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Resource Efficiency within Current Production

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***Abstract*—**In times of global warming and the increasing shortage of resources, sustainable production is becoming more and more inevitable. Companies cannot only heighten their competitiveness but also contribute positively to environmental protection through efficient energy and resource consumption. Regarding this, technical solutions are often preferred during production, although organizational and process-related approaches also offer great potential. This project focuses on reducing resource usage, with a special emphasis on the human factor. It is the aspiration to develop a methodology that systematically implements and embeds suitable and individual measures and methods regarding resource efficiency throughout the entire production. The measures and methods established help employees handle resources and energy more sensitively. With this in mind, this paper also deals with the difficulties that can occur during the sensitization of employees and the implementation of these measures and methods. In addition, recommendations are given on how to avoid such difficulties.

***Keywords*—**Implementation, human factor, production plant, resource efficiency.

I. Introduction

MANUFACTURING companies are currently working in a turbulent market environment [1]. Unforeseen events, such as the economic crisis of 2008, or megatrends, such as the advance of globalization, present them with new challenges again and again. The pressure on costs due to global trade puts companies in a difficult competitive situation [2]. In order to be able to keep ahead of competitors and hence maintain or improve their competitive position, companies need approaches that enable them to improve their processes and organization and thus reduce the total costs at corporate level. Investment in new technologies aimed at making processes, and hence the manufacture of products, more economic represents a major challenge for small and mid-size enterprises in particular because funds in these businesses are often limited.

Companies often try to use improvements in productivity [3], resulting from the relationship between output in terms of quantity and input in terms of work [4], to reduce the total costs. They do this even though in 2011 only just under 17% of the total costs were attributable to wage costs. The costs of material and energy represent a much larger block, totaling 47% [5], which in this article are subsumed under the heading "resources". Nevertheless, so far companies have prioritized approaches for improving productivity over approaches for improving the efficient use of resources, despite the fact that saving resources clearly has substantial economic and ecological potential. That potential not only helps companies to improve their long-term competitiveness through the efficient use of resources and energy in times of climate change and ever scarcer resources, but to make a contribution to protecting the environment as well. When it comes to energy consumption, it is estimated that manufacturing industry could save 15% on average, which in monetary terms could result in annual savings of €5 billion [6]. Using materials more efficiently could reduce the cost of materials by 20%, saving up to €100 billion every year [7].

Besides these potential economic benefits, the sustainable use of resources also improves a company's image and hence its reputation [8].

II. Resource Efficiency as an Across-the-Board Topic in Companies

The efficient use of resources concerns all areas of a business. Along the value creation chain there are many places where the use of resources can be reduced, often independently of other measures. For example, the use of recyclable materials in product development can improve resource efficiency. Within procurement activities, sustainable purchasing strategies can optimize the use of materials or energy, e.g. through targeted investments in energy-efficient machinery. Also within the scope of procurement, suppliers can be selected on the basis of defined evaluation criteria, such as acknowledgement of a sustainable corporate policy. However, different areas of a company should not act independently of each other in this respect. Rather, many aspects of resource efficiency must be considered across, and above all integrated into, all areas of the business and the value-creation process. For example, procurement must receive information from product development because otherwise there can be no changes to policy regarding bought-in materials. Only when resource efficiency is understood as an interdisciplinary topic is it possible for a company to exploit the potential savings to the full.

The level of implementation of the subject of resource efficiency in individual businesses is just as diverse as the businesses themselves. The essential prerequisites for successful implementation are embedding the philosophy,

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creating a joint (planning) principle, initiating and stabilizing improvement processes, and monitoring successes (see Fig. 1). Whereas a number of companies see embedding the philosophy as an almost insurmountable hurdle (because they fail when developing and implementing sustainable corporate values or the active shaping of their image and reputation), others are already able to monitor their successes, e.g. via an "originator pays" cost accounting system. Each of these prerequisites can be satisfied in different ways or to different degrees.

