

NASA/TM—2002-211365



Energy Management Control Systems— Tools for Energy Savings and Environmental Protection

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July 2002

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Summary

The change in the price of energy has encouraged the increase of energy efficiency. This report will discuss a tool to promote energy efficiency in intelligent buildings, energy management control systems (EMCS). In addition to the online control of energy production, supply, and consumption, the function of the EMCS is to support short- and long-term planning of the system operation as well as to collect, store, and regularly evaluate operation data. The strategies behind planning and implementing the EMCS as well as the manipulating the resulting data are discussed in this report.

Introduction

In order to be classified as an intelligent building, four practices must be implemented: energy efficiency, lifesafety systems, telecommunication systems, and workplace automation. This report addresses one of these practices, energy efficiency. The installation of energy monitoring systems, computerized systems that document and control energy consumption and reduction, is a requirement for intelligent buildings.

Intelligence with respect to energy management in an intelligent building is known by many names; however, this report will discuss the most commonly known, energy management control systems (EMCS). All energy-producing systems, suppliers, and consumers can be divided into subsystems. The function of EMCS is to provide the online control of these individual systems, collection of operation data, storage and evaluation of operation data, support of the short- and long-term system planning, and ultimately reduction of the energy cost.

This report describes the following:

1. EMCS planning strategy
2. Preparation of the EMCS
3. Path of information flow
4. Implementation of the EMCS
5. Expected results

Practices of the EMCS

Planning Strategy

The first step of the EMCS is data collection, and this may happen either manually or electronically. Modern systems allow for remote operation and processing. There are systems under development that apply to the operation diagnostic model (fig. 1) as the basis for operation simulation to help the design and evaluation of the data collection method. Within the EMCS framework, the data collecting and processing control occurs in three steps:

