Invest Northern Ireland

Metering, Monitoring and Targeting

A best practice guide for businesses in Northern Ireland

Invest Northern Ireland
Sustainable Development Team
T: 028 9069 8868
E: sustainabledev@investni.com

Table of Contents

1.0 Purpose of the Guide

All businesses consume or produce energy - understanding how much energy we use, for what purpose, and how we exercise control over energy consumption and cost, is vital for environmental and commercial security.

This guide explains, concisely, the basic guiding principles relating to the conception, development and procurement of metering, monitoring and targeting systems (MM&T).

1.1
Who is this guide for?

This guide is primarily intended for companies who currently do not use MM&T, but it is also relevant to those who already operate MM&T systems for building energy consumption or for industrial activities.

1.2
What is the scope of this guide?

This guide covers aspects of concept, development and the practical operation of an MM&T system. The guide does not cover specific installations or products other than by way of example.

It provides a detailed explanation of some of the fundamental aspects of MM&T installation and operation and includes the following:

- The basic concepts
- The system requirements
- The benefits
- Operational considerations

1.3
How to use this guidance

This guide is split into stand-alone sections that may be read in isolation or in sequence. If read in sequence the document follows the procedure that should be adopted to develop a successful MM&T project. However, guidance on specific subject matters may be obtained by reference to the relevant section.

1.4
Additional sources of guidance

This guide contains a list of additional sources of guidance.

2.0 What is Metering, Monitoring and Targeting (MM&T)?

2.1
What is monitoring and targeting?

Monitoring and targeting is a term used to describe a range of management techniques employed to improve understanding of how energy is consumed and business costs are evolved. MM&T is a management system for controlling energy consumption and cost. It allows performance measurement with a greater degree of accuracy and can be used to improve accountability, quality and profitability.

If, specifically, your process systems performance deteriorates, you will be faced with increasing costs and perhaps even product quality or productivity issues.

It is therefore prudent to manage these systems effectively. To manage any system effectively you must have knowledge of its performance.

An excellent analogy is the fuel consumption of a car. A poorly maintained car with worn engine, under-inflated tyres and poor carburettor set up will have poor fuel performance.

Recognising poor fuel performance with fluctuating petrol prices is difficult. But if you keep a simple record of fuel consumed and mileage travelled you may well be able to determine performance. In addition:

- You will be able to identify performance loss quickly.
- You will be able to predict the fuel consumption for a specific journey.
- You may care to drive more sensibly when you are able to see clearly how much fuel you use.
- You may be able to predict the need for service or tune up. (PPM Planned Preventive Maintenance).
- You will be able to see the benefit of tune up.
- You may make allowances or corrections depending on the type of driving you are doing (motorway or urban).
- You could establish whether your Ford Escort compares favourably with the Fords published figures. (Benchmarking).
- You could set your own fuel performance targets to be achieved by careful driving and good car maintenance. (Internal Benchmarking).

The same concepts are true (if not more so) for any fuel or power consuming processes. The process of monitoring and targeting is very similar and can be as elaborate or as simple as required to allow your complete understanding of system performance.

2.2
Is Monitoring and targeting complex?

Monitoring and targeting can be as simple as routinely taking a meter reading and checking consumption against production. Or it can be a complex multivariable process based analytical tool.

Contrary to common belief a useful M&T (monitoring and targeting) system can be extremely simple. It is really not about how complex the system is, it is about how appropriate the system is.

2.3
Is monitoring and targeting easy to implement?

Yes it is a simple management procedure requiring the collection and analysis of energy and production data. In some cases the process can be largely automated using data collection and analysis software.

2.4
Will MM&T save money?

Yes - If you do not meter, then you do not measure and therefore you cannot manage energy effectively.

2.5
Does MM&T require trained or specialist staff input?

Generally not, although some knowledge of process and spreadsheets are useful. MM&T (metering, monitoring and targeting) is really the application of techniques that allow you to carry out existing business and process function with improved control and awareness of energy consumption and cost.

2.6
Is there a significant associated investment cost?

Not necessarily. MM&T can be implemented with relatively little cost (sometimes no capital cost). Where it is necessary to purchase additional metering, there are additional costs.