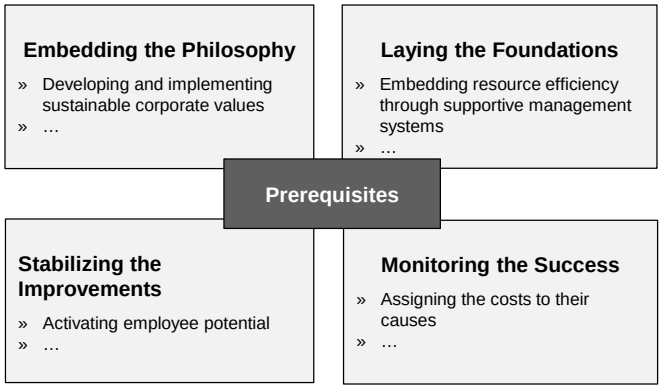

Fig. 1 The prerequisites for implementing an integrated resources management system

III. Estimating the Level of Implementation of Resource Efficiency in Current Production

The first step in improving the efficient use of resources in a company is to estimate the level of implementation. Based on this, it is then possible to derive specific recommendations for action in a second step. This is the starting point for the research project. The aim of the project is to develop a procedure for the systematic introduction and embedment of company-specific, selected measures to improve the efficient use of resources in current production. In order to analyze the actual situation in a company, a quick check was devised in the form of a capability maturity model.

This quick check was developed based on the "20 Keys" evaluation method of Kobayashi [9]. In the end, 13 keys were determined which address various resources-critical business processes or issues within the company and hence describe the current status of the form of resource efficiency efforts within that company. The keys are shown in Fig. 2.

These keys concern, for example, the issue of an "originator pays" cost accounting system within the company or the development and implementation of sustainable corporate values. Five levels of implementation in which a company can find itself were defined for each key. The five levels correspond to difficulty of attainability. Each level in turn consists of two sub-levels. The ensuing scale enables a differentiated assessment of the resource efficiency within the company being investigated. Moreover, it is possible to define a desired target status in addition to the actual status. The difference between current status and target status enables a company to derive the first measures for achieving the desired target status. To reach this status, the company must pass through every level, step by step, to improve resource efficiency. Skipping a level has not been allowed for. A radar chart is used to display the result graphically (see Fig. 3).

Keys	
Key 1	Developing and implementing sustainable company values
Key 2	Realizing improvements continuously
Key 3	Implementing resource efficiency standards in daily production
Key 4	Embedding resource efficiency through supportive management systems
Key 5	Assigning the costs to their causes
Key 6	Activating resource efficiency with the help of graphic support
Key 7	Mobilizing employee potential
Key 8	Organizing the distribution logistics sustainably
Key 9	Organizing the procurement logistics sustainably
Key 10	Actively shaping the company's image and reputation
Key 11	Developing resource-efficient products
Key 12	Creating sustainable building structures
Key 13	Developing or procuring resource-efficient production technologies

Fig. 2 The 13 keys of the quick check for an overall assessment of resource efficiency in a company

IV. Implementing Measures to Increase Resource Efficiency

Once a company has estimated its resource efficiency by carrying out the quick check, the challenge is to increase resource efficiency according to the desired target level. However, many measures designed to improve the efficient use of resources can only be introduced within the scope of restructuring. For example, it is not generally advisable to reduce the use of materials or use alternative, sustainable raw materials in current production. Instead, such measures require a redesign or redevelopment. What happens when this planning phase is already over, i.e. current machinery is already manufacturing a product made from a specific material that the company procures from suppliers with long-term contracts? In this case the methods and measures employed must enable the optimization of the use of resources in current operations. Method here means "a procedure based on a system of rules for obtaining [scientific] knowledge or practical results" [10]. One application of this method is to develop or derive measures. A measure here is defined as an "action, rule, etc. intended to bring about something in particular" [11]. An Ishikawa diagram, also known as a cause-and-effect diagram, is used to explain the difference between these two concepts. The Ishikawa diagram method enables a systematic procedure when analyzing a problem or an unwanted effect. Potential root causes of a specific problem are compiled within the scope of the analysis. For example, if the consumption of compressed air is too high (problem/effect), a comprehensive catalog of potential causes is drawn up for the Ishikawa diagram in the categories

