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Empirical analysis of energy management in Danish industry

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Abstract

In this article we examine energy-management practice in the Danish manufacturing industry. The paper addresses the following: To what extent is energy management put into practice in Danish industry? From which sources does Danish industry obtain its information about making improvements in energy management? Based upon the results of a telephone survey covering 304 Danish industrial firms and by use of our definition of the minimum requirements for energy management, we concluded that between 3% and 14% practice energy management. Inspiration to manage energy comes from many different sources, but the electricity utilities emerge as the main source of inspiration. This leads to a presentation of a statistical model synthesising two types of energy management and two potential avenues that can lead to improved energy management. One-size-fits-all is not appropriate when giving incentives for firms to practice improved energy management. Possible variations between industrial sectors are addressed.

Keywords: Energy management; Energy conservation; Industrial branches; Organisation; Motivation; Energy savings

1. Introduction

The issue of the article is energy management. The article is split into six sections. Section 1 is the overall introduction to the paper. Section 2 provides a short, general description of the use of energy in the Danish manufacturing sector. Section 3 focuses upon energy management in Danish industry, which is the focus of this article. Energy management is defined in Section 3. Based on the literature on motives for firms to work with energy savings and energy management, we establish in Section 4 an analytical framework for the article. The analytical framework includes prices, regulations, external relations, company characteristics and internal organisational conditions; all characteristics are believed to influence the energy savings and energy management made by the firm. The analytical framework is used as a theoretical background for a telephone survey of energy management. Danish industrial firms were randomly surveyed. The energy management practiced in 304 firms were analysed in relation to motives and inspiration. In Sections 5 and 6 we analyse energy management in practise in Danish industry. In a statistical analysis, two different types of energy management are identified. It is argued by the authors that communication about energy management is more effective if the message is adapted to the relevant management level and style.

2. Use of energy in Denmark

In light of the Kyoto protocol and today's focus on the environment, energy management is becoming more important. Before we turn to focus on energy management, we briefly present some general energy statistics for energy consumption in the Danish manufacturing

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sector. Twenty percent of the energy consumption in Denmark is done within the manufacturing sector. In Table 1 the distribution of energy consumption in Denmark is shown.

With 5.4 million inhabitants in Denmark the energy consumption corresponds to 120 J per inhabitant per year. This is approximately 50% of the equivalent figure for the USA and 60% of the figure for the EU (15). The fraction used in the manufacturing sector is 20% in Denmark and, respectively, 30% and 26% for the EU (15) and the USA. Thus, Denmark has an economy with modest energy intensity and a relatively low fraction is used in the manufacturing sector. In Table 2 the energy consumption in Denmark distributed on fuel type is shown.

The main differences between the energy use in the Danish manufacturing sector and the manufacturing sector in the EU and the USA are a relatively smaller use of natural gas and solid fuels, and a relatively higher use of electricity. In Denmark, the use of liquid fuel and electricity account for 47% and 18% in total while solid fuel and gas only account for 7% and 12%, respectively. In the manufacturing sector the use of gas and electricity account for 43% and 24% of the total use of energy in the manufacturing sector, while distinct heating and solid fuels only account for 4% and 13%, respectively.

The percentage of the firms' total expenses that are devoted to energy is low, on average 1.6%. This is presented in Table 3.

In summary, Denmark has an economy with modest overall energy intensity, and a relatively low fraction of energy used in the manufacturing sector. Also, the composition of the fuels used in the manufacturing sector (relatively more electricity) adds to the picture of a manufacturing sector with few energy intensive firms. Statistics for the US and the EU (15) are from IEA [13].

Table 1
The distribution of energy consumption in Denmark

	Energy consumption in 1000 GJ	Fraction of the total energy used in Denmark
Denmark, total	648,038	100
Manufacturing sector, total	131,955	20.4
Manufacturing sector with more than 20 employees	127,552	19.7
0–19	4403	0.7
20–49	12,447	1.9
50–99	13,340	2.1
100–199	27,586	4.3
200–499	38,419	5.9
500 and above	35,760	5.5

Source: Refs. [4,8].

3. What is energy management?

3.1. The Danish Standard

Energy management is inspired by and similar to other management systems such as: environmental management, health and safety management, and quality and production management. All these management standards belong to the family of so-called Rational Models for Decision-making. In Table 4 the left-hand column describes a version of rational decision-making and the right-hand column describes the new Danish Standard for energy management.

The new Danish Energy Management Standard deliberately uses the same principal areas as the Environmental Management Standard, ISO 14001. In Table 4 the elements of the Standard are shown in the right-hand column. Considering that the description of the rational decision model focuses on one decision, whereas the management system addresses daily procedures, it was found that energy management, as it is specified in the Standard, is rather similar to the thinking behind rational decision-making.

The intentions behind the development of Danish energy management during the last 10 years have been to transform it from a rather technical monitoring and measurement system to a management system with more focus on information, communication, internal and external audits and employee involvement. The Danish Energy Authority has supported this development [11,12]. The Danish Energy Management Standard consists of many elements. So whether or not a firm lives up to the Standard depends on the analytical minimum requirements used.

3.2. Analytical minimum requirements

Energy management includes many different activities; therefore minimum requirements are needed to decide whether a firm actually practices energy management. Thus, it should be noted that a different set of requirements would lead to different results. In this section of the paper we present the minimum requirements we have used (a subset of the elements in Table 4). The firm must:

- put forward an energy policy;
- establish quantitative goals for energy savings or should have objectives concerning implementation of specific energy-saving projects;
- have implemented specific energy-saving projects originating from the energy management.

In addition, the firm should follow at least one of these requirements: