ENERGY SAVINGS FROM INTELLIGENT METERING AND BEHAVIOURAL CHANGE: CASE STUDY
Gymnasium i Aabenraa, High School, Aabenraa, Denmark

This case study examines the benefits to a Danish high school of monitoring its heating, electricity and water consumption using an automatic monitoring system.

General description

Description of the building

Aabenraa High School has 600 pupils ranging from 16 to 19 years old. There is 80 staff employed on the premises.

The buildings were constructed over a period of many years, with the earliest building dating from 1906 and the latest addition being made in 2002. This provides for a very varied energy use/need. The building is owned by the local authority. The total area of the school is 14,352m^2 with the heated area being 13,040m^2.

The buildings are being managed with the so-called BMS system, however this system focuses on managing the temperatures and air flow in the building, amongst other things. It is not aimed at surveillance and controlling of the consumption data, so the Intelligent Metering graphs worked as a supplement to the already existing controlling system.

Location

The school is situated in the centre of the town of Aabenraa, which is located close to the German border, by a fjord.

It is located at a latitude of 55^o 2N and longitude of 9^o 24E.

The energy and water consumption figures are read manually by the technical staff and sent to the local authority, The County of South Jutland, which is in charge of the overall consumption.

Levels of energy consumption

Table 1 presents the DK benchmark figures for energy and water consumption, based on survey data of over 500 high schools in 2004.

	Good practice	Typical	Poor practice
	kWh/m^2/ annum	kWh/m^2/ annum	kWh/m^2/ annum
Electricity	18.6	30.3	46.1
District Heating	69	104.8	147
	m^3/m2/ annum	m^3/m2/ annum	m^3/m2/ annum
Water	0.14	0.24	0.34

Table 1: DK benchmark for energy consumption in high schools

	2004
	kWh/m^2
Electricity	23.55
District Heating	57
	m^3/m2
Water	0.14

Table 2: Actual figures for energy and water consumption for Aabenraa High school

Behavioural patterns

The high school's operational hours are 07:30 to 16:00 with additional evening and weekend use, particularly the sports facilities, which consist of a sports hall, but no pool. Cleaners and maintenance staff are in the building before teaching begins. The school is closed for 12 weeks of the year for holidays.

Needs assessment

Monitoring objectives

Under the regional County, the high school is responsible for their own consumption budgets, which means that the schools are responsible for managing their own finances, including the payment of utility bills, but are then also able to use any gained energy savings as they see fit, which is a strong incentivising factor to make a difference in energy consumptions.

The building has been administered through a so-called BMS system, which enables the technical staff to centrally steer the need for electricity and heating.

However, the number of sensors within the buildings, which the BMS system is based on, were limited or the sensors were not placed in rooms that were used frequently. Consequently it has been difficult for the technical staff to base the requirement for heating and electricity on actual needs. For instance, the heating sensor was placed in a classroom, which was seldom used. This meant that need for heating was registered to be higher than needed, since the classroom that were being used also where warmer from the heat that users give off to the room. Consequently, the windows where opened by the students and wasted heat.

Parameters to monitor

Energy and water are the most controllable elements in the high school's budget and by using simple and cost effective efficiency measures utility bills can often be reduced.

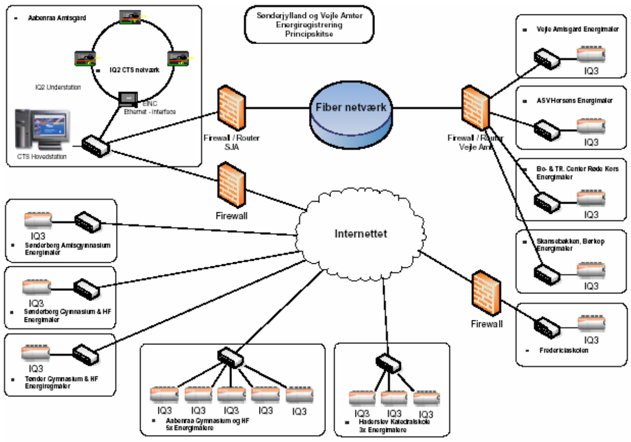
At the same time, an energy and water saving project at a high school gives an opportunity for the teachers to involve students in energy saving measures. With on-line consumption figures, the teachers can make students aware of energy consumptions and what it means for a society in general.