There are costs associated with managing energy. These costs arise from labour engaged in collecting, analysing and presenting data. However, these costs may be relatively small when compared to the prospective savings potential.

3.0 What are the benefits of MM&T ?

3.1
Energy consumption reduction

The obvious benefit is controlling the use of energy. However MM&T can be used for much more and can be used as a performance diagnostic tool for a process or for specific elements of a process. For example, in the context of a boiler, or a steam system this management tool can be adapted and used quite creatively to allow continuous performance analyses.

3.2
How much money will be saved

This is entirely dependent on the process, the site, the existing degree of control and so on. However, for most industrial sites the expectation might be 5% savings potential from MM&T alone.

3.3
Improved product costing

The value of energy as part of the product cost can be assessed and understood using MM&T. If you understand the cost you are more likely to be in a position to control the cost. This is particularly true for variable production runs. It is usually evident that economies of scale exist in most production activities. MM&T can help identify and accurately quantify these economies of scale.

There are two distinct benefits. Firstly, production can be scheduled to achieve the best specific energy consumption and lowest cost per unit production. Secondly, the cost to customer can be passed on accurately and short run product priced with accuracy.

3.4
Improved budgeting

The relationship between production and energy can be established, energy and cost forecasts can be reliably derived for planned production activities.

3.5
Improved planned preventative maintenance

The examination of specific consumption trends can tell a lot about the performance and efficiency. Just as increased fuel consumption in the example of the car can be used to detect the need for a tune up, an MM&T system can be used to detect deteriorating plant performance.

3.6
Improved product quality

Uncontrolled or variable energy performance often results from poor system control with similar adverse implications for quality. A spin off from effective energy management is improved process control and improved production or product quality - It is not a direct effect of MM&T but a secondary benefit.

3.7
Waste reduction

An MM&T system aids the cost of wasted production to be evaluated, understood and hopefully avoided. Waste costs twice in energy terms. The original energy consumed and the energy consumed to make the replacement product.

4.0 What constitutes an MM&T system?

4.1
A system for energy measurement, metering and recording

Metering is an essential prerequisite for effective monitoring and targeting. Energy saving measures may only be identified and implemented if energy performance is understood. To do this metering is required.

The principal barrier to expenditure on metering is the apparent lack of tangible payback. In fact metering provides the evidence to prioritise and justify the installation of energy efficiency improvements.

4.2
A facility for relating energy consumption and production activity

To understand how production activity is related to energy consumption and cost, it is necessary to measure production output.

The energy consumption per unit production is called the specific energy consumption or SEC. The SEC might well vary with production volume - becoming less with large volume production (economies of scale) and often typically increasing with short production runs.

The basis for quantifying production varies from site to site and production activity to production activity. Many companies produce a range of products from similar feed stocks and there may be some considerable variation in specific energy consumption. It may be necessary to develop a series of product specific indicators or develop an SEC that uses raw materials as a measurement basis.

MM&T is routinely used to record and examine the performance of buildings and in that specific circumstance the SEC might vary with external air temperature, occupancy and other variables.

In some cases it may be necessary to develop relatively complex relationships if the consumption patterns are to be understood. However, wherever practical, the least complex and simplest relationships usually work best.

4.3
The derivation of standards – what is current performance?

To evaluate any improvement in control, and variation in SEC or cost, the current performance has to be understood. Since the SEC may vary with production volume, temperature or some other variable, the current performance and the performance relationship must be understood.

The derivation of target data and the analysis of that data is explained in this guide.

It is self evident that unless there is a mass of historical data, then the ongoing comparison of performance cannot be made until sufficient "current performance data" is assembled. There are two possible solutions:

- Sufficient historical data is available and can be analysed to set a target.

or

- The system must be operated and used initially just to collect data to allow analysis and the derivation of a target.

4.4
Comparing performance

Comparison is usually straight forward and visual comparison of data is often sufficient to allow comprehension of the energy trend and cost and ultimately allow action for control.

