Energy Management in Danish Industry: Practice and Policy Implications

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ABSTRACT

This paper examines energy management practice in 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 get its information about energy management? Using our definition of the minimum requirements for energy management, we conclude that only 3 to 14 percent practise 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 potential trails leading to energy management. One size fits all is not appropriate when giving incentives for firms to practise energy management.

Introduction

Energy Management in Danish industry, which is the focus of this paper, is defined in section two. Based on the literature on motives for firms to work with energy savings and energy management, we establish in section three an analytical framework for the paper. The analytical framework includes regulation, external relations, company characteristics and internal organisational conditions; all characteristics that 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. 304 Danish industrial firms were randomly surveyed. The energy management practices in the 304 firms are analysed in relation to motives and inspiration. In a statistical analysis two different types of energy management are identified. It will be argued that communication about energy management is more effective if the message is adapted to the relevant management level and style.

What Is Energy Management?

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 1 the left hand column describes a version of rational decision-making and the right column describes the new Danish Standard for energy management.

Table 1. Rational Model for Decisions Compared with the New Danish Energy Management Standard

The rational model	Energy management (DS 2403)
Identification of a target	Energy policy of the firm: Goals defined qualitatively or quantitatively
Analysis of benefits and costs with alternative solutions	Planning: Review of energy aspects. Production, legal and other requirements. Performance and targets. Decentralized energy management activities
Decision and implementation	Implementation and operation: Structure and responsibility. Training, awareness and competence, communication. System documentation and control, operational control and maintenance of equipment with significant energy consumption. Energy efficient purchasing, energy efficient design activities
	Monitoring and corrective actions: Measurement, non-conformance, corrective and preventive action, recording. Internal and external audits of the energy management system
Evaluation and feed-back	Management review

Source: The rational model in general, based on Doern and Phidd, (1983) and Danish Standard (2001). The DS 2403 exists in an English translation: DS/INF 136.

The new Danish Energy Management Standard deliberately uses the same principal areas as the Environmental Management Standard, ISO 14001. In table 1 the elements of the standard are shown in the right column. Considering that the description of the rational decision focuses on one decision, whereas the management system addresses daily procedures, it will also be seen 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 has 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 (Hansen & Hestbæk 2001 and Hansen & Lund 2002). The Standard consists of many elements, so whether or not a firm lives up to the Standard depends on the analytical minimum requirements used.

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 a different result. In this section of the paper we present the minimum requirements we have used (a subset of the elements in table 1). The firm must:

- put forward an energy policy
- lay down 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:

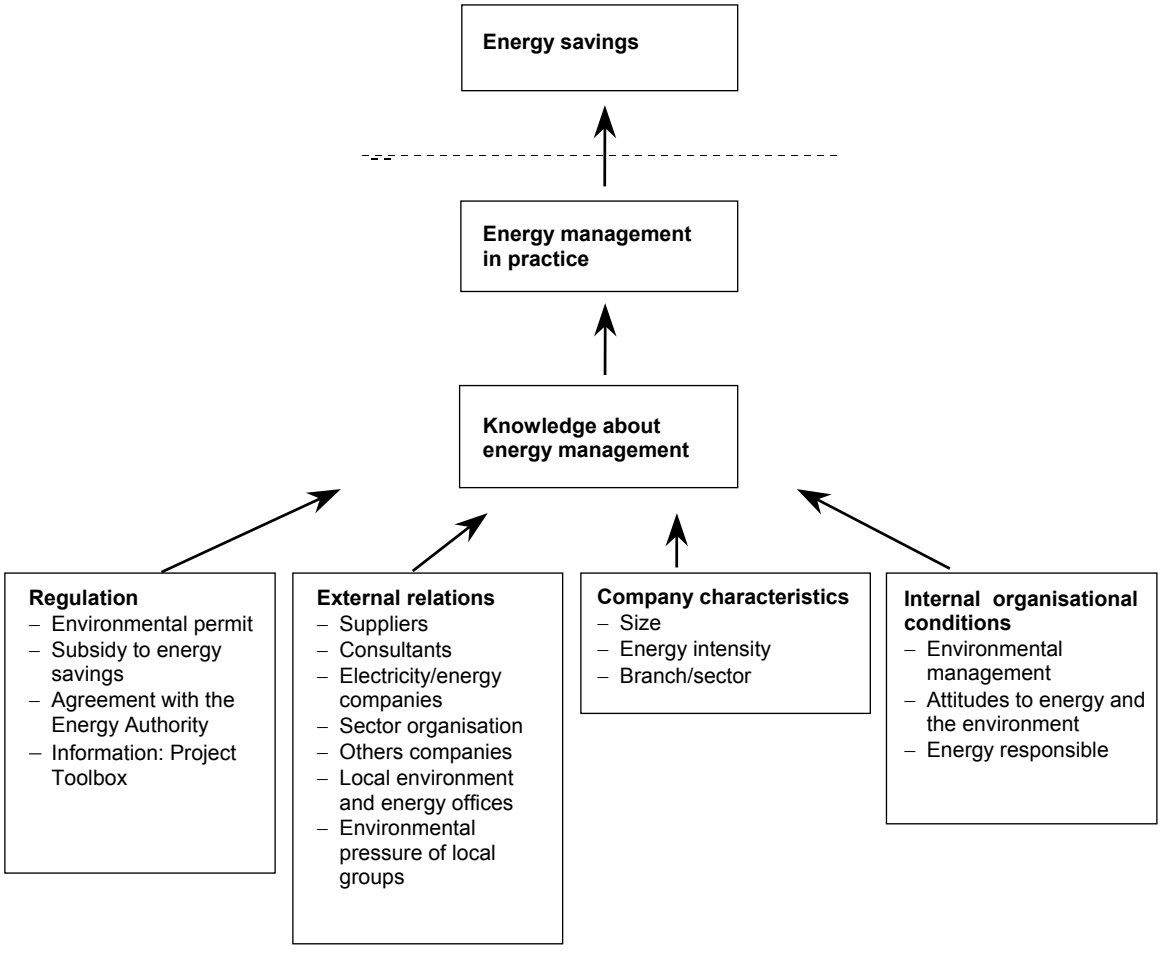
- systematically make energy-efficient purchases following a specified procedure
- organise energy activities by clearly allocating responsibility and tasks
- seek to actively involve the employees in the work of energy saving by informing, motivating and finally educating them.

These requirements for the firms with (and without) energy management highlight the fact that energy management is a management system (not only a monitoring system). This is why the establishment of an energy policy and objectives are included as elements here. And by requiring the implementation of specific energy-saving projects, we seek to ensure that the firm is actively attempting to achieve energy savings.

Analytical Framework

The analytical framework for the article is illustrated in figure 1.

Figure 1. The Analytical Framework



The reality of the firms is obviously more complex, e.g. the background variables in the figure are related to each other. The firms' histories in relation to management systems also play a role, which will be touched upon in section 5. The figure shows which background variables we relate to the firms' work with energy. As illustrated in the figure, we assume that energy management in practice will lead to energy savings, but the assessment of this is not the issue of this article (Larsen & Jensen 1999).

Regulation. Policy instruments in the energy sector, as well as environmental policy instruments will change firm behaviour towards energy activities. Togeby et al. (1998) indicate that firms with an agreement with the Energy Authority and firms that are required to get environmental approvals from the local authority are more active concerning energy efficiency than other firms. Togeby et al. also suggest the two-way relationship: the more subsidies for energy savings, the larger the energy activity of the firms.

External relations. The firms' external relations also have an impact on their energy activities. The firm can collect technical information through its external relations. And the firms more general attitude can also be influenced by external relations. Several analyses indicate this (e.g. DTI 1997; Intersee 1998). They indicate that knowledge transfer from external relations (companies and institutions) plays a central role when complicated and technological challenging energy savings projects are going to be realised within primary production processes. In particular, relations among firms within the same industrial sector or the same industrial group as well as with suppliers are important in relation to the transfer of knowledge. The same analyses indicate that network relations are also important in relation to distribution of qualitative norms and attitudes. Network relations can have a positive as well as a negative influence on the firms' energy saving activities.