machine, method, material, manpower, measurement, and milieu [12].The Ishikawa diagram offers a good structure for deriving measures to rectify problems. Numerous potential root causes, e.g. leaks in compressed-air lines or employee errors during operation, can be compiled. One possible, short-term measure could be to check the lines for leaks and to repair any leaks found. Long-term measures could be, for example, regular inspections of the lines by certain employees or training the employees to handle compressed-air equipment properly and carefully. The measures derived can help to tap the potential established regarding the saving of resources, in this case compressed air. In the research project, clustering was carried out to classify the methods with respect to the purpose of the methods. "Sensitizing", "analyzing", "prioritizing", "developing measures", "implementing", and "checking" clusters were formed. There are different, selected methods in each of these categories. For example, the "analyzing" cluster contains methods with which objects, facts or effects can be investigated systematically. Examples here would be analyzing materials flows with the help of a Sankey diagram, or a root cause analysis with the help of the 5 whys method. The "developing measures" cluster contains largely creative techniques such as mind mapping or brainstorming. However, the methods cannot always be allocated exactly to a certain cluster. The self-recording method, i.e. the independent noting of certain facts over a defined period of time, can be assigned to both the "analyzing" and "checking" clusters [13]. Clusters help companies to select methods to suit their requirements. These methods, and the ensuing measures, too, now have to be implemented in the company by the employees. Many of these methods and measures have to be applied or implemented by production staff. Implementation, however, especially the long-term measures, often means changing the way employees work. And not only that: the entire orientation toward increasing resource efficiency often calls for a process of change within an area of a company or the whole company. For this reason, the particular focus of the "Improving Resource Efficiency in Production" research project is on sensitizing employees to the need to implement resource efficiency measures. Sensitizing and mobilizing employees are the fundamental prerequisites for shaping resource efficiency within a company. This task falls within the remit of change management. Based on eight reasons for the failure of change processes, Kotter derives a procedure for accomplishing change processes successfully [14]. Corresponding to the reasons for the failure of change processes, he divides the procedure into eight steps, which are shown in Fig. 4.