In some more complex arrangements where an MM&T system is used to monitor specific plant or process, it is useful to develop a statistical protocol for analysis that allows rapid trend analysis, alarm setting and provide easily understood data analysis.

In most cases a simple relationship between production and consumption can be established and used for the purposes of comparison. This guide explains several basic techniques, and provides some worked examples.

4.5
A system for analysis – how is performance assessed and variance measured, what does it mean?

The use of CUSUM techniques (Cumulative Sum of Errors from target) is a simple but particularly useful way of comparing performance when there is a scale related variation in SEC. The CUSUM technique allows quick, accurate trend information to be determined and can be accomplished very simply using basic spreadsheet tools.

The CUSUM technique may be used to rapidly analyse large and complex data sets - and vital trends.

A more detailed explanation is given in this guide.

4.6
A system for reporting – how is the information conveyed and to whom?

Analysing performance is meaningless unless the information is acted upon. Even if the sole purpose of the data collection is to check invoices or some equally simple arrangement, the information is worthless unless it is collated, presented and action is taken.

A formal reporting system is therefore required. This might take the form of a straightforward performance or feedback report that is delivered to individuals that have control over the process, heating or other controlled system.

4.7
A system for improvement – how is the information acted upon?

There is little point in having a control system without feedback and error correction - the analogy of the car is ideal once again. If the fuel consumption is consistently poor then the driver may have to service the vehicle, adjust driving style or make improvements to the process e.g. remove items stored unnecessarily in the boot, check tyre pressures, etc.

5.0 Planning for the implementation of an MM&T system

5.1
Establishing Cost Centres (Energy Accounting Centres)

MM&T will be used primarily to ascertain the energy consumption associated with a production activity or building. It is important to establish cost centres. A cost centre is an area of business activity, process or plant that can be metered effectively and where there is opportunity to manage and reduce energy consumption.

Cost centres might be determined geographically - a good example would be a district heating system where individual buildings are metered. The energy flow to each building would be monitored (with or without line losses) and the boiler operation might equally constitute a cost centre. In this way the individual building performance, line losses and the boiler house efficiency might all be monitored and consequently managed.

Likewise where separate processes are conducted in different buildings, e.g. rubber mixing and tyre moulding, and it is relatively easy to separately meter and monitor these processes individually. Cost centres might be determined on existing adopted accountancy bases e.g. the weld shop or the paint shop.

It is more difficult when the process stages are contiguous or there are multiple processes in one building (as often is the case). However if a methodical approach is adopted and in house process knowledge is used, an acceptable compromise will almost always be determined.

The important issue is to create a system that provides useful measurement of operational aspects over which you might be able to exercise cost effective control.

These might be:

- process activities (packing and finishing)
- geographical areas (South side production area)
- specific systems (the steam distribution system or boiler house)
- plant items (the boilers or indeed a specific boiler)

Creating a useful MM&T system will require some careful survey and initial analysis of the energy consumption, consumption patterns and production activities.

5.2
Who is best able to determine the constitution cost centres?

In developing an MM&T system you could solicit advice from a consultant experienced in the development of MM&T systems. However, it is unlikely that an external consultant or MM&T supplier will have the detailed business knowledge required to establish an optimal solution. An external consultant will, however, be able to explain and define relevant analysis methods.

Cost centres are best developed internally - where practical these should be independently metered so that the energy performance can be ring fenced. Often, however it is not possible to arrange for discrete separation and some compromise is required.

5.3
What basis for energy and production activity should be selected?

In selecting cost centres it is also important to consider the Specific Energy Consumption indicators Key Performance Indicators (KPI's) that will be derived – because it is useful to determine clear and easily used, trended Specific Energy Consumption indicators.

Remember that the SEC is a measure of energy per unit product (or similar). In some cases compromise over exact geographical or process stage delineation will allow a far superior SEC to be more easily collected.

Choosing SEC and the basis for deriving SEC is addressed in the following guide section.

5.4
Will additional metering be required?

Yes, because most sites in the UK will only have the utility company's service meter. The accuracy of the meter should be good and there is a legal duty of care for metering to be accurate and within +/-2% (gas) and +2.5% to 3.5% (electricity). Some 93% of meters are generally within these limits. However if you are spending £50,000 on electricity each year the error could be worth as much as £1,750.

