

Energy Savings from Intelligent Metering and Behavioural Change

Contract N°: EIE/04/107/SO7.38635

Summary of monitoring needs (Deliverable 1)

**Work Package 1: Monitoring Specification
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1. Summary

In the project intelligent metering our aim is to reduce the consumption of energy and water. Measuring units collect the amounts of energy and water and send it automatically once a day to a database to analyze the data. The measuring counters must send pulses to a data logger or building management system where they are collected in a temporary memory. This auto collection is the requirement for using small time intervals to monitor. For this project we use 30 minutes intervals, which will be a good assistance to identify abnormal consumption. The caretaker of the allocated building can be informed automatically by email from the controlling program linked with the energy accounting database.

This irregular event of abnormal consumption may be a too high value compared with the average consumption for this hour/weekday. The reason may be a malfunction in the plant or a careless behavior of the building occupants. This reason the caretaker of the building has to find out with the help of the attendant, in our project the energy agencies and administration units. Therefore all this participants will be able to look on the website of the (Esbensen) Server, where the database is situated too, and view there the actual consumption of heating energy, electricity and water of the building. Password and Login will be used to manage the page views and access rights.

A value too low than normal consumption may has its cause in an energy efficient behavior as well as a malfunction of the unit (e.g. a frozen utility line). This must be cleared by the participants too. Other conditions that represent a potential for energy efficiency are a base load, which is too high at times with no or few use in the building or high regular peaks at the same time of the day or week.

To reduce consumption the building occupants will be trained in energy efficient behavior. To have a feedback on their changes of behavior patterns the building occupants have the possibility too to see the latest trends in consumption by entering the website too.

The database will be the key factor for the intelligent metering project. Here the data structure of the incoming data must be defined and the format, we will choose CSV-files. There will be metering data and additional data in the database. The additional data help to describe the building. This will help the building caretaker and the attendant to find out reasons for abnormal consumption. The caretaker should fill in the reason, date and time of these events. So we will get a history. The database will help to evaluate the project and to find out best practice and successful training too.

We suggest using one counter per accounting scope. Electricity suppliers often have different cost rates and therefore different counters, which complicates the controlling system. Some electricity suppliers don't allow to take the pulses from their counters, in such cases an own counter after the one of the electricity supplier should be installed. For heating it is best to install the counter before the boiler, seen in the path of the energy flow. If the energy supply is discontinuous (filling levels) it is also possible to use counter for the amount of heat after the boiler.

In the dynamat software it is possible to use the outside temperature data from a sensor or from files of a nearby weather station. With the outside temperature we can apply a heat degree correction of the consumption data in the accounting scope heating. So colder and warmer days or locations can be compared, and the corrected monitored values are more dependent on the personal behavior of the building occupants.

The meter unit needs electric power for its operation. The outside conditions of a rough climate may influence the meter unit function. A change of shadow and direct solar radiation is unfavorable for the temperature sensor; the best side would be the northern one of the building.

The data line from the meter to the data logger (or substation of a building management system) should be of a short distance (only few meters).

From the data logger the data can be sent to the database by serial port connection, by telephone modem, by TCP/IP-protocol in a LAN, WAN or the internet, and by GSM. An other server with an own energy accounting program may be inserted (like in the energy agency Waldviertel, Austria) to send the data to the Esbensen data base.

The consumption data from the Esbensen SQL database will be transferred to a monitoring program (dynamat from EMT Ltd.) daily. One evaluation of the last days per accounting scope and one of the last weeks should be analyzed and the results sent to the project website located at the Esbensen server to be shown there as pictures on the web pages, allocated to the different buildings, and updated every day.

This form of energy accounting in the project intelligent metering is a very sophisticated one. As there is a lot of information running automatically, we can concentrate in the behavior of the building occupants in their consumption pattern. There are other forms of energy accounting too which are more simple and cheaper in the costs.

2. Introduction

2.1 *What is monitoring?*

Monitoring means to observe. Different aspects can be observed, the condition of devices, the consumption of resources, the behavior of building occupants, parameters representing the general condition inside and outside the monitored objects. Simply we can say every status that might change in time can be monitored.

This leads us to the question why we are monitoring. We observe parameters in order to find out what needs to change to reach and stay in a target status, which is good for the controller. And we want to get informed as soon as possible, if the status changes to worse conditions.

If the monitoring system gives enough information, the cause of the change will be found out more or less easily.

In this project, our aim is to reduce the consumption of energy and water. A tool to achieve these goals is the method of 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 to the place and tool where it will be analyzed. Often an interpretation of the results leads to a reaction of the involved people, e.g. reducing the consumption.

2.2 *The main aspects why energy accounting is done are:*

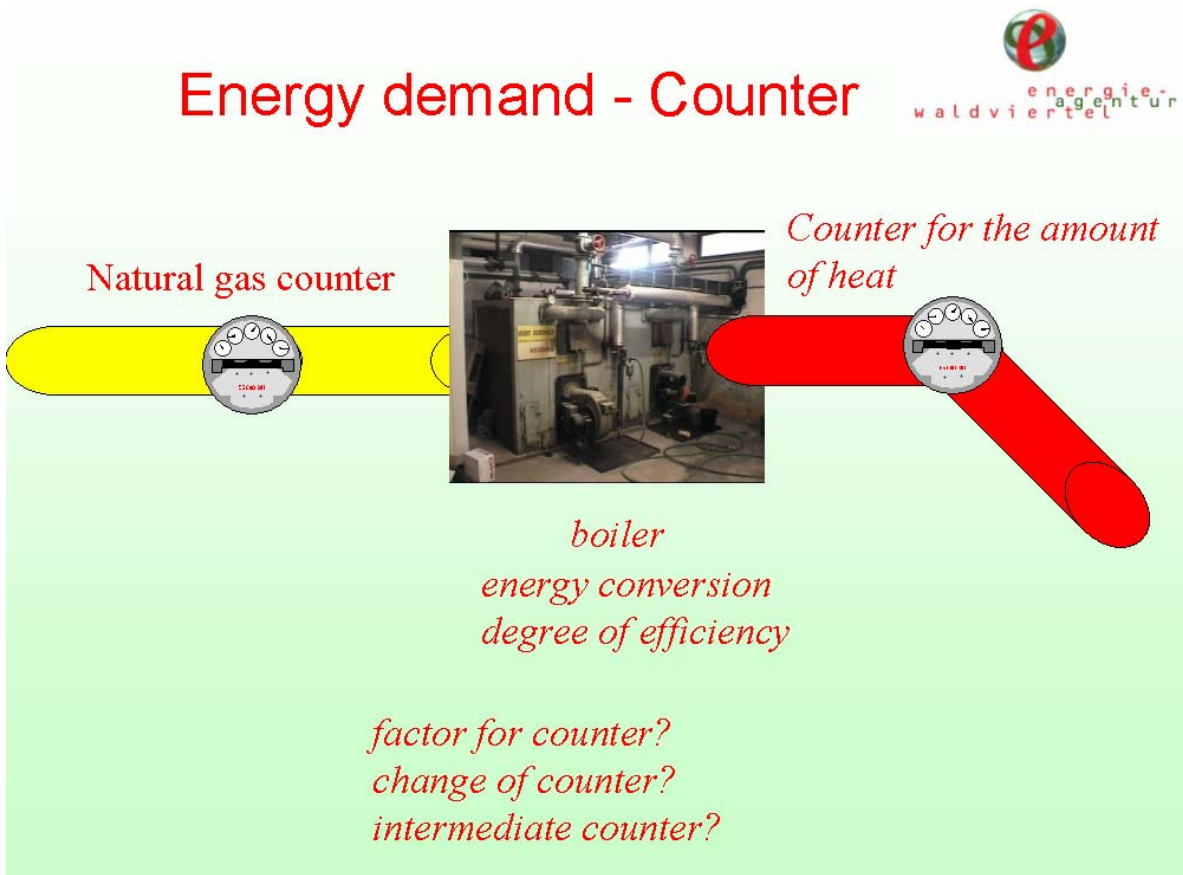
- Reducing the costs of energy and water
- Decrease the required energy and water because resources are not endless. Especially the security of supply will become essential in times of the peak oil problem.
- Cut down the green house gas emissions and the emissions of other air pollutants. Energy efficiency is one of the best measures to do this with the help of energy accounting.
- It is a tool to control plants and devices for malfunction.
- It is a tool for rating contracting and redevelopment measures.

- Object owners get information about their buildings. They can find out the best order in redevelopment their buildings and collect the data necessary for contracting.
- Object owners get an overview about their counters and devices. This is often very helpful in bulk tendering and bulk energy purchasing.
- It is possible to find out trends in consumption and their related aspects earlier and react to them more quickly.
- It is easier to calculate the costs of special events in the monitored buildings and you can charge it right.
- On a liberalized energy market you can control your energy supplier and have better data for a quick change or new energy contract.

3. Discussion of monitoring needs

3.1 Which objects should be monitored?

Each object with at least one own counter can be metered and monitored. The larger the consumption of the object will be the more necessary is monitoring. A problem is very small objects. We suggest if the annual energy costs are less than 4 times higher than the annual costs for energy accounting/monitoring, it will normally not be economic at all. Well this may be a point of discussion.