1. Design
2. Operation implementation
3. Verification, analysis, and evaluation of results

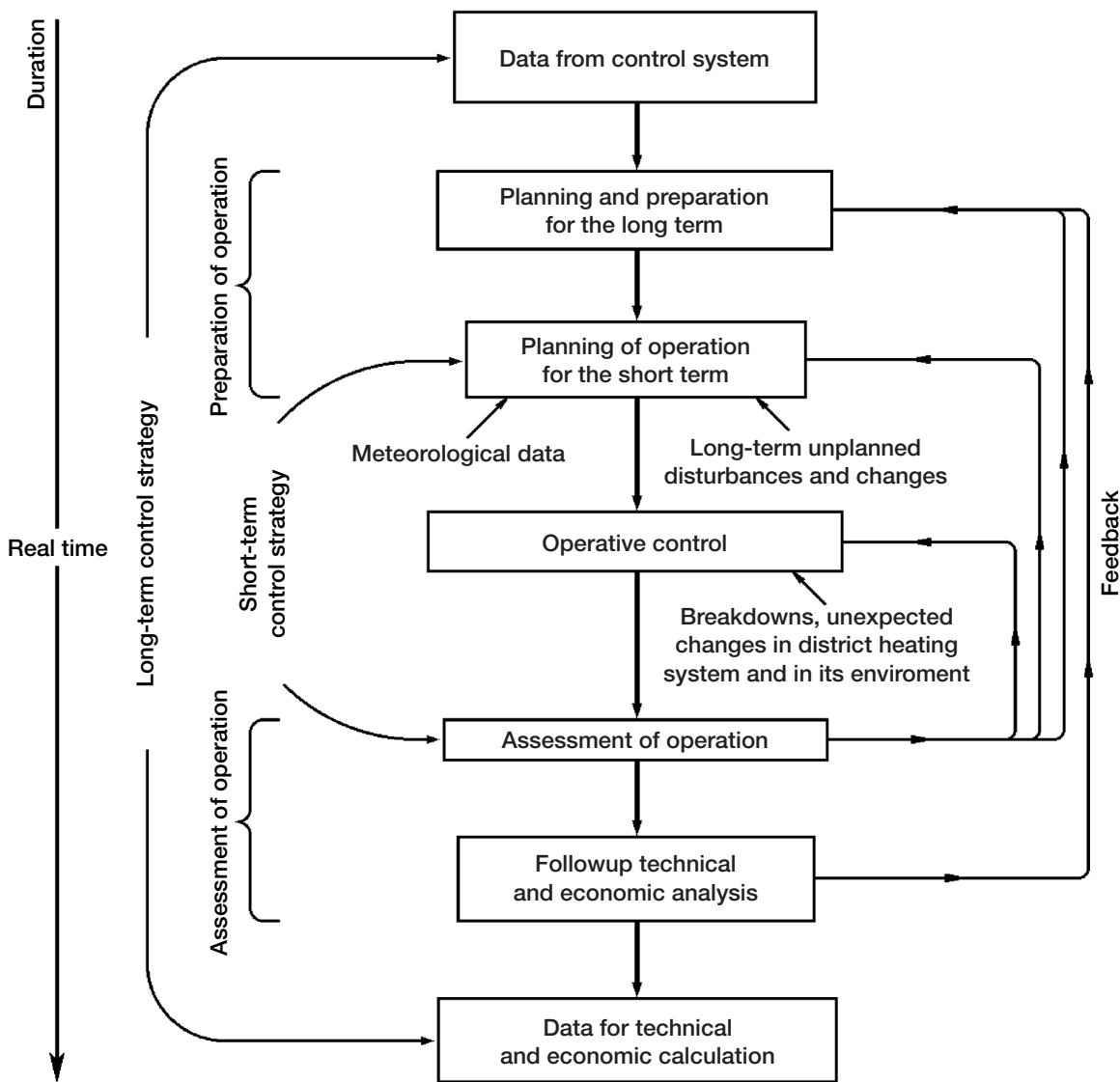


Figure 1.—Stages of operation control.

The implementation of these steps can be further classified based upon their time duration:

1. Operation planning and preparation
 - Short term (daily, weekly)
 - Long term (monthly, yearly)
2. Online control (minutes, hours, days)
 - Online control of the operation and monitoring of the control process in real time
 - Determination of an economic operation based on modeling and optimization (consulting activities) of a more sophisticated control
3. Operation assessment
 - Short term (assessment of daily and weekly operation)
 - Long term (technical operation and economical evaluation as well as specific heating comparison, monthly and yearly)

Energy management can be made more efficient by means of an energy consumption evaluation. First, a consumer prepares a planned energy consumption evaluation based on their requirements and the efficiency of the equipment involved. Then a comparison with actual usage can be made by reviewing the appropriate documents.

The main steps in evaluating energy consumption are (1) survey the energy usage measurement system and actual energy usage, (2) evaluate the production indicators (i.e., production quantities by the piece and heating and/or cooling required each day) that add specific values to the energy usage, (3) compare the projected and actual energy usage, (4) establish goals and methods to achieve them based on factors that determine energy usage, and (5) implement measures to reduce energy consumption.

It is beneficial to increase the energy knowledge of coworkers in order to motivate and direct these activities toward establishing energy savings. This can be accomplished either at no cost or at a very low cost investment.

Considering that the flow of energy is continuous during production, the energy assessment of the last period in conjunction with the preparation for the next period can be implemented simultaneously with an online control of operation. This activity is linked to the development, application, and actualization of databanks for the three stages of control.

In addition to the data relating to the operation that change with time, the databank contains permanent (fixed) data regarding the technical information of the facility and the equipment.

Preparation of the EMCS

To prepare an EMCS, it is essential to know the expected expenses and estimated benefits and yields. The method used to establish the control of the expenses will depend to a great extent on the plant supervision and on the number of measurement parameters (variables). This latter factor impacts upper management such that they should encourage the involvement of the employees by making sure the personnel are acquainted with the desired objectives and by obtaining their opinions and suggestions to accomplish the desired goals.

In order to have a successful EMCS, it is necessary to understand what the building conditions are so that implementation of the control system is a realistic possibility. The goals must be attainable, and the methods to achieve them, feasible.

Requirements for a successful installation of an EMCS are

1. Prepare a list of expenses and the expected estimated yields and benefits.
2. Establish the importance of the design procedure, acceptable to the company's management.
3. Establish a list of activities with time limits, and prepare a cost budget.
4. Prepare a list of personnel and designers who will implement the process.
5. Determine areas of energy usage.

