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MARK THROWER MANAGING EDITOR

SERIES **14** | MODULE **08** | **METERING & MONITORING**

Energy Metering and Monitoring Systems

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Smart metering has been implemented across the UK for many years now. We have installed hundreds of systems across the UK. However, there are still many systems which are still not correctly metered and are losing out on the benefits that good metering information can bring.

Smart metering is a general term used to describe the use of automatic meter reading and data collection technology to remotely monitor and log energy consumption at buildings or machinery. It is generally wrongly thought of as only remote electricity meter reading. It normally always has its data sent via the internet or radio telephone network to remote computer servers which host the data and run energy analysis software.

Systems are now so intelligent that real time energy monitoring and cost allocation is possible allowing actual energy costs to be attributed to departments and products.

Smart metering systems can be described as the remote monitoring of all the energy used in a building or factory, including, ventilation, heating, cooling, humidification, process and power. The metering system could also include non-energy metering such as air quality, temperatures, production output and production variables. Maintenance and engineering variables such as machine running hours, production data, pressure, load, water consumption, compressed air consumption, fuel consumption and voltage, current, power factor and reactive power can all be monitored and graphed in most systems. The metering systems normally send the collected energy or other data to a host computer either on site or remotely which has specific SCADA energy metering software installed which allows display and graphing of the metered data.

Additional software can be added to the basic SCADA metering system which allows management and targeting of energy use and manipulation of the data. This is usually called an energy dashboard or similar which is normally web-based software hosted on a remote computer with access from anywhere on the internet by anyone who has the required access details. In some cases the same system can be used to control the energy use as well as monitor it. Future uses of the monitoring and control system may be for load shedding or load demand control and flex and save purchasing contracts where real time energy is traded every half hour. This allows electricity to be used at low-cost periods and either electricity exported at high-cost periods and demand reduced to minimise costs.

In some cases an onsite system and web-based metering software is appropriate. Various systems exist and technologies are being implemented continually across the world as part of the search for more carbon friendly building design solutions. The implementation of the new part L building regulations will require that we take a closer look at metering to allow operators to meet the necessary energy and carbon reduction targets.Increasingly new real time trading of electricity along with battery storage and other renewable technologies will be implemented. Having good metering systems in place make the decision making process easy as you know on a daily basis your actual energy profile for each major part of the site and how this will fit into battery storage and renewable demand to maximise savings and income.

The prime reason for energy metering is to ensure that the buildings or processes are operated efficiently. Metering with appropriate software allows operators to measure their historical performance and use this to set improvement targets for future performance. It also allows waste to be identified and can indicate how this waste can be reduced. The Carbon Trust Field trials carried out in 2009 indicated that between 5 and 12 per cent energy savings are typically available by installing these systems.

The Building regulations now demand that if a new building is over 1,000m^2 of floor area then at least 90 per cent of the buildings energy use is to be metered and the use identified as per the CIBSE Guidance TM39.

Companies who are in climate change levy agreements or in the Carbon Reduction Commitment or ESOS are required to demonstrate how and where their energy is being used. Automatic metering can be economically set up to do this and produce appropriate reports.

See Fig.1 for typical energy profile showing the repetitive nature of the electrical load over a week. The profile is very good showing good control over the week with plant being switched off at night and on in morning and at weekends. The base load of 50kW could be investigated further to see if further reductions could be made.

Basic Metering Strategies

When installing a metering system a number of factors need to be considered which affect the complexity and cost:

- What is required of the monitoring system? Is it monitoring energy only or is other information such as temperature, production or maintenance information required to be logged?
- Does the system have to provide a future control capability to control the process or energy use if required?
- Is there a requirement for offsite data use or is all the data required on site?
- Is there a large number of signals or only a few energy meters required?
- Is there a multisite requirement with a need to combine or compare data with other company departments or sites?
- Is there an existing data communications system which can be used such as using the existing site

computer network?

• What types of installation may be appropriate radio or hard wired.

There are three basic metering strategies that can be used to collect the data.