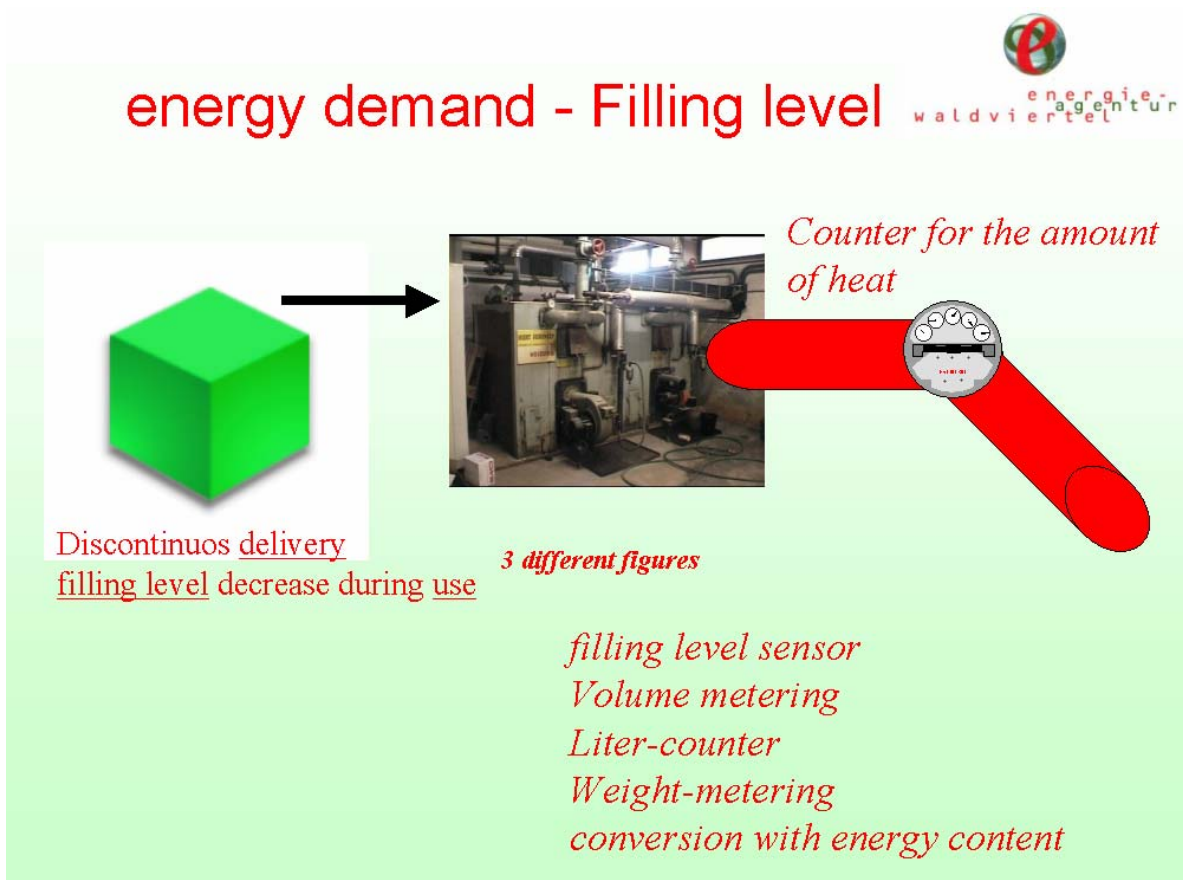
Remember that objects may be buildings in the common sense, but can be something else too. Energy accounting makes sense for e.g. the street lights (if their consumption is metered, there are sometimes older contracts with fixed annual costs existing). Also of importance can be sewage plants, power plants, water pumping stations, sports facilities or open air swimming pools.

The basis for energy accounting is at least one existing counter per accounting scope (heat, electricity, water demand,...) for the monitored object.

If there are counters for energy, these can be before the boiler (German: Endenergie) and after the boiler (German: Nutzenergie). The energy of the natural gas is changed after the energie conversion in the Oxidation process in the boiler to heat energy. The degree of efficiency of the boiler depends on his losses. If both counters, one before and one after the boiler are available at the monitored plant, we choose the one before the boiler, in the example above the natural gas counter. So malfunctions of the boiler can be monitored too.

A special aspect of the counters can be a counter factor for larger buildings. So if the counter counts "1" and the factor is 30, the actual consumption is "30" units. There existing larger factors too.

Some counters belong to subareas of the building. These are intermediate counters. Their determined energy amount is a part of the energy of the whole object, that is metered at the main counter somewhere else.



An important aspect for energy accounting is the comprehensibility of counter changes.

If there are no counters because the energy is supplied in a discontinuous way it is also possible to measure filling levels. The consumption is the reduction of filling levels. 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.

In case of the difficult way to meter the filling level it is suggested to use counter for the amount of heat although these are situated after the boiler. It is much more simple but troubles with the boiler cannot be recognized.

3.2 Different types of energy accounting:

All types of energy accounting have common 3 steps:

- First: to read the counter
- Second: to transport the information
- Third: to analyse the data

3.2.1 Sheets of paper - the simplest way

Someone writes down the counter reading to collect them. From time to time the consumption will be calculated. Costs are the working hours of the person. Not very sophisticated, the assessments are simple, but it can be done everywhere by everyone.

3.2.2 Spread-sheet calculation program

Here someone reads again the counters and write it down. The data are entered into a spread-sheet program, e.g. like the Microsoft-program Excel ®. The software costs are low, but you have to use your own brain to develop calculation procedures. But you can program very complex assessments. There is no fixed structure, the quality depends on the user, and the calculations can be simple to not comprehensive for other users. Data exchange is easy, but it is recommended to exchange the raw data, because processed data can be manipulated in many different ways, often you don't know the story of a processed „value“. Some cheap or free energy accounting programs on the market are based on spread-sheet calculation. The city of Graz, Austria, uses this type of energy accounting for their buildings.

3.2.3 Stand alone energy accounting programs

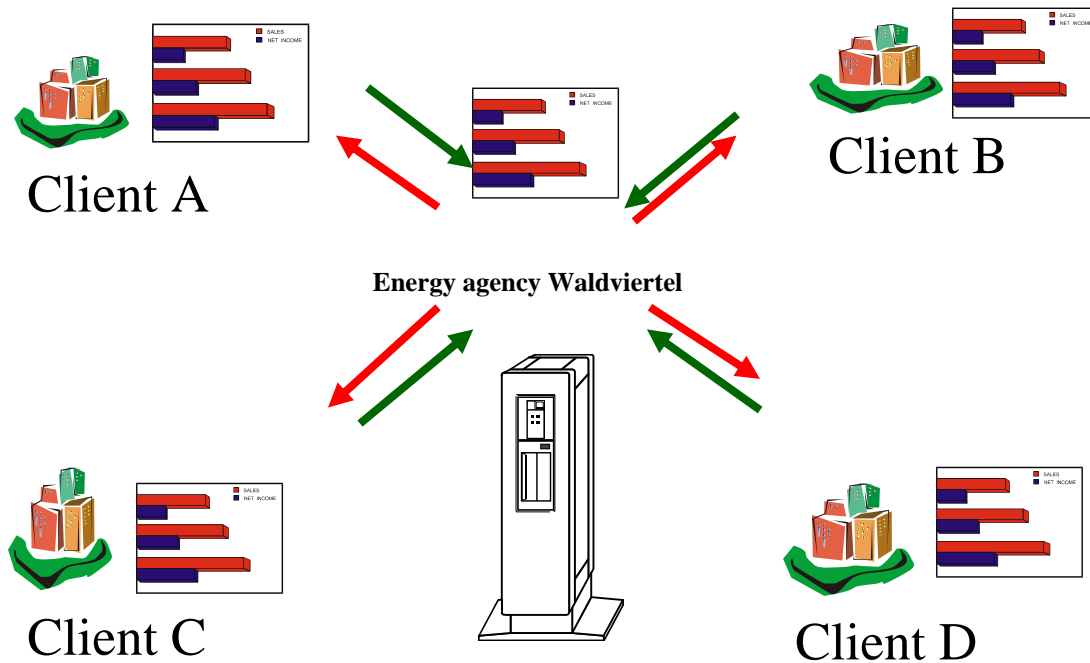
Separately for the purpose of energy accounting programmed, usually combined with a database for collecting the data. Quality and price vary from simple to exclusive. The simple programs are often made for the non experienced user, the complex programs are only made for skilled professions. In some cases the exchange of the data to other programs can be a nightmare. Some complex programs have other tools included, like economy calculation of redevelopment measures, facility management or calculations of the heat demand. Sometimes the program can be used local as a client – server solution in a LAN (local area network). An example of the use of a complex stand alone energy accounting program is Akropolis ®, which the Energie 2000, the energy agency in Wolfhagen near Kassel, Germany is using.

The counters can be read manual, but in some programs there is also the possibility of remote data transmission. There are also some energy accounting systems which use data communication by email or exchange of hardware devices (floppy disks, CD-rewriteable or USB-sticks), but this data import seems a bit inconvenient.

3.2.4 Network solution of energy accounting:

Here a WAN (wide area network) provides all user the energy accounting. The users log in at the server, where the database for all users (clients) is situated. This brings advantages: The data of different objects at different locations can be compared easily; they all have the same data structure. Benchmarking is possible and usual made only by a special administrator, so the assessments in benchmarking can be anonymized. Support and central updates provides more help to the user/client. Data input can be done manually at different places at client computers, remote data transmission is often possible too.

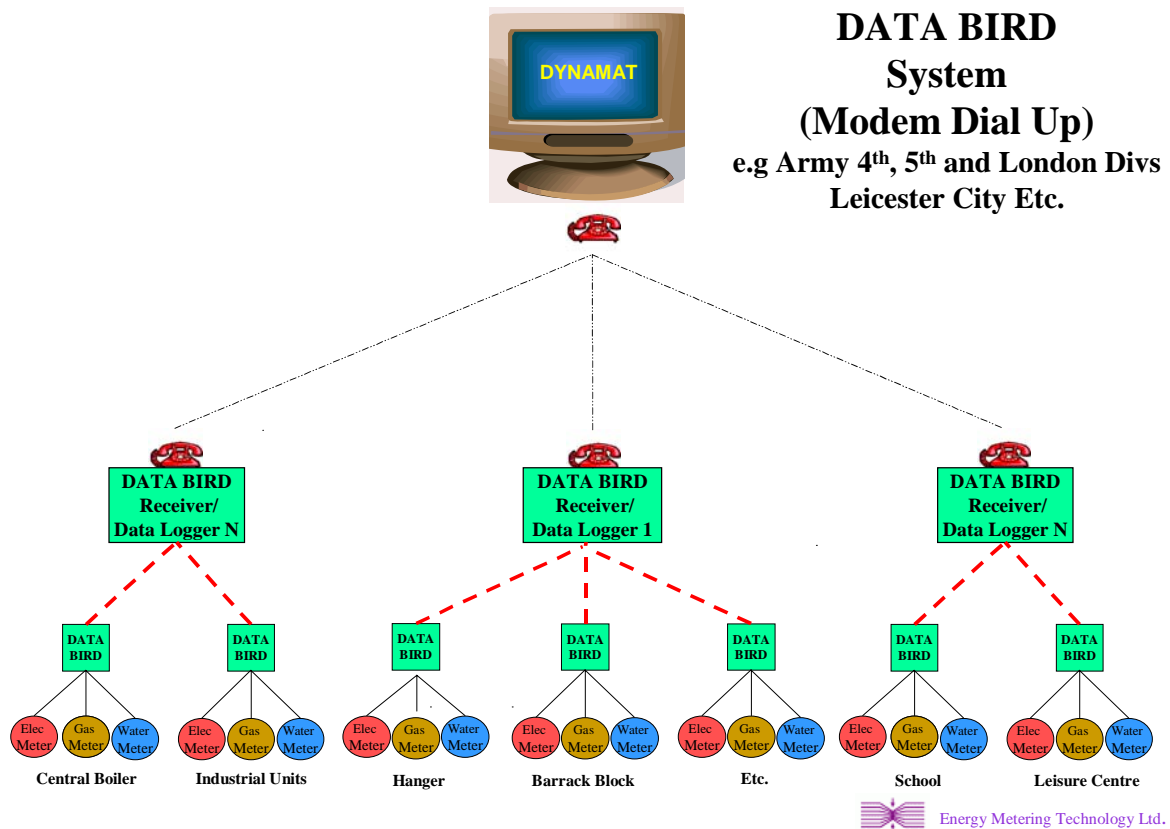
If the client needs an own software on his personal computer to use the energy accounting we name it an Intranet-Energy-accounting. The data can be transmitted by phone line (expensive) in analogue way or by ISDN, but it is also possible to use the Internet as a transport media. The Energieagentur Waldviertel, Lower Austria, provides such a system for 70 clients.



