Intelligent Energy Europe

Intelligent Metering

Energy Savings from Intelligent Metering and Behavioural Change

Contract N°: EIE/04/107/SO7.38635

Roadmap for an Intelligent Metering, Monitoring and Training Programme

Executive summary

This document aims to bring together all the experience gained throughout the project entitled *Energy Savings from Intelligent Metering and Behavioural Change* (the Intelligent Metering Project) EC contract no: EIE/04/107/SO7.38635. It presents a Roadmap for an Intelligent Metering, Monitoring and Training Programme. This roadmap covers the needs assessment, the monitoring and analysis specification and likely associated costs of intelligent metering systems

The Needs assessment aims to support identification of the requirements of an intelligent metering and monitoring system in relation to the requirements of the building, its users and the outputs required. It examines what parameters should be monitored based on the needs of the data use. For any monitoring system, including those in buildings, the decision must first be made as to why the monitoring is required before the monitoring parameters can be set. The main steps in this need assessment process are:

- **-Define monitoring objectives**
- **-Choose parameters to be monitored**
- **-Review implementation needs (meter review/enabling, installation of automatic remote metering, meter data collection and analysis software)**

Once the monitoring needs have been defined then the intelligent metering and **Monitoring system** can be specified. This involves the definition of the actual system inputs and outputs required and the approach to be used. Hence the hardware, data transmission system and analysis software can then be identified. It should be noted that when including a number of buildings/plants in any project then the specification must be checked to ensure that it is applicable to all sites. The main steps in the specification of the monitoring systems are:

- **-Define the system inputs and outputs**
- **-Select monitoring system, which will include hardware for metering, for data transmission and data flows/storage**

Then, the selection of the software/approach to **Data Analysis** has to be considered. The analysis software may be considered the most important part of an intelligent metering and monitoring system, since it is the eyes and brain on the data that provides the user with useful results to help achieve energy savings.
It should be remembered that the demand for monitoring might originate from differing groups with different motivations and approaches. For example, primary reasons often include load management, to control the energy demand peaks; building management in general and from the economic or accounting viewpoint. An intelligent metering and monitoring system and its supporting data analysis tools should try to support all of these differing needs. The main steps in the selection of the Data Analysis process are:

- **-Choose the energy accounting approach to be utilised**
- **-Choose the software by considering parameters and analysis output needs**

Managing the monitoring programme, the data and reviewing the outputs is the next process in the intelligent meeting roadmap. It may be the responsibility of an outside agency but it will still directly involve a large number of people. There are different people involved in the intelligent metering and monitoring of any building or plant, and in the different forms of energy accounting. To all of these people the intelligent metering system will often be required to provide different information, depending on their needs. For this reason these people also interact with the management of the system in different ways. The main steps in the Monitoring, data and outputs management are:

-Consider roles of different groups involved in the project (e.g. Premises Officer, building owner, etc). Ensure the system meets their needs in terms of information supply

-Ensure responsibility is defined, as to who deals with monitoring data and follows up savings opportunities (e.g. abnormal consumption, high baseload when not needed)

Finally, a **Training Process** needs to be implemented. Very wide and varied options exist for approaches to training. This roadmap focuses on the approach, including the background to the choice of approach, and the results of that approach, as used in the Intelligent Metering Project. The purpose of the training process is to train building occupants in energy and water saving through behavioural change and to encourage and allow the building occupants to relate to the data being provided to support this behavioural change.

Roadmap – summary step guide

Step 1: Define the monitoring objectives or reasons for monitoring.

Step 2: Define the level of detail required in terms of building information; this will also be affected by the choice of analysis tool/software.

Step 3: Choose the parameters to be monitored

Step 4: Choose the approach and review the needs, i.e. of existing meters versus new installation.

Step 5: Define the system inputs and outputs and the level of additional data/information required.

Step 6: Select the monitoring system which will include hardware, for metering, for data transmission and data flows/storage, potentially part of a complete package.

Step 7: Choose the energy accounting approach to be utilised.

Step 8: Select the software, through a consideration of the parameters and the analysis output needs.

Step 9: Consider the roles and responsibilities of all of the groups involved with the project. Ensure that any system meets their needs in terms of information/data supply.

Step 10: Ensure that procedural responsibility is defined (i.e. who deals with issues flagged).

Step 11: Consider the proven training techniques which will provide the most impact for the monitoring objectives and required outcomes.

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1 Introduction

The building sector is responsible for a significant proportion of energy consumption. Within the European Union it accounts for around 40% of total consumption. Intelligent metering can be used to maximise the energy savings available from the implementation of efficient technologies and products as well as from the recognition of problems and system errors. In addition there is scope for further energy saving by using the data to support training and promote responsible energy behaviour by building users. By changing building occupant behaviour energy use can be rationalised.

This document aims to bring together all the experience gained throughout the project entitled *Energy Savings from Intelligent Metering and Behavioural Change* (the Intelligent Metering Project) EC contract no: EIE/04/107/SO7.38635 (www.intelmeter.com), a project which has demonstrated economic savings of up to 30% with little or no investment. It forms part of a best practice methodology which provides options for each key step along the road of an intelligent metering exercise (through this roadmap document) and examples of how such exercise could be implemented by providing case studies for different building typology and training actions.

This roadmap covers the needs assessment, the monitoring and analysis specification and likely associated costs of intelligent metering systems. It also reviews training approaches and effectiveness of such activities.

Through an easy to follow step-by-step guide on how to instigate such a project and what needs to be in place to start this document, in conjunction with the case studies, aims to promote increased understanding of the advantages and opportunities available from intelligent metering.

2 Needs assessment

This section aims to support identification of the requirements of an intelligent metering and monitoring system in relation to the requirements of the building, its users and the outputs required. It examines what parameters should be monitored based on the needs of the data use.

2.1 Monitoring objectives

For any monitoring system, including those in buildings, the decision must first be made as to why the monitoring is required before the monitoring parameters can be set. Monitoring may be required:

- As an overall objective of reducing, for instance, energy and water consumption to lower costs and/or consumption levels, simply because resources are not endless (based on background issues, i.e. climate change, air pollutants and/or political and potential future cost issues such as security of supply);
- As a tool to control plants and devices for malfunction;
- As a tool for rating contracting and redevelopment measures, i.e. in bulk tendering and energy purchasing, within a liberalized energy market you can control your energy supplier and have better data for a quick change or new energy contract;
- To provide information about different aspects of the building;
- To assess trends in consumption and react to them more quickly;
- To calculate specific costs, i.e. of special events within the monitored buildings, and hence ensure a correct charging structure.

Once the basis of the need for monitoring has been defined then the parameters to be monitored can be set.

Step 1: Define the monitoring objectives or reasons for monitoring.

In the Intelligent Metering Project, the aim was to reduce the consumption of energy and water by using intelligent metering techniques and training to show that these savings can be achieved at little, or no, additional cost. The approach used to achieve this was through energy accounting. Energy accounting collects the amounts and costs of energy, water, fuel, etc. and analyses the data. First the amounts of consumption must be observed, and then the data have to be transmitted and analysed. An interpretation of the results leads to a reaction of the involved people, e.g. reducing the consumption, in addition to the reduction of consumption by recognising problems. See Section 4.1 for more information on energy accounting.

2.2 Building typology and user characterisation

The information regarding the building type is required to allow analysis and assessment of measured parameters in a realistic and useful way. This is often known as the measuring data and may include some or all of the following: building ID (identity – a unique identifying number or code important if more than one building/site is being monitoring), outside temperature, metering details such as the metered item and scope, the meter code, date and time, the metered data/value, figures relating to the building use and size (although the latter are not technically measuring data these are often included within the measuring data depending on the approach/system/software utilised).

It should be noted that the metered data from the sensor are usually electric pulses which must be translated into values. It must be defined how many pulses are one metered unit at the counter/meter, e.g. 3 pulses are 0.1°C or 10 pulses are 1Wh or 15.000 pulses are $1m^3$, etc. This translation may be completed within the measuring unit or within the software.

In addition some building information may be required to support benchmarking and comparison between different buildings as well as training and the identification of best practice. This is usually identified as additional data, i.e. category of building use, size of building in square meters, load of the units in kW, the date of construction, the net calorific value of the energy carrier, the energy carrier, linked energy costs, linked emissions, and the persons responsible for the building. A system to review assessments, consumption targets, the aberration from normal consumption for alarm, the alarm contacts (e-mail) may be data of interest too.

Table 1 and Table 2 show typical measuring data and additional data, although these should be used as examples and are in no way intended to be exhaustive, nor would all parameters necessarily be needed depending on the level of monitoring required. The actual specification of data required (overall and separately within the two categories) will depend upon the approach used and any specific analysis software.

Field	Comments
Floor Area (GIA)	For use with heating metered items, usually gross internal area, floor area excluding walls
Heated gross area/volume	To help define between heated and un heated areas – if different
Occupancy levels/ Staff Numbers/ Building users	Figure used to ascertain the number of people using the building services, i.e. water, heating and electricity.
Occupancy usage	Hours/day, days/week, weeks/year – to allow usage patterns to be defined and hence problems identified.
Location sheltered / normal / exposed	Maybe required as part of the heating based information
Building ID/Code	Unique identifier often used when more than one building is being monitored mainly for analysis purposes
Building Name	Potentially required part of the identification process
Building Type/Alias	To allow easier comparison of different building types this may help any analysis software
Building Address	Maybe required as part of the identification of location for external climate information
Date Built	Maybe required in relation to build type, likely levels of insulation, etc
Outside temperature	As part of the heating assessment
Type of service being metered	Electricity, Gas, Mains Water, Oil, Coal, Hot Water Heat, or other (please specify)
Pulse value	Value of one unit in the collected data, i.e. in kWh for energy meters, or cubic metres for water meters.

Table 1: Typical measuring data

Field	Comments
Additional activities and date	Critical activities in relation to items that could externally affect consumption profile of metered elements, e.g. personnel training 25th September 2006, water leakage 3rd October 2006
Occupancy usage: additional details	Specific date related events that will significantly change consumption profile of metered elements, e.g. holidays on 30th June to 10th July, 2006; special event (ball) 2nd Oct, 2005
Larger electrical/heating/water consumption devices	To enable specific losses to be reviewed e.g. 10 kW lightning, 12 kW IT-devices, 15 kW kitchen, 9 kW cooler, etc. (same for heating or water)
Category of usage	May be the same as building type although this may be for specific categories if comparisons are being made, e.g. school
Detailed specification of usage	To allow more detailed analysis on comparison, e.g. extended primary school open whole day
Emissions (usually more detailed)	This might include recognised conversion for kWh consumed of different fuels into emission of greenhouse gases, i.e. carbon dioxide, methane or nitrous oxide and to emissions of air pollutants.
Costs	Via outline cost information input from bills
Alarm level	Many packages will trigger an alarm if levels vary from “normal” consumption.

Table 2: Typical additional data

Step 2: Define the level of detail required in terms of building information; this will also be affected by the choice of analysis tool/software.

2.3 Parameters to monitor

2.3.1 Background

Any object with an input/output where a counter (usually this is a meter) may be placed can be metered and monitored. The larger the consumption of the object the more useful monitoring will be to provide usable data for significant changes in the system, i.e. savings. Small consumption objects are more problematic. As a general rule of thumb if the annual object usage, i.e. energy and water, costs are less than 4 times higher than the annual costs for monitoring/energy accounting, it will normally not be economic to monitor.

Objects may be buildings themselves or they may be components within the building, i.e. the boiler, or outside of it. Energy monitoring and accounting is useful in a wide range of situations, e.g. street lights (there are sometimes older billing contracts with fixed annual costs if consumption is metered this can be checked for suitability), sewage plants, power plants, water pumping stations, sports facilities or open air swimming pools.

The basis for energy accounting (see Section 4.1) is to have at least one counter per accounting scope (heat, electricity, water demand, etc.) for the monitored object.

If there are counters for energy, these can be before, i.e. the boiler, and after, i.e. the boiler, Figure 1. The primary energy, natural gas, is converted in the boiler to heat energy. The degree of efficiency of the boiler depends on its losses. Using two counters enables the boiler efficiency to be monitored.

