# Validation of Measurements and Energy Management Programs implemented in 22 Public Buildings of the District Schwandorf in a Retrofit Job

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## Introduction

In the district of Schwandorf a Dual Energy Management System together with various energy management adapted to parallel traditional remodelling were to be implemented beforehand in a total of 22 already existing buildings.The efficiency of these strategies with regard to energy consumption and comfort (i.e. thermal comfort of the occupants) was to be measured over a three year period. The subsequent evaluation was to result in recommendations concerning the design and operation of The EMS and the building facilities under the given conditions.

## Background of the Project

Schwandorf is a rural district in northern Bavaria with 32 communities in an area of app. 1.500 square kilometers and with about 130.000 inhabitants. Within the district 160 public and municipal buildings exist and are operated by district or communal authorities. Increasing energy, maintenance and personal costs in the operation of the buildings made it appear attractive to consider a centralised building and energy management approach. In 1985 the envisaged layout of the BEMS (Building and Energy Management System) was roughly conceptualised and performed during the period 1988 - 1993.

## Project Phases

DEMSS stands for "Dual Energy Management System Schwandorf" and aims - in the first phase - to connect 22 public buildings to a network with the objective of reducing energy consumption and operating costs by the use of a high-tech BEMS

Phase DEMSS I). The objects are of different types such as administration buildings, schools, hospitals and municipal depots, with with a total of app. 113.00 sqm conditioned floor area. Operating cost reduction is achieved with the implementation of a distributed BEMS with one operation centre (OC), accompanied by retrofit measures in the HVAC and heat generation plants and by improving the buildings' envelope (windows, insulation etc.). The system is called "dual" because the EM strategies are applied at different system-hierarchical levels:

- local control functions (DDC direct digital control) of the remote systems (DDC outstations) at plant level with adaptive, i.e. selfadjusting control loops,
- operating functions of the remote systems at building level via portable or permanently installed terminals for larger objects (e.g. hospitals) and
  - simultaneously at the supervisory level at the "intelligent" central facility, located in the Landratsamt, the council's administration building in Schwandorf.
  - process data analysis and response at the BEMS centre.

Energy cost reduction amounts to a representative mix of 25 percent of the various public buildings in the district, which could be shown in Phase 2 (DEMSS II).

The different uses, size, HVAC equipment and the remoteness of the buildings to be integrated into DEMSS make it clear that EM cannot be accomplished by a simple, conventional approach. Furthermore, special attention had to be paid to securing reliable start-up procedures (in case of a power failure or of the break-down of the communication lines), since the technical staff qualified to deal with problems in the complex control system is located in the BEMS centre.Thus, parts of the hardware used in the DDC outstations, particularly for storing data over a medium term period (more than one week) and for dial-up data transmission as well as the software for adaptive control algorithms and long term data storage and analysis, to name just a few, had to be developed completely new that time, but are today part of the product offering powerful manufacturors.

**Central BEMS Facility in Schwandorf**

The BEMS operating centre is located in Schwandorf. It consists of the Building Automation System SDC 8001 with functions for remote Building Management (RBM 3000). The CPU is a DEC PDP11/83 mini computer with two PC workstations and several peripherals connected.Connection with the up to 30 kilometers distant buildings is provided by gate-controllers, modems and dial-up-lines of the public switched telephone network.Via these communication facilities, which are switched demand driven, information can be exchanged bidirectionally to and from the DDCs at the various sites and the OC:

- fault and diagnostic messages (accident driven),
- measurement data (periodically),o from the central facility:
- operating "commands" (on/off, time schedules etc.),
- set-points,
- start, stop and alter programs
- download of programs and
- energy and maintenance management instructions based on analysis of alarms and trend logging.