Above illustration shows a diagram of the energy accounting system of the energy agency Waldviertel.

The state of the art is to use the Internet browser for the energy accounting, the software is only installed at the server, the users only have to login with password at a special website in the internet. This we call Internet-energy-accounting. The program EMC of Siemens is an example for this version.

The next step is to automate the energy accounting - the counter reading is sending automatic to the database. Therefore the data read intervals getting shorter. The software automatically analyses in short intervals (which means daily to every 15 minutes) the consumption data, compare it to standard consumptions of the object and inform the user of the object automatically if the consumption is out of range. This is done by EMT (Energy Meter Technology), England. The Leicester City uses this system too, the data transmission works in many cases by radio.



This system works by counting pulses from the meters and maintaining a continually incrementing register value for each meter. At a preset interval, usually 30 minutes, the transmitter sends its current register values to a receiver / data logger, which then date and time stamps the readings and stores them in its non-volatile logging memory. The logger is then downloaded at intervals; say once per day, over the phone or Internet by a dedicated piece of communications software. This software produces a simple comma separated file of data which can be read in by EMT's software DYNAMAT or any other analysis software package.

This system is very close to the way, we will do our intelligent metering project. Because of the small intervals detected it is simpler to find out the reasons for abnormal scheduled consumptions.

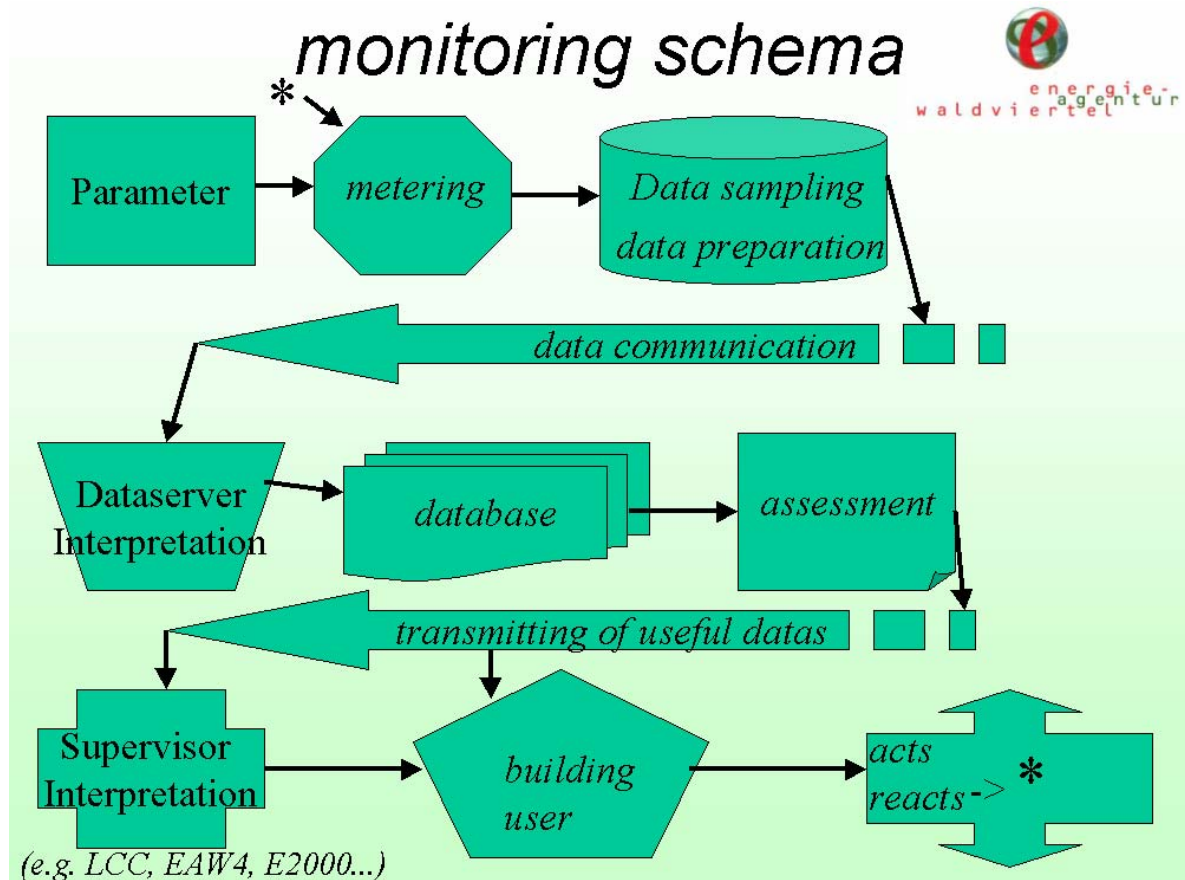
Instead of build in new data loggers an existing load management system or building management system can be used for data collection. Pure mechanic counters must be replaced or completed with counters, which provide electronic signals or values.

3.3 So what are the basics for intelligent metering in this project?

The participants all have to use counters that provide electronic signals or values. The minimal time stamp interval should be half an hour. The consumption data of energy and water should be sent to an SQL-Database (Esbensen) in a CSV format at least once a day. The EMT software Dynamat should calculate the consumption once a day with the new figures. The results will be shown on a website (Esbensen), where the building occupants can see their actual situation and can react to reduce their consumption in energy

and water. The energy agencies will have a look on the objects too and will help the caretakers of the buildings to interpret the results of the website displays.

3.4 The components for monitoring:



Certain parameters will be metered in intervals. This data will be collected and manipulated. From time to time this data will be communicated to a Data server, which has to fill in the data in the right place in the database. The energy accounting program evaluates the data in a preset routine. The assessment is displayed at a website in this project. So the building user can see the results and reacts. The changes influence the consumption, which can be metered again. The data on the website will be checked by the energy agencies too, who help the building user to interpret their normal and anomaly consumption.

3.5 At which parameters are we looking?

Almost every parameter could be monitored. But we have to think over the costs for the device and metering and the need to meter it. And some parameters to monitor will not be metered but given by devices like the ID – identification number of the metering instrument or building. Or the time stamp, which is given by the counter or data logger or building management substation.

The most important parameter is the amount of energy or water used since the last time unit.

Don't forget the unit of the amount (kWh, MWh,...). Sometimes indirect parameters are measured like the 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).

Energy carrier	unit	net calorific value
bark (50% moisture)	bulk cubic meter	600
biogas	m ³	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	liter	9,86
fuel oil extra light	liter	10
fuel oil light	liter	10,5
fuel oil medium/heavy	liter	11,2
gasoline	liter	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	2410
Log wood (soft)	cubic meter of stacked wood	1520
natural gas	m ³	9,5
rape oil	liter	9,6
sewage gas	m ³	4,4
straw	kg	3,6
wood briquette	kg	4,6
wood pellets	kg	4,7

List of net calorific value, the energy agency Waldviertel is using for different energy carriers.

If it is a discontinuous energy supply, maybe the fill level will be measured. In electricity units also the load and reactive current may be metered, because the electricity supplier uses it for standard price components.

To get additional information to the consumption the next important group of parameters is those for the climate. We can distinguish between the room- and outside climate. E.g. Esbensen simulates room climate conditions. The most important parameter is the temperature. There is a clear connection between temperature and consumption. One more degree Celsius room temperature means about 6% more of energy consumption. The colder the outside temperature the more energy is needed too. 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 works better in cold climate. In more moderate climate (e.g. like in England) other climate parameters have a more important influence on the energy consumption in comparison to temperature than in colder climate.

These other parameters can be the solar radiation, shading, wind and humidity.

The next group of parameters which is monitored sometimes, especially in combination with building management systems, is information about the actual use of the object and the condition of the plants. These may be the information, if devices or light is on, the blinds or windows are open and the ventilation works. Often these conditions will not only be controlled from the building management system but also be regulated by the system. The security system can tell, if somebody and how many persons are inside the building. Failures and alarms can be transmitted too. These information are often only in a digital status of on or off. But real metering can be done by controlling the CO-Concentration (or other air parameters) of the ventilation or the amount of solar radiation intensity.

3.6 Metering data

If the sensor has a pure mechanical system we can't get data for a digital collection and transmission. Electronic meters can provide numeric data or/and pulses. Both can be used. Julian Edmonds from Energy Metering Technology limited writes:

Reason for using pulse outputs

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" which is available for all 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 such as DYNAMAT to calculate the meter face reading from the data, if it is given an initial starting reading when the data collection hardware is commissioned. LCC are able to produce accurate "meter face" readings from their system where the initial reading is over three years old.

Reason for using a dedicated meter reading system

Some sites have gone down the route of connecting their meters to a Building Energy Management System (BEMS) whose main purpose is control of the building services plant. This was the earliest method of automatic meter reading that was attempted on a wide scale, but because BEMS are 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 system."

Well, EMT is selling the pulse reading device. Sellers of the dedicated meter reading system speak about the advantage, that in case of data loss, the meter gives the correct figures in consumption whereas the pulse method have lost the pulses for ever.

In summary, both systems are possible for the intelligent metering project.

At one point of the monitoring system the pulses have to be translated into values. This will be decided by each partner to fit best to the data flow of the intelligent metering project.