Having identified cost centres it will be necessary to meter these in order to provide a basis for an energy/ production relationship.

Notwithstanding the Government's 'Smart' metering programme (which will affect domestic and small commercial users) larger sites will be equipped with 'Smart' or advanced utility metering by 2019 allowing full data download. However, the installation of client owned sub metering is a vital part of understanding the breakdown of energy use.

For each cost centre the requirement for metering should be assessed. Metering is addressed in a following section of this guide.

5.5
What data collection procedures will be required?

Clearly the meters must be read. Meter reading gives rise to the most difficulty in data analysis. Automatic data collection is far superior to manual collection because the "time of reading" errors can largely be eliminated.

Manual meter reading is acceptable but may be time consuming, depending on the number of meters. Sometimes manual data collection can be irregular or introduce meter reading errors.

Of course the energy or water consumed is only one half of the equation. Accurate energy metering is pointless if the production related activity cannot be measured. Likewise then a means of measuring production must be determined.

Data must be collected regularly, at the same time each day, week or whatever the metering period selected so as to provide comparative intervals of energy and production data.

5.6
Is management commitment essential?

Yes, senior management backing and support are required. This is important because the performance of cost centres or buildings will be examined and there must be a commitment to act on the information distilled from the MM&T process.

It is important to understand that MM&T is a management diagnostic system and it requires management input to affect an outcome - MM&T is not a passive system and the managerial structure and staff accountability are a key component of the system architecture.

Senior management commitment is required to support and underwrite the project. Local or cost centre management is required to review and determine the cause of performance variation and provide rectification or control.

5.7
Preparing a business plan for MM&T

There is a cost associated with providing and operating an MM&T system and therefore to implement an MM&T system, a structured development and implementation plan is usually required.

- The potential costs and savings have to be identified.
- The concept must be sold to senior management.
- The methodology and timescale for implementation must be determined.
- The functional and operational requirements of a system must have been established.
- The staffing and skill requirements assessed.

The costs arise, amongst other things, from:

- The level to which monitoring and targeting is exercised (keep it simple)
- Additional meter requirements
- Data collection (time if the system is not automated)
- Analysis requirements (this can also be automated)
- The actual implementation and day to day operation

A balance is required to ensure that the cost of operating the MM&T system does not exceed the potential benefit. Clearly it would be nonsensical to measure monitor and target every aspect of one business or production activity.

6.0 Cost Centres and Specific Energy Consumption (SEC)

6.1
What basis should be used for SEC?

MM&T is generally used to trend performance, so repeatability is more relevant than accuracy (this is explained further within metering section).

The cost centres should be first determined – this is a fundamental consideration of any MM&T system. Refer to the preceding guide section.

Explaining the nature of cost centres and the selection of SEC is important and best explained by the following example:

In the glass container industry, raw material is mixed and fed to melting/holding furnaces. The molten glass is conditioned and sent to moulding machines. The bottles are then annealed and quality inspected before packing.

Mixing sand to melt for glass is an electrically intensive process stage. This is an ideal cost centre as the energy consumed in this process activity is easily measured. The installation of sub-metering allows the kWh/tonne batch to be determined. The large mill motors will have very large fixed losses. It is therefore essential that the mills are loaded optimally and the monitoring process ensures this is the case.

The derivation of a simple kWh electrical power per tonne mixed, allows the volume related performance and the ongoing performance of the plant to be monitored “the mpg of the batch mixing plant”

The batch mix is melted and the melt energy is dependent on a range of factors. In most furnaces it is dependent on the ambient conditions (which affect the temperature of the charge and the combustion air) and the preheat delivered by heat recovery. The melt energy per tonne is a critical factor for energy efficiency and commercial success.

The melt energy/tonne can be correlated with ambient air temperature and that relationship used to establish a target kWh/tonne melted. Large or consistent variations from this target will be indicative of reducing heat recovery performance, poor mixture control, electrode failure (requiring more gas) and so on. The derivation of an automated trending system will quickly alert the operators to system underperformance which in the case of large furnaces could cost many tens of thousands of pounds per year.

