system received gas and water data through pulse pick-ups.

The meters transmitted data at 15 minute intervals via a hard wired communication line direct to a central server communication network in York House. The data is then transmitted from the server to their external service provider, EP&T via ADSL every four hours.

The external service provider undertakes off-site data analysis to identify any issues/anomalies in the patterns of energy consumption, and to indicate potential energy and cost savings which can be made through appropriate energy efficiency measures which are then reported to the on-site building engineering team. With a detailed knowledge of what equipment or BMS setting each sub-meter is measuring it is often possible for the service provider to indicate to British Land engineers which piece of equipment or BMS setting is causing a problem. Each month British Land receives report which highlights the financial impact of actions completed, as well as providing an on-going record of outstanding actions. The offsite team also have a short teleconference each month with the site team to discuss the report and have technical discussion to consider solutions to more complex problems.

Critically, the service provider guarantees a minimum amount of cost savings in common parts and central heating and cooling plant. The service provider's 'top-up' guarantee is applied to York House as well as a number of other British Land buildings which relies on the offsite monitoring team finding enough operation savings through the process described over a 3-5 year period to ensure that the building's consumption in these areas is reduced by approx 10%-12.5% against a baseline year set before the service was introduced.

The service provider also supplies a statement for each occupier's energy bill which the managing agent then uses to produce an invoice for each occupier.

A significant benefit of the metering system is how it has helped British Land engage with their occupiers. British Land uses metering data to individually review with each occupier their contribution to the overall energy use in the building, and to discuss how to make savings. Metering data is then also used to demonstrate improvements and savings over time. The AMR software is web-based and can be accessed by occupiers and owner alike on a shared license to provide real transparency and data sharing between the two.

Overall, British Land has invested approximately £65,000 in installing the metering system, and there is an on-going cost of approximately £12,000 per year for maintenance of the metering and off-site analysis and reporting. This has helped optimise the heating and cooling system (including prompt identification of a broken sensor that had been causing constant gas use for heating and re-programming of the Building Management System to introduce economy cycles and new deadband set points for cooling). As a result, British Land saved £45,000 in the first year and expects to achieve payback in 18-24 months.

## Implementation of AMR metering at GE Capital Real Estate's London HQ

In 2009, GE Capital Real Estate trialled the use of an AMR metering system at its then London Headquarters, a 4,650 $m^2$ office building in Berkeley Square, London. An important aspect of the project was to learn from the experience and assess the potential for a wider roll-out across its property portfolio.

The implementation of AMR metering was inspired partly by a desire to reduce energy consumption and $CO_2$ emissions and partly by compliance preparations for the incoming CRC Energy Efficiency Scheme. A decision was taken to focus only on the main utility meters as this was seen as providing the greatest value in terms of energy saving potential and costs. It was also the option that could most easily be rolled out across their portfolio if proved successful. Whilst this solution only provides a limited level of detail, i.e. data would not be able to be broken down to an individual floor level, there is the capacity to link the building's sub-meters to the AMR system at a later date.

The main electricity meter was already an AMR capable meter, which logs and provides half-hourly consumption data to the utility company via a telephone line. The existing gas meter had a simple dial display that needed to be read manually. However, like many modern gas meters it had a pulsed output. By a simple wired connection from the pulsed output to a small data logger and communication device, half-hourly gas consumption data was then sent daily to their external service provider, WSP, (who also provided the AMR metering solution) using the mobile phone network (GSM). A similar approach was also undertaken for water metering. To assess electricity consumption the service provider was given permission to access the half-hourly electricity data sent to the utility company.

The external service provider supplies the half-hourly electricity, gas (and water) data to GE's building managers on a dedicated website on a day-plus-one basis, together with alarms, reporting and management tools. The building managers use this information to ensure efficient management of the building and make any necessary correction measures.

Initially, GE asked the external service provider's energy specialists to provide energy management advice. The specialists analysed half hourly weekday and weekend profiles for each of the utilities and advised on areas to investigate to cut waste and reduce consumption in the building – especially out of hours. This was provided to GE's building management team in a 'remote analysis report', who then implemented changes to drive the reductions. The changes were low cost, mainly adjustment and reprogramming of the Building Management System, changes to temperature set-points and evening and weekend operating procedures. Visibility of the half-hourly data and knowing how much could be saved by changing equipment or operating practices was key to driving the changes.

Overall, the cost of implementing the AMR metering solution was around £1,000 and with no disruption to utility supplies. There is an on-going fee of approximately £500 per year for reports, on-line tools and alarm management.