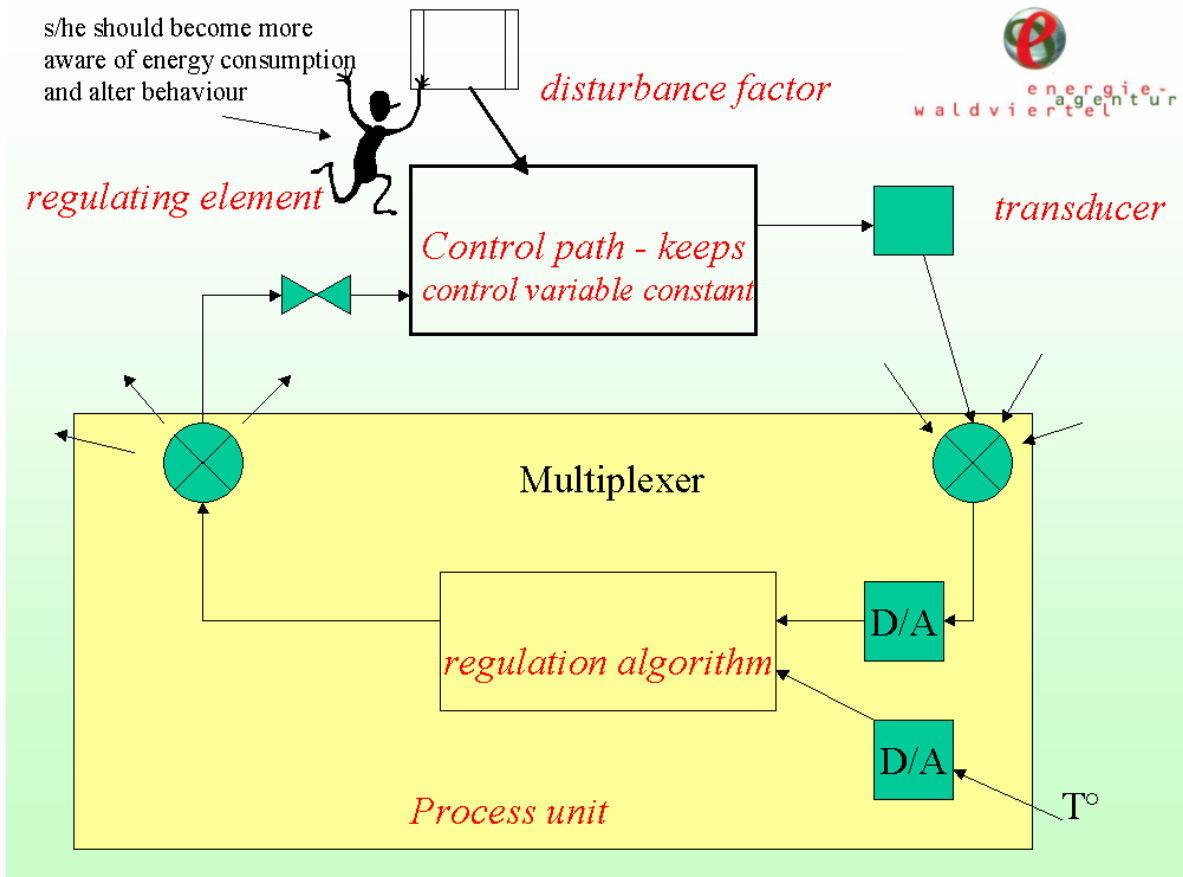
The need is to get an electronic signal, pure mechanic counters have to be changed or completed with electronic sensors! If the metering instrument needs to be adapted or changed out, and the utility company will usually want to carry out this work and charge for it.

3.7 The metering instrument

The metering instrument has a transformer inside. E.G. the electricity sensor scales down very low a certain amount of the consumed electricity in a fixed ratio. This small amount is counted in the counter. If the signal, e.g. of temperature comes from an outside sensor, it is a voltage in correlation with the temperature. In the metering instrument the pulse generator translates the analogue value of the voltage to impulses, which can be handled in digital form. Status information (e.g. window open) comes to the metering instrument often in digital form. Between the parts of the metering instrument are the connections, where

signals/information is transported. From the metering instrument the pulses or values are delivered to a data logger or a substation of a building management system.

The distance, the data are transmitted from the metering unit to the data logger/building management substation should normally not exceed 2 meter for a trouble free communication. There should be taken into consideration that the metering instrument needs an electrical supply to work. This is no problem with counters for electricity, whereas can be a big problem for counters for water, which are often far away from the electrical installation. Maybe a battery or a solar driven unit can be used in such cases.



This is an example of a regulation system. The transducer sends data of a control variable (e.g. the inside room temperature or the flow of an amount of heat to the process unit). The multiplexer asks different parameters or different sensors in a predefined sequence. If the data are in analogue condition (e.g. in form of a voltage) they will be transformed to digital signals. The regulation algorithm calculates the new status of the regulating element to keep the viewed variable of the control path constant. A disturbance factor from outside may influence this variable, the process unit has to calculate again for the status of the regulating element to keep the control variable constant. The disturbance factor can be very often the human being. E.g. the person opens the window. It is cold outside, so it gets colder inside too, the process unit calculates to open the valve of the heating system to keep the temperature inside the room constant. If the building occupant is not trained, the person forgets to close the window. In the case of intelligent metering an abnormal rise of energy consumption may be seen, somebody reacts and close the window. A trained building occupant reduces the room temperature manually, when s/he opens the window. After closing it, the person will raise the room temperature to normal level again.

temperature has minus 10 degree Celsius or less, it may even stop to work. So it should be thought over in general at which places the counters are mounted.

Most of the installed counters belong to energy or water supplying companies. Some of them collect the data in short intervals and send them with data transmission to the supplying company and could therefore send them forwarded to the user too. The supplier companies often don't give allowance to this procedure. Normally the companies read the counters in longer intervals per data transmission or have no one at all. Most of the meters in this project will be main fiscal meters which are 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. This is not always possible. Energie 2000 (Kassel, Germany) is not allowed to use the data directly from the metering instrument. As a last resort the consumer can install a secondary meter 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.

3.8 The data logger

A data logger is an electronic instrument that records measurements (temperature, relative humidity, light intensity, on/off, open/closed, voltage, pressure 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 utilize turn-key software on a personal computer to initiate the logger and view the collected data. Often data loggers for electricity are combined with a load management system.

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 to use an hand held device for data download from the logger, it is not suitable for the daily data transmission of the intelligent metering project.

Data loggers are 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) can not reach. E.g. the data bird and chick system with radio transmission of the data from Energy Metering Technology Ltd. . The wiring of the metering and logger units can raise the costs very much.

3.9 The building (energy) management system

Also called Building automation (BA), building management system (BMS), building energy management system (BEMS).

The entire Air Conditioning & Mechanical Ventilation (ACMV) system, the heating system, the electricity system including load management and many other aspects are centrally monitored and controlled. This ensures that the comfort level in the premises is maintained at all times and consumption runs low. Lifts, fire protection system, water level status and common area lighting can be monitored and controlled centrally as well as many other aspects. Caused by the complexity of the system, sometimes the energy consumption rises again if not monitored by a responsible supervisor.

If a building management system is already running it is cheaper to use a substation to transfer the data from the metering units to a computer which works as well as a permanent data memory as an analyzing tool. Normally the building management system is connected with the internet, which makes it easy to send the information to a WAN-based energy accounting system.

The costs for a new building management system may be €20.000, - or much more. A problem of the BMS can be that each company uses different bus-systems and data formats. The bus-system transports the data

from the measuring unit substation to the central control area, uses interfaces like the serial ones RS 232/485. Different bus-systems are e.g. LON, EIB, MOD or the Ethernet field bus.

The data of the compiled files are in different formats, depending on the company producing the BMS. The format can be e.g. xml, LPEX, edifact. A translation between different formats can be difficult.

The building management system needs counter driver, this is software information like dll-files to operate with the different counters. Two aspects are containing this counter driver, the rules for data queries and a data interpretation. The first aspect gives definitions and program instructions and predefine the protocol and the second one gives the analysis instructions (e.g. corrections) and determinate the error handling (what do to, if no value is possible cause of a failure, is it zero, is it nothing, is it an interpolation between known values?).

3.10 Communication methods:

Once the data are collected, they have to be transmitted to a database. This can be the Esbensen SQL-Database in the intelligent metering project as well as an other database with a linked energy accounting program, as it will be done by the energy agency Waldviertel, Austria. They will analyze the data with an Internet based program and send the data from there automatically forward to the Esbensen Database. There are several methods for data communication:

- **1. Direct serial port connection to a PC.** This would not be the main method of communication for this project but could be used where a site wants to collect and analyze its own data. Normally each building management system has at least this option.
- **2. Land line telephone modem.** This is used on most of EMT's projects. However it can be extremely expensive to operate if all data collection calls were being made from a single location in Europe. The rates of international calls are too high for using this system more than in regional dimensions. Also it can be difficult finding a dedicated phone line on some sites. There are two different subdivisions you can use, 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.
- **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, in EMT's experience it is often 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. LCC did try this method for one of their secondary schools but have had to abandon it. The energy agency Waldviertel uses the internet for transport data in a tunneling variant without problems. They use a ssh-forwarding with a small program called teraterm. The main aspects for a successful data communication are to know the operating systems, the open ports and IP-addresses defined in the firewalls. Our international project of intelligent metering needs this form of data communication from the objects (or energy accounting systems) to the Esbensen database.
- **4. GSM.** 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. Because of rates of international calls it is suggested to use the GSM regional to send them to a PC and send the collected data from PC per TCP/IP over Internet to the Esbensen Database.

Not only the measured data can be sent but it could be also possible to send supplementary data like log-files and data transmission protocols. This can be of some help to examine the plausibility of the measured data.

3.11 The collecting database:

The metered data are collected in a database. In the case of intelligent metering every half an hour data of 80 objects in 4 different countries will be sent daily to the SQL-database of Esbensen. These are quite a lot of data: 480 data sets per hour, 11.520 data sets per day, 4.204.800 data sets per year, or 6.307.200 data sets during the project duration.

This needs a powerful database like SQL or Oracle. There are other databases too, like access®, but this one is less suitable because of the amount of data records and it is not stable enough, if more user want to access to the same data set.

There are 2 ways to get the data into the database. The clients may send the data at a fixed time to the database or the database is asking for the data at the different clients by its own by a remote procedure call. The second type distributes the traffic to the database much better than the first one. For smaller solutions (not in this project) the more clients accessing at the same time to the database makes the price of the database-server may be more expensive. However, in this case, the SQL database is of such a size that it does not matter how many clients enter their data at the same time, and therefore it is preferred that the clients send the data to the SQL database at a fixed time. The database server is managing the traffic to and from the database and may be an own computer (better for performance) or on the same one where the database is installed.

The database also provides the Information to the energy accounting program Dynamat from EMT. An automatic routine has to actualize the data daily for the assessment. Therefore EMT and Esbensen have to work together to arrange this procedures. Especially the data structure must be defined by these partners.

Esbensen is also responsible for data security and back up execution. Security measures are secure layer technology for data transport, control of login and password, selected rights for different users, encrypt – decrypt measures, firewall settings and virus scanning. Different user rights are necessary for different groups of users: the building occupants and caretaker, the supervisor like the energy agencies, the administrator.

