EXECUTIVE SUMMARY

Energy Management Technologies for Towns and Municipal Quarters

THERMIE PROGRAMME ACTION
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Produced by:

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1 OBJECTIVES

The overall objective of the project is to assess the feasibility and to prepare the implementation of energy management systems for electricity and heat supply and use at the level of a municipal quarter or a whole town in order to decrease the energy demand and thus contribute to the reduction of CO_2 emissions.

2 BACKGROUND

Energy management in cities is mainly restricted to single public buildings or to several large offices, industrial or public buildings which are connected to a central control unit. As the experiences with such systems proved, significant energy and financial savings can be achieved. New developments on energy management technologies, especially installation bus systems, open new possibilities of designing and using energy management systems also in the residential sector. Among these are systems which could be applied an the level of a town quarter or a whole town.

With municipal energy management systems local authorities, municipal works or housing building societies get the possibility to co-ordinate energy demand and supply on a higher level. It is a tool to decrease the overall energy demand and to avoid peak loads in electricity and heat supply. On the background of increasing insulation of buildings towards low energy houses energy management is necessary in order to minimise energy losses due to wrong user behaviour and thus to save energy. Furthermore related impacts on wrong user behaviour like retrofitting costs could be also reduced by this approach.

The new approach of municipal energy management is a possibility for European technologies to open and push new markets and thus increase their market position inside and outside Europe.

3 WORK PROGRAMME

Phase 1: Assessment of the state of the art of the European energy management technologies

Within the first phase of the project, the proposers commonly assessed the state of the art of European energy management technologies which are able to be installed at city quarter level focusing on innovative bus systems. Special emphasis is laid on developments in the near future which would influence the usage of the available systems for municipal energy management. The determination of the state of the art of the technology is necessary in order to assess the market potential in the second phase.

Phase 2 : Market analysis for municipal energy management systems

The market for this new approach of municipal energy management was assessed in Germany, UK and France considering especially the different frameworks of the countries and also different implementation schemes, e.g. in areas of new building development or in areas with existing building structure, implementation in local authorities, in municipal works or in housing building societies. Targeting and monitoring of energy demand will be one major advantage at the level of a town quarter or whole town which could be a push to the market and open a wide range of applications and thus a respectively promising market.

Phase 3: European implementation strategy

Out of the results of phase 1 and 2 a European implementation strategy was developed for local authorities, municipal works and housing building societies which gives guidance on

- how and where to use municipal energy management systems,
- which systems are available,
- which technological developments are being done or should be done,
- which structures within the local authority, the municipal works or the housing

building society should be available,
- possible financing schemes,
- how to overcome legal, administrative and organisational constraints.

The strategy can be used as a tool to identify possible fields of application for municipal energy management systems and as a guide on how to implement them.

Phase 4: European Workshop „Municipal Energy Management and Building Automation"

The gained results of the action were presented in an European Workshop on municipal energy management systems. Target groups invited to the event were local authorities, municipal works, utilities, housing building societies as well as manufacturers of energy management systems and innovative engineering companies.

The results of the workshop were disseminated in form of proceedings, which were also be made available for interested groups which could not participate at the workshop.

4 RESULTS

Phase 1

The technology area of building automation and energy management includes a variety of systems, over a wide range of complexity, designed for the control, monitoring and optimisation of various functions and services provided in a building, including heating and cooling, ventilation, lighting, telemetric services, security and safety. The structure of building automation and management systems is characterised by sensors and actuators, networked according to a specific topology, part of which act multi-functional, i.e. they can take over several control functions and process different types of commands. This allows efficient and sensible interaction between various building services.

Building services can be controlled by numerous methods. Most systems seek to control either by time or a parameter representative of the service like temperature for space heating or illuminance for lighting. This can also vary with time. PC workstations can be used to implement timing programmes, logic gating, event atmospheric conditions programmes, status logging and event logging supplemented by appropriate instructions or messages.