A single point meter sends back the data individually to the monitoring system. These are similar to the site billing meters having a radio telephone SIM card installed and using radio telephone technology to send back the data from the meter to a telephone modem on a computer. They normally send the data back to the energy dashboard daily in a block and have some limited on site storage. These are usually expensive to operate if there are many metering points on site. They have no control capability and only bring back energy data. The data transfer is relatively slow and in many cases only supply daily data or every half hour. Not appropriate if data required is better than half hour. The radio phone transmission system is now very busy and becoming less reliable for data transfer.

A centralised metering system collects the data from numerous metering points and sends the information for all the meters back in a block at pre set intervals usually every 24 hours back to the remote energy dashboard. This data can be collected by radio communications or hard wired using a modbus or similar communications highway or through the sites existing intranet to a remote computer with a unique IP address. The meter readings are typically every 15 or thirty minutes for energy data. These systems generally only log energy data

Finally, a centralised metering system can collect the data from numerous metering points and sends the information for all the meters to a local PC with SCADA software logging and graphing the data. In addition, the data can be manipulated at the DCU (data collection unit) or PC and only the necessary information forwarded to the remote dashboard if required. This is normally historical data from the previous day in a block at pre set intervals usually every 24 hours sent back to the remote energy dashboard. This data can be collected by radio communications or hard wired using a modbus or similar communications highway or through the sites existing intranet to a remote computer with a unique IP address. The meter readings are typically every 15 or thirty minutes for energy data. In some systems local software is installed and the data held locally on a PC and can be viewed by the local site and only selected

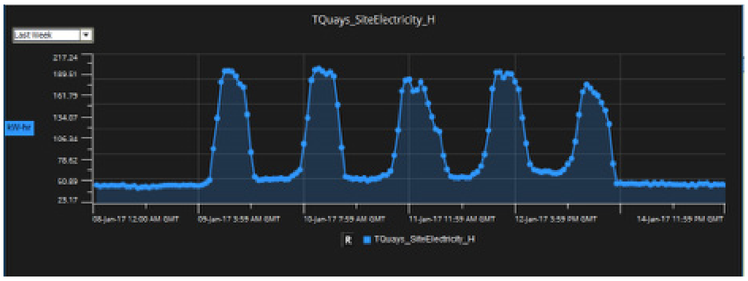


Fig.1 Typical well operated site weekly electrical demand profile

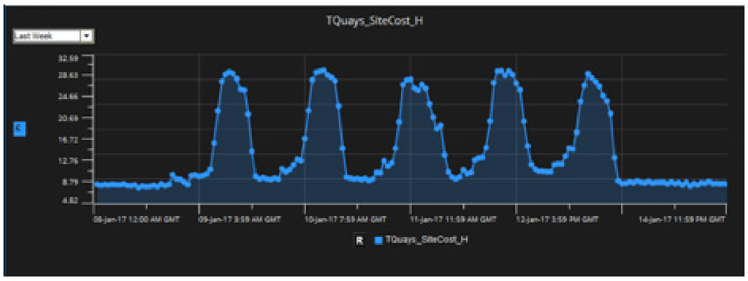


Fig.2 Graph showing actual hourly total energy costs for the site.

points sent the remote dashboard if required. It could be that there is only a site-based system required with no remote dashboard. On the best-distributed systems the real time monitoring data is gathered round the network from input devises usually hard wired using Modbus or some similar communications protocol or where necessary wireless can be used. The existing intranet can also be used where appropriate. The actual design is usually based on cost. Hard wired is always best but in some locations wireless is the only viable solution. The data from the input cards is feedback to a local data collection unit where it is vetted and either fed to a local PC where all the data is stored and can be displayed and graphed or sent to the remote energy dashboard. This data can be used on site to produce site reports many of which may be for maintenance and not energy. Specific energy data is also normally sent to the remote energy dashboard where it can be used for group energy analysis to compare the group's overall performance and the relative performance of each site.

Two basic types of smart metering data collection systems are available: hard wired or radio.

Hard-wired systems have a central data collection unit which is connected to remote modbus or Ethernet devices by hard wired cabling. These devices can collect data in real time and show the data as real time. Information is gathered from the various meters either using digital input or analogue input cards, or directly from the register of modbus or Ethernet addressable electricity meters. Hard-wired systems are the most reliable method of collecting data, and especially of collecting of real time data from a large system. The speed of the network is key to how much data can be read back. As the number of metering points increases then the time to gather the information increases. Typically, over 1,000 metering points can be read back within a minute.

Radio systems have the advantage that they do not require cabling and can get data back from remote areas where it would be impossible to cable. The data collection unit communicates with the remote devices using digital radio signals. Radio systems are more practical when operating at lower frequencies. The slower the operating frequency the higher is the signal strength and the longer the distance between transmitter and receiver.

With high frequency systems the practical distance between devices is so short it would be easier to hard wire unless there is a problem such as a road crossing.

Because radio systems communicates at a much slower rate than hard wired systems it is only able to poll the input signals relatively slowly usually over 10 seconds per point. In many systems it is the remote sensor which poles the data collection unit when it wants to send data. This makes it impractical for real time data collection and use with a large number of points. It can however be very useful if the data is only required for historical analysis when the site data is down loaded regularly to the hosting computer either directly or via the radio telephone system. The download is typically every day with half hour data.

Hard wired systems give better data security and faster polling allowing real time data use. This is especially important in larger systems.

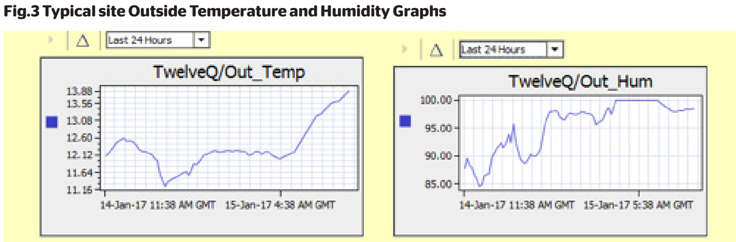
Radio systems are more suitable for small installations, temporary installations such as for site test work or where temporary data loss is less important. In all cases good data back up on site is essential.

A mixed hard wired and radio solution may be appropriate where there is difficulty in installing the hard wired communications network.

Radio systems are cheaper to install than hired wired systems. This is not always the case as hired wired systems usually require less hardware and less commissioning time. If cable routes exist hard wired is very cost effective. In some cases radio systems are necessary as there are no practical cable routes such as for road crossings, but these can now be used in conjunction with hard wired systems as part of the hard wired network using radio bridges between the hard wired system and the radio system.

One of the main issues with metering systems is overall installed accuracy. This should be a major consideration as accuracy inevitably affects the cost. In many cases absolute accuracy is unnecessary but meter repeatability is essential. It important to understand what level of accuracy is required and is achievable within a limited budget. In many instances it is a change in the energy performance which is required to be identified and not necessary the absolute accuracy of the energy

Fig.3 Typical site Outside Temperature and Humidity Graphs



use. The system accuracy depends very much on the specification and installation of the metering. If the wrong size or type of meter is specified or if the meters are wrongly installed then the system accuracy will suffer badly. It is estimated that over 30 per cent of all installed meters are either wrongly sized or wrongly installed. In most cases the monitoring system has to interface with existing meters many of which are wrongly specified but are uneconomic to replace.

Three phase electricity meters require that the L1, L2 and L3 phase currents and voltages are correctly identified and wired to the meter correctly in phase. This is often not the case as the cable colours do not guarantee that the phases are in the correct sequence as the phases. The cable colours can be swapped within the wiring network with colours not matching the phases resulting in the electricity meters reading low.

Meters with a pulsed output have additional potential problems with contact bounce or missed pulses. This can be avoided if modbus or similar multi register meters are used where the actual meter register is read back and pulses are not counted.

In the case of mechanical meters such as water or gas the meters are almost always oversized or of the wrong type resulting in poor accuracy. Some mechanical meters are good for continuous flow but very inaccurate when the flow is intermittent. Correct meter specification and installation is essential if the best accuracy is to be achieved.

Electrical and mechanical system metering accuracy is generally a problem as the metering system accuracy is normally described as a percentage of full scale. This means that if the meter is oversized then the accuracy will be low. For example, a 3 per cent error on a meter sized for 100m^3/hour of flow will be 3m^3/hr. If the actual flow rate is only 10m^3/hr then the meter accuracy will be 30 per cent of the actual flow rate. Most meters are not truly linear and if operating out with the linear band they will be very inaccurate.