Another type of external relationship that can have an impact on firms' work with energy is pressure from neighbours, environmental organisations and customers. This pressure might relate to environmental issues such as waste, water, noise, smell, or hazardous materials and thereby have an impact on the firms' environmental management. Energy management and environmental management are normally integrated. Energy efficiency is an integrated part of the Environmental Management System, ISO 14.001, and of the European Eco-Management and Audit Scheme EMAS. These environmental management systems are widely used in European firms.

A special programme supported by the Danish Energy Authority, Project Toolbox, has intensively distributed information about and advocated for energy management.

Company characteristics. The energy activities of the firms will also depend on a number of specific characteristics. Increased energy intensity increases the firms' energy saving activities (Togeby et al. 1998). Furthermore, it is concluded that sectoral relationships also have an impact on the companies' energy saving activities. In Hansen & Togeby (1993) the same relations and the size of the company are described as conclusive factors for determining the energy activities of the firms.

Internal organisation. The last type of background variable that has an impact on firms' work with energy is the internal organisation of the firms. The firms' previous experience with work with the environment, e.g., environmental permits from local authorities and

environmental management, are important as explanatory factors. This is underlined in Intersee (1998). In DTI (1997) two types of attitudes to energy issues are identified: Proactive and reactive. In a proactive attitude, energy is an integrated part of the strategic targets for the firm and primary as well as secondary production processes are integrated in the saving activities. The energy manager has a central role in the company hierarchy and is able to make important decisions. In a reactive attitude the focus of energy activity is typically on secondary production processes. Energy savings happen coincidentally through "end-of pipe" solutions. The energy manager is marginal in the process of decision-making.

Energy Management Practise in Danish Industry

The Data

The analysis in this article is based on 304 firms randomly chosen from Danish industrial firms with more than 20 employees. The interviewer asked to talk with the energy manager in the firms. The interviews took place in April 2001.

As the sample was randomly chosen, the distribution of the various characteristics in the sample is approximately the same as in Danish industry as a whole taking the limited number of firms in the sample into account. This is illustrated for the number of employees in the sample compared with a number of employees in Danish firms (see table 2).

Table 2. Employees in the Sample Compared with Employees in all Danish Industrial Firms

Employees	Sample (per cent)	Denmark (per cent)
20-49 50-99 100-	63 19 18	57 22 21
Total	100	100

All firms are from the manufacturing industry. More details about the sample can be found in Hansen & Hestbæk 2001.

Energy Management in Practice and Inspiration to Energy Management

All 304 firms were asked what kind of activities they have implemented in order to save energy. The firms were asked first, which activities were implemented "without help/ unaided" and secondly "with help/aided". When asked "aided" a number of possible activities (see table 3 in section 5) were presented to the firm, this was not the case when the firms were asked "unaided". When answering the question "unaided", two kinds of activities were mentioned relatively often:

- implementing specific energy-saving projects (41%)
- regularly measuring the energy consumption in detail (34%).

In addition, 23% of the firms indicate that they systematically make energy-efficient purchases following a specified procedure. Based on the answers given without help, only 3% of the firms practise energy management with the definition used in this paper.

When asked the same question and presented with a list of elements (i.e. aided), the firms frequently point to the following activities:

- implementing specific energy-saving projects (65%)
- regularly measuring energy consumption in detail (61%)
- seeking to actively involve the employees in the energy saving work by means of "passive" information (e.g. on a notice board) (44%).

Of these three activities, the first and the third one are included in our requirements for energy management. The survey also indicates that the least widespread activities actually put into practice are, to organise energy matters by clearly allocating responsibility and tasks (20%), to put forward an energy policy (19%) and to seek to actively involve the employees in the work concerning energy savings by means of education (19%). Based on the requirements used here and the answers given with help, 14% of the firms are practising energy management.