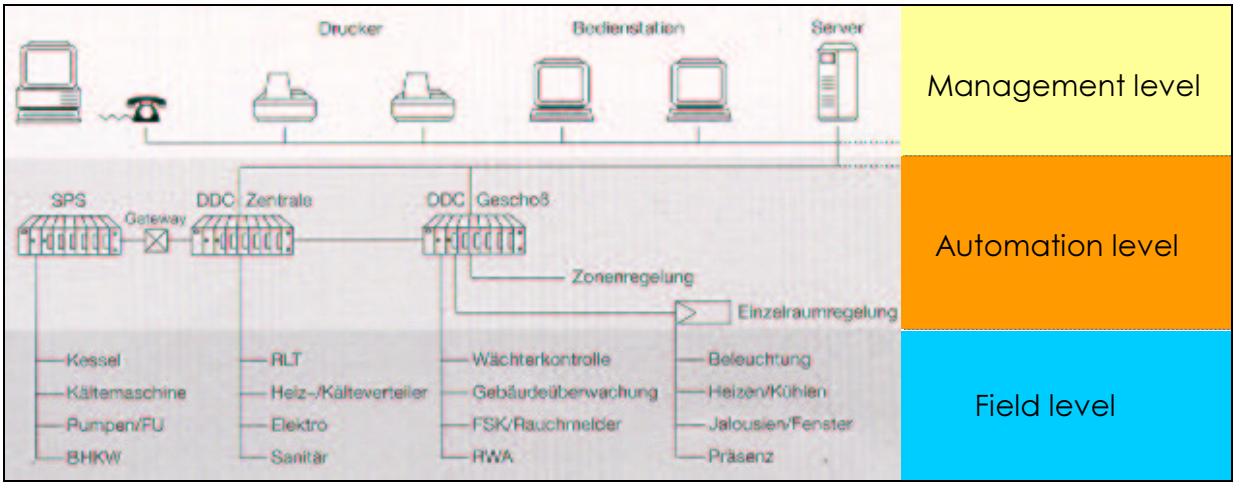
Table 1 summarises the various control and optimisation algorithms of modern building automation and energy management systems. The programs correspond to the state of the art and are already readily available as standard software.

Table 1: Diverse management and automation options of BEMS

Diverse management and automation options of BEMS
▪ Time-related switching of devices
▪ Event-related switching
▪ Sliding switching
▪ Load management (heat, electricity): load dependent set value management, maximum load limiting, tariff-related switching
▪ Demand related and atmospheric conditions controlled adjustment of devices according to various concepts and algorithms
▪ Control of limiting values
▪ Co-ordinated operation of various devices with different performance functions
▪ Demand oriented maintenance of systems
▪ Utility data tracking for monitoring, controlling and diagnostic purposes

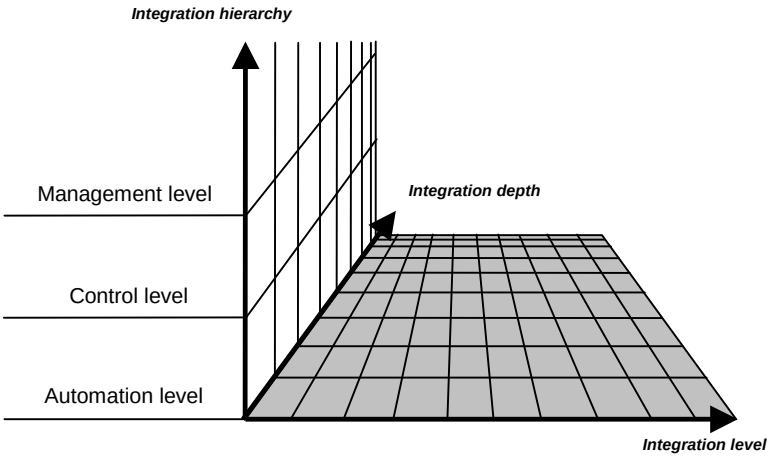
Nowadays international standards subdivide building functionality into three different levels: the field level, the automation level and the management level.

