On the Selection and Application of a Convenient Energy Management Software for Industrial Purposes

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Abstract. The profitability of companies, especially in Germany, is affected by rising energy prices and increasingly stringent energy legislation. Certification according to ISO 50.001, an international standard for energy management systems, can help to meet legal requirements and increase energy efficiency. This article offers assistance in the form of a methodology that provides a structure for the selection process of an energy management system (EnMS). Considering properties of the individual company, it helps to identify an appropriate software solution. It is applied to a globally operating metalworking company in an example study. Furthermore, the measurement infrastructure in particular is a basic requirement that should not be overlooked in addition to the process of choosing an appropriate software solution. In this context, suitable metering points or criteria must be defined as well as sufficient attention paid to the anticipated costs for acquiring and integrating new measuring transducer and energy meters. The type and number of relevant measuring points must be considered in particular. Discussing these aspects, this article facilitates the process of planning and implementing an energy monitoring.

1. Introduction
The subject of energy management is becoming increasingly important. This is attributable to, among other things, stricter and stricter regulations being imposed on companies to meet energy targets and ensure that production changes towards carbon neutrality. Therefore, the certification in the complicated area of energy management according to ISO 50.001 is a major milestone for many companies. The purpose of this article is to illustrate a methodology for the selection of an appropriate energy management system (EnMS) solution. We will define the related terms and state reasons that support the introduction of an EnMS (Sec. 1). Accordingly, we will explain how to deduce the general conditions and requirements for the implementation in Sec. 2. The individual aspects, including the possible costs of implementation, will be presented in Sec. 3. Furthermore, we will examine the selection of suitable meter operators and energy metering equipment as well as the metering infrastructure in Sec. 4. Sec. 5 summarizes our contribution.
1.1. The terms “Energy Management” and “Energy Management System”

The term energy management is defined in the VDI 4602 standard as "the forward-looking, organized and systematic coordination of procuring, distributing and using energy to meet requirements while considering ecological and economic objectives" [1, p. 2]. In this paper, energy management is limited to the interaction of energy controlling and energy monitoring. It comprises energy data collection and energy data analysis.

The standard ISO 50.001 defines an EnMS as a “management system to establish an energy policy, objectives, energy targets, action plans and processes to achieve the objectives and energy targets” [2, p. 15]. The organizational and informational structure plays a crucial role for the EnMS implementation. Special attention should be applied into the selection of appropriate software and hardware. [1, p. 5]

1.2. Motivation for Introducing an EnMS

It is becoming increasingly important for companies, especially in Germany, to obtain certification according to ISO 50.001. In addition to financial benefits, such as the EEG levy, this offers further advantages like an increase in general energy efficiency, especially a lower electricity consumption, and transparent insights in the CO₂ output. [3, p. 3]

Many production units lack transparency into how much energy they consume, especially in their infrastructure and production processes. Moreover, their system of energy reporting is relatively complicated and time consuming. An EnMS can help overcome these challenges. [4, p. 5] A key aspect is increasing production efficiency. By reducing, the amount of material and energy consumed and raising the quantities produced while at the same time reducing the time needed to produce them, it strengthens a company's competitiveness. Another key aspect is compliance with statutory regulations and guidelines, for example ISO 50.001, which requires a continuous improvement process (CIP). [2, p. 17]

2. General Conditions

The essential tasks of an EnMS include the systematic collection and communication of energy flow as well as automatic control of facilities and production equipment for improving energy efficiency [5]. It is useful to collect the most significant energy and media consumptions within the production unit. At the very least, the consumption on the reviewed production hall as well as the major individual consumers should be monitored. The more detailed the breakdown with respect to consumption is, the higher the density of the data collected will be. But accumulating in a too fine granularity will cause an unnecessary amount of data. It appears more beneficial to concentrate on the essential consumers. One option is to install additional energy meters as time goes by in order to obtain higher data density. Key factors in the production environment are also the monitoring of grid quality and the integration of the company's internal databases – for example, the production calendar [4, p. 11].

3. Methodology for Selecting an EnMS

The basis for selecting EnMS software is an organized procedure devised by Treutlein and Sontow [6], originally created for choosing Enterprise-Resource-Planning (ERP) software solutions. It is used to narrow down the EnMS solutions examined as part of a market analysis (see Fig. 1). [6]

3.1. Best Fit Principle

First available providers are narrowed down by conducting a comparative market analysis. The focus laid on the basic features of the various solutions. [6] One possible method of performing the screening is to create a matrix table and use it to evaluate the different EnMS solutions based on specific criteria. Essential criteria are presented in Fig. 2, which shows an example of a matrix table generated in accordance with the best-fit approach. The energy management solutions can be pre-screened using the matrix table. The following prerequisite must be established for doing so: The companies wishing to implement an appropriate software solution needs to have examined in advance the criteria essential to it and demands placed on a suitable EnMS solution.
Fig. 1. Selecting ERP software [6].

Fig. 2. Section of a matrix table.

3.2. Best Practice
As a next step we analyze the costs incurred when implementing an EnMS [6]. The comparability of costs and licensing models for the different vendors pose a special challenge. To illustrate the procedure, we use an example of a large company in the metalworking industry with global operations and that, thus far, has no EnMS.