Our requirements for energy management did not include the measurement of energy consumption (energy accounting), even though this is an important aspect of energy management. This has been omitted from the minimum requirements in order to focus on the management of energy consumption and to minimise the number of compulsory elements in the requirements. However, the results of the survey of firms' knowledge and understanding of energy management and their energy-saving activities suggest that energy management in practice often begins with energy accounting. Adding energy accounting to the obligatory requirements would not increase the number of firms we accept as having energy management.

Motives for energy savings. As we assume that the firms consider energy management as a means, not an end in itself we decided to ask for motives for energy savings and not motives for energy-management.

Concerning the motives to work with energy-efficiency, figure 2 illustrates that the expected and absolute top scorer is reduction of costs (76%). After this comes the environment (26%) and image as a green firm (16%) and finally energy management is a natural element in environmental management (11%). Other explanations, all 3% or below, are demand from customers, enthusiastic employees and suggestion from accountant.

Inspiration to work with energy-efficiency. In figure 3 we show the source of main inspirations to work with energy efficiency**.**

Figure 2. Motives for Energy Savings

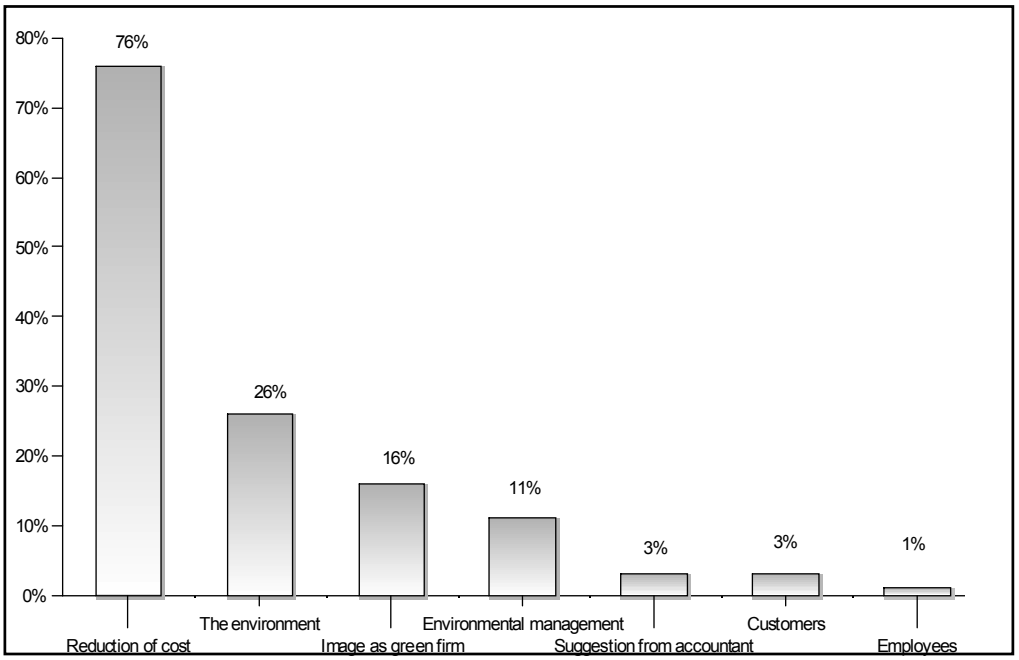
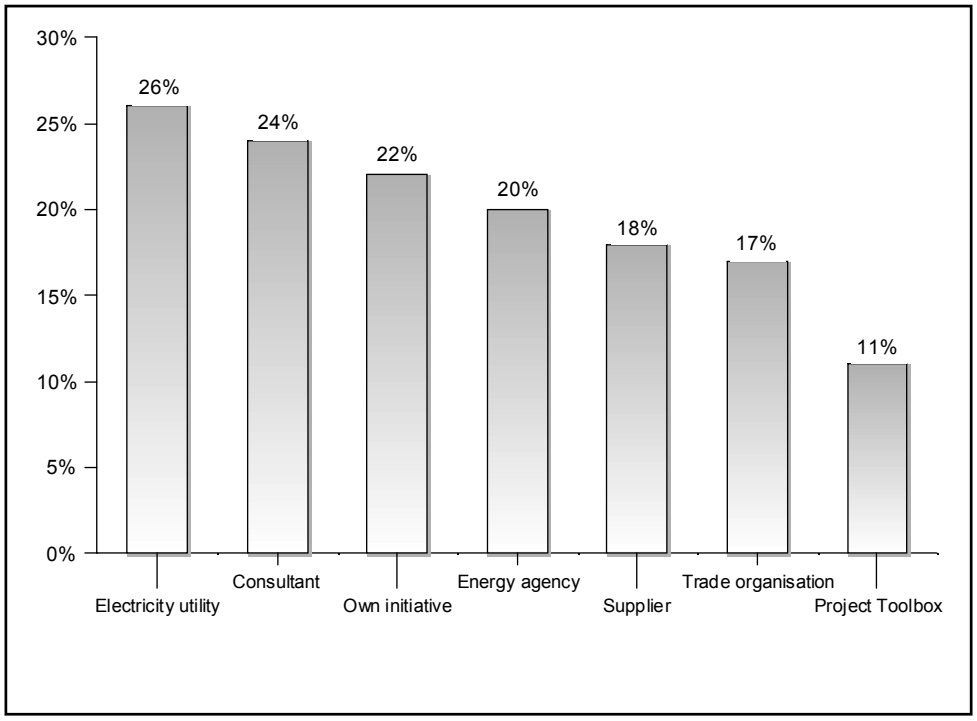