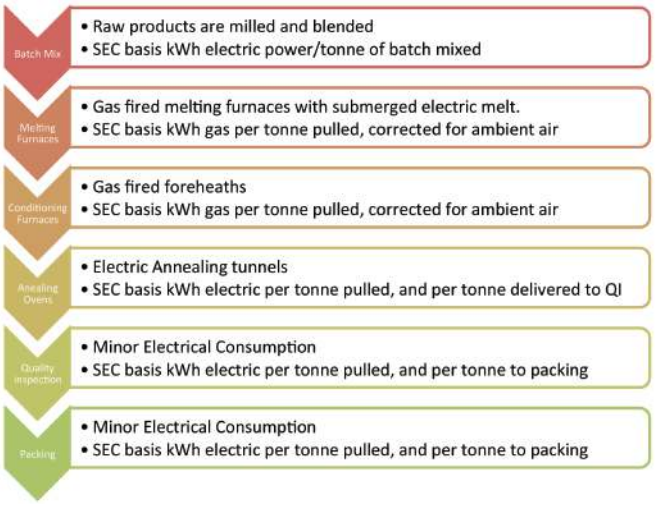
The furnaces might therefore usefully be considered as a separate cost centre and the primary kWh/tonne pulled (pulled from the furnace - the batch weight) considered as the KPI (key performance indicator) with seasonal correction.

The glass must be thermally conditioned prior to moulding as this process is extremely sensitive because temperature stratification will result in a partly formed or deformed bottle at moulding. Monitoring the gas consumed/tonne flow through the conditioning furnaces (forehearths) is also an important KPI. If defective product is produced then it will not be detected until it has been through the annealing ovens consuming electric energy and is either rejected because of breakage after the annealing oven, or as a result of inspection rejection at the quality inspection stage.

The forehearths or conditioning furnaces each have their own gas and power supplies and are thus easily metered separately - the performance of the forehearths is of interest because it is indicative of initial melt condition, forehearth control and an indicator of quality issues to come.

After moulding glass containers are reheated and distressed in annealing ovens. Mouldings of defective quality tend to become over stressed and fail during this annealing process. The performance of the annealing ovens, expressed in terms of kWh/tonne processed is valuable - but the quantity that progresses to be packed, is also critical because it is indicative of the initial mould quality and annealing effectiveness, so kWh/tonne pulled and kWh tonne packed are critical KPI.

The quality inspection process which counts bottles and weight is of low power consumption. However, the metered production data quantifies the losses between tonnes pulled and packed and the cost of waste to the business. The variation in loss is indicative of the process performance and the individual KPI trends flag up specific process variations.



With some relatively simple metering and process quantification, significant insight into the energy and correct process performance can be established.

In practice, the operation of specific plant might be monitored in more detail (again for example), the air flows to the forehearths might be monitored and the correlation between quality or gas consumed would be established.

The preceding example illustrates how cost centres and SEC may be established. These indicators allow analysis of the different processes, process stages and may be used to gauge process control as well as simply keeping track of energy and cost.

By splitting the processes down into logical cost centres (EAC) with appropriate KPI the opportunity for improved management then arises.

Again by way of an example, if the ratio of tonnes glass bottles packed to tonnes melted starts to fall whilst the forehearth gas/tonne produced rises it might logically be assumed that the bottle rejection or break rate has increased, and because the overall gas/tonne has increased this might be an initial molten glass quality or conditioning issue. A decrease in gas consumption might prompt the same investigation. Regardless, the variation and any trend are used to prompt investigation and resolution before any major technical or commercial damage is done.

Specific Energy Consumption Indicators are usually Key Performance Indicators of kWh/unit raw material or kWh/unit finished component or kWh/degree day for a buildings energy consumption. In some circumstances however it might be necessary to relate kWh to hours of production time or some other less tangible measure of production activity. For most industries however there are usually some good credible KPI's.

6.2
What data frequency is required for my cost centres and SEC?

The frequency of data measurement depends entirely on the likely variation in consumption of the processes and what is to be achieved with the data.