6. Establish measurement and instrument locations (energy consumption meters and production quantity meters such as counters).
7. Determine and implement measurement and data collection processes (manual or electronic).
8. Establish a method to process and analyze data, allowing for evaluation of the data's validity.

Cost Estimates

Prepare a cost estimate that considers the following:

Service structure.— The measuring system should record the estimated cost of the structure of the distribution and also the cost breakdown (heating, cooling, electrical energy, etc.).

To accomplish this, the base cost is estimated based on earlier accounts, the measuring points of consumption should be identified in blueprints, and these measurements of consumption in a specific area should be meaningful.

Areas of consumption can be grouped as follows: large individual consumers, including boilers, furnaces, and dryers; low-usage consumers with small energy demand units; and consuming systems, including heating or cooling systems.

Survey of producing plants.— To have a more meaningful basic value, consider the energy usage in relation to production quantities using the degree day for such processes as heating or cooling.

Selection of areas of energy usage.—The areas of energy usage to be monitored should be chosen with the cooperation of the production supervisor and associated energy team members.

The decisionmaking shall be based on the following:

- Consumption must be able to be measured.
- Measuring devices must show the expected energy savings.
- Measurement of energy usage should be handled by appropriate, responsible personnel.
- The specific volume pertaining to a specific area of production must be able to be guaranteed.
- The company's accounting structure should be able to integrate the areas of energy usage.

Establishment of secondary measurement locations.—After the installation of the measuring instruments, it may be discovered that additional measurements and instruments are required for data collection. The actual location of these devices will require the uniform approval of the management. The implementation of these additional devices should only take place if the savings cover the expenses.

Data collection.—Collection must be performed within the defined time period. (The risks of extensive or limited data collection must be kept in mind.) Punctual data recording and evaluation are also to be considered. The information to be collected must warrant the associated cost. The selection of evaluation cycles (daily, weekly, or monthly) depends upon the technology and quality of the monitoring system.

The four methods of collecting data are

1. Agree on an accounting method (for example, monthly). This method is too superficial for analyzing and correcting data.
2. Enter hand-gathered data shown on the preprinted forms into the computer. This method of data collection is the simplest and most economical way to introduce and implement at the beginning of the application of the EMCS. This method can serve as the basis for preparing a more expensive method and also for verifying the system operation. The data entered can be verified more accurately against more inaccuracies by using a computer software program.
3. Gather data electronically. The data would be automatically fed into the analysis program; this reduces the errors involved with manually reading data into the computer.
4. Employ a built-in automatic data collecting system. The biggest drawback in this up-to-date solution is the high cost and the time required for installation. The most important advantage is the elimination of the human error.

Data evaluation.—The evaluation of consumption and production data is done by computer software. A good quality software package will have the capacity to handle large amount of data, be user friendly, and provide simple solutions for plant additions and modifications. It will be able to verify and reject data. The software should also have appropriate graphics, and the results should be easy to understand on the monitor screen and in printed form. It will present the data in tabular form, yet have the flexibility to utilize different methods to analyze the entered data.

Implementation of the EMCS.—The EMCS implementation involves expenses. The expected expenses should be considered initially in the design stage.

Information Flow

The information flows from the measuring points to the data gathering system (fig. 2), which forwards the information through different processes that analyze the data and prepare the reports required at different management levels.

Information Sources

A continuous monitoring system must manage the information it receives from the data collection instruments (continuous measurement and indicating devices) such that it provides true, meaningful information. Information can originate not only from energy systems, but also from external sources. These can be weather forecasts and other parameters as well as data from expected operating conditions.

Information Processing

Data collection.—The EMCS requires the continuous selection of typical characteristics like the determination parameter control and adjustments to the Digital Data Control (DDC) online control. Additional tasks are to maintain daily logs of events and disturbances (mechanical and electrical) in the system as well as the status viewed from the operator's monitoring working station.