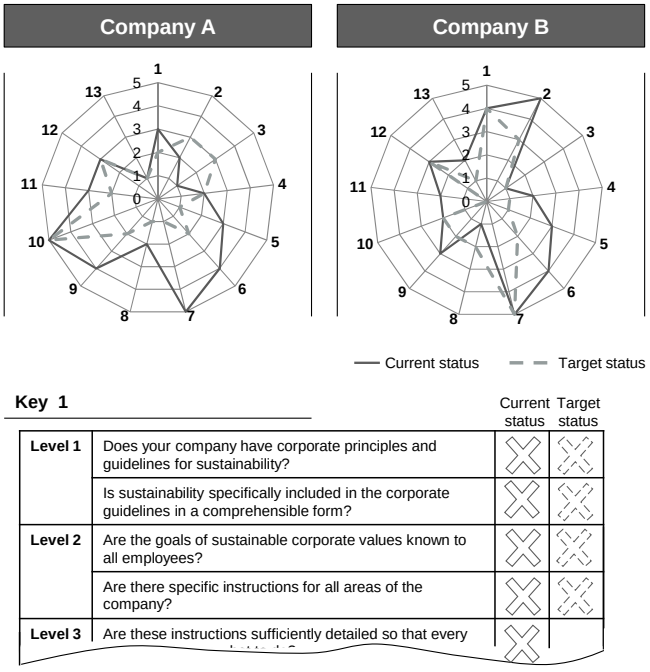

Fig. 3 Estimating and displaying the resource efficiency of two sample companies

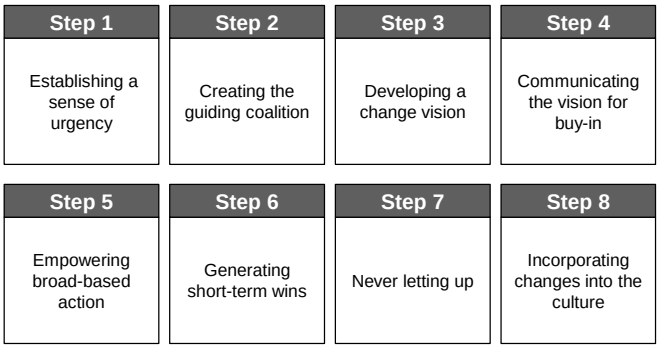

Fig. 4 Kotter's eight change management steps [14]

A systematic procedure for carrying out change processes is very important for their success because employees can develop a defensive attitude toward changes. This reluctance can appear when, for example, an employee feels that a change imposed from outside restricts his or her scope for making decisions [15]. Accordingly, it is therefore important that a high degree of acceptance for upcoming changes be encouraged among the employees affected and that they are sensitized to the need for changes and mobilized to favor implementation. Experience shows that frequently, especially when it comes to using resources efficiently, considerable effort still has to be devoted to convincing staff.

So far, however, there has been a lack of suitable concepts that provide small and mid-size enterprises in particular with the support they need to establish a resource-efficient orientation. There is also a lack of specific recommendations regarding how to implement these concepts and how resource-efficient behavior can be anchored permanently in the minds

of staff. Practical experience has shown that implementing resource efficiency in current production can often lead to big challenges. In the next section, some of these challenges are illustrated using examples taken from a typical company in the foundry sector along the eight change management steps according to Kotter.

V. Challenges when Implementing Resource Efficiency in Companies

One particular challenge is communicating to employees the need for, or as Kotter puts it, the urgency of, resource efficiency. If a company finds itself in a state of lethargy, the communication can be achieved primarily by confronting the company with looming threats or fascinating chances for the future [16]. Experience shows that only after employees have realized the need for change in the company and their own conduct are they prepared to make a positive contribution to resource efficiency throughout the company. This is the case, for example, when the employee is made aware of the positive aspects that can ensue for each individual when the savings are achieved.

In the next phase, the sensitization, a management coalition has to be set up which must have enough drive to implement measures and also demonstrate a clear commitment to saving resources. Difficulties are often encountered in practice when the management coalition has neither the necessary teamwork abilities, so the work is hampered from within, nor the necessary support from corporate management. The development of an understandable resource efficiency strategy is another step critical to the success of improving resource efficiency in a company. If employees do not understand the strategy, that makes it difficult for them to act appropriately. To deal with this challenge, the strategy should be communicated as vividly as possible with the help of specific examples from the respective company.

The fourth step relates to communicating the vision for change. First of all, it is important that changes are not only initiated by managers from the top down to shop-floor level, but that those managers are themselves good examples. Managers must set an example for resource-efficient behavior in order to be able to convey the need to increase resource efficiency credibly to their staff. For example, if managers ask their staff to make sure that they switch off equipment or lights when production is not running, then the managers themselves must make sure that the lights in their offices are switched off when they are away attending meetings, for instance. Support for the understanding for the need to save resources could be in the form of publishing meaningful figures, which are readily understood by every employee, or displaying posters with bold, simple messages. In particular, when the respective message addresses the employee's emotions, then this is when they will recognize the need to save resources and act accordingly [17]. Figures that show how many jobs could be created by reducing the consumption of resources help employees to understand the urgency of saving resources.

The demand for empowerment not only stands for developing the necessary abilities, but also for mobilizing the readiness of the employees. Merely setting an example for resource-efficient behavior at management level is not always sufficient on its own to overcome the reluctance of employees. For in the end, focusing on resource efficiency as prescribed by management signifies a change to the way in which employees work. In order that employees can implement the new methods and measures, they must be given the necessary time plus training. In particular, employees must be trained to understand the methods. Furthermore, practical experience shows the significance of clear responsibilities. This on the one hand increases the sense of responsibility and employees' identification with the task. On the other, any successes can be assigned to specific persons. This initiates a competition, which also promotes motivation through positive results.