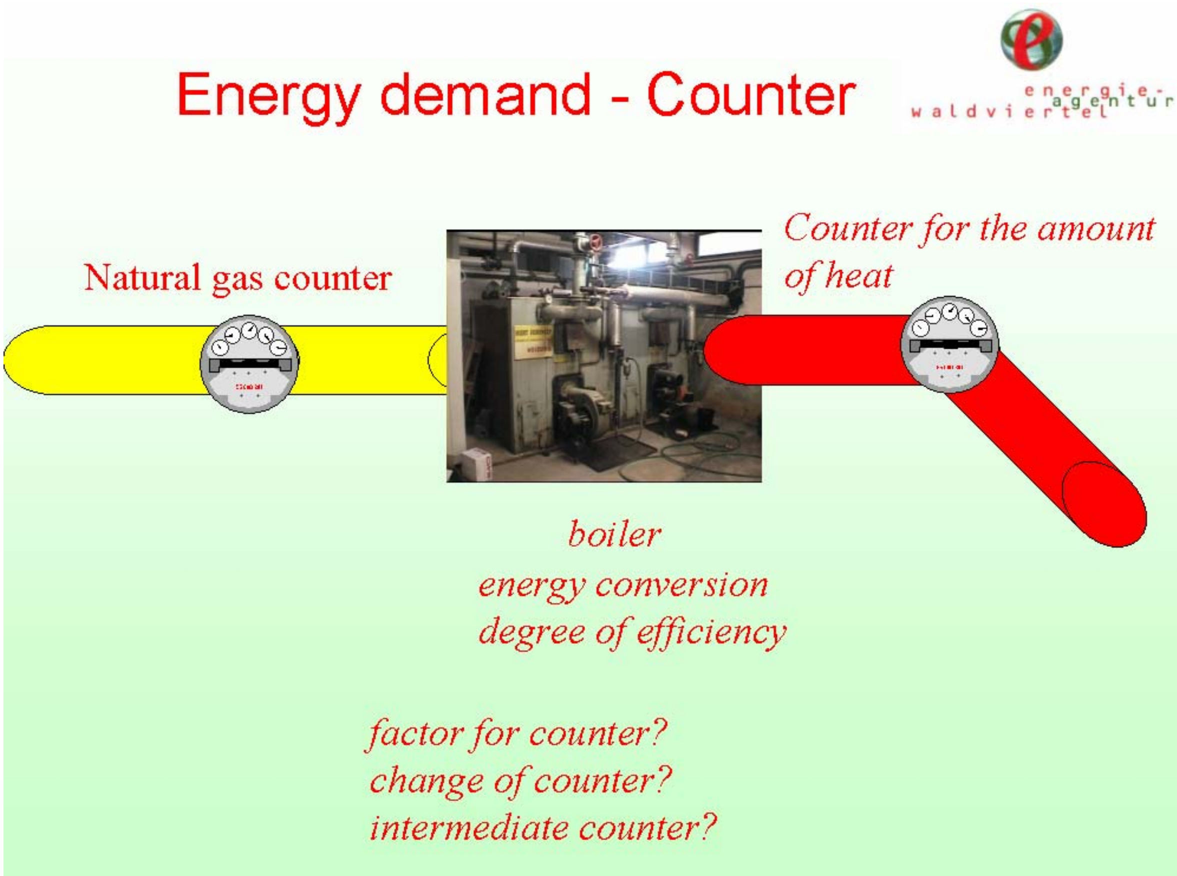


Figure 1: Counters monitoring a boiler

As well as converting the counter pulses to values there may also be counter factors used in large consumption units, i.e. whole buildings. For instance if the counter counts “1” and the factor is 30, the actual consumption is “30” units. Some counters may be part of sub-areas of the building/plant being monitored. These are often known as intermediate counters. Their measured units form a part of the overall consumption of the whole object, that is metered at the main counter elsewhere.

If there are no counters because the energy is supplied in a discontinuous way it is also possible to measure *filling* levels, Figure 2. The measured unit is the reduction of filling level. New deliveries increase the filling level. The energy carrier is linked with its net calorific value. Energy accounting programs may record delivery, filling level and consumption. Typical energy carriers with filling level are oil/petrol and biomass like wood, chops and pellets. Filling levels can be metered with radar, laser, swimming levels. Weight or volume can be metered too. If filling levels are difficult to monitor it is possible to use only the counter for the amount of heat from the boiler, although this will limit the effectiveness of the data.

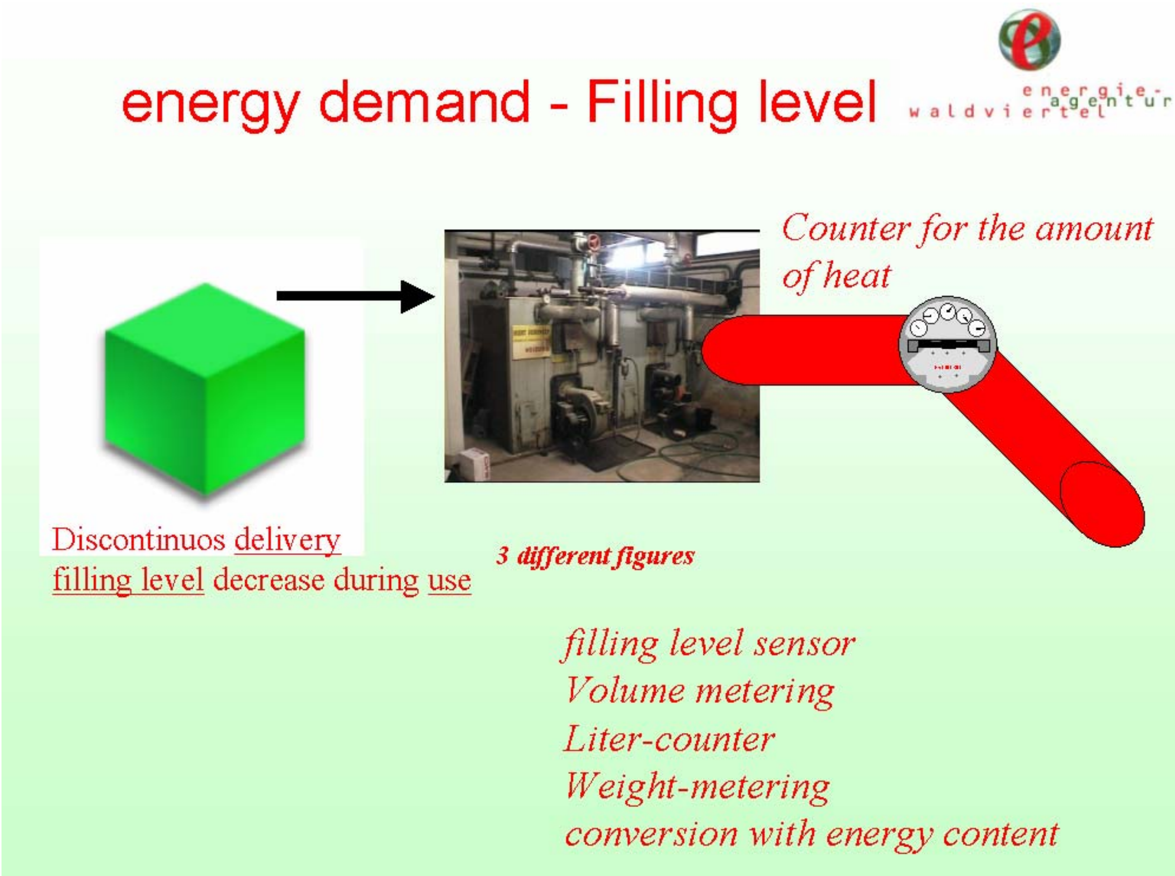


Figure 2: Filling level counters

2.3.2 Choosing parameters

Almost every parameter could be monitored, however the costs for the device and metering and the need to meter it must be considered.

Typical parameters might include:

- Mains water and sewerage;
- Gas;
- Electricity;
- Steam;
- Hot Water;
- Oil;
- Industrial and medical fluids and gases.

Some parameters to monitor will not be metered but monitoring must be considered in terms of their identification, i.e. unit of the amount (kWh, MWh, etc.), ID number of the metering instrument or building, time stamp (generally given by a main counter, data logger or building management substation). The key parameter is the amount of energy or water used since the last time unit.

In addition indirect parameters will be required, such as volume, pressure, temperature and connected with other information like the net calorific value of the metered energy carrier (e.g. a natural gas counter counts the volume – the net calorific factor is necessary to find out the energy amount of the used gas), see Table 3.

Energy carrier	unit	net calorific value
bark (50% moisture)	bulk cubic meter	600
biogas	m³	6
brown coal	kg	3.9
chopped wood dry (25% moi.)	bulk cubic meter	850
chopped wood wet (35% moi.)	bulk cubic meter	780
coke	kg	7.5
cutting from wood	bulk cubic meter	650
diesel fuel	litre	9.86
fuel oil extra light	litre	10
fuel oil light	litre	10.5
fuel oil medium/heavy	litre	11.2
gasoline	litre	8.77
hard coal	kg	7
hard coal briquette	kg	8.3
liquid gas	kg	12.8
Log wood (hard)	cubic meter of stacked wood	2,410
Log wood (soft)	cubic meter of stacked wood	1,520
natural gas	m³	9.5
rape oil	litre	9.6
sewage gas	m³	4.4
straw	kg	3.6
wood briquette	kg	4.6
wood pellets	kg	4.7

Table 3: List of net calorific values as used by the energy agency Waldviertel for different energy carriers as part of the Intelligent Metering Project.

If it is a discontinuous energy supply, the filling level will be a measured parameter. In electricity consuming units the load and reactive current may also be metered, because in some instances electricity suppliers use this for standard pricing components.

Other important parameters are those relating to climate. Temperature is clearly an important parameter since there is often a clear connection between temperature and consumption, i.e. in terms of heating requirements. The colder the outside temperature the more energy is needed. In addition in terms of internal temperature it has been found that an increase of 1^{o}C room temperature usually equates to approximately 6% higher energy consumption. To compare the consumption of colder days with warmer days, the outside temperature is used for a heat degree correction. A heat degree correction can also be used to compare objects at different locations. The heat degree correction is more critical in colder climates. In slightly more moderate climates (e.g. like in England) other climate parameters have a more important influence on the energy consumption in comparison to temperature; these include solar radiation, shading, wind and humidity.

The next group of parameters which may be monitored, especially in combination with building management systems, is information about the actual use of the object and the condition of the plants. This may be, for example, information on devices, i.e. lights switched on, blinds or windows open allowing ventilation, security systems which provide information on occupancy. Some of these conditions may be regulated as well as monitored by the building management system. Failures and alarms can be transmitted too. These data are often only in a digital format, on or off, however real metering can be done by controlling for instance the concentration (or other air parameters) of the ventilation or the amount of solar radiation intensity that the blinds allow to enter.

For the Intelligent Metering Project the scope was to monitor heat, electricity (both in kWh) and water (in m^3). In most situations one area per object/one counter per object was used.

Table 4 shows a real example of measuring data collected, including counter information, for a building within the project.

Object	BH Wiener Neustadt
built in year	1999
Heating	District heating (natural gas)
heated area net [m²]	6871.9
heated area gross [m²]	8085
heated volume [m³]	18091.7
installed power [kW]	395
using hours per month	182
regular users	160
counter	Nr. 81184
type	amount of heat
counts in	MWh
"1" in counting is in kWh	1000
Electricity	
area net [m²]	9436.7
area gross [m²]	11102
volume [m³]	26957
using hours per month	182
regular users	160
counter	sum of 80283072-1 + 80283072-2
counts in	kWh
"1" in counting is in kWh	60
Water	
area net [m²]	9436.7
area gross [m²]	11102
using hours per month	182
regular users	160
counter	will be new - Nr. = ?
counts in	m³
"1" in counting is in m³	1

Table 4: Typical data collected indicating the counter identification, its units and other useful measuring data

Step 3: Choose the parameters to be monitored

2.4 Implementation needs

There are three basic steps in the implementation process for an automatic intelligent metering system:

1. Meter enabling works;
2. Installation of automatic remote monitoring (ARM);
3. Supply and commission of meter data collection and analysis software.

Each step is considered here to allow some discussion of the different implementation needs that each will entail.

2.4.1 Meter review and enabling works

A meter review will allow existing meters to be surveyed. It is also required to identify the need for, and potential location of, additional meters.

Meter enabling involves the basic step of obtaining useful data from the meter, usually a pulse output. If the intention is to use the main fiscal (used as part of the conventional billing system) meters then the ownership of these meters needs to be addressed. They are usually the property of the utility supplier or distribution network operator. On larger sites the meter usually already has a pulse unit built in and it is a matter of obtaining permission from the utility company to connect the consumer's own monitoring equipment to it. On smaller sites the meters may need to be adapted or changed out, and the utility company will usually want to carry out this work and will charge for it.

This may be one of the most difficult implementation issues, particularly in the UK where the fragmented structure of the utilities sector can make communication and understanding of the project needs, at best, time consuming. If this presents a problem then a secondary meter can be installed downstream of the utility meter. This can provide accurate enough data for energy management but cannot be used to challenge inaccurate bills or offer data to the energy supplier that would be acceptable in place of their own meter reading.

2.4.2 Installation of automatic remote monitoring (ARM)

Meters can easily be read manually but this is time consuming and can usually only be done infrequently, there may also be limitations on when this can be carried out, i.e. in schools, during holidays. Automatic meter reading carried out at frequent intervals, typically every 15 or 30 minutes, will allow the data to be used to its full potential.

There are a number of approaches for getting data from a meter to a computer or similar where they can be analysed these include using an existing Building Energy Management Systems (BEMS), dedicated hard wired data logging networks, modems, Local Area Networks (LAN), low power radio, mobile telephone systems and internet based systems. The most suitable option will depend on: the services already available within the building, BEMS, LAN, etc.; and the site layout, i.e. proximity of the meters to the initial data collection point.

2.4.3 Supply and commission of meter data collection and analysis software

This may include cost related to the installation of telephone lines, line rental, call charges, Internet subscription charges, software setup, training and support, and cost of bespoke software development. This aspect is covered in more detail in Section 3, but it is mentioned here because it is a key part of the implementation needs.

Step 4: Choose the approach and review the needs, i.e. of existing meters versus new installation.

3 Monitoring systems

Once the monitoring needs have been defined then the intelligent metering and monitoring system can be specified. This involves the definition of the actual system inputs and outputs required and the approach to be used. Hence the hardware, data transmission system and analysis software can then be identified. It should be noted that when including a number of buildings/plants in any project then the specification must be checked to ensure that it is applicable to all sites.

3.1 Definition of system inputs and outputs

As well as defining the inputs and outputs the level of analysis or precision required should form part of this definition. Obviously the more precise the analysis the better the evaluation; however, this must be balanced against the overall cost.