Figure 3. Inspiration to Work with Energy Efficiency



The inspiration to work with energy-efficiency mainly comes from 5 sources: The electricity utilities (26%) consultants (24%), the Energy Agency (now Authority) (20%), suppliers (18%) and a trade organisation (17%). 22% of firms tell that they work with

energy-efficiency is their own initiative. Project Toolbox comes next with 11% together with 3 other sources of inspiration.

Answers to the survey questions also revealed that firms with 100 employees or more that had a turnover of at least 34 million Euro and firms with large energy expenses, were particularly inspired by Project Toolbox.

Smaller firms (with less than 40 employees) have, to a larger extent, been inspired by suppliers. This suggests that smaller firms use relatively few resources on professional guidance in relation to energy-efficiency.

Five Different Types of Energy Management in Danish Industry

In this section we will use the survey data to describe different ways to manage energy. The basic idea is to create something equivalent to the "life styles" often used in relation to persons and families. Companies are more complex than simple descriptions of their size, sector, energy intensity or drive for profit would suggest. Within these conditions (see figure 1), companies work in different ways, e.g., due to different histories and company cultures.

The practice of energy management is described in 26 variables in the survey. Each company was asked to describe their energy management and the answers are grouped into 13 predefined actions related to the Energy Management Standard (see table 1). They were then asked if they undertook any of the 13 actions. The first 13 answers we have called "unaided", and the following 13 we have called "aided". All answers are dichotomous.

The 26 variables allow for much flexibility in the description of the energy management practices, but are impractical for analysis. Therefore the information is compressed into two new variables by using a factor analysis. The two new variables are constructed based on the 26 original variables. Table 3 shows the coefficients that the 26 original variables are multiplied by to construct each of the two new variables. The idea of this segmentation is a continuation of the work presented in Togeby et al. (1997).

It can be seen from table 3 that the first variable is primarily constructed from all the aided answers. The second new variable is constructed from seven of the 13 unaided answers and one of the aided. It is remarkable that these seven unaided answers all describe the organisational aspects of energy management (policy, goals, education and motivation of employees).