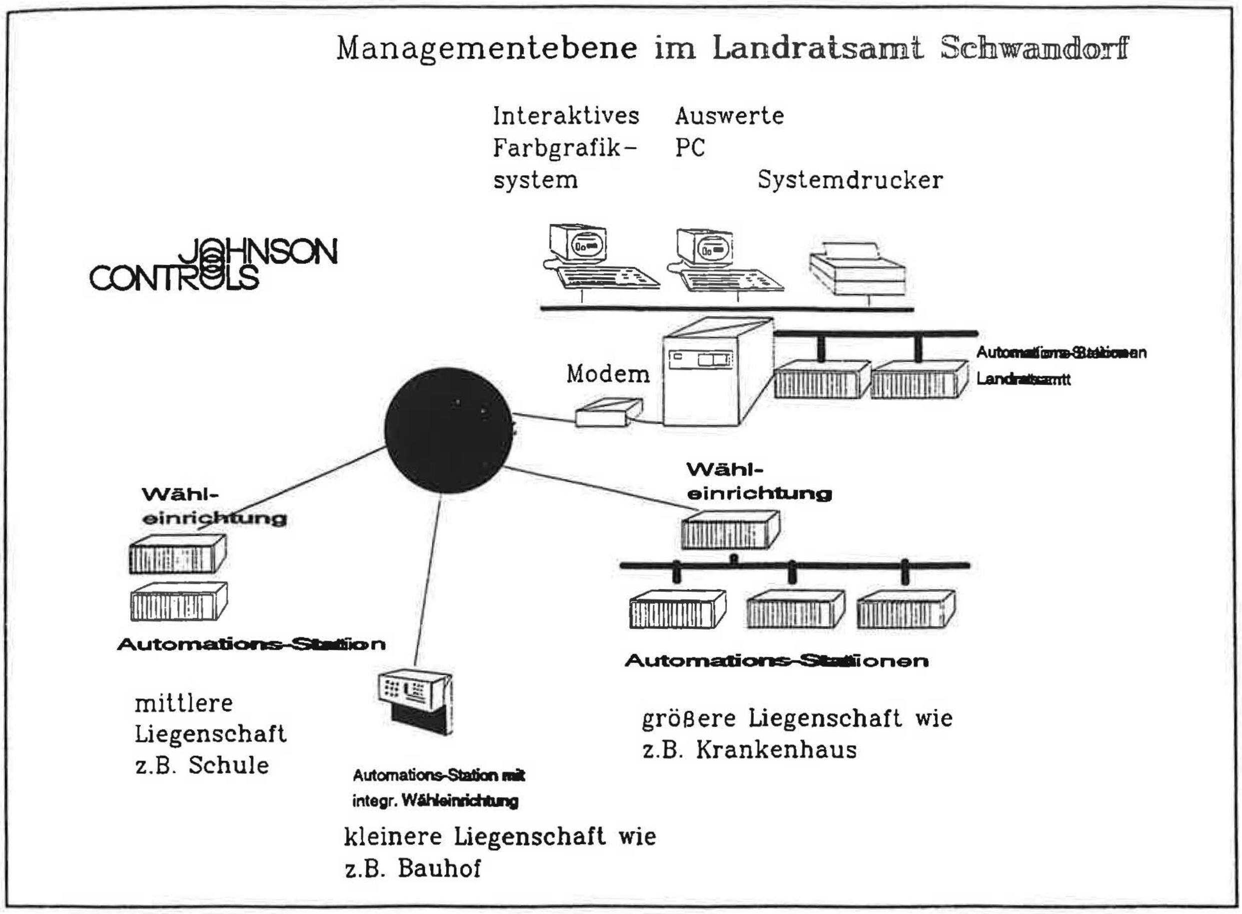


Figure 1: Schematic layout of the DEMSS configuration.

Figure 1 gives the schematic layout of the DEMSS configuration.The field consists of app. 4.000 "real" data or information points (e.g. analog points (temperature, humidity etc.), binary point and counters) with 2.800 additional pseudo or virtual points (e.g. calculated values such as enthalpy which is a product of temperature and humidity, compound alarms etc.).

## Measurements and Success Control

Within the framework of the project's measurement the information of about 2.500 data points of the system continously have been collected, stored on an hourly basis and evaluated with statistical methods.

## Energy Savings and other Results

The results can be summarized as follows:

- Compared to purely local or "standalone" solutions, a central EMS represents an advantage as to comfort, energy savings and (energy, staff, building facility maintenance and service) costs. This was objectively confirmed by the measured results, as well as subjectively by the building occupants and building owners.
- Concerning the annual heat or fuel consumption, EMS resulted in energy savings of 25% and in total of 5.600 Mwh/a. The energy savings obtained by 1993 were significantly lower, with an approximate average of 16%. Among other things, this was caused by the retrofit-related conditions of the building facilities which were not always ideal, and the - underestimated - amount of time needed for "fine-tuning" and optimising the EM strategies. In addition to the fact that during the commissioning phase some buildings could only be manually controlled.

| a) Optimized Buildings | Savings Percent | Absol. Savings |
|---|---|---|
| Landratsamt Schwandorf | 30% | 360 MWh/a |
| Realschule Burglengenfeld | 23% | 220 MWh/a |
| Realschule Nabburg | 10% | 50 MWh/a |
| Realschule Schwandorf | 44% | 470 MWh/a |
| Gymnasium Burglengenfeld | 25% | 400 MWh/a |
| Gymnasium Nabburg | 47% | 1040 MWh/a |
| Gymnasium Nittenau | 40% | 580 MWh/a |
| Gymnasium Oberviechtach | 38% | 260 MWh/a |
| Gymansium Schwandorf | 30% | 500 MWh/a |
| Berufsschule Nabburg | -4% | -60 MWh/a |
| Berufsschule Schwandorf | 23% | 360 MWh/a |
| Berufschule Neunburg | 31% | 250 MWh/a |
| Berufschule Oberviechtach | 20% | 60 MWh/a |
| Schule f. Lernbehinderte Burglen. | 29% | 60 MWh/a |
| Kreiskrankenhaus Oberviechtach | 15% | 1050 MWh/a |
| | | |
| b) Convent. Controlled Buildings | | |
| Schule f. Lernbehinderte Schwandorf | -35% | -45 MWh/a |
| Kreisbauhof Burglengenfeld | 0% | 0 MWh/a |
| Kreisbauhof Nabburg | -32% | -30 MWh/a |
| Kreisbauhof Neunburg | -21% | -45 MWh/a |
| | | |
| Savings A) | 25,50% | 5600 MWh/a |
| Addit. Consumption B) | 22,00% | 120 MWh/a |