It may be at this stage that possible weak spots concerning usage, control systems, equipment set-up, etc. can be determined, providing potential actions for energy saving before the monitoring even begins.

It is essential to determine which meters are assigned to which sector of the building. It is essential that the different uses are also defined, i.e. school kitchen in a full-time-school, an office building with museum-service, etc.

Step 5: Define the system inputs and outputs and the level of additional data/information required.

Appendix 2 shows the definition of inputs and outputs required from the Intelligent Metering Project.

3.2 Hardware

3.2.1 Meters

3.2.1.1 Meters in general

If existing meters are to be utilised they will have to be surveyed, as discussed in Section 2.4.1. The choice of meter, where new meters are used or existing ones replaced, is an important step.

There are a multitude of meter types and choices. Each product range has features which will impact on performance and cost so must be considered in terms of best value for money. Almost invariably, meter size has an impact on accuracy and cost. Often, flow meters are installed on the basis of pipe size with no regard to the actual flow rate, when a smaller meter could be installed which would cost less and be more accurate. In addition the type of technology used has an impact on accuracy. Some of the considerations when selecting meters should be:

- Actual flow rate figures;
- Recorded profile results;
- Load demand reports;
- Attached plant and equipment;
- Longevity;
- Communications;
- Ease of installation;
- Accuracy of meter;
- Cost.

Communications is perhaps a key issue and this has led to a common format of meters providing pulse outputs which are frequently used, especially within automatic metering systems.

3.2.1.2 Analogue and digital meters

In general there are two sorts of meters/counters: analogue and digital. Analogue meters are usually those seen traditionally, i.e. electricity meters incrementing on a continuous basis. Digital meters measure quantity in a series of distinct steps, or pulses. For example, an analogue clock measures time by means of a continuous movement of hands around a dial, whereas a digital clock measures time with a numerical display that changes in a series of discrete steps.

There are many meters on the market today that can send the meter face reading as a numerical value. Unfortunately there is no standard protocol for this so every manufacturer's meter speaks a different "language". Several different networks would be needed to collect all the meters on one site, and many different communication software packages would have to run on the same PC, causing errors.

The pulse output is a "common denominator" available for many types of meter. One data collection device can count pulses from all the meters in a building – electricity, gas, water and heat. Most of the meters that come with a built in communication protocol also have the option of a pulse output.

It is easy for a software package to calculate the meter face reading from the data, if it is given an initial starting reading when the data collection hardware is commissioned.

3.2.1.3 Electricity meters

Analogue electric meters are still widespread. They are very robust and easily read. The disadvantage is that these meters are not suitable for remote-metering. For this reason these meters have to be replaced with digital, pulse output, meters.

Digital meters do vary in terms of their structures, i.e. impulse frequencies (sampling interval). Hence a calculating algorithm in the meter, data-logger or via software is required to convert to values.

3.2.1.4 Natural-gas meters

Analogue natural gas meters include the bellows-type gas flow meter. These operate by periodically filling four chambers with gas and the content then being registered. Calibrated mechanical meters are also used. These require recalibration at intervals of a few years. Gas meters for higher pressure are similar to the function of water meters. The pressurized gas runs a turbine, which registers the revolutions in the meter. These types of natural gas meters have to be equipped with a pulse generator to allow the automatic readout of the meter data. Impulses per m^3 natural gas can differ in different meters. For this reason, the values have to be determined via a calculating-algorithm. Furthermore the natural gas calorific value in different countries is also different, because the natural gas comes from different sources. In addition the energy content per volume of the used gas also depends on the atmospheric pressure, a function of the height above sea level of the observed objects. This should also be taken into account at the conversion of the energy demand into kWh.

The use of digital meters for natural gas measurement is not yet widely spread, although there are a number of different approaches that can be used.

3.2.1.5 Heat meters

Within heat meters the litres of warm water are counted via impulses (e.g. 12 or 6 pulses per litre). In combination with the temperature difference, the heat flow volume is determined. All types of meters require an energy supply, generally battery based, for this reason periodic services (including changing the batteries) and calibrations are essential. Nowadays there are two widespread systems: heat meters with a mechanical wheel and ultrasonic meters.

Heat meters with a mechanic wheel operate because the wheel is based on an impeller. The amount of water, which flows through, operates an impeller. Its revolution speed is sampled.

Metering/counting of the heat flow volume using ultrasonic heat meters occurs through the determination of the flow rate via the delay of sound waves.

3.2.1.6 Water meters

There are three widespread systems: water meters with a mechanical wheel, ultrasonic-meters and induction meters.

For meters with a mechanical wheel, Figure 3, the water enters the meter through the lower openings which are situated on the impeller, operates the impeller and leaves the enclosure through the upper openings. Optional in such mechanical meters are built in reed-impulse-generators, which emit defined consumption-impulses. Recalibration is necessary at given intervals.

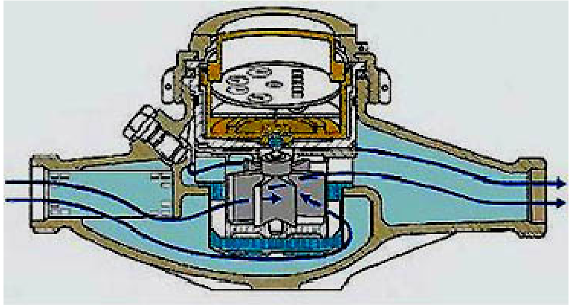


Figure 3: Water meter with a mechanical wheel

Ultrasonic meters work in the same way as ultrasonic heat flow volume meters.

Induction meters count the water flow via electromagnetic-induction. This kind of meter is maintenance-free as there are no mechanical parts used for the metering.

3.2.2 Data collection

3.2.2.1 Data loggers

A data logger commonly used to collect data. A data logger is basically an electronic instrument that records measurements (temperature, relative humidity, light intensity, on/off, open/closed, voltage, pressure, pulses and events) over time. Typically, data loggers are small, need energy and are if not connected to the mains powered by battery or solar-powered. The device is equipped with a microprocessor, data storage (and often with a sensor). Often other sensors can be connected with a data logger. Most data loggers utilise turn-key software on a personal computer to initiate the logger and view the collected data.

First the data logger must be initiated. The collected data are stored in a non volatile memory and read out in certain intervals. The data can be sent to a computer or called by request from the computer (by a remote procedure call). Data shuttle is a system which uses a hand held device for data download from the logger.

3.2.2.2 Data collection via BEMS

Some sites have Building Energy Management System (BEMS), whose main purpose is control of the building services plant, to which meters are already connected. This was the earliest method of automatic meter reading that was attempted on a wide scale, but because BEMS are often not designed for long term continuous monitoring this method cannot be relied on to yield good quality data. However, where meters are connected to a BEMS it does mean that pulse outputs have already been obtained from the meters and therefore reduces the cost of installing a dedicated AMR (automatic remote monitoring) system. Although care must be taken to ensure that the data formats and data transmission systems are compatible.

3.3 Communication (Data Transmission)

This section briefly describes the main components and systems of the data communication system. Appendix 3 provides an overview of the structure of the data flow in the Intelligent Metering Project in detail, supplying an analysis of a specific system layout and further developing some of these issues.

3.3.1 Types of data transmissions

Data transmission via impulse-signals (or pulsed output) is straightforward and is the standard offered by remote-read-out meters/counters. The impulses are transmitted from the meter to the data-logger, where they are converted in meter readings via a calculating-algorithm. The counter-pulses are binary signals (0,1). The pulse can be generated via a switch (mechanical), light-barrier (optical), or via approximation induction (electrical). The length of the data-transmission-line is 1.5m at maximum. If bigger distances have to be overcome, repeaters have to be integrated.

Data transmission can also be carried out by a system known as S O signal input. An S O signal-input is a potential-free contact. The signal-voltage is provided from the external data-logger. The timing is initiated via the meter and the clocked signal is processed in the data-logger. The line lengths are limited to about 100 m.

Data transmission via M-Bus (Meter Bus) uses a system in which there no longer impulses, but counted measurands are used. The meters/counters convert impulse-values into counted measurands, and transmit them to the data-logger. Up to 250 end devices can be attached to each channel. The maximum line lengths depend on the supplier and can be from 100m to 400m. Requirements are counters with an M – Bus output.

3.3.2 Physical data transmission

As discussed previously there are a number of steps which can utilise different approaches for getting data from a meter and using it for analysis. For intelligent metering systems the first step is to move the data and collect it, the data transmission. Primarily the data transmission will be carried out via hard wired cabled systems or low power radio, this is dependent on the services already available within the building, BEMS, etc.; and the site layout, i.e. proximity of the meters to the initial data collection point.

Data transmission via hard wired (copper) cables is probably the most common approach. There are some key points to take into account if using this system. It is essential to ensure that there is no interference, which could affect the signals, present (induction-voltages, electrostatic fields, etc.). This is avoided by shielding the cables and laying data-cables separately. A further problem is the limited cable-lengths which can differ according to the transmission method and the dimensioning of the cables. This system requires sophisticated wiring-techniques, but usually at a lower cost.

3.3.3 Data transmission via radio:

These systems are spread widely and offer a cost-saving alternative to the data transmission via wiring. This system consists of a transmitter and a receiver. These devices are operated via solar or via batteries. The transmission is carried out via radio waves, the range is around 1.5km to 15km. Due to this flexibility these systems can be used in specific buildings as well as in bigger building-complexes.

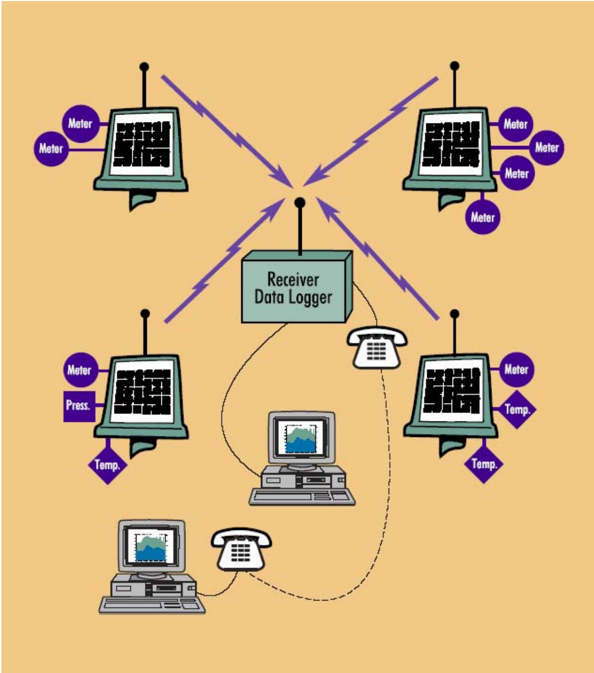


Figure 4: Example of solar powered data transmission to receiver/data logger. Data is then communicated with the analysis computer via a modem link

3.4 Data management (storage)

As discussed previously a data-logger usually collects and saves the data. This will include the metered data but also other parameters, i.e. temperature, pressure, etc. Thence the data is forwarded to a database or other storage facility for analysis. Figure 5 illustrates the Intelligent Metering Project as an example of data flows (further information on the Intelligent Metering Project and data flows is available in Appendix 3) and the possible modes for the movement of data to a management site are discussed below.

3.4.1 Direct serial port connection to a PC

This method of communication may be used where a site such as a school wants to collect and analyse their own data. It may be an available option as part of a building management system. It is not suitable when multiple buildings/sites are involved.

3.4.2 Land line telephone modem

There are two different subdivisions of this system: analogue line or ISDN-line. The first one is slower, the second more expensive. By calling a local number of a company telephone network and forward it in this company phone network, larger distances can be managed at a cheaper price. This is a common system used within a single region/country. However, for a European wide project such as the Intelligent Metering Project, or even a sometimes a countrywide one, the high cost of calls would make it extremely expensive to operate. There may also be a problem finding a dedicated phone line on some sites.

3.4.3 TCP/IP over Internet or local authority intranet

This has the advantage that distance is no object and there are no call charges. However, it may be difficult dealing with I.T. departments, particularly when access from outside the local authority's intranet is required. Once communication is established, it is often later disrupted by the continual "chopping and changing" by the IT department as it struggles to cope with the constantly changing requirements of the sites that make up a local authority estate. The main aspects for a successful data communication are to know the operating systems, the open ports and IP-addresses defined in the firewalls.