The costs for the database vary from freeware to about €50.000, - for the licenses of the database. Costs for data communication are also to keep in mind, a flat rate with a telecommunication cable, ADSL or MDSL which have high up and download rates is recommended. The database can be operated by the service provider like Esbensen, but the database can be rented from a place somewhere else. If the whole program is provided somewhere else for you, it is called an application service provider (ASP).

Which data should the database include? There are measuring data, like the building ID, the metered scope, the meter code, Date and time, the value, outside temperature and additional data like the net calorific value of the energy carrier, the energy carrier, category of building use, counter factor, linking of intermediate counters (sub counter) to main counter, sub area ID, linked energy costs, linked emissions, key figures of the building like number of users or size of building in square meters, load of the units in kW,..., the date of construction and the persons responsible for the building. The allowance to look at the assessments, the consumption targets, the aberration from normal consumption for alarm, the alarm contacts (email) will be some data of interest for this project too.

The metered data from the sensor are electric pulses. Somewhere the pulses must be translated into values. There must be the definition how many pulses are one metered unit at the counter. E.g. 3 pulses are 0,1°C or 10 pulses are 1 Wh or 15.000 pulses are 1 m³,.. This translation can be done in the measuring unit, at the inserted energy accounting program, at the (Esbensen) data base or the analyzing energy accounting program. This is an important aspect we have to clear for the intelligent metering project.

What kinds of accounting scopes are possible in energy accounting?

- Heating
- Electricity

- Water
- Process energy
- Ventillation/climatisation
- Hot water
- Waste
- Energy production
- Waste water
- Fuel for motor vehicles

We will use the first 3 aspects in our project. Energy for hot water will be included into heating, climatisation included into electricity.

The energy for heating may be provided by different energy carriers. The assessment will have to look at each of the energy counters as well as on the summary of all heating counters.

Category of usage:

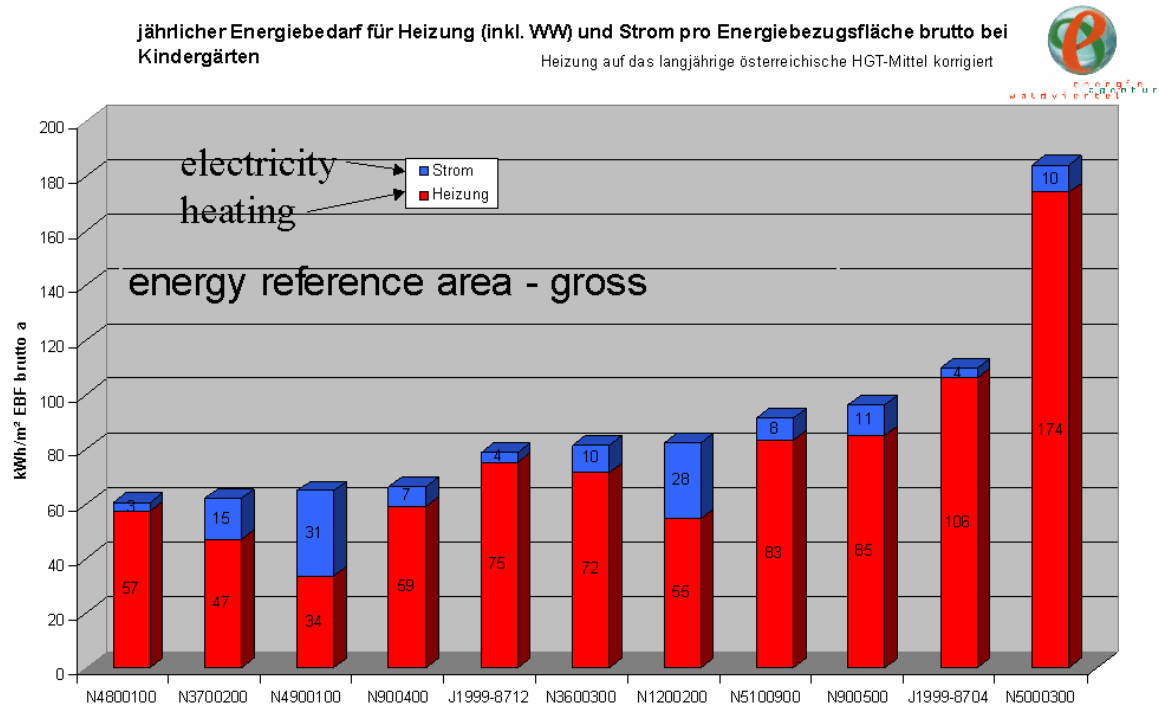
- Administration and office buildings
- Nursing homes
- Schools
- Museum
- Historic objects
- Conference house
- Kindergarten
- Street lightning
- Sewage plant
- Indoor swimming pool

This list is a small extract of some categories. Sometimes during benchmarking we find out that it is useful to divide the categories into subtypes like primary school, extended primary school and secondary school. The first seven categories are probably of interest for the buildings of the project intelligent metering. If an object has different categories of usage it is often very useful to have an own metering instrument for each of these sub areas.

Key figures of the objects:

The key figures describe the objects. If we look at the ratio of energy consumption per key figure we get comparable information to other objects of the same category (especially with the corrected values of a heat degree correction). This compares we call benchmarking and tell us if the object is more or less energy efficient.

Examples of evaluations of energy accounting



Example of a benchmarking: Annual energy consumption for heating (inclusive hot water) and electricity per m² heated area inclusive walls (gross) for different kindergartens. In the example of the energy agency Waldviertel a climate correction for the location is made.

There are different key figures like

- m² heated area inclusive walls (gross)
- m² heated area exclusive walls (net)
- m³ heated volume
- load of units in kW
- persons using the object
- hours the persons using the object per month, week or day

and lots of other key figures

In Germany they normally use net square meter, in Austria they use gross square meter, the way to find out the area may be very different in different countries. Especially the details make troubles, like counting a staircase, a heated room in the cellar, the winter garden,.. Often the same square meters are used for the energy scopes electricity and water.

The key figures and benchmarking makes sense for evaluating the quality of the intelligent metering and its success and to find out best practice examples.

For different categories different key figures make sense.

The next picture in German language shows a matrix for the accounting scope electricity, which compares categories with different possible key figures (Energy Agency Waldviertel, 2001).

Kategorien	Anzahl an Objekten	Strom																		
		EBF Brutt[m ²]	EBV [m ³]	Nutzer [n]	Nutzdauer [h/Mon]	Inst.Leistung[kW]	Bel.Straßenlänge [km]	Lampen [n]	EBF netto [m ³]	Klassen [n]	Stellfläche [m ²]	Parkplätze [n]	EWG	Beckenvol. [m ³]	Wasserberfl. [m ²]	Jährl. Einnahmen [ATS/a]	J. verkaufte Karten [n/a]	gepumpte Wassermenge [m ³]	Beiten [n]	
Bauhof	2	2	2	1	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bestattungsgebäude	1	1	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feuerwehrhaus	5	3	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Freibad	2	1	1	-	1+	-	-	-	-	*	-	-	-	2	2	1	1	-*	-	-
Gaststätte	1	1	+	-	+	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Gemeindeamt	10	9	8	9	8+	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Hallenbad	3	2	2	1	1	1	-	1	-	-	-	-	-	2+	+	+	-*	-	-	-
Kapelle	4	1	1	-	1+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kindergarten	12	12	11	12	12+	-	-	1+	-	-	-	-	-	-	-	-	-	-	-	-
Kläranlage	3	-	-	-	1	1	-	-	-	-	-	-	2	-*	-	-	-	+	-	-
Museum	2	1	1	1	1+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
Musikschule	4	4	2	3	3	1	-	-	-*	-	-	-	-	-	-	-	-	-	-	-
Parkplatz	1	-	-	-	1	1	-	1	-	-	1	1	-	-	-	-	-	-	-	-
Schule	7	5	4	5	4+	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-
Straßenbeleuchtung	16	-	-	-	+	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Turnsaal	1+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Übernachtungsbetrieb	1+	+	+	+	+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+
Veranstaltungsbgeb.	4	4	4	1	1+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Verwaltung	1	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wasserversorgung/Pumpwerke	24	-	-	-	3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Kanalpumpwerk	1	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Summe	105	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Anzahl der Objekte mit Jahresverbrauch
 Kennzahlen: Anzahl an vorhandenen Kennzahlen - Kennzahl wäre möglich
 + Kennzahl wäre günstig -* Kennzahl adaptierbar

It is possible to produce a matrix for key figures making sense for different categories.

The assessment of the data with the energy accounting program

First we have to define what we want to analyze in general.

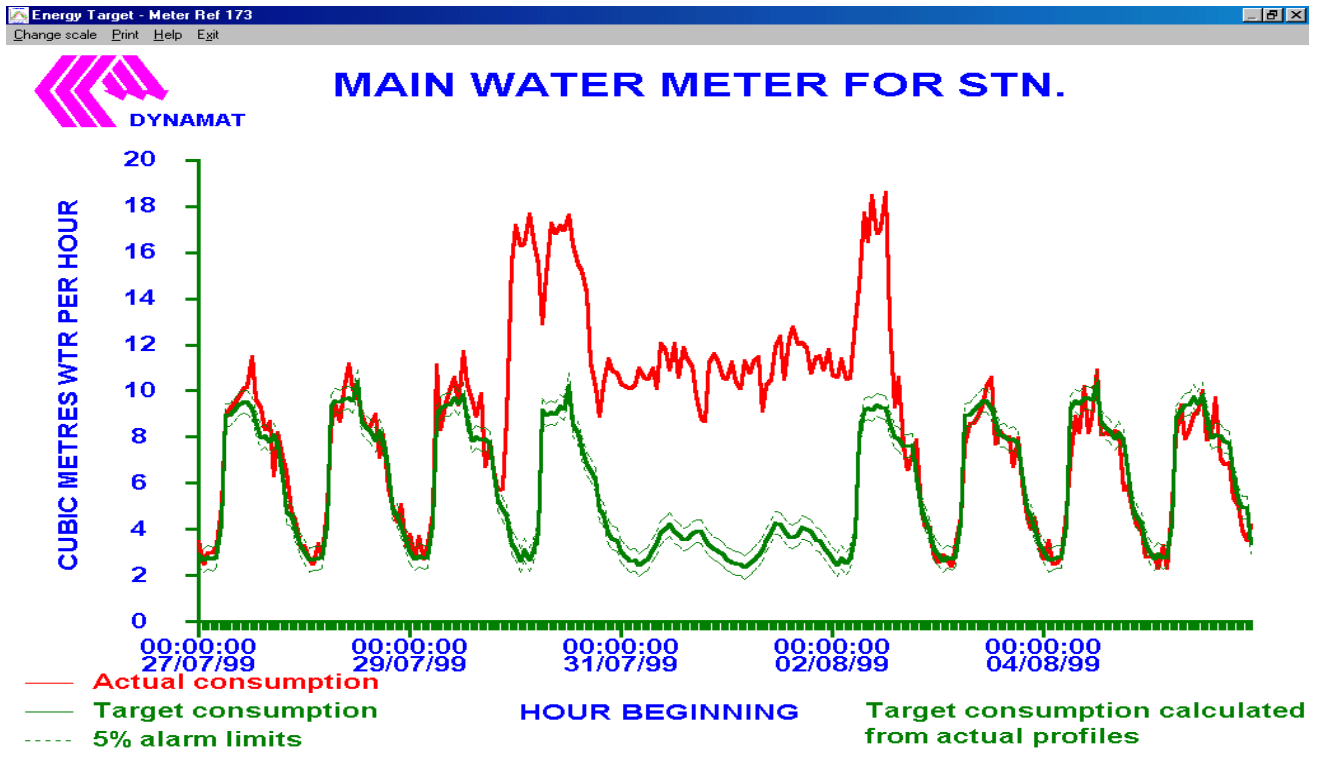
- A single monitoring scope like heating, electricity or water for the object.
- The whole energy for the object, which means heating plus electricity.
- A single counter, which gives detail information, especially if the consumption is abnormal.
- A combination of some counters, which maybe correspond to a sub area of an object.