Based on the new variables, the firms' relations to energy management are defined, corresponding to A, B and C in figure 4. The three types can be called:

A (A1 and A2):	Low degree of energy management or no energy management
B:	Relatively high degree of energy management in general, but low on the organisational aspects
C:	Relatively high degree of energy management in general, as well in relation to the organisational aspects

Table 3. Construction of Two Dimensions of Energy Management

	New variable 1: General energy management, primarily based on aided answers		New variable 2: Organisational aspects of energy management, primarily based on unaided answers	
Original variables	Unaided	Aided	Unaided	Aided
Mapping of energy use		0.548		
Continuous energy accounting		0.663		
Energy policy		0.513	0.503	
Quantitative efficiency goals		0.514	0.501	
Action plan/Goals		0.540		
Concrete efficiency projects	0.447	0.695		
Energy efficient purchases		0.512		
Systematic EE design		0.521	0.484	
Organising EE questions		0.501	0.698	
Inform employees		0.608	0.736	
Motivate employees		0.607	0.801	
Educating key employees		0.402	0.832	0.488
No action	-0.746	-0.744		

Rotated component matrix. Principal component analysis with Varimax rotation. Loadings below 0.4 are not shown. The two new variables contain 39% of the total information in the original 26 variables. Note EE = Energy efficiency.

From a normative point of view, the companies with the most advanced energy management should be in the upper right corner of figure 4, with high values in both dimensions. None of the companies interviewed scored high values in the two dimensions. Those with high value in the organisational dimension have only medium high values in the general energy management dimension. As we will see later, these companies have typically entered the energy management area from the environmental management area, and it appears that they have not yet caught up with the energy specific issues.

Using our minimum requirements, we saw in section 4 that less than 40 firms (or 14%) were considered to have energy management. Here there are 162 firms in groups B and C. But the firms in group B and C do not meet any specific requirements, but simply have above average energy management activity.

The companies with more energy management have more employees, have more often received subsidies, have more often made a CO_2-tax agreement, and more often have environmental inspections by the local government.

It could be interesting to examine the degree to which the subsidies, agreements, and inspections have contributed to a higher degree of energy management, but this is not possible from the data set.

Figure 4. All Observations Shown in the Two Constructed Dimensions. Each Point Can Contain Several Observations

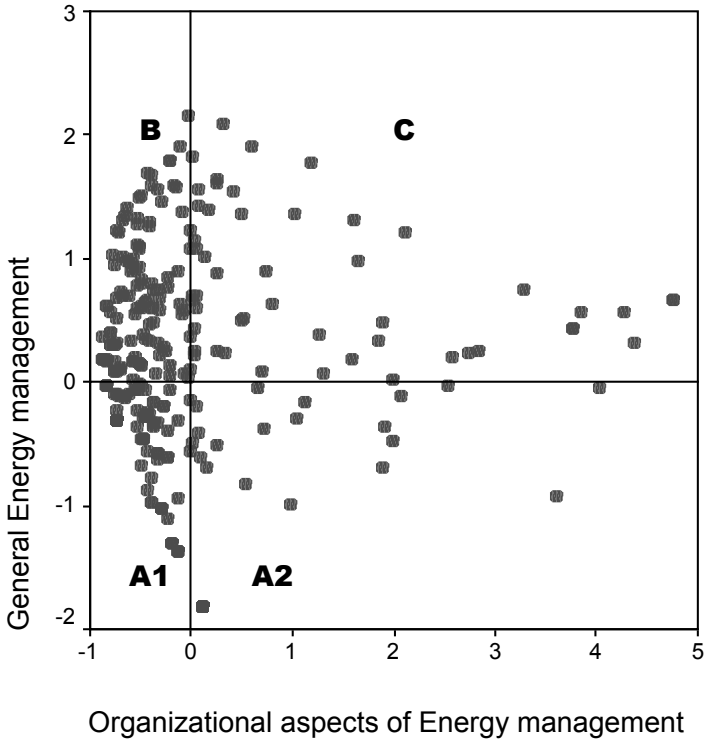


Table 4. Description of Companies with the Three Types of Energy Management

Type of Energy management	A	B	C
Number of companies in sample	142	112	50
Average number of employees	60	78	85
Received subsidies from the Danish Energy Authority	13%	39%	47%
CO_2-tax-agreement with the Danish Energy Authority	2%	11%	19%
Environmental inspection from the local government	14%	14%	33%

Throughout table 5 the A-type companies score low values, e.g. they give relatively few arguments for working with energy management, which is consistent with defining the group as having a low degree of energy management or no energy management.