Results show significant improvements in consumption. GE has reduced building electricity consumption by 16%, gas consumption by 42% (and water consumption by 74% through the installation of a waterless urinal system). Annual operating costs on the building have reduced by around £60,000. When all expenses for installing the system (including water metering) and taking corrective actions are taken into account, they are paid back in little over one month.

Since this initial successful trial, GE Capital Real Estate is now rolling out this system to most of its multi-occupied office portfolio.

LandSecurities capital commitment

## Implementation of an AMR metering strategy for Land Securities' portfolio of office buildings

Land Securities own and manage offices buildings in London, and shopping centres and retail parks throughout the UK. Between 2009-10, Land Securities rolled out an AMR metering strategy across its office portfolio. The focus has been offices as retailers tend to separately organise and manage their own electricity supplies.

The main drivers of the AMR metering solution were to achieve more accurate utility billing for occupier recharging, as well as improving energy management to help reduce $CO_2$ emissions across their portfolio. As a result, Land Securities developed a metering strategy which included the replacement of the main utility meters and installation of sub-meters.

Both electricity and gas main utility meters where replaced with AMR capable meters where necessary and AMR electricity sub-metering was installed to measure energy consumption on each floor of the buildings. In addition, meters are located to measure the different loads (e.g. lighting, small power, air conditioning, communications room) depending on the arrangement of the existing distribution boards. Large new developments have a Power Management System (PMS) which manages the electricity supplies in buildings as well as providing AMR data. The PMS is there to control the power demands in a building particularly when it is needed to operate on a standby generator.

Data is transmitted externally from the meters via GSM to Land Securities' meter operator. Overall, GSM transmission has proved to be a suitable mode of external transmission and Land Securities have had few issues in achieving adequate signal strength wherever meters have been installed within their buildings. On occasions external antennas or GSM boosters have been required in areas such as switch-rooms in basements/sub-basements,

The data is collected by the meter operator and provides the data to Land Securities on a daily basis (day+1). The PMS transmits live data, but this is analysed as day+1 along with the metering data. Therefore, each day Land Securities receives for each meter, 48 half hourly data points, plus total energy consumption for the 24 hour period. The data is accessed via a web portal and entered by Land Securities into purchased aM&T software. The software provides energy management and reporting, and billing capability for occupiers.

Numerous benefits have been delivered through the installation of the portfolio wide AMR metering strategy:

1. Land Securities have been able to deliver more accurate and timely occupier billing. Previously, manual readings had contained incorrect data due to human error.
2. Land Securities has a carbon reduction target of 30% over 10 years. Engaging and working with their occupiers to influence behavioural change is an important aspect of this and the use of half hourly data has provided occupiers with detailed feedback on their individual energy consumption. This information has shown that in a short-time, the occupiers can reduce energy use by 5-10%.
3. Land Securities has been able to improve the efficiency and reduce wastage from the central services they also manage. For example, the output of an AMR sub meter identified a significant load in an unoccupied building on a Sunday. This turned out to be a chiller incorrectly being started by the BMS, an energy wastage that could easily be rectified.

Whilst a successful initiative, there were some common installation difficulties:

- Many meters needed to be installed at weekends due to the need to stop electricity to the relevant distribution board for half an hour. In some cases, work had to be linked to planned power outages six months to a year in advance.
- There was often a need to gain access to occupiers' area to install the sub-meters which required permission from each occupier.
- Occasionally, there were space issues where the new meters were too large to fit in the original space. This has resulted in extra work to fit the new meters.
- Occasionally, additional changes were required during installation e.g. in one building a new distribution board was needed due to health and safety reasons.

Transport for London

## Implementation of AMR metering within Transport for London's Cranbourn Street Office

This case study outlines the approach that TfL has taken to AMR metering in their Cranbourn Street building. This is part of a general roll-out of AMR metering in TfL's portfolio of commercial properties that started in 1996. The case study also highlights challenges TfL have faced with their overall metering solution and outlines the planned changes to overcome these.

Cranbourn Street is a five storey office block, with a floor area of 2260m², based in central London. Like most of TfL's buildings, it is solely occupied by TfL. The main electricity meter was originally already a half-hourly meter on their half-hourly supply contract with data sent to the utility company via a standard BT telephone connection. In 2006, TfL used the two spare input channels on the electricity meter to start recording half hourly gas and water data. This information was then fed into their central AMR system.