If the data is being used to trend overall kWh/kg or kWh/unit of production over a long time frame to determine any drift in performance, then a longer time frame between measurements is appropriate - a daily consumption or weekly consumption might suit.

If, however, the data is being used to say examine compressor performance and the suitability of sequence control, then data collection might have to be every minute - just for example.

6.3
What if I produce different products on the same machines?

If for example you were logging a textile conditioning process and you switched from a grade 1 cotton to grade 12 cotton then it would be appropriate to MM&T these processes separately.

The same would be true for any other industry whether it be castings, injection moulding, glass containers and so on.

Break it down logically so that you are not comparing oranges with apples.

7.0 Meter selection

7.1
What is the Measuring Instruments Directive?

The MID (Measuring Instruments Directive - 2004/22/CE) is a 2004 European Directive applicable to measuring devices and systems in the context of commercial transactions (e.g. the sale of heat, power fuel etc). However the MID is having a profound effect on the quality of metering available in the market and non MID metering will become rarer.

The benefit of MID compliant metering is that the metering is built, classified and certified to BSEN standards and therefore can be relied on to produce reliable metered data. You do not legally require to install MID compliant metering unless you are using the metering to charge a third party.

The MID sets out standards of accuracy, durability (repeatability) and turndown requirements for MID metering.

7.2
Criteria for meter selection

The choice of metering equipment will be determined by site conditions and by the metering objectives. These in turn will determine the relative importance of criteria such as:

- Turndown ratio
- Accuracy
- Repeatability

7.3
Turndown ratio

Is the ability of the metering to function sufficiently accurately over a range of flow without loss of accuracy or potential repeatability.

This is an important factor in meter selection if the process variable to be measured (e.g. gas, oil, water or electricity) varies significantly during production.

7.4
Accuracy

Might be considered as the ability to report a measured value that was close to the actual value or within an acceptable % of the real flow. Accuracy would be determined by testing and the meter subsequently calibrated.

Most modern electricity meters are extremely accurate e.g. +/-0.5%.

Most modern heat meters are extremely accurate e.g. +/-2.0%.

7.5
Repeatability

Reflects the variation in measurement made by the same meter for the same flow and all other conditions being the same. Repeatability is relatively important for MM&T particularly where there are small changes in process efficiency

Curiously perhaps, accuracy is less important for MM&T than turndown or indeed repeatability.

Accuracy, for instance, may be less important than repeatability for an MM&T system, but the reverse may be true where the performance of an item of equipment such as a boiler needs to assessed. An accurate meter costs more than a meter which is simply capable of good “repeatability”. A careful choice must be made to make best use of capital available?

7.6
What does Modbus compatible mean?

Metering will generally provide a measure of cumulative flow e.g. the digits on a gas meter, electricity meter or oil meter - but most meters will provide a pulsed output. Many meters will also be addressable and use a serial bus to transfer data. This is similar to the way that data is transferred inside a computer. A common bus (wires) is used to transfer discrete packages of encoded data. The encoding contains the address of the meter and the encoded raw measurement data. A central computer based monitoring system can poll up to 47 individual devices and receive measured data in return. The data can then be decoded and presented as raw data in text, csv (comma separated value) or other formats depending on the data processing provided in your computer.

7.7
What meters do I need?

Accuracy is not critical for MM&T unless the MM&T system is used for specialist process control. Thus a lower accuracy is acceptable. A MID compliant meter is preferable. When you purchase a meter it is beneficial to have:

- A physical indication of instantaneous flow or power
- A cumulative record of flow or power
- A pulsed output
- Modbus compatible

8.0 Operating the MM&T system

If you require this leaflet in an alternative format (including Braille, audio disk, large print or in minority languages to meet the needs of those whose first language is not English) then please contact:

Invest NI Equality Team
T : 028 9069 8273
Text Relay Number : 18001 028 9069 8273
E-mail : equality@investni.com

Invest Northern Ireland

Bedford Square
Bedford Street
Belfast BT2 7ES
T : 028 9069 8000
F : 028 9043 6536
Text Relay Number: 18001 028 9069 8000

investni.com