- Concurrently with the energy savings, the district's environmentasl balance was able to be improved as well. A reduction of about 1.000 tons of carbon-dioxide has been achieved annually

| | | |
|---|---|---|
| CO2 | 21% | 972000 kg/a |
| CO | 21% | 734 kg/a |
| NOX | 21% | 680 kg/a |
| SO2 | 33% | 413 kg/a |

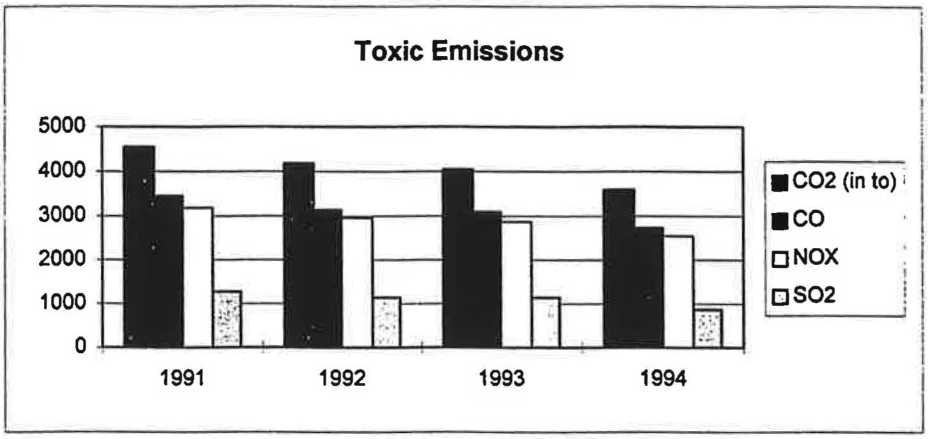


Figure 2: The graphic shows the reduction of pollution in the period 1991 -1994.

**Project Participants**

EMPLOYER: District of Schwandorf.
CONTRACTORS: Coordination: Zweckverband Regionale Entwicklung und Energie, Regensburg.
BEMS supplier: JOHNSON CONTROLS JCI Regelungstechnik GmbH, Essen and Nürnberg.
Consultant: IDB Dr. Brendel Cons. Engineers, Frankfurt.
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# Methodology

- Instrumentation of Buildings with Meters for Energy Consumption
- Monitoring and Archiving of Meteorologic Data and Standardisation (e.g. Degree Days)
- Selection of Data Points for long term storage
- Selection of Energy Management Programs for Optimisation
- Database DEMSS-Input for Validation of Savings by Conventional Retrofit Measures and Energy Management Measures

# Considered Energy-Management-Strategies

- Peak Load Demand / Load Shedding
- Optimal Start / Stop Program
- Time Scheduling for Demand Site Management
- Setpoint Adjustment depending on Time and Outdoor Conditions
- Adaptive Control Algorithms (self tuning of working point)

# Savings in Heat Consumption

A) Buildings with optimized controls

| | |
|---|---|
| Landratsamt Schwandorf | 30% =>360 MWh/a |
| Realschule Burglengenfeld | 23% =>220 MWh/a |
| Realschule Nabburg | 10% => 50 MWh/a |
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| Berufschule Oberviechtach | 20% => 60 MWh/a |
| Schule f. Lernbehinderte Burglen. | 29% => 60 MWh/a |
| Kreiskrankenhaus Oberviechtach | 15% =>1050 MWh/a |

# Savings in Heat Consumption

B) Buildings with conventional controls

| | |
|---|---|
| Schule f. Lernbehinderte Schwandorf | -35% =>-450 MWh/a |
| Kreisbauhof Burglengenfeld | 0% => 0 MWh/a |
| Kreisbauhof Nabburg | -32% => -30 MWh/a |
| Kreisbauhof Neunburg | -21% => -45 MWh/a |
| | |
| Savings Buildings of Type A) | 25,5% => 5600 MWh/a |
| Increase in Buildings of Type B) | 22,0% => 120 MWh/a |

# Reduction of emitted Polutions

| | |
|---|---|
| $CO_2$ | 21% => 972000 kg/a |
| CO | 21% => 734 kg/a |
| NOX | 21% => 680 kg/a |
| $SO_2$ | 33% => 413 kg/a |

# Reduction of emitted Polutions