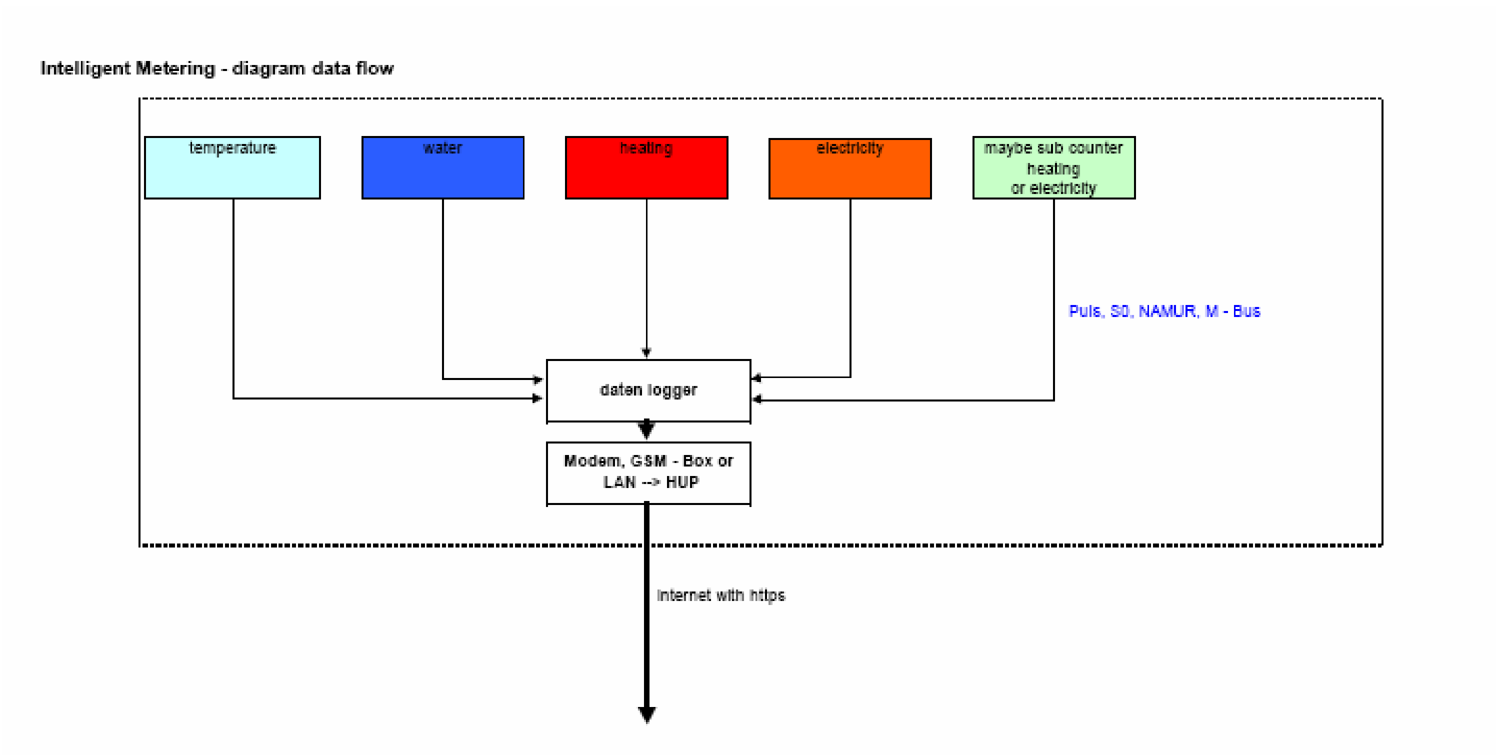


Figure 5: The Intelligent Metering Project approach to data flow

3.4.4 GSM (**G**lobal **S**ystem for **M**obile Communications)

This is the most expensive option but has the advantage that it is totally independent of any other network on site. A dedicated GSM module would be installed with a SIM card on an "incoming data calls only" tariff, and a PC equipped with either a land line modem or a standard mobile phone could be used to dial it up.

3.5 Costs

The cost of meters is very variable but as a general guideline:

- Electricity meters – may be as much as €135/channel plus the high level of administration that may be required to liaise with the utility company;
- Gas meters - usually cost between €150 (isolating relay cost) and €570;
- Water meters - €120 (pulse output module)

Data loggers are much cheaper than new building management systems. The costs of data logger may range from €100, - to €1,000, - and data loggers can be placed in areas that permanent digital systems (normally a wired system) cannot reach, e.g. the data-bird/data-chick system, with radio transmission of the data, from Energy Metering Technology. The wiring or radio transmission unit costs must be factored in. The costs for a new BEMS (building energy management system) may be €20,000, or more.

Step 6: Select the monitoring system which will include hardware, for metering, for data transmission and data flows/storage, potentially part of a complete package.

4 Data Analysis

As noted previously the choice of software/approach to data analysis is critical to a successful project. The analysis software may be considered the most important part of an intelligent metering and monitoring system, since it is the eyes and brain on the data that provides the user with useful results to help achieve energy savings.

It should be remembered that the demand for monitoring may originate from differing groups with different motivations and approaches. For example, primary reasons often include load management, to control the energy demand peaks; building management in general and from the economic or accounting viewpoint. An intelligent metering and monitoring system and its supporting data analysis tools should try to support all of these differing needs.

4.1 Defining the approach/Energy accounting systems

Figure 6 illustrates the components of a typical intelligent metering and monitoring system and clearly indicates that there is more to the system than defining the inputs and outputs and installing meters to collect the data. This data must also be collated and manipulated. An intelligent monitoring system communicates this data to a data server. The software evaluates the data in a preset routine. The assessment of the issues involved can then be made.

The assessment is usually based on energy accounting described below. All types of energy accounting have three common steps:

1. Read the counter;
2. Transport the information/data;
3. Analyse the data.

There are two very basic methods by which the meter readings are taken manually. A supervisor interpretation will be needed to explain diagrams in the simplest way. Someone should write down the counter reading to collect the information. From time to time the consumption would be calculated. The costs related are the working hours of the person. This approach is not sophisticated and data can easily be missed, an i.e. school during holidays, but assessment is simple and it can be carried out at any level.

A spreadsheet calculation program is again a method by which meter readings are taken manually but with the data entered into a spreadsheet program. Software costs are low and more complex assessment can be carried out, but time must be spent setting-up calculation procedures initially. There is no fixed structure; the quality depends on the programmer, although there are some basic spreadsheet based programmes available for this approach, at very low cost.

The more software based choices in terms of the energy accounting approach are described in the following sections.

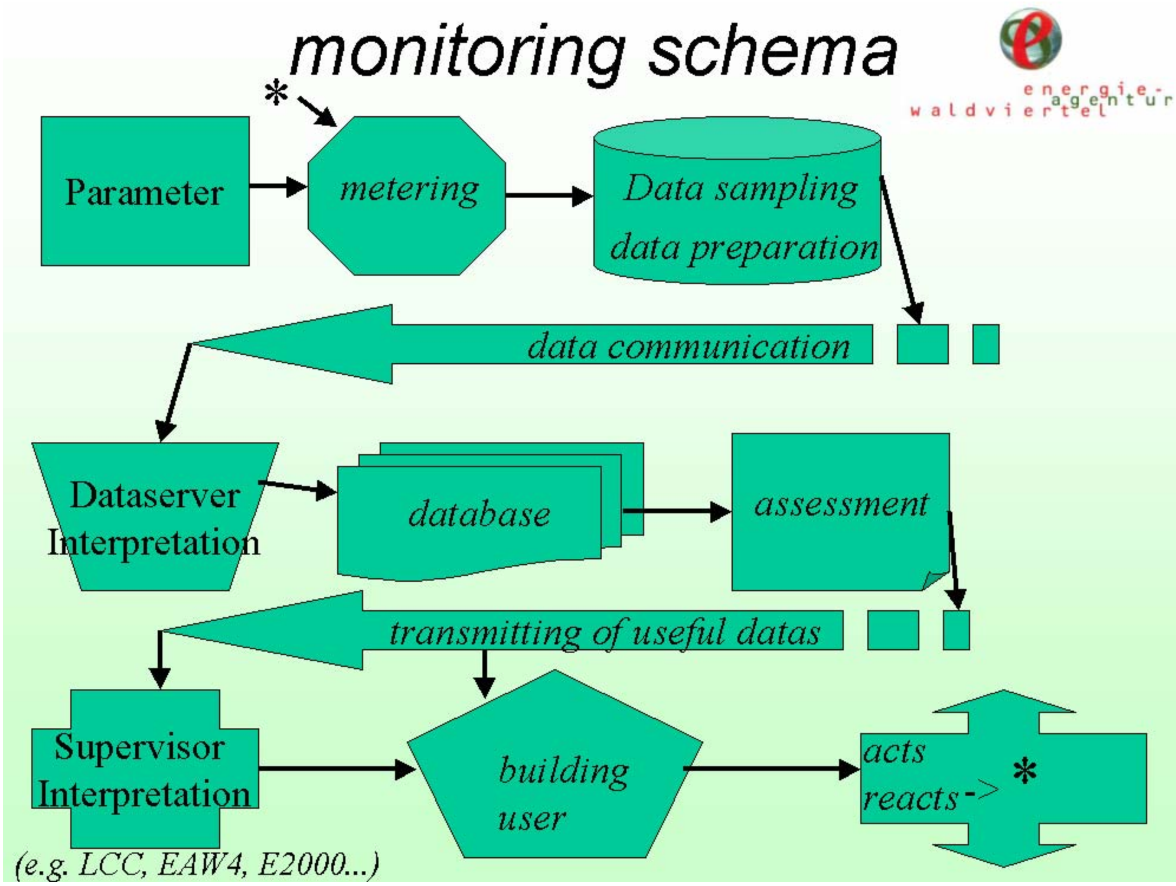


Figure 6: The components for monitoring

4.1.1 Stand-alone energy accounting programs/software

This uses a similar approach to spread-sheet calculation programs although there are two basic differences: meters can still be read manually although some programs allow for remote data transmission and the software programs are more complex than those used in spread-sheet based systems (although there is still a wide range of level of complexity within this sector with simple programs intended for the non experienced user and complex programs for skilled professionals).

4.1.2 Networking

Here a WAN (wide area network) provides all users with access to the energy accounting system. The users log in at the server, where the database for all users/clients is situated. This brings advantages. The data of different buildings or other plant/objects at different locations can be compared easily; they all have the same data structure. Benchmarking is possible and usually made only by a system administrator, so the assessments in benchmarked form can be anonymous and based on the same criteria. Support and central updates provides more help to the user/client. Data input can be done manually at different places at user/client computers, and remote data transmission is often possible too.

4.1.2.1 Client's own energy accounting software

If the user/client also has the energy accounting software on their computer it may be called an Intranet-Energy-accounting system. The data can be transmitted by phone line (expensive) using analogue or by ISDN (Integrated Services Digital Network), but it is also possible to use the internet as a transport media. The energy agency Waldviertel, in Austria, uses a system based on this approach for 70 users/clients, see Figure 7.

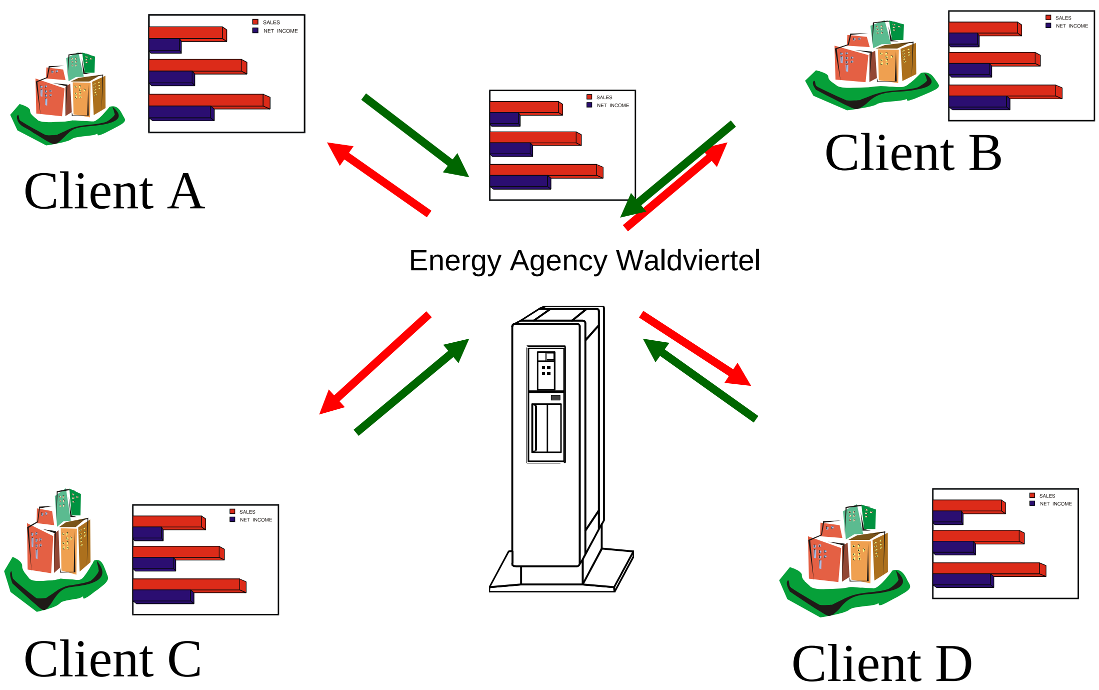


Figure 7: Schematic illustrating one of the energy accounting systems used by energy agency, Waldviertel, in Austria

4.1.2.2 Energy accounting by application service provision (ASP)/server based

The state of the art is to use the Internet for the energy accounting process. The software is installed at the server, but the users simply login, with password, via a special website on the internet. This is called Internet-energy-accounting. In this case the user/client does not need his own software programme but uses the standard software browser of his personal computer. The administration may be sold as a service. One such system as used by the energy agency Waldviertel is named emc, from Siemens.

4.1.2.3 Energy accounting by application service provision (ASP)/server based including automated data input from remote sensors

The final step to fully automate the energy accounting process is to send the counter/meter reading automatically. This also allows shorter data reading intervals. The software automatically analyses this short interval data (short interval is usually defined between daily to every 15 minutes) and compares it to standard usage. Feedback is only provided if there is a variation/problem detected. Figure 8 illustrates a system that uses this approach.

The Intelligent Metering project used this approach. A shorter data interval, 30 minutes, was utilised to more easily recognise deviations from normal operating conditions.