Figure 1: Principal hierarchical structure of building management systems



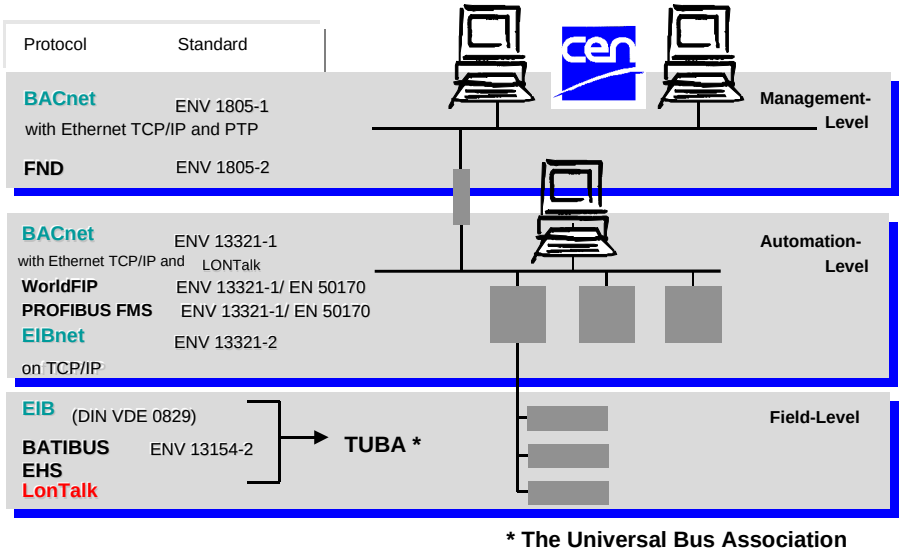
Against the background of the hierarchical levels and of the tasks intended to achieve, several integration options emerge. In this context an integration hierarchy can be defined (s. figure 2).

Figure 2: Integration options of modern building management systems



To provide a framework for the common definition of functioning of products and systems in the field of building management products and systems for HVAC applications and interfaces to them a European standard for building automation and control systems was drafted by the European Committee for Standardisation (CEN). According to this normative approach a product or system complies with the European data transmission standard, if it supports one of the pre-selected European communication protocols.

Figure 3: Pre-selected European protocol standards for building automation



*** The Universal Bus Association**

The following trends and technologies which could play an important role for the future development of building management systems were identified (s. table 2):

Table 2: Future developments and trends of BEMS

Java/Internet	Fuzzy logic	Power Line
▪ unique and flexible architecture of Java technology provides platform independent development and deployment of Java applications; ▪ Java applications can run on almost all platforms and easily intercommunicate between platforms; ▪ very comfortable remote control of buildings through the connection of Internet and BEMS.	▪ especially suitable for complicated non-linear controlled systems with several influencing variables; ▪ incorporated in expert systems it is expected that fuzzy logic can help to meet users' needs in a very flexible way; ▪ the design of complex adaptive controllers may become much easier by the use of fuzzy logic and thereby less cost-intensive.	▪ facilitates data communication between different electrical appliances inside a building through the existing electric network; ▪ no extra cables are required, costs can be reduced, occupiers are not disturbed by the installation work; ▪ some systems are compatible with twisted pair EIB systems; ▪ the public grid for communication over larger distances can be used.

Phase 2

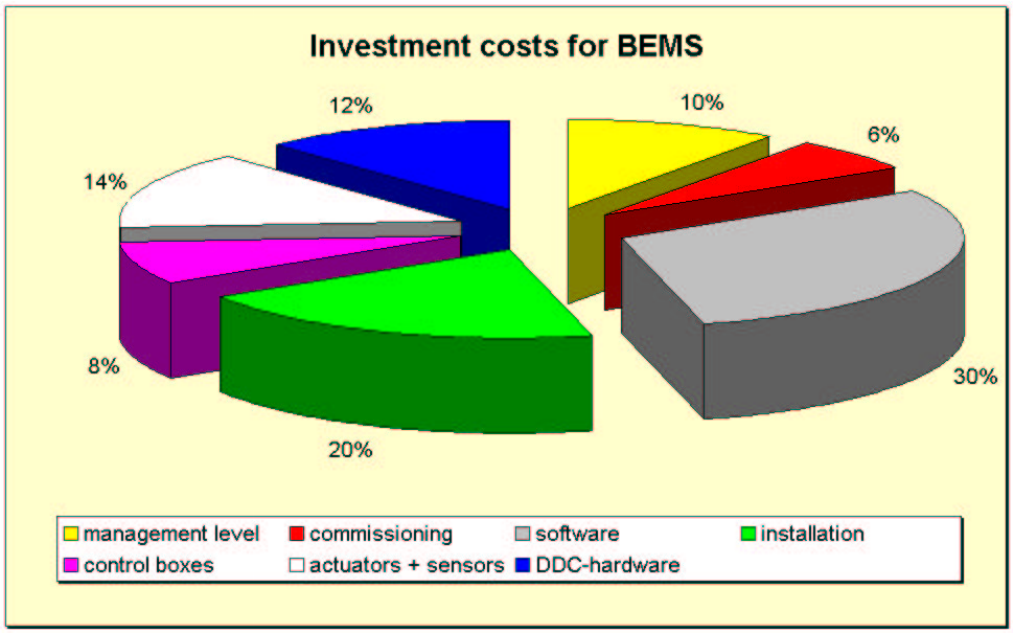
The domestic and tertiary sector constitutes a major energy consumer within the EU and world-wide. The energy consumption of EU's building sector amounts to