In 2009, TfL installed 34 AMR sub-meters in the building. Typically, TfL separately sub-meter the central building services plant and the total consumption on each floor. As TfL are owner-occupiers, a particular advantage of measuring consumption on each floor (e.g. from lighting and small power load) is that TfL has greater ability to use the information directly to influence behavioural changes of their staff rather than if they were an owner with a separate occupier using the space. In this case, there were separate distribution boards for small power, mechanical (fan coils) and lighting loads on each floor, which TfL decided to separately sub-meter to meet CIBSE TM39 recommendations on sub-metering. A problem was identified in that the distribution board for lighting on each floor also included WC ventilation. They addressed this by using small 'din-rail' meters mounted within each lighting distribution board to separately meter the relevant individual WC ventilation circuits. A set of carefully configured 'virtual' meters in their aM&T software then removes the WC ventilation loads from the Lighting distribution board metering to provide actual on floor lighting usage reports, and adds them to the Mechanical distribution board metering to provide actual on floor HVAC usage reports.

In a similar manner to TfL's other buildings, the sub-meters are all connected together using standard data-cables. From this they are connected to a modem, which is accessed via a dialup modem facility in TfL's energy management office and downloaded to a stand-alone server prior to weekly transfer to their networked aM&T software which TfL use on a daily basis to manage their energy use.

At this site a combination of sub-meters' own in built memory and data loggers are used to store the last 35 days of data allowing the central server to access at any point during the 35 days with no data loss. However, the server is programmed to dial up daily, with failed attempts checked weekly to highlight any communication or metering maintenance issues. TfL currently also do a weekly manual check of their AMR meter readings to check the accuracy of the data being automatically collected.

The cost for TfL to set-up the sub-metering system was £19,000. The advantage of using telephone lines to transmit the data is that the line rental is already paid as part of TfL's contract for internal communication between buildings. However, TfL has recently uncovered a potential problem with this approach during their phased upgrade of internal communications to VOIP, as this appears to block this transfer of data, requiring separate BT PSTN phone line installations at these VOIP sites.

The sub-metering data has assisted TfL to improve the building's DEC rating as it allows server room 'separable' electrical energy loads (equivalent to 18% of total electricity consumption) to be removed from the benchmarking calculation. The sub-metering data has also been used to resolve HVAC control time scheduling issues and identify 28% occupant small power base loads that allowed the Building Manager to focus 'Switch Off Communications' on the worst offenders (see chart on next page).

Continue

# Transport for London

TfL is also in the process of changing its approach to data collection, storage and analysis across its portfolio of metered buildings. The key reasons for this are as follows:

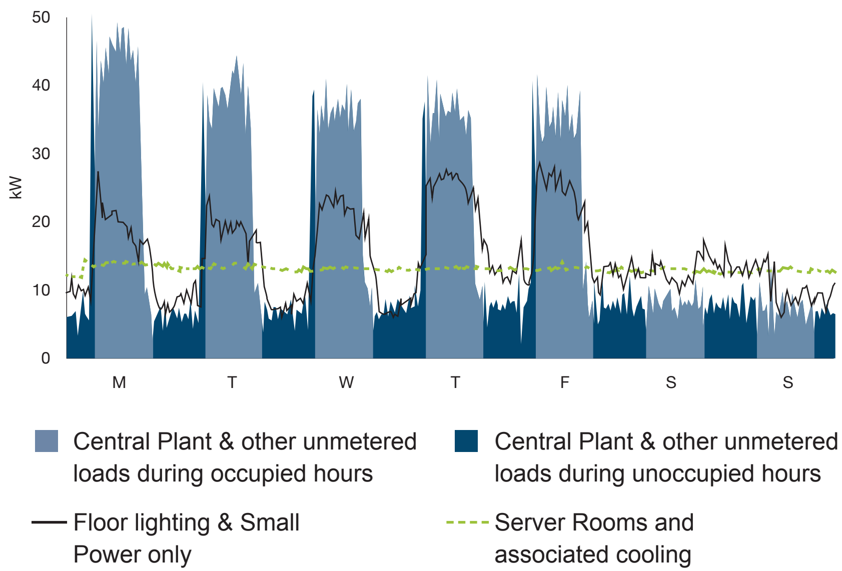
- TfL's IT network cannot be used for transmission of metered data between buildings due to security risks. As a result, the central server is not allowed to sit on the TfL network. Consequently data has to be manually transferred to the TfL networked aM&T software which is time consuming and can introduce human error.
- It takes significant time to process the data into an appropriate format for use by the aM&T software
- The current 10-year old aM&T software is inadequate for TfL's current needs (eg for accessing GSM modems at various sites)

The new approach is as follows.