First, the individual production plants of this sample company are divided into different categories based on size. That establishes three separate categories of plant sizes that differ based on assumptions of how many metering points they wish to install. Tab. 1 shows these assumptions. The next step is inserting the costs determined for the software solution in Tab. 2.

Tab. 1. Plant sizes and metering points.
Tab. 2. Sample calculations of software cost.

| manufacturer x | cost [€] | update | support | server connection | installation data points | training | project management | total costs [€] |
|----------------|----------|--------|---------|-------------------|--------------------------|---------|--------------------|----------------|
| basic license  | cost [€] | cost [€] | quantity | cost [€] | quantity | cost [€] | cost [€] | days [d] | cost [€] | one-off payment | annual payment |
| basic license  | S        | 96.000 | 17.000  | 115.000          | 14.000                   | 53.000  | 11.000             | 850.000        | 106.000 | 330.000        | 79.000         |
| basic license  | M        | 340.000| 42.500  | 412.500          | 65.000                   | 220.000 | 55.000             | 1250.000       | 108.000 | 790.000        | 790.000        |
| basic license  | L        | 64.000 | 9.000   | 122.500          | 29.000                   | 57.000  | 13.000             | 329.000        | 106.000 | 330.000        | 79.000         |

The one-time and annual costs for each vendor are first extracted from Tab. 2 and determined for each plant size.

The one-time costs consist of the following expenses:

\[ \text{Total one-time costs [€]} = \text{basic license [€]} + \text{one-time license fee [€]} + (\text{number of servers [ea.]} \times \text{cost of server connection [€]}) + (\text{number of data points [ea.]} \times \text{cost of connecting the data points [€]}) + (\text{number of training sessions [ea.]} \times \text{cost per training session [€]}) + (\text{number of project management days [d]} \times \text{cost per project management day [€]}) \]  
(1)

The annual costs consist of the following expenses:

\[ \text{Total annual costs [€]} = \text{annual license fees [€]} + \text{cost of updates [€]} + \text{support fees [€]} \]  
(2)

The next step is to take the one-time and annual costs calculated per vendor and determine the amount for each location of the example factory. The results are shown in Tab. 3.

Tab. 3. Excerpt from comparison of EnMS costs by plant size.

| plant size | quantity | manufacturer A | manufacturer B | manufacturer C |
|------------|----------|----------------|----------------|----------------|
| S          | 2        | 96.000         | 115.000        | 53.000         |
| M          | 5        | 340.000        | 412.500        | 220.000        |
| L          | 1        | 84.000         | 122.500        | 57.000         |
| total      | 8        | 529.000        | 650.000        | 330.000        |

The costs are calculated for each vendor using this formula:

\[ \text{One-time costs [€]} = \text{number of plants per size category} \times \text{total one-time costs per vendor [€]} \]  
(3)

\[ \text{Annual costs [€]} = \text{number of plants per size category} \times \text{total annual costs per vendor [€]} \]  
(4)

An extrapolation of the individual results based on a useful life of five years, including an annual increase of 2% in running costs is recommendable.

The EnMS implementation costs can depend on the complexity of the system, the needed customizations and also the company size plays a crucial role. [7]

4. Meters and Infrastructure

4.1. Selecting Appropriate Meter Operators and Energy Recording Equipment

Preparing a careful metering strategy is crucial to determining the number of metering points and designing their layout. The operational reality reveals the applicability of the Pareto principle, also known as the 80/20 Rule. In the area of energy management, this means that approximately 20% of the energy loads are responsible for 80% of energy consumption. [8], [9] For that, it is a good idea to start energy monitoring considering the most extensive loads first [9].

In selecting the energy metering equipment, attention must be paid to ensure that they are appropriate for the respective metering task. They should guarantee high levels of data quality and operational reliability. When implementing additional metering points and equipment, the components should be
added ordered by the consumption. This requires to scout all production processes with their respective energy consumption and detailed consultations with plant representatives and process owners. [9]

4.2. Infrastructure Costs
The infrastructure costs are the foundation of an EnMS. For the calculation of them let us remember Tab. 1. Based on that, we get the infrastructure costs for each plant size and, finally, the total cost of implementation on the infrastructure end as found in Tab. 4.

**Tab. 4.** Excerpt of infrastructure costs.

| Plant | Cost | per unit | amount | cost | per unit | amount |
|-------|------|----------|--------|------|----------|--------|
| 0     | 2    | 390      | 780    | 1    | 5,094    | 5,094  |
| M     | 5    | 400      | 2,000  | 2    | 9,096    | 18,192 |
| L     | 1    | 800      | 800    | 3    | 13,604   | 39,812 |

5. Summary and Outlook
The introduction of an EnMS is an essential requirement for obtaining certification according to ISO 50.001. Over the medium term, every manufacturing enterprise should strive to implement such a system. Within this paper a detailed method for the selection and application of an EnMS has been presented. The terms energy management and energy management system (EnMS) has been introduced and defined. A model for the calculation of the implementation costs has been explained.

Key steps in this are the installation and the daily work with an EnMS, plus expansion of the metering infrastructure down to the machine level. When procuring new machinery and equipment, companies should factor account energy data collection equipment into the scope of their orders. Last but not least, a holistic view and optimization of energy and materials cycles within production will be indispensable measures for achieving energy policy targets and, thus, making factories energy-efficient in the future.

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