In many cases the existing system load is very low relative to the installed capacity of the installation especially where the system has been designed for future expansion. The metering system installed is usually rated at the maximum capacity of the system even though the load is much smaller. For example a1000A electrical switch board with a 100A load on it. The metering system would normally be

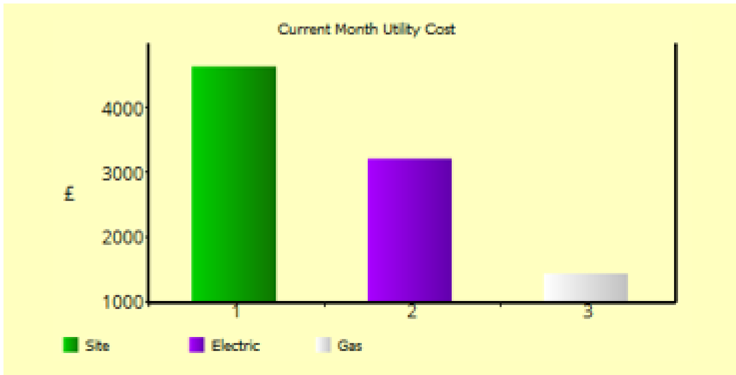


Fig. 6 Display of site cost breakdown by energy type

sized at 1000A which will give very poor accuracy at the actual working load of 100A. In these circumstances a compromise should be reached to improve accuracy. The switch should be metered with a smaller range metering system rated at say 250A with alarm levels set within the metering systems such that if the actual demand approaches the 250A level in the future then an alarm would be instigated and new 1000A metering CT's could be fitted. Unfortunately, most electrical and fluid metering systems are installed to meter the maximum capacity of the installation and not the actual load on the system giving large inaccuracies.

Another potential problem is meter zeroing and rollover. If there is a small number of available meter register digits on the meter relative to the actual load, then the numbers will rollover very quickly as the register is filled. It is important to use the largest numerical register available.

Some monitoring systems allow the user to manually enter the actual meter values if required, in order that the actual physical meter and the displayed value in the energy monitoring system or energy dashboard read the same. This is especially important when a new replacement meter is fitted or a meter value rolls over back to zero.

If you need to add a number of meters to get to a total then the percentage accuracy of each meter will also be added. If poorly specified or installed this overall accuracy could be very poor. It is not recommended to add meters together to get to a total. It is better to measure the main supply and split the main meter output in relation to the percentage of the total supply by each sub meter. By doing this the system accuracy is maintained as the accuracy of the main meter. This is true for electrical and fluid metering.

Once you have installed your metering system and have started collecting your data the next objective must be to make the best use of the data.

In order to do this you must have specified the metering and metering system correctly and also built in to the software requirement the necessary targeting and data management routines. These should include total

Fig. 5 Display of site daily CO2 generated by electricity consumption.

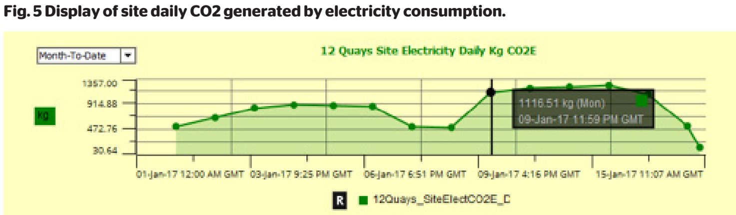
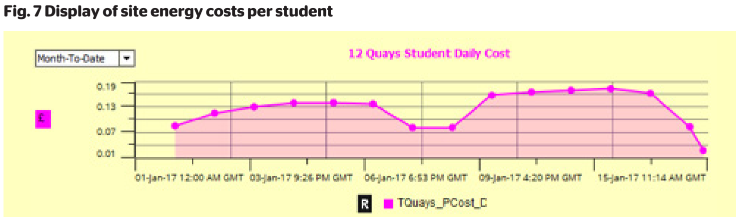


Fig. 7 Display of site energy costs per student



energy used daily, weekly and monthly and methods to allow comparison against the previous year's data. Where possible it should include some typical key ratio's to allow the consumption to be compared against key operating parameters such as for example; outside temperature using kWh/degree day, production in kW/unit of production, sales in kWh/unit of turnover, occupancy in kWh/man hours or kWh/unit of floor area. If used correctly, these key ratios can produce useful information about how well the energy is being used compared with previous years and other facilities or departments within the organisation.