- A data collection service will be responsible for capturing all metered data on a daily basis, reporting communication problems and generating weekly data files for TfL to import into their dedicated aM&T software. This aM&T software package fully integrates the analysis and reporting of utility meter and sub-meter AMR and manual readings data and invoice data.
- Only main utility meters will be manually read on a two weekly basis to fulfil major financial and environmental reporting requirements, while all AMR meters will be manually read on a 12 weekly basis to ensure AMR data is correct.

Further information on TfL's approach to energy metering is provided as a case study in the Appendix of CIBSE TM39: Building Energy Metering.

**Example half-hourly sub-metering analysis enabled by AMR installations**



# Glossary

### Automatic Metering Reading (AMR)/ Advanced Meter

In addition to traditional metering functionality (measuring and registering the amount of energy which passes through it), AMR or advanced meters are capable of one-way communication allowing them to transmit meter readings remotely.

### Automatic Monitoring and Targeting (aM&T) software

Software that collates and analyses data provided by AMR meters (both half-hourly and manual readings) & Utility bills. aM&T software can then be used to produce reports (including automatic 'out of range' reports) to enable building management to more effectively manage the energy use in a building.

### Building Management / Energy Manager

The person(s) responsible for the energy management of the building.

### Building Management System (BMS)

A computer-based control system installed in a building which controls and monitors the building's plant and systems such as HVAC, lighting and power systems. A BMS can be configured to receive half-hourly data from AMR meters and used to analyse and report on performance to improve energy management.

### Carbon Reduction Commitment (CRC Energy Efficiency Scheme)

A UK-based carbon emissions trading scheme for large public and private sector organisations. It is a mandatory scheme which aims to both improve energy efficiency and regulate the amount of greenhouse gases that are released from the burning of fossil fuels by an organisation.

### Check Meter

A meter required for validation purposes by comparing readings against the main meter's reading to ensure that it is operating correctly. Check meters are required buildings with over 1MW electrical supply, the utility company provides both the main utility meter and a check meter.

### Corporate Social Responsibility (CSR)

A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis.

### Data Collection Service

An external provider who collects AMR metering data on an owner or occupier's behalf. They may also provide other services such as designing and installing metering systems and analysing the collected data on an owner or occupier's behalf.

### Data Logger

An electronic device which stores half-hourly data readings from AMR meters.

### Display Energy Certificate (DEC)

A certificate which shows the energy performance of a building based on its annual energy consumption and the associated $CO_2$ emissions. This is shown as a rating from A to G, where A has the lowest $CO_2$ emissions (best) and G the highest $CO_2$ emissions (worst).

### Global System for Mobile Communications (GSM)

A form of cellular wireless communication. GSM modems are used to transmit metering data over long ranges external to the metered building. This may be to a data collection service or central storage point. Data is sent in the form of SMS messages.

### Half-hourly Contracted Site

A site or building where an AMR main utility electricity meter is a mandatory requirement by the utility company. This is required for a site or building where the average peak electricity demand over a three month period exceeds 100kW.

### Half-hourly Data

The interval which metered data is typically sent from AMR meters. This is also the interval at which utility companies collect AMR data from main utility meters.

### HVAC

Heating, Ventilation and/or air conditioning plant in the building. This is normally centrally provided and managed by the building management for all occupied areas.

Continue ▶

# Glossary

### Main Utility 'Fiscal' Meter

A measuring instrument that records the quantity of electricity and gas (or water) supplied to a building. It is used by a utility company for billing purposes. A basic main utility meter allows manual reads only, while AMR main utility meters provide automatic readings to a utility company at regular intervals (typically half-hourly).

### Short Message Service (SMS)

A text communication service component of phone, web, or mobile communication systems, using standardised communications protocols that allow the exchange or short text messages between fixed line and mobile devises. Metering data from GSM modems are sent via SMS messages.

### Smart Meter

In addition to traditional metering functionality (measuring and registering the amount of energy which passes through it), smart meters are capable of two-way communication allowing them to transmit meter reads and receive data (e.g. tariff changes) remotely.

### Sub-meter

Sub-meters are used to measure part of the energy load in the building. This may either by location based e.g. the energy use of a floor or occupier, or energy load specific e.g. lighting or chillers A sub-meter can be manual-read only or have AMR functionality.

### 'Virtual' Meter

The use of algebra to calculate the energy consumption of a specific energy load which otherwise would have required an 'actual' sub-meter. This form of metering is also known as 'in difference' metering and is used when the total energy supply and specific downstream sub-metering is used. Actual sub-metering data is then subtracted from the total with remainder being used to provide the 'virtual' meter reading.

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