Implementation needs

The BMS system is more a building control system rather than a surveillance system, so this has been a missing factor at the high school. For example, the surveillance of water consumption does not indicate whether there is any sign of overnight consumptions caused by leaks. The Intelligent Metering system was in this case a good way to keep surveillance of the everyday consumption.

Monitoring systems

For all the buildings that are a part of the Intelligent Metering project, the data is collected in the same way.



Above is the drawing of data collection from the Danish buildings to the central server (CTS) in Aabenraa.

Communication (Data Transmission Protocols)

From the CTS on the main station in Aabenraa County building, the data is collected once a day from the IQ3 boxes. This takes place between 6-7 p.m. It takes approximately a minute per sensor. The sensor data is transported to Aabenraa County via the local network and the line that connects the two county buildings included in this project.

The collected data is saved in an Access database. When the data is transported on to the Intelligent Metering database, the data is sent as CSV files. The CSV files are sent daily via FTP to the SQL database around 9 pm.

Data management (Data storage)

Within the European Commission supported Intelligent Metering Project (ref. EIE/04/107/S07.38635) the half hourly information, once collected, which is transmitted to an SQL database, is used to generate consumption graphs which are displayed on the project website (www.intelmeter.com). The school can then access their information via the public Internet.

This automatic reading of meters and data analysis allows monitoring against historical targets or theoretical guidelines. Consumption can be related to weather, occupancy, production or a signature of past consumption profiles.

Costs

The cost for the system was 18,400 DKK (approx. 2,500 EURO) including all components, programming and electrical works.

Lessons learnt

The collection of data in an SQL database proved to be a successful solution due to the possibilities for analysing data afterwards. However, since the building is now also using the figures for showing students in classes, it would have been beneficial to make consumption data available as quickly as possible, perhaps updated once an hour on the internet. As the system is now, the data is one day old and therefore perhaps less interesting for students, but good for energy management.

This particular high school met the project with some sceptism, particularly the technical staff. However, the teachers paid an interest in the running of the school and therefore the technical staff was forced to focus on the energy saving issue.

Monitoring Management

Procedures

The system automatically sends data to the Esbensen SQL-database once a day with half-hour pulses from the last 24 hours.

Responsibilities

As with all of the buildings based in Denmark managing the monitoring output has been the responsibility of HO Service A/S, a service provided by the local authorities.

Lessons learnt

It is beneficial to have alarms set that warn the technical staff about unusual behavioural patterns, especially if it is not possible for the technical staff to view the graphs on a daily basis.

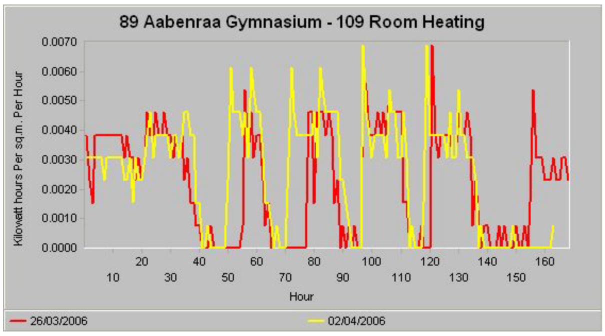
Data Analysis

The energy consumption data is compared as key figures to the previous day, week and month, so that the images of the consumption are always two graphs on top of each other. This gives a clear image of how the energy and water is consumed compared to a similar day/week/month.

Saving identification

Heating

Example from a DYNAMAT graph –week-on-week heating consumption.