The fact that companies often consider the costs of materials and energy as overheads and do not assign them to the true originators leads—owing to a lack of transparency—to little sense of responsibility on the part of the originator. Practical experience has shown that in many instances companies limit performance figures to those at corporate level. However, at the level of individual departments these figures are less relevant. It is not infrequently the case that those departments are not sure how they stand in relation to other departments—whether they are good or bad examples. For this reason it is important to break down the corresponding figures to the level of departments or cost centers.

Step number six relates to achieving quick successes. Regarding the success of new resource efficiency measures, the employees affected require feedback without delay. Experience from practical consultancy projects reveals that employees participating in workshops can often be made enthusiastic about the topic of resource efficiency and be encouraged to submit diverse ideas and suggestions for improvement. If these ideas are not put into practice quickly, however, this generally leads to unmotivated employees. Measures that can be implemented at short notice should therefore be preferred to long-term measures, especially during the initial phase, because such measures promise quicker tangible successes.

Within the scope of consolidation and introducing further changes, the aim of step seven is to use the acceptance of staff to initiate further changes with regard to handling company-related resources. Both the frequency and consistency of implementing measures are extremely important here. Furthermore, regular communication about the successes ensures that the resource efficiency theme remains topical within the company. Otherwise, the initial enthusiasm and motivation for the changes quickly wanes.

Embedding the new approaches in the corporate culture is the eighth and final step in Kotter's change management procedure. The new behavior must be anchored as a whole in the corporate culture. To this end it is necessary to establish the concept of saving resources and fix the corresponding resource-efficient behavior firmly in the minds of the employees, and ensure that everything becomes a matter of

course for them. Ongoing training of staff with respect to the resource-efficient use of materials and energy is beneficial for the goal of increasing the efficient use of resources. It must be ensured that, again and again, employees are shown what they can help to achieve in the short- and long-term through saving resources. This work should include success stories that are communicated throughout the company at regular intervals. Again, that helps to keep the theme of resource efficiency in the limelight within the company and therefore anchored in the corporate culture.

In principle, every company must ask itself to what extent employees really are willing and able to implement the proposed measures when introducing resource efficiency concepts. Such aspects are difficult to measure in practice. Every single employee can be told about the need to save resources and also take note of these. In addition, he or she can be trained in the use of resource efficiency methods. But whether these employees are fully in favor of the concept, accept the measures, and develop an intrinsic motivation is very difficult to judge. In the end, lasting success is only measurable through the definition and incorporation of corresponding performance figures, e.g. the energy saved per employee per unit of time.

VI. Summary

The subject of the efficient use of materials and energy is hugely relevant for all areas of a company because there is great potential for saving money. In order to enhance this savings potential, companies must implement methods and measures that help to save resources. However, there are currently no procedures available which enable the systematic introduction of measures to improve resource efficiency in current production. Reviewing the actual status of a company by means of a capability maturity model is the first step in discovering the target status and using this to derive which specific measures can be implemented. Achieving the target status is supported by applying various methods. Clustering the methods enables companies to choose the ones they need for their purposes and derive measures to increase resource efficiency within the scope of the application. In the end it is always individual employees who are responsible for the long-term implementation. For employees, implementation often means changing ingrained ways of working. According to Kotter, eight steps are required to anchor changes in the company and its corporate culture. In the course of these eight steps, implementing resource efficiency measures in practice results in challenges that must be faced.

It is obvious that the key to implementing resource efficiency measures in a systematic procedure for introducing measures to improve resource efficiency in current production lies in sensitizing staff to the need for the measures. If staff on the shop floor are not properly informed and motivated in advance, they will not support the saving of resources. The consequence of this could be that potential within the company goes undetected. When it comes down to it, it is the employees working on the shop floor who possess the greatest expertise regarding processes, use of materials, and hence wastage in the company. They are also the persons whose conduct and ways of working can have a distinct influence on precisely this wastage in current factory operations.

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