320 Mtoe per year (1995), which represents around 40 % of total EU energy consumption. The "intelligent" demand-based and co-ordinated operation of different technical building appliances holds an enormous potential for the reduction of the energy consumption and the related energy costs in the commercial and residential building sector as the use of these systems is expected to save up to 15 % of primary energy in the EU by 2010 which would contribute decisively to the necessary abatement of environmentally harmful emissions. Experiences in Germany, France and the UK show that for heating and cooling the energy saving potential is up to 30 % in the public buildings area and fairly of the same scale in the residential sector.

Management systems for municipal and commercial buildings in Germany, France and the UK vary from non existent/very simple (i.e. no more sophisticated than typical dwellings), though a range of complexity to very comprehensive installations. The majority of modern BEMS are moving towards local controllers with data transfer to a central location and an element of remote control. In some cases controls can be adjusted remotely, in others manual intervention is required at the remote controller. A wide range of data communications media is in use, including dedicated cable, network cable (twisted pair), fibre optics, modem/phone/ISDN, radio and mains power cable (now feasible).

The investment costs for building automation and energy management systems depend on the degree of desired functions, the complexity and size of the buildings and the implementation into new or existing buildings. In general investment costs for BEMS amount to 150 - 300 € per "Information point" (that means per elementary function like switching or sensor signalling) which results in specific costs of about 5 - 20 € per square meter useable floor space. The main part of BEMS investment costs is apportioned to software and installation which is shown in figure 4.

Figure 4: Average breakdown of different BEMS investment costs (medium and large sized projects)



According to estimations the total potential short- to medium-term investment for large energy management systems in Germany suitable to be applied at town or municipal quarter level is expected to be about 410 M€ per year. The estimation is based on fundamental considerations (e.g. typical annual retrofitting rates) as well as an taking into account economical restrictions (e.g. assuming that the investments are paid back by energy saving within 8 years). Overall European market parameters show that sales are currently worth up to 1,600 M€ a year (1995) and could achieve sales worth up to 17,000 M€ a year by 2010.

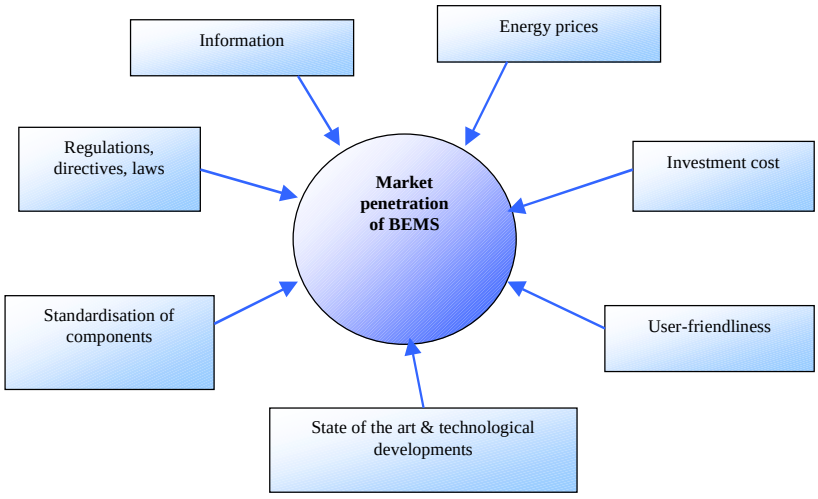
There are a number of important manufacturers in Europe which are able to supply about 80 % of the European market. At present the sector is experiencing a large market concentration and restructuring in order to be able to face the competition with US and Japanese manufacturers.

Phase 3

The market penetration of BEMS on city quarter or municipal level is dependent on a whole lot of influencing factors. Apart from financial and technical aspects information and user-friendliness of available technologies are important points to pay attention to.

Figure 5 presents an overview of a broad variety on factors influencing the market penetration of building automation and energy management systems. The set of these factors as a whole build a framework which has to be investigated when defining a strategy for a wider introduction of systems.