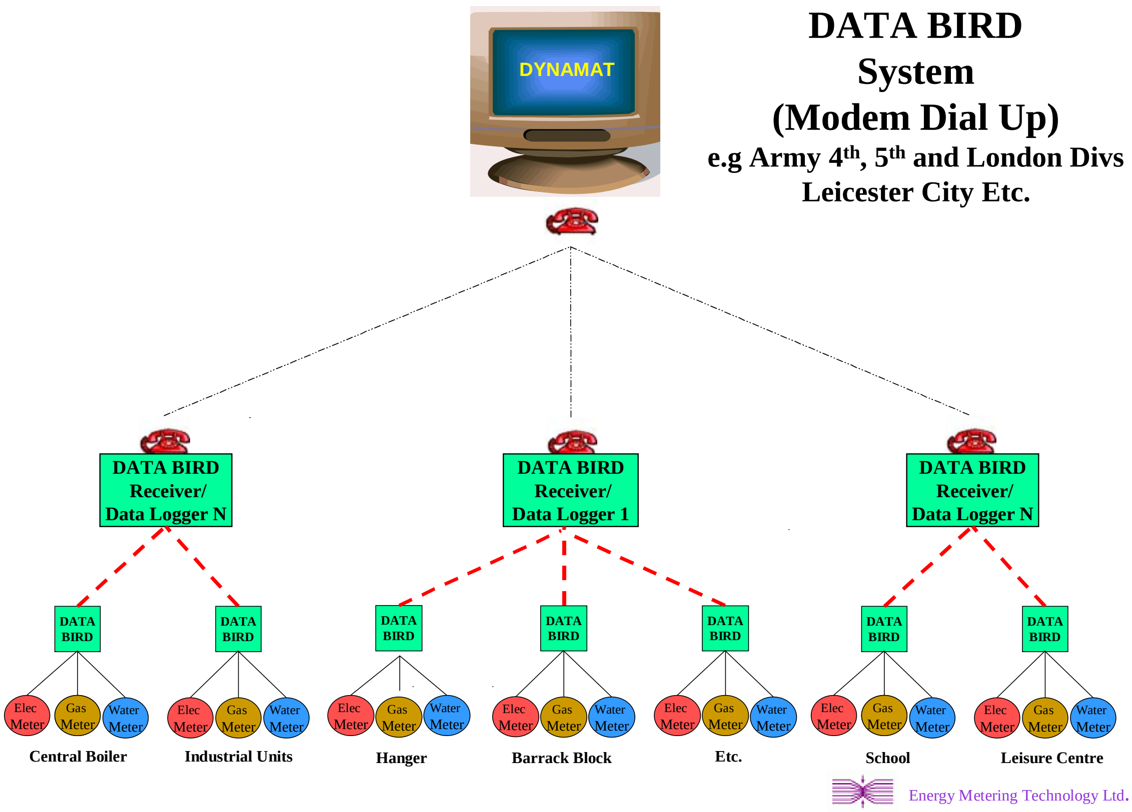


Figure 8: Fully automated energy accounting system as used by Leicester City Council. Data transmission is by radio signal.

4.1.3 Summary

Choosing the right analysis approach/software for the needs of the project is one of the main aspects of a successful approach to monitoring (also of critical importance when utilising software is its user friendliness and support), Figure 9.

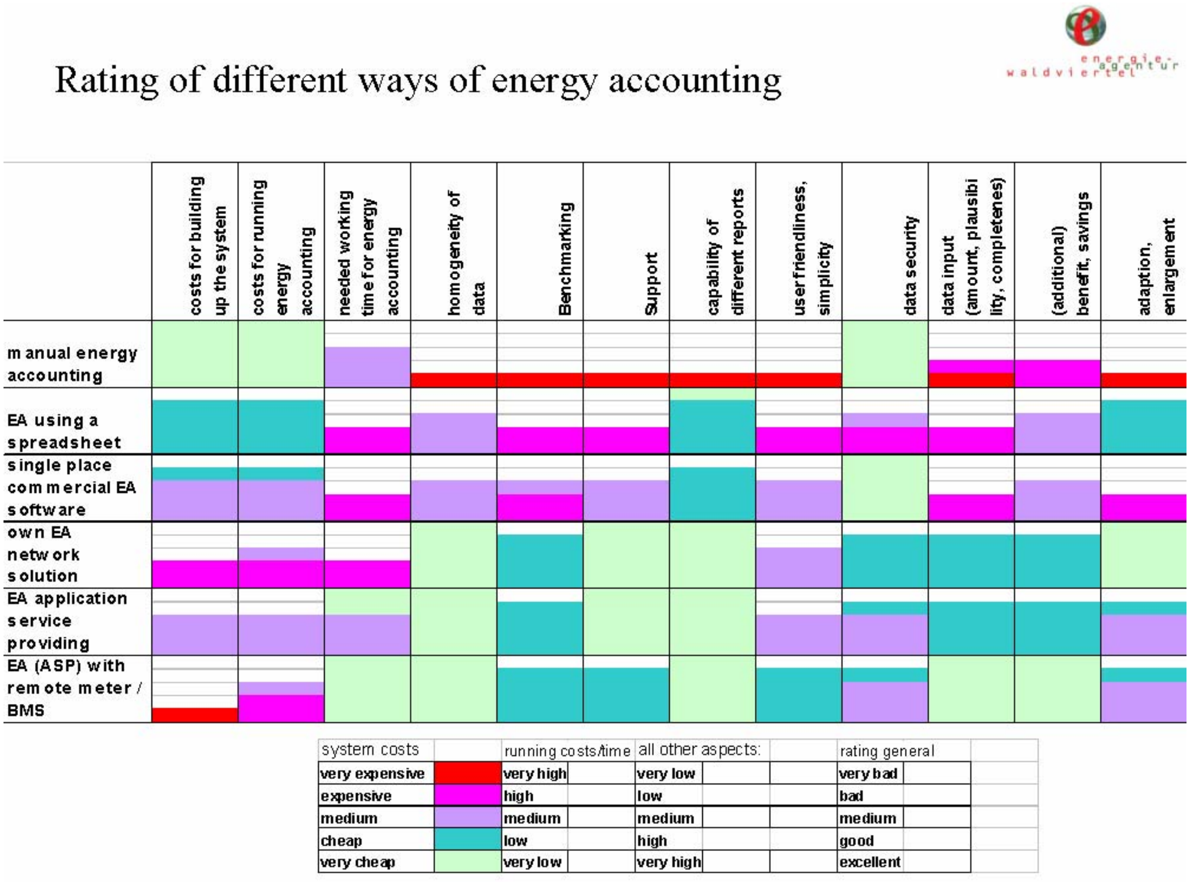


Figure 9: Review of different approaches/energy accounting systems

Step 7: Choose the energy accounting approach to be utilised.

4.2 Defining the analysis

The first step is to define the analysis requirements in general; this may be partly completed within the assessment of the monitoring objectives, for instance:

- A single monitoring scope like heating, electricity or water for the buildings/object/site;
- The whole energy for the buildings/object/site, (usually heating plus electricity);
- A single meter/counter, which gives detailed information, especially if the consumption is abnormal;
- A combination of some counters, which maybe correspond to a sub area of an object.

Then the detail of the analysis output is required. Some important analysis considerations are illustrated in the following sections.

4.2.1 Time frames

A consideration of the possible timeframes is required, i.e. the last 24 hours or the last 3 years? Time period can be chosen freely or may be fixed within a programme. The consumption usually has significant repeating curves, e.g. a day-line, a week-line or a year-line. A number of repetitions of these time-unit-lines are recommended to give good information for interpretation.

4.2.2 Consumption

Considering the consumption, usually energy (in kWh or MWh) or water (in m³), in detail is key. This information in time is compared with other older time units and alarm limits can be set, defining abnormal consumption. A graph can also give additional information, e.g. water consumption when not needed should be "zero" or at least a minimum, when some functions in the building need this source continuously. Figure 10 illustrates an example of an evaluation from the Dynamat software. It shows the repetition of the day line, target consumption and +/- alarm limits connected. An abnormal additional consumption starting one day before the weekend and lasting 4 days can be seen.

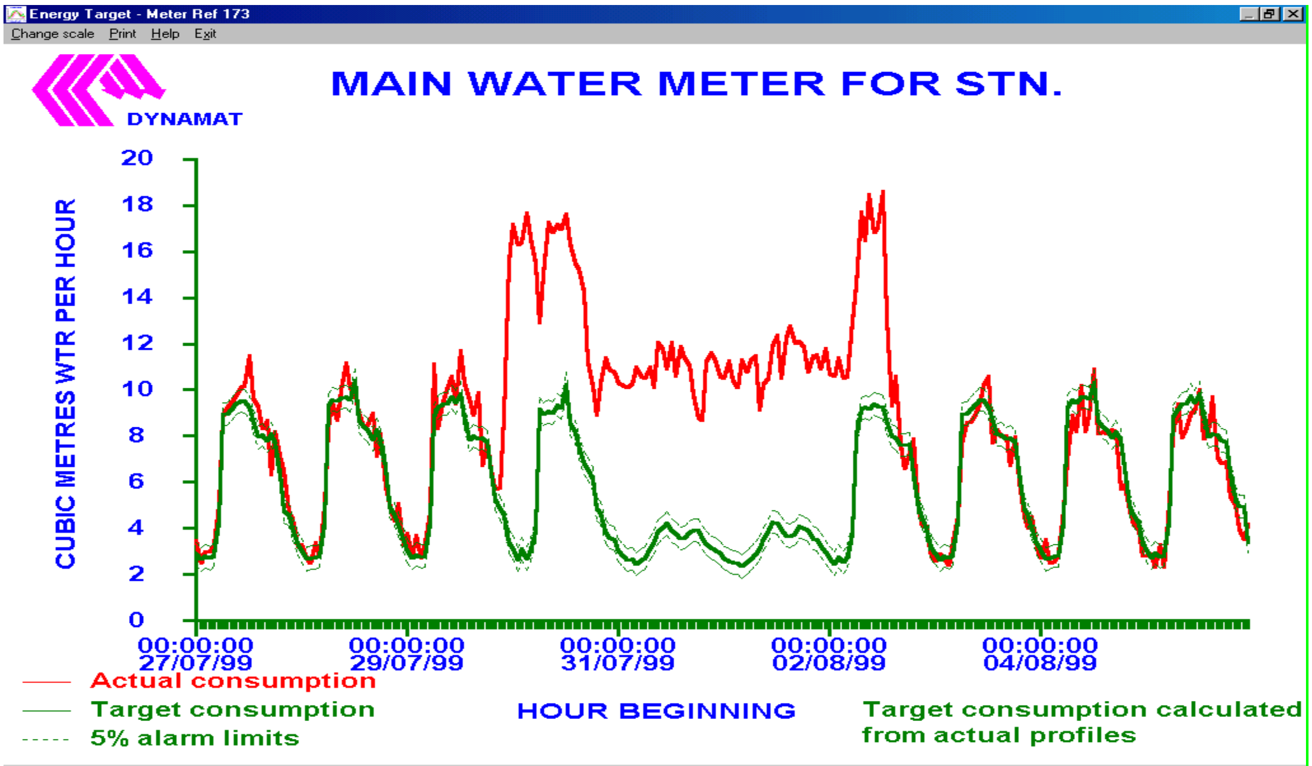


Figure 10: Example of an evaluation from the Dynamat software.

The actual consumption can be compared with the previous years, or across other time units, or with the mean over the previous year. Different seasons can be compared or season with non season, school time or working time with holidays. Holidays or shut down periods can provide information on the potential for energy savings, by showing unnecessary consumption.

4.2.3 Benchmarking

Benchmarking can be used to compare different energy consumption figures across a whole range of different objects, i.e. from boilers to buildings, etc.

In order to commence the process of benchmarking there are a number of definitions to make. These include, for buildings:

Category of usage: e.g.

- Administration and office buildings
- Nursing homes

- Schools
- Kindergarten
- Indoor swimming pool

This list is a small extract of some categories. It may also be useful to divide the categories into sub-categories, i.e. primary school, extended primary school and secondary school. If a building has different categories of usage it can be useful to have a separate metering instrument for each of these sub areas.

Key figures:

The key figures describe the objects. A consideration of the ratio of energy consumption per key figure then allows comparison with other objects of the same category. This will provide information on the relative efficiency of an object. Key figures - for benchmarks include:
- m^2 heated area inclusive walls (gross)
- m^2 heated area exclusive walls (net)
- m^3 heated volume
- load of units in kW
- persons using the object
- hours the persons using the object per month, week or day

Different countries or even groups often use different key figures as standard, i.e. Germany net square meters is used and Austria gross square meters, also the consideration of additional, non-heated spaces may be different.

Benchmarking is often carried out by an administrator, who will provide the results anonymously for data security reasons. Benchmarking also provides information about user behaviour, building quality and condition of the technical plant by comparing different key figures.

4.2.4 Costs

Costs can be linked with the consumption and evaluated.

4.3 Energy performance analysis software

Many different software analysis packages are available and this is a dynamic market with changes occurring frequently. The choice of a suitable system will need to consider the parameters and outputs that are required. Appendix 4 presents a table of characteristics that might be needed for inclusion in such software. This may help to review project needs and to choose the most suitable product.

In addition it is always worth checking the source and age of the background data, conversion figures for pollutants, billing calculations, etc. used within such programmes to ensure a suitable match for the intended use.

Finally try to talk to other users about their experiences, problems and support.

Step 8: Select the software, through a consideration of the parameters and the analysis output needs.