We have to define which object we want to analyze. If a building owner (e.g. municipality) has more different objects to monitor, he is maybe interested in the assessment of the summary of these building consumption values or/and in the single values too. Same would be of interest for persons doing benchmarking for a couple of objects. Therefore the selection of one or more objects to evaluate could be by name or by category first and by name as a second selection. It is simple, if the building occupant wants to analyze his object. According to his login s/he may has automatically a pre-choice to his/her object.

Next we have to define the time we want to look at in our assessment. The last 24 hours or the last 3 years? Of course this will modify the time axis and unit. This time period can be chosen freely or may be a fixed one. The consumption has significant repeating curves, e.g. a day-line, a week-line or a year-line. 3 to 7 repetitions of these time-unit-lines are recommended to give good information for interpretation.

Now we look at the analyzed aspect in detail. The main aspect we want to analyze is the consumption on energy (in kWh or MWh) or water (in m³). We can compare this information in time with other older time units of this object/building. The graph itself gives additional information too, e.g. water consumption when not needed should be “zero” or at least a minimum, when some functions in the object need this

source continuously. Alarm limits to the actual curve are generated by sampling the older time-lines and allowing them a defined aberration. Special abnormal consumption days must be communicated to the analyzing program.



Example of an evaluation of EMT software dynamat (England). 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 lasts 4 days.

The actual consumption can be compared with the last year(s – or other time units) or with the mean over the last year. Summer with winter season can be compared, or season with non season, school time or working time with holidays. Especially the period of the less or not used building gives hints for potential of energy efficiency.

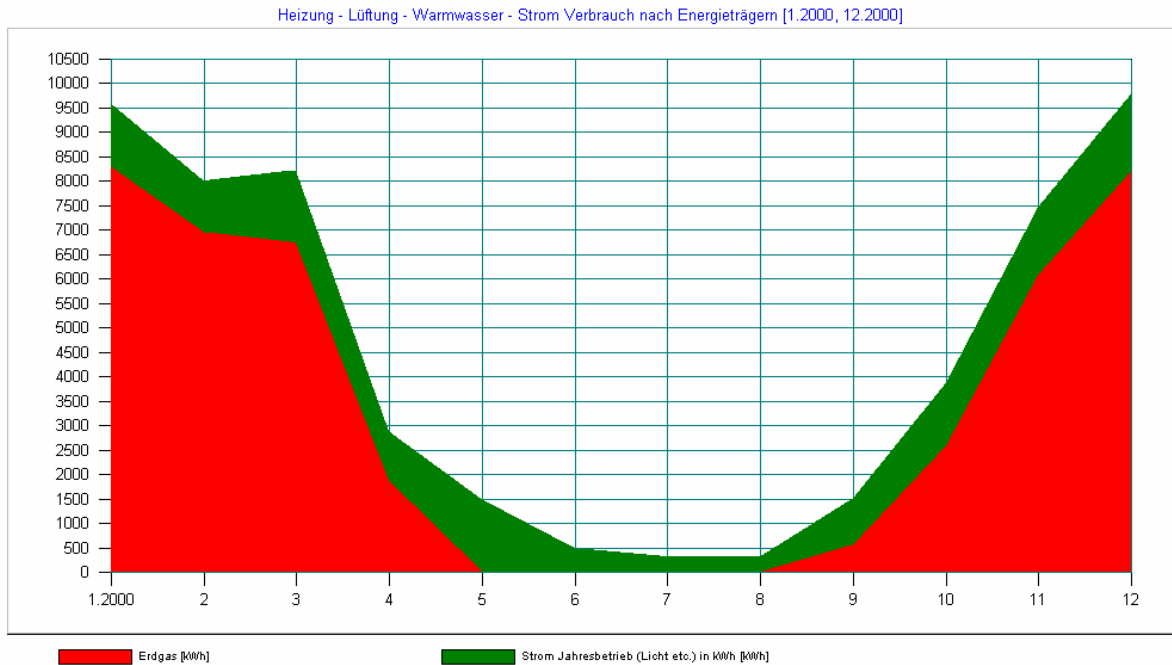
Costs can be linked with the consumption and evaluated too. There are two ways to handle the costs:

1. If you get a new bill, you input it into the database. Plus: it is easy; you can deal with discounts and price fluctuation without problems. Minus: You get the information about the costs only after filling in the bills.
2. You link the energy consumption with a mathematic correlation of the price. There is normally a fixed price component, which is charged per time unit (year, month,..) and a variable price component, which is connected with the consumed amount of energy or water or load. Plus: you get the information about costs the moment you consummated and monitored the amount. Minus: it is really difficult to build up these mathematical functions, they differ often to the real paid costs, discounts and price fluctuation are not considered.

We suggest using the first model. As somebody has to input these data, it should be done as simple as possible.

Other aspects related to consumption, which could be evaluated are emissions, caused by the consumption of energy. This can be Greenhouse gases like carbon dioxide, methane or nitrous oxide or their summary in in CO₂-equivalent or air pollutants like NO_x, SO₂, C_xH_y, carbon monoxide or dust.

Another assessment can be the load of the electricity or the distribution of different energy carriers in time.



Distribution of energy carriers in time of one object. Program Audit Gema, Austria, shows in green the amount of electricity and red of natural gas. One axis shows the months, the other one the kWh energy.

The amount of energy used for heating an object is highly dependent from the temperatures outside and inside the building. Normally the room temperature is more or less constant (it is often the control variable) and depends only on the category of the object and personal behaviour of the building occupants. The outside temperature is the crucial aspect in energy consumption in climates with distinct winters. Therefore we correct the consumption with a heat degree correction. It considers the difference between outside temperature and room temperature to correct the consumption. Sometimes this temperature is metered actually at the location and in some cases, the nearest meteorological station is used. In the first case the data are corrected hourly (or less if it is a short time unit to measure), in the second case daily or monthly data are corrected (after summarisation of smaller time units).

EMT uses the real data heat degree correction.

The monthly heat degree correction can be used for comparison of the climate of different months and years, or for the compares of different places that have a different climate. In the energy agency Waldviertel, Austria, they use the following equation:

$$\text{Consumption correction} = \text{real consumption} \times \frac{\text{local mean HDD}}{\text{local actual HDD}} \times \frac{\text{regional mean of mean HDD}}{\text{local mean HDD}}$$

(time-cor. Climate) (geographic-correction of climate)

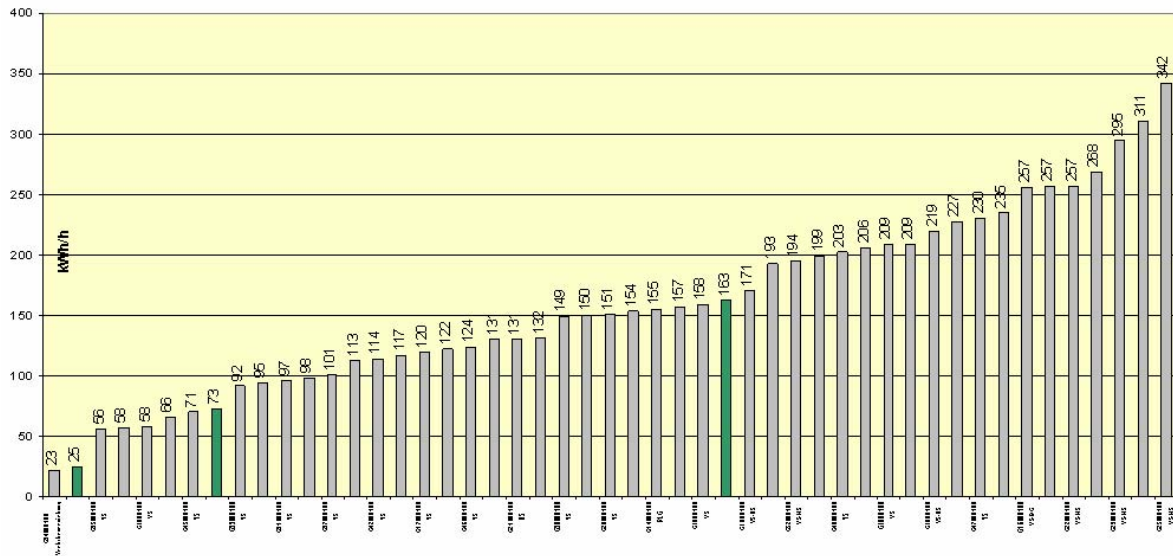
HDD heat degree days in °C

A problem can be if the local actual heat degree has the value “zero”, then the whole consumption gets undefined! The geographic correction of climate is done if a benchmarking, which compares different objects of the same category on different places is intended. The regional mean depends on the regions to be compared. With the applied heat degree correction the consumption in a colder climate as normal gets reduced, in a warmer climate gets enhanced. There are different heat degree corrections, depending on the outside temperature to start heating, e.g. 12° C or 15° C outside temperature and 20°C room temperature, which means a correction 20/12 or 20/15.

In a warmer climate the heat degree correction does not work as well than in a colder one, because other disturbance variables are important too, like the radiation, wind exposure or shadowing.

Benchmarking is done often by an administrator, who anonymizes the results, because the objects are belonging to different building users, which want their data security. In benchmarking not only the consumption but especially key figures are often used, to find out best practise. We also get information about user behaviour, building quality and condition of the technical plant by comparing different key figures.