Figure 5: Factors influencing the market penetration of BEMS



Based on examinations and surveys within the three investigated countries of concern the following major factors which mainly constrain implementation of BEMS have been identified:

- high costs of installation (especially in the case of existing buildings) and maintenance of systems,
- current low energy prices,
- a lack of knowledge in potential user organisations, architects, planners and engineers; users fail to understand the system properly or find it cumbersome,
- risk of incompatibility between parts of the system affecting technical

performance; missing local checks to ensure that systems are being properly operated,

- the systems' lack of flexibility to adapt to a wider range of potential usage which varies with the age, size and ownership of buildings,
- non-appropriate organisational structures of potential user organisations, e.g. most municipalities have no representative responsible for cost- and energy-efficient operating of municipal buildings or plants,
- lack of user-friendly design of human-machine-interfaces (e.g. being over-informed by too many or badly structured/visualised data),
- appropriate design features are sometimes suppressed in production to reduce the overall cost of the system.

In order to overcome these barriers and to strive for large scale implementation of energy management systems on a municipal level the following requirements have to be met: beneficial structural and organisational prerequisites, increased compatibility of system components, intensified RTD, appropriate financing schemes and detailed information campaigns.

As the introduction and application of building automation and energy management systems at the level of a municipal quarter or a whole town constitutes a complex and comprehensive task it should be realised in three phases:

- Phase 1: Analysis
  This involves the analysis of the current situation of energy demand, energy support and costs. Discussion about possible upgrade wishes. Evaluation of user's specific situation concerning interfaces and levels of the processes to be controlled.

- Phase 2: Fixing the needs and demands
  Fixing the demands to the energy management system, based on the interfaces and control levels. Reviewing the upgrade capability of energy management systems and final decision on the energy management system to be used.

- Phase 3: Introduction
  Elaboration of a plan to introduce energy management systems, including training of staff, new organisation structures etc.. Introduction of the energy management system and parallel comparison of the fixed needs and demands with the results achieved.

However, before introducing a comprehensive BEMS into several connected buildings, certain points should be considered:

- What kind of tasks are to be performed by the BEMS?
- Which processes are to be controlled/managed in what way?
- Can the BEMS be easily adapted to existing organisational structures?
- What kind of accompanying measures (e.g. training courses) are necessary to make the work easier and more acceptable to the staff?
- Which interfaces must be available for further communication between personnel and other microelectronic units?
- Is there a possibility to easily upgrade the system to suit further needs?

Local delivery and support networks which focus on building relationships in a small area are a vital part of the growth of this market and of the successful implementation of these systems on city quarter or municipal level.

Energy savings on a large scale across Europe could be realised with BEMS technology. However, usage is unlikely to develop beyond the very largest organisations until the price and adaptability of the systems make them more accessible. Third Party Financing (TPF) could be an appropriate financing scheme to overcome financial barriers and thus contribute to exploit at least a certain share of the existing energy saving potential related to BEMS. The elaboration of common standards and norms has not kept abreast of the fast development of specific hard- and software components for building automation and management systems. Efforts to establish a standard, which ensures the mutual compatibility and interoperability of the products from different manufacturers and different trades, have been only partly crowned with success and are on their way of being developed on European level.

RTD activities could help to develop more modularised energy management systems, which are flexible and easy to handle, use international standards and common interfaces and are characterised by a high degree of interoperability. The most promising elements for development over the next years appear to be: demand-control strategies for ventilation, lighting, heating and cooling; control and management strategies for appliance loads; control of heating and cooling processes to achieve optimal performances; fuzzy logic systems for a more flexible representation of users' needs; expert systems based an neural networks for "smart" response to users' needs; reliable, tamper-proof, low intrusiveness monitoring of energy consumption of different parts of large commercial or residential buildings or cluster of buildings; low cost fault detection; adaptive PID controllers.

To overcome the identified lack of knowledge related to building automation and energy management systems there is a key requirement for improved dissemination of information and better demonstration of the capability of these technologies to varying types of users. Attention needs to be given to making BEMS more user-friendly and to the effective training of users who often find them intimidating and difficult to operate correctly. Know-how should be disseminated by free publications, videos and software, seminars and workshops and by marketing the results of successful projects.

Phase 4

In order to contribute to the successful dissemination of BEMS applications and technologies, ZREU, supported by the partners, has organised an European workshop on 25 May 2000 in Regensburg, Germany as a fundamental element of the work programme entitled "EnergieManagement und GebäudeAutomation".

The one day event was a big success, attracted more than 30 experts from four European countries and features were broadcasted on two TV channels. All presentations of the speakers and more detailed information about the workshop topics is presented in the accompanying proceedings.