4.4 Summary

The main aspects of a successful approach to intelligent metering and monitoring and to energy accounting are:

- Choosing the right analysis approach/software for the needs of the project (also of critical important are software user friendliness and support);
- Calculating and allowing for staff time, this is one of the most important and under rated factors;
- Communicating the results to the right people.

5 Monitoring, Data and Outputs Management

Managing the monitoring programme, the data and reviewing the outputs may be the responsibility of an outside agency but it can still directly involve a large number of people. There are different people involved in the intelligent metering and monitoring of any building or plant, and in the different forms of energy accounting. To all of these people the intelligent metering system will often be required to provide different information, depending on their needs. For this reason these people also interact with the management of the system in different ways.

5.1 Responsibilities

The building owner will only be interested in particular questions. The building owner will look at the data only in long and unsteady intervals and potentially uses the system for controlling, e.g., annual energy use and costs. The building owner may be a regional government, the municipal administration or the representatives of them.

There will also be, in larger structures, the administration department/group responsible for the consumption of energy and/or water, and especially in relation to cost. This group will usually consider the data in detail and at regular intervals, although they may not be based within the building itself (e.g. at Leicester City Council the Energy Management Team monitor the data, identify alarms from the analysis software, and report to a contact in the building, such as the Premises Officer), and they may even be located in a different town or region.

The premises officer/caretaker is directly responsible for the care of the building and can be the contact within the building who responds to immediate problems and issues as they arise. It would be suggested that this person(s) should also be involved in reviewing the data at regular intervals to consider the figures and any abnormalities. This person can also respond to activities of the building users and be involved in their training.

The building occupants live or work inside the monitored buildings. They will often have the opportunity to look at the consumption figures (probably at irregular intervals) but will do so only if they are interested enough. This is usually the large group who affect the building's energy consumption the most and should therefore be trained to consider energy efficiency. It is especially important after training to provide feedback to indicate the effect of their actions.

Within the Intelligent Monitoring Project the figures could be accessed over the internet and the occupants were made aware of this during training sessions to allow them to view the information if required.

These are also energy agencies or similar groups who may be involved with the data from a particular building or group of buildings/sites. They will require access to the data if they are tasked to help control the building's consumption and support investigations into abnormalities. They may also be involved with training and also evaluating the whole intelligent metering and monitoring approach and measuring its success.

It is important that all of the groups work together in order for the project to be most effective.

Step 9: Consider the roles and responsibilities of all of the groups involved with the project. Ensure that any system meets their needs in terms of information/data supply.

Figure 11 illustrates the information flow and participants involved in intelligent metering and monitoring of a building. Blue lines indicate a flow of metered data; black lines are the results of actual energy consumption seen; red lines indicate a potential alarm alert; fine black line shows potential communication between groups to assess abnormal consumption figures.

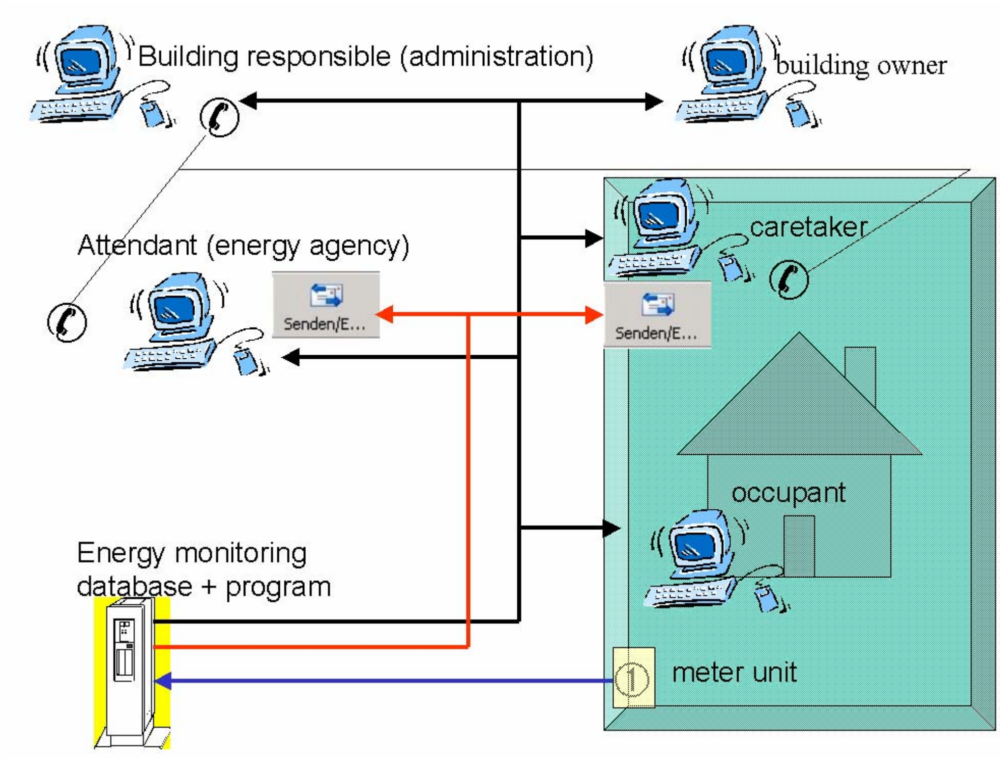


Figure 11: Information flow and participants involved in intelligent metering and monitoring of a building

5.2 Procedures

The aim of any intelligent metering and monitoring project will be to reduce consumption, and hence usually costs. To achieve this there are three strands to consider:

1. Irregular events of abnormal consumption;
2. A high base load at inappropriate times, e.g. when the building is empty during holidays for a school; or at weekends or overnight when not needed
3. High regular peaks at the same time of the day or week.

With regard to abnormal consumption events systems can be installed to trigger an alarm and give notification to the appropriate person/people, who then will investigate the problem, which may be due to a technical malfunction (within the item monitored or occasionally within the monitoring unit itself), poor behaviour in energy use or other issues.

The other items will require detailed initial review and after a period of time to assess any problems once changes, including training, have been implemented.

Step 10: Ensure that procedural responsibility is defined (who deals with issues flagged).

6 Training package

Very wide and varied options exist for approaches to training. This section will focus on the approach, including the background to the choice of approach, and the results of that approach, as used in the Intelligent Metering Project.

The purpose of any training should be related to the initial objective(s), i.e. in the case of intelligent metering and monitoring the reasons for monitoring. For this reason the training objective for the Intelligent Metering Project was to train building occupants in energy and water saving through behavioural change and to encourage and allow the building occupants to relate to the data being provided to support this behavioural change. The outcome was to have trained building occupants and resultant energy savings.

6.1 Training techniques

Research has indicated that setting specific targets, i.e. energy and water use reduction, within a wider context, i.e. with a more general approach to energy efficiency and across the structure of the organisation, provides more powerful and effective training. A broad approach is more likely to have an impact on developing change.

For this reason with the Intelligent Metering and Monitoring Project a broad approach to changing behaviour was adopted. Research also confirmed that within the broad approach one method would not be sufficient. A number of different methods are better and were therefore used within the project. A training pack was therefore produced to give comprehensive advice on the complex factors involved in changing the behaviour of individuals and groups with regard to energy and water. However the overarching philosophy was that by taking a broad approach and engaging groups to consider wider issues such as quality of life and sustainability the training was more likely to be successful.

6.1.1 The Model

The main aim of the training package produced under the Intelligent Metering Project was to provide support so that building users could change their usage patterns in order to save energy and water.

A broad approach to changing behaviour was adopted and this section summaries the theories that underpin the training. This includes a consideration of the drivers that can help citizens act more sustainably.

Appendix 5 indicates the known factors that impact upon the sustainability of an individual's behaviour and actions. The drivers are divided into three categories.

- **Enabling** - this is the range of techniques and factors where the intervener provides alternatives to existing unsustainable actions and behaviours.
- **Engaging** - these are the tools available to communicate with and engage in the sustainable development process.
- **Incentivising** - in this case they are municipal authority interventions, for example rewards for reducing energy and water use.

To ensure that these drivers translate into real change the following also needs to happen:

- **Catalysing** - this is where combinations of the three drivers are brought together with one key element that stimulates mainstream change in actions and behaviour.

6.1.2 Factor 1: Enabling

These are the steps that a project should put in place to encourage and allow the changes required to take place. In the case of the Intelligent Metering Project this would be promoting building users to act more sustainably and hence reduce the consumption of water and fossil fuels. Steps could include:

- Removing barriers - Much unsustainable behaviour is justified by the absence of easily accessible alternatives. Convenience and ease of use are key factors. Those responsible for managing the energy and water use in the building need to ensure that good house keeping measures are put into place. For example a barrier could be the unclear labelling of multiple light switch points making it hard for building users to identify their local lighting point.
- Information giving - accepting that information giving has a role to play, but with an analysis of how it works will make any information supplied have a bigger impact. Learning from the theories of 'social marketing' to understand how to influence behaviour towards 'social goals' (i.e. getting them to use water and energy more efficiently) is the approach used. The programme was consumer orientated; asking what was needed to be understood about the target audience. It ensured that an exchange developed, i.e. through incentives and a supportive climate. It also aimed to take the long term approach, with mechanisms to check results, to recognise and reach the different target groups, to involve consumers and to "beat the competition", in this case, inertia.
- Educating, training and providing skills capacity – for the Intelligent Metering project work it was recognized that training and providing capacity to adults has proven to be one of the real success stories in changing attitudes towards sustainability. One such approach, the WWF (World Wildlife Fund) Pathways project (available at http://www.wwflearning.org.uk), was adapted for adult building users. Essentially this is a training package that helps individuals and groups look at what we actually mean by sustainable behaviour.

- Staff development - encouraging the involvement of any human resources department should be very beneficial. Their remit after all is to create a motivated workforce.

6.1.3 Factor 2: Engaging

Typically these are actions of groups or individuals that promote citizens to act in the required manner, in this case more sustainably. For any project to be successful in changing behaviour it needs to be addressed from the start. This includes activities:

- Involving building users in other projects on the key theme, i.e. 'sustainability', can have a big impact on engaging stakeholders in the project. In the UK, Global Action Plan and Environment Champions are examples that provide mechanisms to engage building users in sustainable projects.
- Community action involving the local community, of which stakeholders may be a part, can help.
- Co-production - this is where stakeholders, i.e. building users, are not mere consumers of, or responders to, interventions /programmes but are intimately involved in the process of their development. Schools that involve pupils in a meaningful way in sustainability plans have shown that this also motivates their pupils in many other aspects of school life.
- Personal contacts - individuals will listen to those in positions of power and credibility when they communicate a message of power outside their area. Lunchtime events have been used successfully in a number of organisations. Informal dialogue with other professionals who all profess to the same agenda has been shown to be effective.

6.1.4 Factor 3: Incentivising

The provision of incentives can be made through:

- Rewards, i.e. for the Intelligent Metering Project there was rapid feedback when intervention strategies were implemented and progress was gratifying for building users.
- Recognition and social pressure – this might involve use of a staff newsletter/journal and involvement of staff in support activities.

6.1.5 Factor 4: Catalysing

This is the key driver that makes behaviour change happen on a large scale. The research on this is very limited. It appears that it is the ethical and moral reasons that have underpinned, for instance, the change from recycling being a peripheral to a mainstream activity.

Awareness of the key drivers that catalyse large scale changes can inform the actions that we take. If ethics and moral considerations are likely to have an impact on the stakeholders then we should use appropriate information in our posters and literature.

6.1.6 Training techniques summary

In preparing the training package, it was considered:

- Single interventions to support building users to change their behaviour are unlikely to be successful. A programme of measures needs to be put into place.
- Information alone e.g. a poster campaign, is unlikely to support municipal staff in actively changing their behaviour.
- Persistence is fundamental. Unsustainable actions will be deep rooted and it will take a long time to change these.

- Any project will lose its impact if it does not have anything to ‘exchange’ with the building user.
- In schools the teacher will become engaged with the project if improved energy efficiency improves the learning environment and thereby the attainment of the pupils.
- In buildings in general the office worker who cares about global issues will become engaged with the project when links are made with climate change and, for instance, the impact on low lying coastal states.

Step 11: Consider the proven training techniques which will provide the most impact for the monitoring objectives and required outcomes.

Further detailed information on the training used (strategy and actions) within the Intelligent Metering Project can be found in Appendix 5.