It is interesting to compare the two types of companies that have extensive use of energy management, types B and C. The most distinct difference between the two types can be found in the first part of table 5: Aspects contributing to the start of energy management activities. The type B companies focus on reduced costs as the main contributing factor. A hypothesis concerning the type B companies thus could be, that they came to energy management from rather technical, cost focussed energy accounting.

The type C companies also have a high score on reduced costs, but compared to the type B, external relations (see figure 1) have a larger impact: Take care of environment, environmental image, PR, and natural part of environmental management are also important. A hypothesis concerning the type C companies thus could be that they are more influenced by external relations of all sorts, and linked to this, environmental management might have served as a bridge to energy management.

Table 5. The Background for Energy Efficiency in Companies with the Three Types of Energy Management

Type of Energy management	A	B	C
Aspects contributing to the take-up of energy efficiency activities *			
Reduced costs	47%	81%	88%
Take care of environment	13%	27%	42%
Environmental image, PR	8%	15%	30%
Natural part of environmental management	5%	7%	26%
Who has inspired the take-up? **			
Suppliers	10%	21%	20%
Advising engineers	10%	29%	32%
Trade organisation	5%	22%	16%
Electricity utility	15%	28%	30%
Other energy supplier	5%	9%	22%
Project Toolbox	6%	13%	16%
Energy Authority	8%	26%	26%
Which types of information have been especially helpful?			
Concrete answers to concrete questions	8%	24%	14%
Information about subsidies	14%	41%	46%
Information about energy savings in the production process	20%	54%	60%
Information about energy savings in auxiliary equipment	8%	33%	44%
Examples of energy management in other companies	8%	27%	26%
Professional information about energy management	8%	26%	24%
Laws, governmental notices	7%	21%	38%
Sources of information ***			
Advising engineers	11%	12%	26%
Trade organisation	5%	22%	22%
Electricity utility	11%	21%	25%
Other energy supplier	4%	7%	10%
Project Toolbox	6%	23%	20%
Energy Authority	12%	18%	26%

* Other answers, such as Driven by employees/Demanded by customers/Pressure from neighbours/ Recommended by accountant/Demanded by law, were given by less than 4%.

** Other answers, such as Accountant/Local government/Public authority//Media/High energy bill/High environmental taxes, were given by less than 8%.

*** Other answers, such as Accountant/Local government/Courses/Media/Occupational health service, were given by less than 5%.

Discussion

Industrial companies strive for profit, and policy instruments such as energy/CO_2 taxes focus on the direct economic benefit for the company of increased energy efficiency. Energy audits focus on technical and economic issues. However, the task of promoting energy efficiency is difficult and is hindered by many restrictions – some of a political nature. Many different policy instruments can and must be used if major improvements in energy efficiency is the goal.

Information about energy management and financial support for the development of energy management have been used in Denmark as two of the ways to achieve improvement in energy efficiency in industry. There are indications that energy management implemented with ambitious goals can be an important policy instrument.

When information is targeted at households, it is common to divide the target group into segments, and to adjust the message to each segment. For industrial companies a similar approach can be used to avoid a "one-size-fits-all" message.

Our study shows that energy management, which is a natural part of general management, is practised to very different extents within the 300 Danish companies studied here. Using the minimum requirements for energy management presented in section 2.2 between 3 and 14 percent practise energy management. The most widespread element of the management system was monitoring, 34 per cent (unaided) and 61 per cent (aided).

Company size and energy intensity can be used to segment the industrial target groups. Our analysis of different types of energy management in Danish industry reveals that two other dimensions can be used to do the segmentation. The background and information needs are clearly different for the three types of firms, A, B, and C, in section 5. The C-type companies are strong in the general organisational aspects, but weak in the energy specific aspects, including the realisation of concrete energy efficiency projects. Whereas the B-type companies might need to strengthen the organisational parts of their energy management to make it a lasting activity. And the A-type companies might need general motivation to engage in energy management.

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