Examples of evaluations of energy accounting

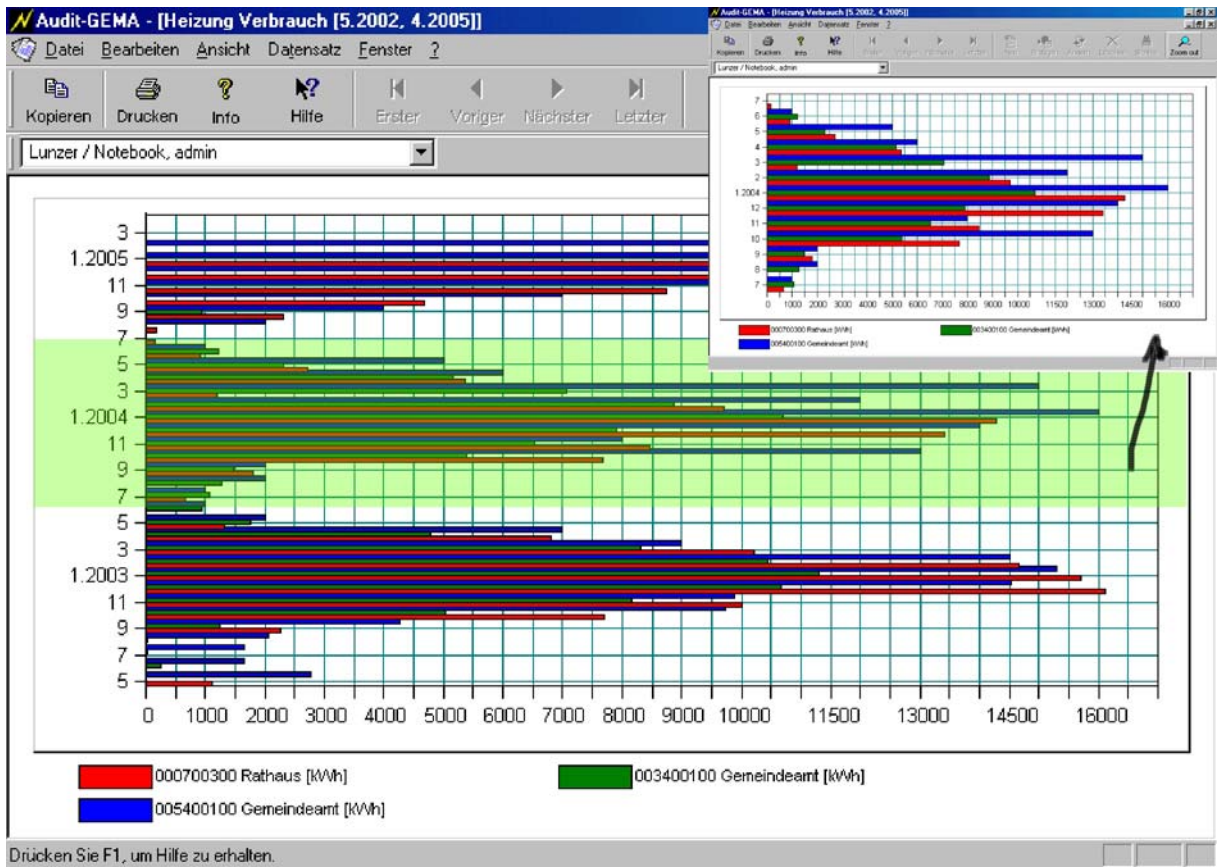


kWh/period of use during the school season

Example of a benchmarking of different schools in Austria (Energy agency Waldviertel). The key figure kWh consumption for heating per using hour is displayed. The first 2 schools are special schools, the next till 171 kWh/h are primary schools (“Volksschule”), the next starting with 193 kWh/h are primary extended schools (“Hauptschule”). The picture shows, that the category “schools” could be divided into sub-categories.

The results can be presented as a table or a graphic. The energy accounting program should have the possibility or export the tables into a spreadsheet-program. Tables and graphics should be saved under

common data formats. You should have the capability to edit the results. For printing it is a good feature to optimize colour graphics to black and white. If the graphic consists of a lot of data, a zoom in function into graphic details is also very helpful.



Example of a zoom-in function on an energy accounting assessment (Program Audit from energy agency Waldviertel, Austria): Drag the mouse over an area of the evaluation produces a new detailed picture.

The graphic should be simple and to understand at the first glance. Axis should be labelled as well as the scope and topic of the diagram itself, a clear legend helps to identify the analyzed aspects.

During evaluation of the data the more complex energy accounting programs make validity check of the used data. If single data points are missing, some of the programs give them the value “zero”, other more sophisticated ones calculate the most probably value of the fitting into the graph.

3.12 Responsible Persons and building occupants

There are different persons involved in the intelligent metering and in each form of energy accounting too. To all these persons the system of intelligent metering will provide information, which can be different depending on the needs of the person. Let us look on them in detail:

The building owner

is only interested in peculiar questions. The building owner will look at the data only in long and unsteady intervals and maybe uses the system as a sort of controlling. The building owner can be a regional government, the municipal administration or the representatives of them.

The building responsible

This will be in larger structures the department which is responsible for the consumption of energy and/or water, or for the costs (that can be a different section too). The building responsible/building manager will control in regular intervals and stays somewhere outside the building, maybe even not in the same town in which the building is situated.

The caretaker

This is the one, who has to take care for the building, stays inside the building and therefore can react, if something is going wrong. The person will look in regular intervals for the consumption and search for the reason if it is abnormal. The caretaker will also keep an eye on the behavior of the building occupants and will train them if necessary in energy efficient behavior.

The occupants

The building occupants live or work inside the monitored buildings. They have the possibility to look at the actual consumption (probably in irregular intervals) if they are interested enough in their consumption of energy and water. This is the large group, which is important to be trained in energy efficient behavior. Especially after the training they want a feedback to see, if their change of behavior brought some success in reducing their consumption. In the case of intelligent metering this will be the website from Esbensen with the dynamat assessments.

The attendant

These are the energy agencies or similar groups. They will control the building consumptions from time to time. They will help the caretaker to find out the reasons for abnormal consumption of energy or water. They will train the caretaker and sometimes the building occupants too. They will also try to evaluate the intelligent metering system and their success.

The measured consumption data are transmitted to the energy accounting server at Esbensen. This data are evaluated by the monitoring program dynamat of EMT. The assessment results are displayed at the Esbensen Website. Now the persons allocated to the buildings by login and password can use the internet to see this assessments. In the case of intelligent monitoring these are the building owner, building responsible, caretaker, occupant and attendant.

After changes in the building structure or after training sessions the interest in looking to this page is high. But normally as long as there is no aberration to the normal consumption, the interest of the users of the website is low.

If there is an abnormal consumption the dynamat program can start an alarm if wanted, which means to send automatic an email or sms to the building caretaker and attendant. They have to find out the reasons for this aberration. The caretaker, attendant and building responsible may phone or mail to communicate and find out the reason for the aberration, which may be a technical malfunction, a worse behavior in energy use or other problems.

To reduce the consumption there are 3 different aspects we have to look at:

- A) this irregular events of abnormal consumption
- B) a base load, which is too high at times with no or few use
- C) high regular peaks at the same time of the day or week

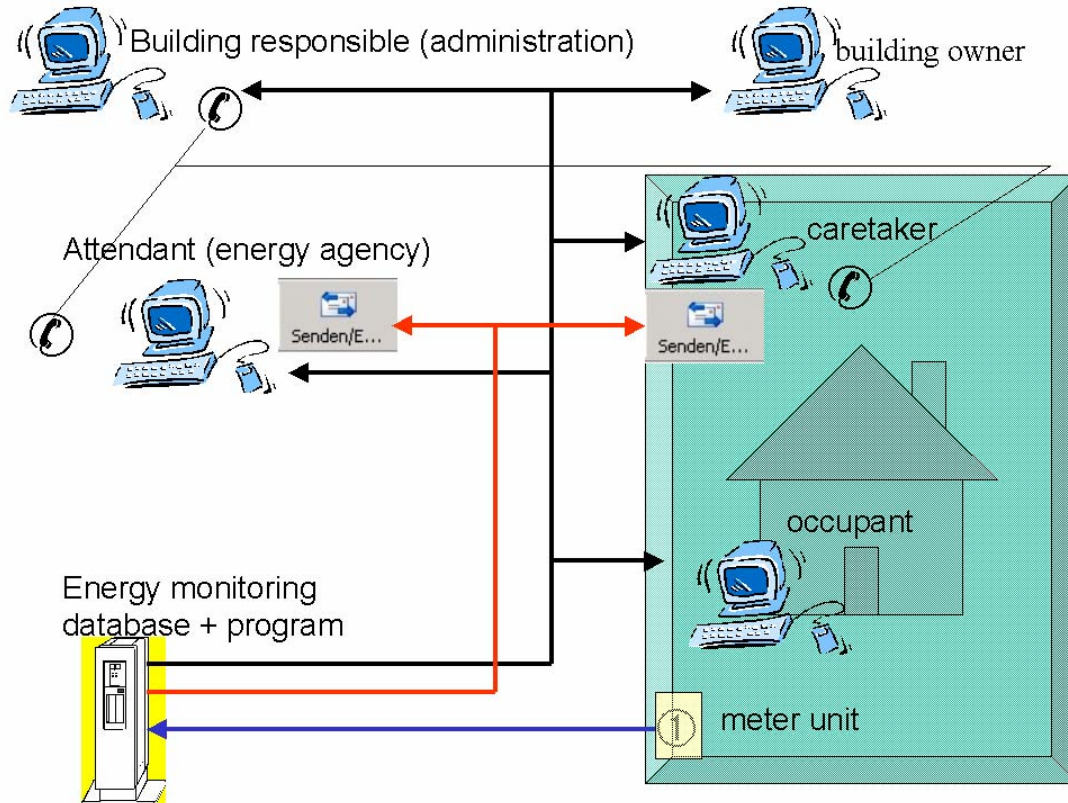


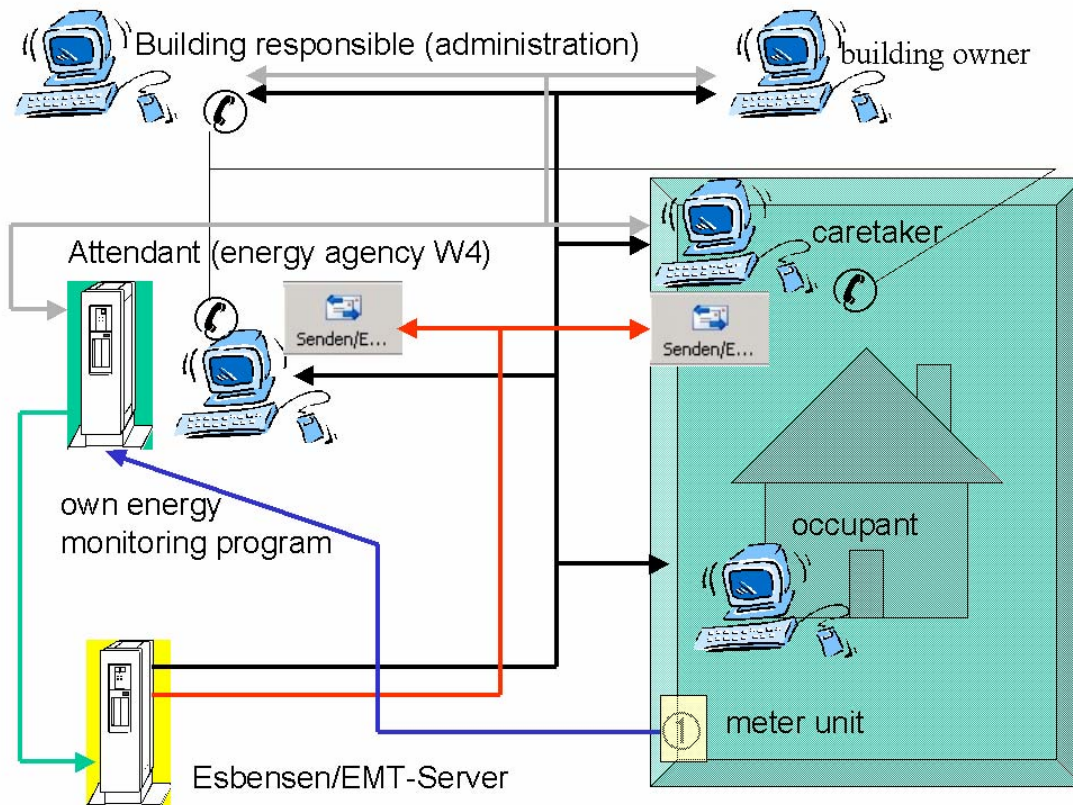
Diagram of information flow and participants in intelligent metering: Blue line...flow of metered data; black line...results of actual energy consumption seen on the website; red line...in case of alarm an email will be sent; fine black line...participants will communicate to find out the reason for abnormal consumption and will alter this state.

The attendant (with writing right), the caretaker (writing comments to times of abnormal consumption possible) and building responsible (only viewing right) may look to the other additional sampled data of the object on the Esbensen database (not only measuring data but also additional ones for example key figures, histories, specific data are written in this database). This will help the communication and evaluation.

The working together of the caretaker of the building and the attendants is of high importance. The attendant will find out the detailed information of the building (key factors, use specifics, characteristics and special features) best together with the help of the caretaker. The work with the building occupants will examine how the outputs from the Intelligent Metering will be used. The caretaker knows the building occupants best to influence them to energy efficiency. If the caretaker is an interested person (s)he will find out some more intelligent parameters to succeed in reduction of the energy and water consumption.

To the diagram above there is a possible alteration to the intelligent metering, as some energy agencies (e.g. Energieagentur Waldviertel, Lower Austria) doing already a form of energy accounting may do the following:

Blue line...flow of metered data sent to the energy accounting server, which may be an application server – there the energy data are evaluated; green line...from the energy accounting program the necessary data are sent to the Esbensen Server, where the program dynamat evaluates and send the results to the Esbensen website; grey line...additional information of the energy accounting program of the server of the attendant (e.g. EAW4) black line...results of actual energy consumption seen on the website; red line...in case of alarm an email will be sent; fine black line...participants will communicate to find out the reason for abnormal consumption and will alter this state.



Example, how intelligent metering will be done at the energy agency Waldviertel (EAW4) in Lower Austria.

Especially the attendant will use the Esbsensen data base with their additional data for finding out the reasons of abnormal consumption, for a history of these “events” and their reasons (the caretaker will give comments to this events) and for the evaluation of the whole intelligent metering project. The designated project website will be the main source to view and evaluate the quality and effects of training and to find out best practice examples.

4. Conclusions

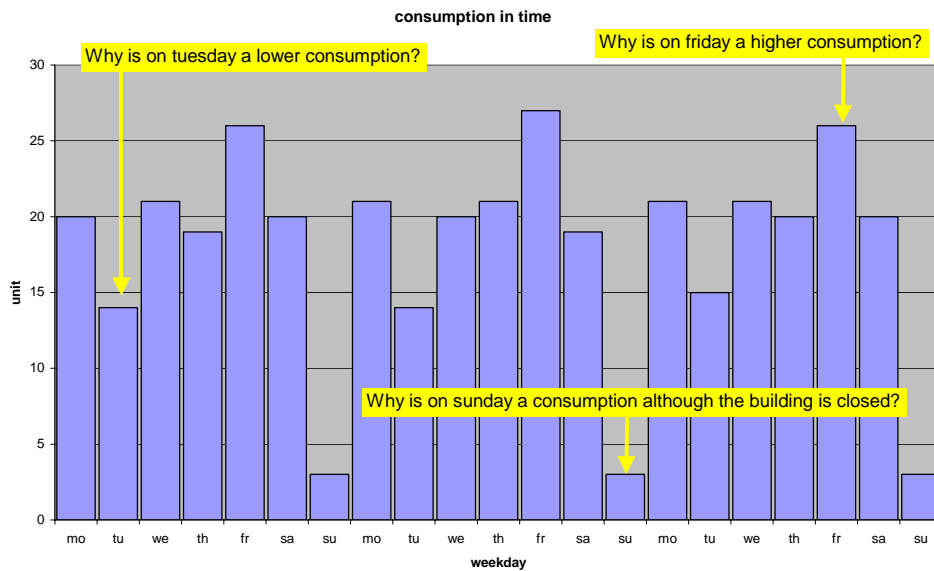
Measuring Data can be inputted into a controlling program manually by hand or automatically read out by remote control. Only the second type allows controlling of short measuring intervals. A shorter interval enables to recognize a singular event much better than a longer one.

In some countries the electricity suppliers use 15 minute intervals for analyzing the load and amount of provided energy for billing reasons. To identify the reasons of abnormal energy/water consumption events 30 minute intervals as we will use in the intelligent metering project are sufficient.

We will control the consumption for heating, electricity and water of the chosen objects. If we have more objects of the same category of use, it is easier to compare them and less work in the development of training programs for the building occupants and caretakers.

In some countries the electricity consumption of one object is not linked to only one counter but more different ones because the electricity suppliers have a lot of different rates, depending on the use of the flux or the time of consumption (e.g. summer-winter, day-night). In this case we can monitor different counters, which will raise the costs for monitoring. Or we will analyze them in an energy accounting program sum the counter up for each of their 30 minutes intervals and send them to the control program (dynamat of EMT).

The assessment is primary applied to the consumption in a specific period of time. The first information will be the value itself, which may be high, low or normal. Second it is also of high informative value to compare the actual consumption value with recurrence intervals. These intervals may be days, weeks or in a few cases months. If there are recurrence intervals of weeks a possible day of the week with an abnormal consumption can be found out. If there are recurrence intervals of days a possible (half an) hour of the day with an abnormal consumption (high or low) can be found out.



If special time units have specific consumption abnormalities, questions will arise for their reason. Somebody, normally the caretaker of the building is able to identify the causes. In some cases the caretaker will need the help of the building occupants to identify the incident of the abnormal consumption. The attendant will support the caretaker with professional advice.

It is obvious, that the caretaker needs a possibility to control the consumption at the (Esbensen) website in the internet. The Caretaker should also be informed in an automatic way if the value of the normal/target consumption is exceeded or fall under a predefined aberration. This will be by email on the personal computer (like EMT's dynamat) or SMS (short message system) on the mobile. Identified causes of abnormal consumption events should be inputted into the (Esbensen) database by the caretaker in date, time and reason. So we may find out pattern in the use of energy or water. These patterns can influence the content of the training program of the building occupants.

Some building occupants may be interested in the absolute consumption, but there maybe key figures, that will interest them more like the consumption per person or the consumption per usage hour. This values may be translated into costs or (especially Greenhouse gas) emissions. This will give them a feeling of the influence of their energy efficient (or not) behavior.

After the training of the building occupants their interest in energy efficiency can be estimated in the number of accesses on the Esbensen website and in the energy consumption of the building too. If the consumption is rising and the number of accesses on the Esbensen website is low, this will point to the conclusion that the training didn't work well or was forgotten. So it should be done again (or maybe in another way).

The outside temperature must be considered in the assessments of the sector heating, because it may strongly influence the consumption, and therefore mix up with the effects of behavior changes. After the correction of the climate the interpretation of the user behavior will be possible. The outside temperature will be metered with sensors on a suitable place and sent together with the consumption data. But also malfunctions of the plant influence the aberration to the normal/target value. So the plant has to be controlled too. This is done by the caretaker of the building. The attendant may help the caretaker with checklists to find out possible incidents.

Some premises for the intelligent metering project are following now:

The counters for heating, electricity and water have to send out pulses which will be collected in units and have to be transmitted automatically at least once a day.

A database (in our project provided by Esbensen) receives the counter data in a predefined form (a CSV-file with 6 fields) and imports it automatically.

Once a day the consumption data from this database will be analyzed automatically with the controlling program Dynamat (of EMT).

The results of these assessments will be sent automatically to predefined pages on the Esbensen website, maybe best in form of a picture file. So the Esbensen web pages showing the actual (or at least one day old half hourly consumption data) are renewed daily. Best would be one evaluation showing the last days and one showing the last weeks for each counter/accounting scope.

The Esbensen data base does not only collect these measured counter data but also standing building and meter data. These data will describe the monitored object and collects the abnormal consumption events (date, time and comment of the caretaker, allocation of the reason to the event). An abnormal consumption occurs, if the normal consumption – a mean over the pre-values of the same time and weekday – has a predefined aberration. On an abnormal consumption event, the Dynamat program (EMT) can be programmed to inform the allocated attendant or/and caretaker of the building in a self-acting way. Best may be, if only the allocated attendant who will be a project partner like an energy agency gets this auto generated alarm by email from the DYNAMAT programme and decide if it is a short-term aberration or and important event to inform the caretaker by himself. So the caretaker gets not to many alarms but is informed of relevant key changes only. The Esbensen data base will also help by the evaluation of the project and for finding out best practice examples of buildings und training.

The results of the assessments of the buildings can be viewed by different participants in using their own login and password, which is connected with different rights.

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