Although data evaluation belongs in a different task group, in the case of measurements it is possible that the data need to be looked at before they are accepted. The well-informed plant expert has an advantage over automatic remotely installed measuring devices in that he can perform the first step of evaluation and possibly notice any erroneous data. Programmable measuring devices can be used to complete the task, but a more advanced application involving an error-correcting algorithm makes it possible for an instantaneous comprehensive examination and validation of all known data. A well-designed data base is needed to accept all measured data and to record analysis methods. Future demands must be kept in mind when designing the data base: For example, provisions shall be made for continuous improvements to the storage files.

Data analysis.—The calculations and the preparation of reports are fundamental elements of the EMCS. Complete efficiency of an individual installation can be determined from the preparation of energy and expenses balance sheets. Calculations of the expenses incurred between the energy supplier and the consumer also belong here. The success of the selection of the initial established goals can be determined from the analysis of the operation. The conclusions of each analysis can be taken into consideration for the online control algorithm or determination of decisionmaking goals.

The principal user of the information originating from the operation analysis is not the actual operation personnel but the management. The decision of how this information is going to be used will be made by the management. The higher the level the report reaches, the more expensive it gets, and the longer the time that is involved. This should be emphasized to all management levels to whom the reports are intended and should be done at the time the report is put together.

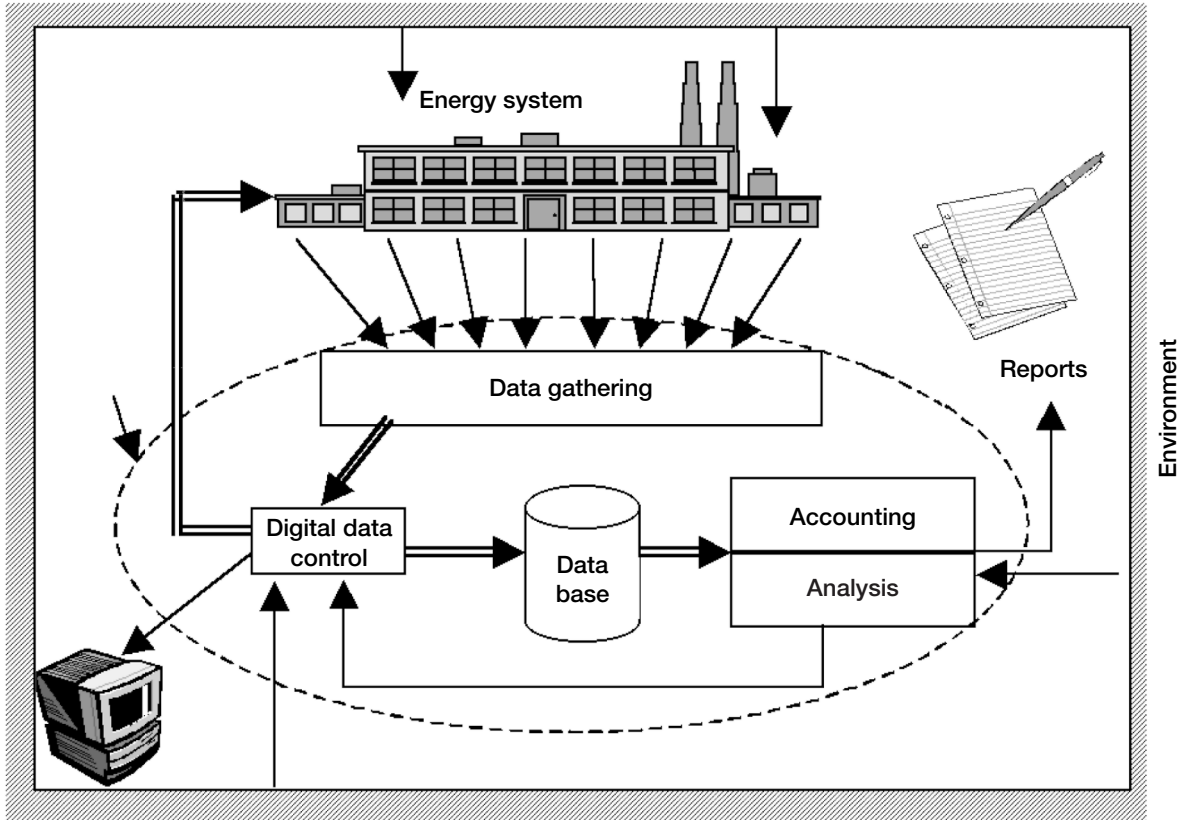


Figure 2.—Information flow in system.