6.2 Analysis of training actions

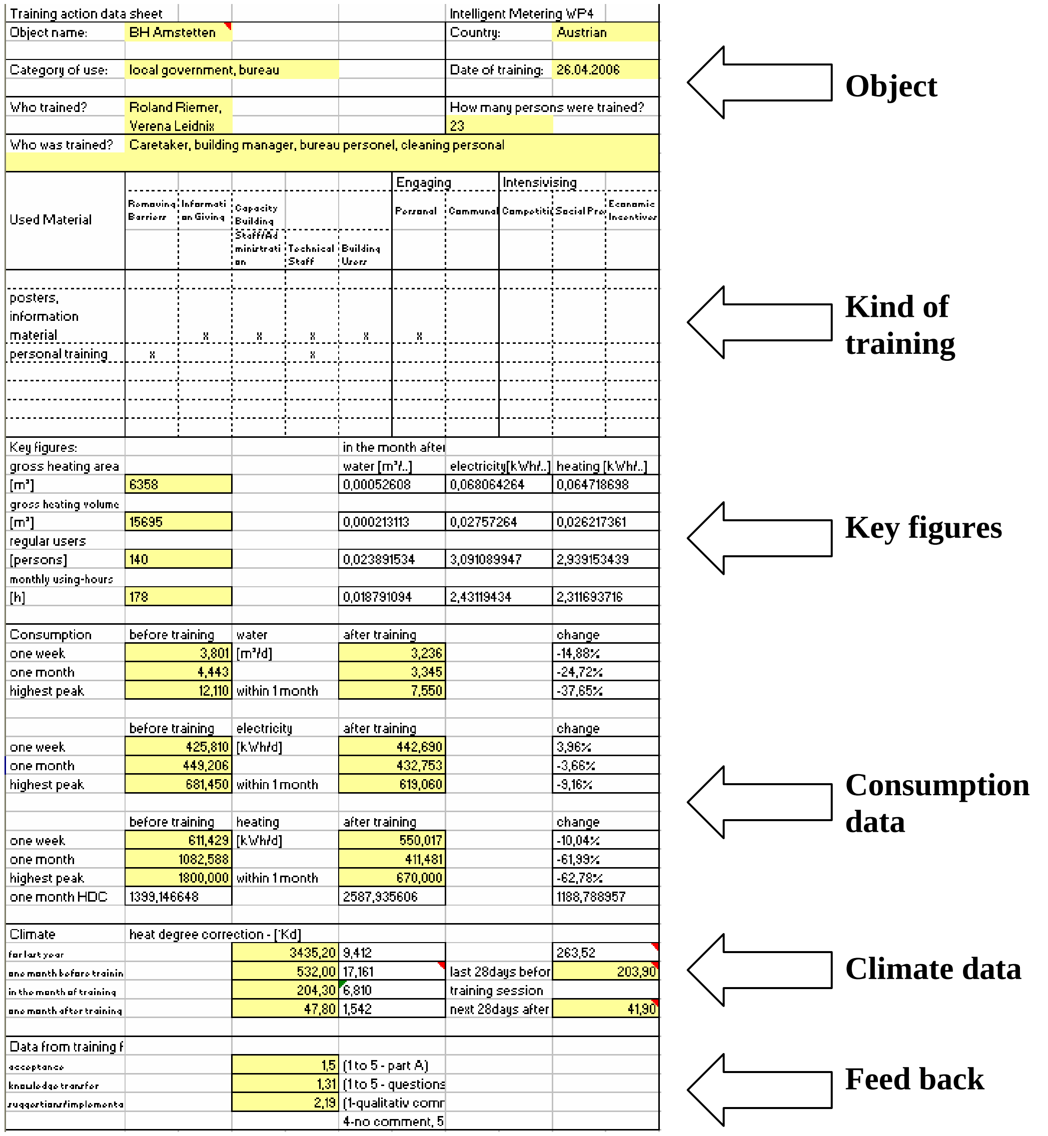
To collect data for training analysis actions, training-action-data-sheets (TADS) have been produced. Details of training actions have been recorded into the TADS. In the following figure the TADS used in this project is shown as an example.

In the “**Object**” part we collected data from the object and the training. Very important for the analyses was the date of training and the number of people trained. Also important was the category of use of the building and which persons were trained.

“**Kind of training**” gives information about the activities. The activities are in three main-groups and are divided into different actions. The main groups are:

enabling
engaging
incentivising

“**Key figures**” contains the consumption divided by area, volume, persons and using hours. Key figures make objects with the same category of use comparable. Different partners start their savings on different levels. Key figures can help to identify those levels. It is necessary to be aware that some consumptions and therefore key figures too are dependent on climate.



Training action data sheet				Intelligent Metering WP4	
Object name:	BH Amstetten			Country:	Austrian
Category of use:	local government, bureau			Date of training:	26.04.2006
Who trained?	Roland Riemer, Verena Leidnix			How many persons were trained?	23
Who was trained?	Caretaker, building manager, bureau personel, cleaning personal				

Used Material	Removing Barriers	Information Giving	Capacity Building Staff/Administration	Capacity Building Technical Staff	Capacity Building Building Users	Engaging Personal	Engaging Communal	Intensivising Competiti	Intensivising Social Pro	Economic Incentives
posters, information material		x	x	x	x	x				
personal training	x			x						

Key figures:			in the month after		
			water [m³/..]	electricity[kWh/..]	heating [kWh/..]
gross heating area [m²]	6358		0,00052608	0,068064264	0,064718698
gross heating volume [m³]	15695		0,000213113	0,02757264	0,026217361
regular users [persons]	140		0,023891534	3,091089947	2,939153439
monthly using-hours [h]	178		0,018791094	2,43119434	2,311693716

Consumption	before training	water	after training		change
one week	3,801	[m³/d]	3,236		-14,88%
one month	4,443		3,345		-24,72%
highest peak	12,110	within 1 month	7,550		-37,65%
	before training	electricity	after training		change
one week	425,810	[kWh/d]	442,690		3,96%
one month	449,206		432,753		-3,66%
highest peak	681,450	within 1 month	619,060		-9,16%
	before training	heating	after training		change
one week	611,429	[kWh/d]	550,017		-10,04%
one month	1082,588		411,481		-61,99%
highest peak	1800,000	within 1 month	670,000		-62,78%
one month HDC	1399,146648		2587,935606		1188,788957

Climate	heat degree correction - [°Kd]				
for last year		3435,20	9,412		263,52
one month before trainin		532,00	17,161	last 28days befor	203,90
in the month of training		204,30	6,810	training session	
one month after training		47,80	1,542	next 28days after	41,90

Data from training f			
acceptance		1,5	(1 to 5 - part A)
knowledge transfer		1,31	(1 to 5 - questions
suggestions/implementa		2,19	(1-qualitativ comr
			4-no comment, 5

Figure 12: Example of a TADS

“**Consumption data**” is the block with the most important data. In this block are the consumption data weekly (7 days), monthly (28 days) and the highest peak value listed up.
A week is the shortest time unit to look at, because normally the consumption is different every weekday. To look at short term effects you have to sum up the consumption values from Monday to Sunday. For the monthly consumption we took 28 days because of the different weekday-consumption and the different month-length. The highest peak is an indicator for unusual consumption (special events).

“**Climate data**” gives information about the temperature and the heating days (in Kelvin days [Kd]). Therefore we collected the data of the last year and especially the data 28 days before and after the training-session. The data were taken from the nearest meteorological station.
In order to compare the data from different actions at different periods of the year, it is necessary to make a heat-degree-correction. This procedure makes the data from one action comparable to others, but it’s not possible to compare the month before training with the month after training.

“Feed back” was planned to find out the acceptance and implementation of our training. It is divided into 3 categories with school note system (1 very good to 5 poor). The categories were acceptance of the training, knowledge transfer and suggestions from the trainees. Most trainees gave a school note of 1 or 2.

Some key lessons learnt during the training session of this project were:

- For the savings in electricity, it is very important to train the administration staff. If the boss says: “turn off the lights”, the lights will be turned off. If somebody who has the technical know-how and a lot of experience would say the same thing, it may not have the same effect.
- For the heat savings the training of building users was best. They influence by their need for warmth and by their way of ventilation (open windows, how long).
- In saving water the technical staff has a big influence. They keep an eye on running water, and can repair leaky pipes.

7 Success Criteria

Criteria for measuring success include the energy and water savings achieved, the number of training sessions delivered, feedback from workshop participants, and the availability of energy use data for the building users and an increase in energy awareness among building users.

Some possible success factors include:

Monitoring/data

- Initially careful consideration of monitoring requirements, ensuring correct monitoring equipment is used
- Availability of funding for monitoring hardware
- Access to expertise on metering/data systems
- Use of data management software enabling various analysis of data to be carried out

Ongoing monitoring

- Ability to give rapid feedback to building contact on unusual consumption
- The ability to set alarms to highlight unusual consumption is useful in ongoing monitoring of consumption
- Energy/water management support available to help building contact to follow up savings opportunities identified from intelligent metering monitoring

Training

- Potential for savings from staff behavioural actions (e.g. there may be limited control of energy using equipment such as lights)
- There is scope for the building to become more energy efficient, and for improved energy housekeeping by building users
- Good levels of interest and cooperation from building managers and building representatives
- Sufficient resources (staff, time and material) to provide training
- Not staff changes for trained staff
- Practical actions/tips for building users helpful
- Availability of detailed energy monitoring information as graphs can be easy to understand and helps with training
- Combination of training approaches can be helpful (e.g. engaging, enabling and incentivising)

Appendices

Appendix 1: Typical data collection sheet as used in the Intelligent Metering Project

Monitoring Object

country Austria
organisation Energieagentur Waldviertel

name of building Bezirkshautmannschaft Waidhofen an der Thaya
building owner Lower - Austria
address Aignerstraße 1
A-3830 Waidhofen an der Thaya; Austria

building caretaker
name Karl Bittermann
telephone 0043-2842 - 9025 40066
email address karl.bittermann@noel.gv.at

building responsible / department
organisation LAD 3 Geschäftsstelle für Energiewirtschaft; gov. of Lower Austria
name Reinhold Kunze

building information
building category office, public administration buildings
other use flat, rented by a company
number of buildings 1
address Aignerstraße 1
A-3830 Waidhofen an der Thaya, Austria
year of construction 1973
orientation of building south

short description of building
The building has two storeys/floors, a simply rectangular structure. In the Year 2003 – 2005 to a heat insulation with 16 cm on the external wall was added, new windows were built in, the old electric storage heating was exchanged into a biomass- district heating for heat supply; the lighting system was substituted with energy saving lamps.

heating:energy carrier biomass district heating (EVN)
amount of counters 1 piece
counter for building areatotal office building with rented flat and company

electricity: amount of counters 1 piece
counter for building areaoffice area without rented flat and company

water : amount of counters 1 piece
counter for building areatotal office building with rented flat and company

building management system		☐ yes	☒ no
amount of building occupants	64		
hours of occupancy [hours/month]	289 hour per month		
energy reference area [m²] gross or net	1998 m²	☒ gross	☐ net
energy reference volume [m³] gross or net	6250 m³	☒ gross	☐ net
installed power for heating [kW]	200 kW		
kind of hot water production	production with the heating		
installed power for hot water [kW]	13,6 kW		
kind of climatisation	Server room		
installed power for climatisation [kW]	6,4 kW		
kind of cooling	neither		
installed power of cooling [kW]	neither		

Appendix 2: Definition of inputs and outputs required from the Intelligent Metering Project

Inputs required:

Per building:

- Counter/meter for heating (cumulative)
- Counter/meter for electricity (cumulative)
- Counter/meter for water (cumulative)

Pulse data (within the intelligent metering system pulses require translation into values)

- Value counter for outside temperature

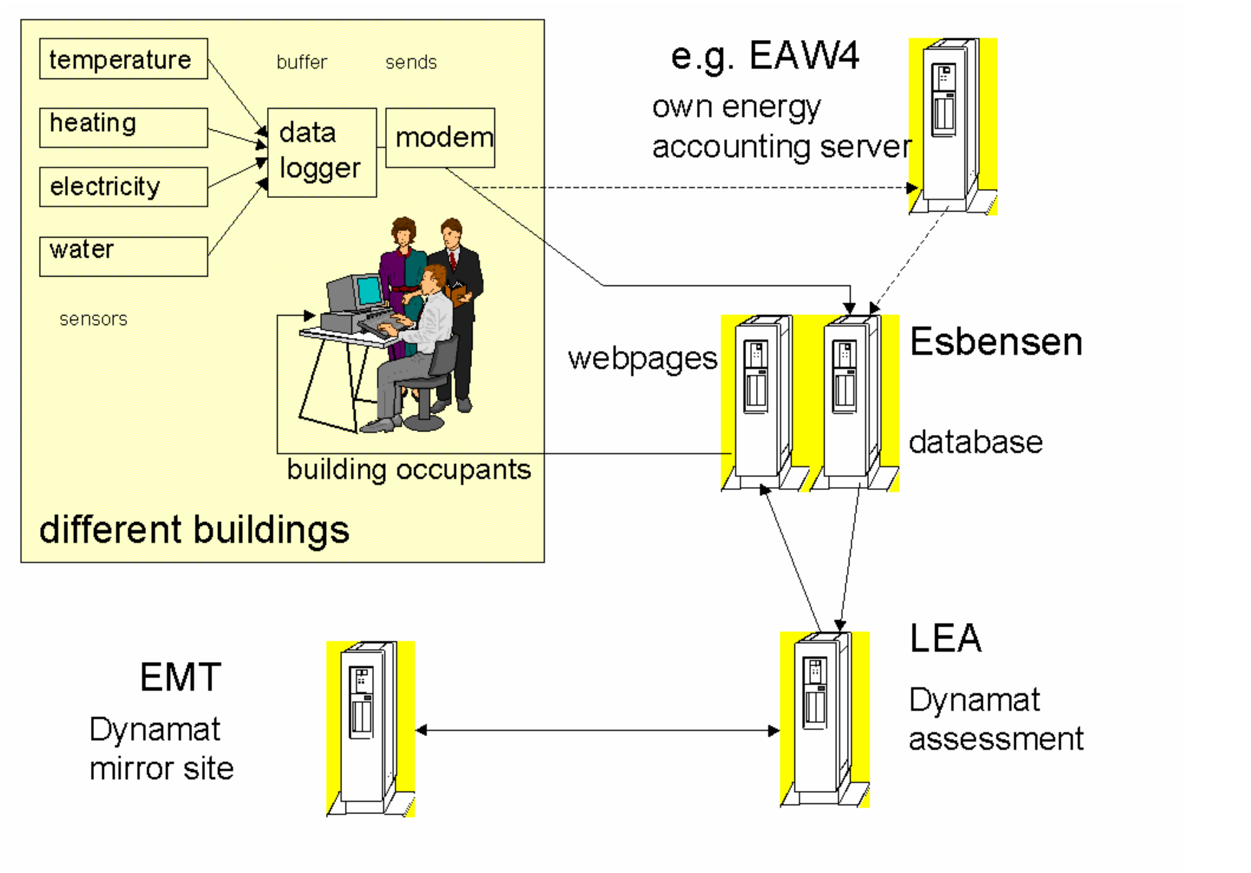
Delivers a voltage, which has to be transformed into values

Half hourly data is metered, collected and sent to a database.