Normally various graphs can be produced to show the increase or decrease in corrected energy consumption.

In many systems it is also possible to produce graphs and key ratios using carbon and cost as the criteria as well as kWh. This is becoming more popular and gives some interesting information when comparing fuel types.

Once some historical data has been accumulated then it is possible to start looking at energy use using statistical methods; such as regression analysis and CUSUM to identify trends. Most systems have this capability and also allow the user to set targets. These energy targets can be very simple such as using the best historical typical week or typical month's data as the ongoing target. Whatever targeting method is used the accuracy and repeatability of the metering system data is essential to the success of the system.

It is now very economic to install intelligent metering systems which allow the user control their energy use by knowing exactly how they are using their energy and how much it is costing across the various areas of their business. It is always wise to start small and build up the system by adding meters when they are required to get the best results and not metering for the sake of it. These systems are generally easy to expand and provided they are specified and installed correctly will supply many years of reliable data about their business in a simple to understand manner. It is best to select appropriate systems for appropriate uses. A mixture of metering systems can sometimes be advantageous.

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CPD SERIES **14** | MODULE **08** | FEBRUARY **2017**

ENTRY FORM

METERING & MONITORING

Please mark your answers on the sheet below by placing a cross in the box next to the correct answer. Only mark one box for each question. You may find it helpful to mark the answers in pencil first before filling in the final answers in ink. Once you have completed the answer sheet in ink, return it to the address below. Photocopies are acceptable.

QUESTIONS

1. What is smart metering?

- ☐ A system which monitors gas meters.
- ☐ The use of automatic meter reading and data collection technology to remotely monitor and log energy consumption at buildings or machiner
- ☐ A system that reads electricity meters
- ☐ A remote monitoring system.

2. The Building regulations now demand that if a new building is over 1000m2 of floor area then at least what percentage of the buildings energy use is to be metered and the use identified as per the CIBSE Guidance TM39.

☐ 90% ☐ 75% ☐ 100% ☐ 50%

3. If you are in a Climate Change Agreement would you need metering?

- ☐ Only if you use over 100,000kwh of energy per annum
- ☐ No
- ☐ Yes
- ☐ Only if you have gas on site

4. When installing a metering system a number of factors need to be examined which affect the complexity and cost. Which of the following should be considered?

- ☐ Is there a requirement for offsite data use or is all the data required on site
- ☐ The amount of energy monitored
- ☐ The type of electrical supply HV or LV
- ☐ If LPG is used on site

5. Which of the following is one of the three basic metering strategies?

- ☐ Use pulsed output meters
- ☐ Use hard-wired systems
- ☐ Use remote logging
- ☐ Use single point meters which send back the data individually to the monitoring system

6. Two basic types of smart metering data collection systems are available. These are:

- ☐ Hard wired and radio
- ☐ Mains borne and radio
- ☐ Hard wired and mains borne
- ☐ Hard wired and radio telephone

7. A 3 per cent error on a meter sized for 100m3/hour of flow will be 3m3/hr. If the actual flow rate is only 10m3/hr then the meter accuracy will be what of the actual flow rate

☐ 1% ☐ 10% ☐ 30% ☐ 5%

8. If you need to add a number of meters to get to a total then the per cent accuracy of the total will be what?

☐ 5 per cent ☐ Deducted
☐ Subtracted ☐ Added

9. Where possible the energy analysis should include some typical key ratios to allow the consumption to be compared against key operating parameters such as:

☐ kWh/year ☐ kWh/degree day
☐ kWh/day ☐ kWh/week

10. Once some historical data has been accumulated then it is possible to start looking at energy use using statistical methods such as:

- ☐ Regression Analysis
- ☐ Histograms
- ☐ Graphs
- ☐ Mathematics

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