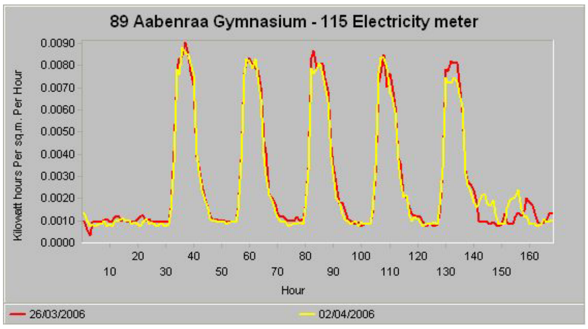


There are three key issues to consider:

1. sudden jump, found to be due to colder weather conditions or use of larger facilities
2. low consumption over night.
3. high peaks

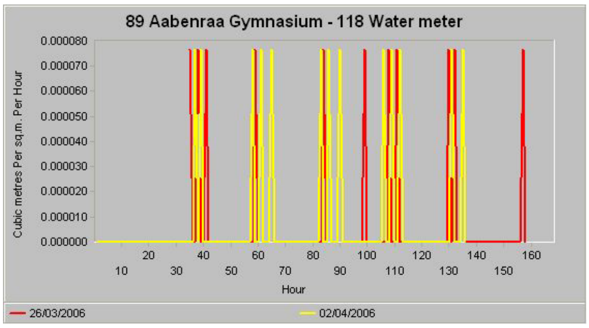
A similar graph (below) for electricity also illustrates two key patterns:

1. very even weekly pattern;
2. stand-by consumption.



A graph (below) for water consumption illustrated that:

1. there were no leaks during the week;
2. there was an uneven pattern, which called for the sensor to be altered and more sensors to be put up



Lessons learnt

During personal visits (see Training section) to the High school, the consumption graphs were reviewed and the building was examined together with the technical staff. It was concluded that the building, being a mixture of new and old blocks, needs different energy supply to different areas in order to maintain an acceptable indoor climate.

Heating:
The building needs to install more sensors in the classrooms in order to be able to run the Building Management System (BMS) on actual values. For example, the heating sensor can be placed in classrooms that are rarely used, and can therefore be informing the BMS to add heat in all classrooms but this may not be needed so much in the rooms where there are students that give off heat or in the new building that is insulated better.

Electricity:
The server room is ventilated with electrical ventilator, but two holes have been made in the wall to make use of natural ventilation. It is now possible to use the electrical ventilation only when the temperature difference between inside and outside is very low.

The kitchen had a separate water boiler, running on electricity, which has now been connected to the district heating system instead and save on the electricity consumption.

The roof lights needed a thorough clean in order to give off the proper light in the classrooms. There were several individual lights installed as a compensation for the ineffective light, however, these could be saved if the roof lights were improved.

The building was suffering from moisture problems, which also causes an increase in electricity consumption, as a number of de-moisturisers had been installed. It became clear that a few drains needed to be cleaned, so that the water outside would not run into the building.

Training package

A training package, produced as part of the Intelligent Metering project was developed and customised towards Danish buildings and standards. It was then presented at a launch event for the building managers and teachers. The training package's aim was to provide support so that building users could change their usage patterns in order to save energy and water. In order to give the training more structure, the training plan was divided into three main areas:

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 the building users in the sustainable development process.

Incentivising - In this case they are municipal authority interventions, for example economical rewards for reducing energy and water use.

Training used

As well as the launch event for building managers, teachers and technical staff, individual meetings were made by the local authority, the County of South Jutland, to the high school, in order to show the graphs for consumption figures and firstly, to review the immediate and future potential for energy efficiency. Secondly, to define the need for training building users to enhance awareness on energy savings and hence cost saving measures, based upon the graphs provided on the website.

The County was met with some scepticism from the technical staff, due to the fact that they did not know that the savings on energy would benefit the budget and would give them free hands to invest. Once this was established, the door was open for the County to suggest savings.
The goal to involve students did not work as intended as they were unable to see what the graphs COULD be used for and focused too much on what the graphs COULD NOT be used for.

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