Outputs delivered:

- Consumption results for the different accounting scopes on the project website updated once a day
- Database for identifying abnormal consumption and its causes
- Database for identifying of best practice examples
- Database for evaluation of the project itself
- Trained building occupants

Appendix 3: Structure of data flow in the Intelligent Metering Project



The sensors of the metering units send their pulses to a data logger every 30 minutes. The internal buffer collects them. Every 24 hours the modem is activated to send the data to the database. The translation from pulses into values can be done in the data logger, in the inserted energy accounting server (if there is one), in the database or the Dynamat evaluation program. The heating, electricity and water counter send pulses, if the right counter is used. The temperature sends normally a voltage that can be translated in data loggers with an analogue input into values. If possible the database wants to receive values and not pulses.

If the data are already values and have to be interpreted by another program, that normally reads raw data (=pulses) like Dynamat, they only have to use a conversion factor of „1“.

The modem may send the data directly to the database, but an own energy accounting program may be inserted. This program has to forward the metering data to the database. The metering data sets must have a fixed structure.

The new metered data are forwarded from the database to the server of the Leicester Energy Agency (LEA), where the analyzing program Dynamat is installed. A mirror site exists in the internet; this is the one of Energy Metering Technology Ltd (EMT). Each building consumption of every accounting scope is evaluated regularly. The results are sent to the Esbensen Server, where the result-pictures are placed on the website of Esbensen and automatically updated. The building occupants can view their consumption on the website.

The sensor of the metering unit sends out pulses. The results of the assessments are always values. The conversion of pulses into values may happen at different places. Different partners or even different buildings of one partner may have a different place for this translation.

Appendix 4: Possible characteristics of energy accounting software

Possible characteristics of energy accounting software
Energy accounting for buildings, plants, car pools
Generation of data sheets for input data
Remote meter reading integrated
Type of network
Client-server solution in LAN/WAN possible
Economy calculation of redevelopment
Calculation of presumable demand of heat of objects
Actual value/target value analysis of consumption
Facility management
Access rights for data base can be defined
Software of data base
Automatic energy reports
Objects with new parts of buildings expandable
Different key figures for energy possible
Key figures can be defined as desired
Allocation of more sub counters to one counter possible
Maximum accuracy for consumption data
Adding counter
Subtracting counter
Value counter (e.g. Kvarh)
Load and energy collected (kW, kWh)
Changes of tariffs/rates registered
Automatic alert at high/low consumption
Calculation of energy costs
Cost components registered
Heat degree correction (hdc) possible
Maximum accuracy for hdc-data
Greenhouse gas emissions calculated
Other air pollutant parameters possible
Results in tables possible
File type for table export
Results in graphics possible
File type for graphics export
Graphics can be edited in the energy accounting software
Program specialities
Language(s)

Appendix 5: Training used (strategy, structure and actions) within the Intelligent Metering Project

Training Strategy

Training has been provided to the building occupants on changing their usage patterns in order to save energy and water. Other work has identified a number of ways in which buildings can make savings. These results have helped in developing training material. Training sessions have been carried out within each building so the occupants can be introduced to the intelligent metering systems and see the results coming from these.

The aim was that the training was adapted for different building users in different types of building. The detailed energy and water monitoring data already collected as part of the project has been used to identify potential areas for savings and areas for the training to focus on.

In addition to training sessions, posters have been developed or selected to be displayed around the buildings, reminding the occupants of the training they have received and important actions they can implement. An example of a relevant poster is the “Display” poster from the DISPLAY project, being supported through the IEE programme (http://www.display-campaign.org/), which highlights the energy performance of the building and is being utilised to facilitate the introduction of Buildings Directive.

Mechanisms for enabling, engaging and incentivising building users have been considered in the training.

Training Structure

Resources were provided for the building occupants in order that they could change their usage patterns in order to save energy and water.

This was supported by work using the intelligent metering data which identified a number of ways in which each building could make savings. These results and a review of current research on effective models to change the behaviour of building occupants were used to develop a general training package. Two manuals were developed; one contains specific resources aimed at the special needs of school buildings and their users, while the other has resources for use in a range of other buildings. These manuals were used as a basis for training with an allowance to enable bespoke material to be created for each building individually, if required.

Intelligent metering represents a unique opportunity to create a truly ‘sustainable’ project. Its main focus is energy and water, however research shows that setting these aims into a wider context provides more powerful and effective training. A broad approach is needed to produce a long term impact on changing the behaviour of the people young and old who inhabit our municipal buildings. For this reason the manuals also incorporated the common theme of Learning for Sustainability based on the Pathways development framework produced by the WWF. This pack produced by the WWF although specifically aimed at the school market was adapted so that it could be used in both school and non-school buildings. It contains, within the development framework, six activities and tools that will help to plan, implement, monitor and evaluate the Intelligent Metering project. These are practical training tools that help to give a strategic overview of energy and water use in buildings.

Training sessions were carried out within each building so the occupants could be introduced to the Intelligent Metering systems and see the results coming from these in real time. Some building occupants were also introduced to the broader aspects of ‘Learning for Sustainability’. As per the strategy, the training was adapted for different building users in different types of building. For example, in offices training was provided for managers (including building and energy managers) using small group/one to one meetings, and larger group presentations/training sessions have been given to staff. In schools, the training has been directed in different forms at the management and teachers, and at the pupils, e.g. using special educational materials. In addition a review of over 50 websites on topics related to the project aims was produced.

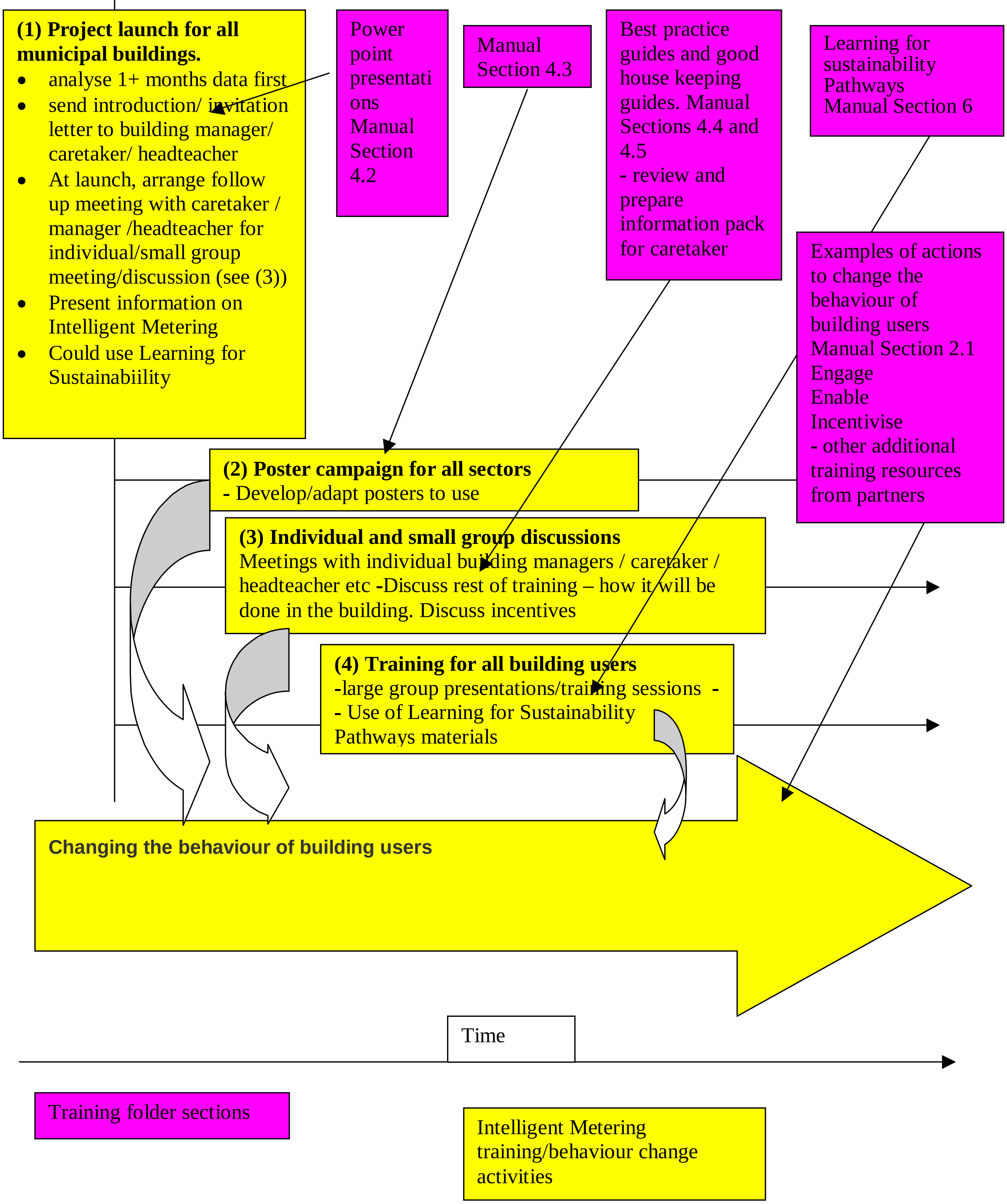
In addition to the training activities contained within the ‘enabling model’ a range of other necessary ‘actions’ were detailed in the training manual that ‘enable’, ‘engage’ and ‘incentivise’ building users to change behaviour. For example as part of the ‘enabling’ model any ‘barriers to change’ were addressed before embarking on the training plan. Simple measures included ensuring that the training takes full account of the building users’ personal circumstances so that they are able to fully comprehend the training: Are their other roles taken care of whilst they are training? Is the material at the correct level and delivered in an appropriate and stimulating manner? Likewise a range of ‘engaging’ and ‘incentivising’ actions were detailed in the manual. The website acted as an important mechanism for sharing good practice. To quote from Section 2.6 of the training manual:

> *‘Single interventions to support building users to change their behaviour are unlikely to be successful. A programme of measures needs to be put into place’*

As discussed in the strategy, the data already collected, as part of the project, was used to consider potential savings from the occupants carrying out the actions recommended by the training. This was used to demonstrate to them the importance of their actions. This is an important aspect of ‘incentivising’.

Posters and stickers were displayed around the buildings, to remind the occupants of the training they had received and important actions they can implement.

European Intelligent Metering project: Training structure



Training Actions

A wide range of actions were suggested in the training manual.

Enabling actions:

1. Removing barriers /provide facilities
   a. Physically – for example can the light switches easily be located?
   b. Administrative – Do the trainees have the resources to be able to go on the training?
2. Information giving
   a. Posters and stickers -are available on the Web site (www.intelmeter.com)
   b. PowerPoint presentations are available on the Web site and can be adapted for training different audiences
   c. Best practice guides - are available on the Web site.
   d. Good housekeeping guides. A brief summary is included in the manual but more complex information details can be found in the Best practice guides.
   e. Good housekeeping guides - visual guides - on the website.
   f. The Learning for Sustainability - Pathways booklet has been adapted for both school and non-school building users. This gives a global perspective on Intelligent Metering, can be delivered to large and small groups.
   g. The Role of the Energy Manager in Intelligent Metering. This section gives details of how their role can be enhanced with intelligent metering.
   h. Case studies – The manual contains descriptions of inspirational buildings and successful approaches to changing behaviour. Specific examples are given for the school and non-school sectors.
   i. Catalogue of web resources – A review of the best sites on the internet. This also includes resources that are translated into the languages used by the project partners.
3. Skill provision
   a. In –house provision will already exist and will be identified via whole municipality actions (for example Investors in People, in the UK).
4. Increasing capacity
   a. Those responsible for monitoring energy will find that Intelligent Metering streamlines this process (also see (2.f) above).

Engaging Actions:

1. Co-production
   a. In schools the formation of an ‘e-team’ truly involves pupils in the intelligent metering process. http://www.schoolsenergywise.com/Your_Mission/body_your_mission.htm is an example of a pan European ‘e-team’ initiative.
   b. The manual gives detail of local and national UK initiatives that fully involve building users in the process of saving energy and water. For example The Trades Union Congress recently commissioned a paper called ‘Greening the Workplace’ containing many effective partnership ideas. http://www.tuc.org.uk/economy/tuc-9996-f0.cfm
2. Community action
   a. Research shows that setting Sustainable Development into a wider context has a big impact on changing the behaviour of our citizens. There are many new national and international initiatives and examples of some are given in the manual.
3. Personal Contacts

   a. Individuals will listen to those in positions of power/credibility when they communicate outside their field – so ensure that there are mechanisms for inviting local medical / community workers into the workplace.
4. Media Campaign
   a. From the beginning ensure that the local media network is used. Ensure that regular press releases are issued.

Incentivising Actions

1. Rewards
   a. Use the fast feedback from Intelligent Metering to certificate the best local teams when energy and water targets are achieved.
2. Recognition and social pressure
   a. Harnessing the power of 'social pressure' will have a big impact on changing behaviour.