Implementation of the EMCS

Determination of Basic Usage

Each EMCS needs to establish a standard measurement technique when planning a monitoring system in the plant for providing actual energy usage data. (Base this on 10 to 15 weeks of data collecting.) This can happen as follows: (1) The EMCS can select the analysis methods to determine the energy consumption (including continuous analysis and regression analysis), (2) The changes in consumption and input data can be a function associated with a mathematical expression, and (3) The consumption (monthly or yearly) needs to be systematically verified and updated.

Establishment of the Target Value

One of the functions of the EMCS is to allow the establishment of target values: Once a cycle of data collection and analysis has been completed, it is clearer as to what an achievable goal might be. A meaningful

goal could be the reduction of energy usage by an average of 30 percent. This is often a goal that can be attained. The decision to use the method of continuous analysis to analyze the data will help achieve this value. It will then be necessary to pay attention to the significant influencing parameters impacting energy consumption. This value should be compared often with the actual values.

The consumption and operation data from an earlier period (or from mathematical models) determine the target value function, which, in turn, can help compare the actual operational data with the base data and create the graphical representation.

Concluding Remarks

Results from implementation of an EMCS are expected to be observed in performance management as well as in energy reduction.

Performance Management

Performance management is a means to provide immediate energy cost reduction. The purpose is to reduce the peak demand performance with the help of operation planning and a monitoring system. The operation is controlled with the help of the monitoring system so that the peak energy remains below the designed and contracted performance.

In the course of planning the performance, the energy producer can reduce the equipment and installation time of the distribution system. In the case of existing generation plants that already have higher capacities built in, adding new energy sources can be avoided by applying proper performance management. The energy expenses can be reduced from the agreed contract amount to a significant extent. This in turns reduces the performance cost.

Energy Reduction

The processing of the operation data and its evaluation will serve as the basis to draft further control methods. The records of energy usage and corresponding expenses will enable new energy savings ideas to be developed; the documented information, including procedures and results, gives a clear picture of the current status of operation; and the achieved savings serve as an example for future energy-saving endeavors.

In addition to energy management, EMCS can also help determine the specific cost of production (in many cases the production cost plays a role in the energy expenses) as well as reduce failures, time interruptions (small errors such as poor air quality or wear of the steam distribution system can be immediately noticed), and the use of auxiliary materials.

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REPORT DOCUMENTATION PAGE			<i>Form Approved</i> <i>OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE July 2002	3. REPORT TYPE AND DATES COVERED Technical Memorandum	
4. TITLE AND SUBTITLE Energy Management Control Systems—Tools for Energy Savings and Environmental Protection			5. FUNDING NUMBERS WU-772-20-02-02	
6. AUTHOR(S) Albin Zsebik and Laszlo F. Zala				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration John H. Glenn Research Center at Lewis Field Cleveland, Ohio 44135-3191			8. PERFORMING ORGANIZATION REPORT NUMBER E-13187	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA TM-2002-211365	
11. SUPPLEMENTARY NOTES Albin Zsebik, Department of Systems and Control Engineering, Budapest University of Technology and Economics, Budapest, Hungary; and Laszlo F. Zala, NASA Glenn Research Center. Responsible person, Laszlo F. Zala, organization code 7511, 216-433-5443.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified - Unlimited Subject Categories: 81, 83, and 89 Available electronically at http://gltrs.grc.nasa.gov/GLTRS This publication is available from the NASA Center for AeroSpace Information, 301-621-0390.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The change in the price of energy has encouraged the increase of energy efficiency. This report will discuss a tool to promote energy efficiency in intelligent buildings, energy management control systems (EMCS). In addition to the online control of energy production, supply, and consumption, the function of the EMCS is to support short- and long-term planning of the system operation as well as to collect, store, and regularly evaluate operation data. The strategies behind planning and implementing the EMCS as well as the manipulating the resulting data are discussed in this report.				
14. SUBJECT TERMS Commercial energy; Electric power; Industrial energy; Energy conservation			15. NUMBER OF PAGES 13	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	