Linking Lean to Green – Energy Efficiency as a Value Stream

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ABSTRACT

Over the past few decades, lean management philosophies have penetrated various sectors of industry. At same time, dynamic environmental, or green, management is needed to succeed in the current green conscious market. Some research has already been conducted on the potential synergy gains of the two management philosophies, since both are known to strive towards efficient use of resources, eliminating waste, as well as human health and well-being. This study looks into the similarities between lean management principles, more particularly the typical wastes found in lean management, and energy management aiming at mitigating the climate impact of operational buildings. The aim of the study is to illustrate how added value to the end-customer can be created via effective energy management. In line with lean management principles, the non-value adding parts of energy consumption are identified. The study considers the case of a Finnish facility management organisation providing a remote energy management service. Energy consumption data from two Finnish retailers with locations throughout the country is used to evaluate the effectiveness of the service. The study shows how value (i.e., energy efficiency) is increased and waste (i.e., excess energy use) diminished through a service concept aimed at reducing costs and producing positive environmental impacts. The study shows that many parallels exist between the types of lean waste and the non-value adding parts of energy consumption, i.e. waste energy. Furthermore, eliminating waste from the energy management service will automatically conserve energy, as well as reduce greenhouse gases. Minimizing the use of resources, such as energy, is an essential part of the lean management philosophy. It can even be argued that incorporating lean thinking into energy management innately generates greener energy management practices, and vice versa.

Keywords

Lean management, green management, energy management, facility services, energy efficiency, optimizing

1 INTRODUCTION

Climate change is considered the main environmental challenge of our time. Furthermore, over 40% of global annual energy use, and consequently, nearly 40% of global annual greenhouse gas emissions are derived from the built environment. Moreover, most of the 40% energy use is consumed by existing, operational buildings (UNEP 2007). Therefore improving the operational energy-efficiency of buildings is essential in mitigating climate change. Improved energy-efficiency of existing buildings can be achieved through effective energy management. O'Callaghan (1996) defines energy management as:

> "*the systematic quantification of energy-related activities within a system boundary, e.g. site, a region or a product*"

Energy management aims at optimizing all HVAC-R operations, as well as operating schedules and set point values to conserve energy in a building or organization. Most commonly, energy management is a service provided by a facility management organisation in conjunction with other facility services.

Lean management is a philosophy that aims at eliminating the non-value adding parts - referred to as waste - of a value stream. Some research has already been conducted on the potential synergy gains of the two philosophies. Previous research (Rothenberg et al. 2001; Pil & Rothenberg 2003; King & Lenox 2001) has focused on manufacturing operations, mainly in the automobile industry, the industry within which lean thinking was invented and consequently most widely used. These studies have shown positive correlations between some of the key elements of green and lean management, such as, buffer minimization, and human resource management. Furthermore, Florida (1996) argues that lean and green management strategies share their main principles: improving productivity and quality, reducing costs, commitment to continuous improvement as well as technological innovations. Collaborate problem solving is another common feature with the two management systems (King & Lenox 2001). In addition, it is considered that on an organizational level it is likely that the presence of one management system makes the other one easier to adopt (King & Lenox 2001; Rothenberg et al. 2001).

This study looks into the similarities between lean management principles, more particularly the typical wastes found in lean management, and energy management. The aim of the study is to illustrate how added value to the end-customer can be created via effective energy management. In line with lean management principles, the non-value adding parts of energy consumption are identified. The study considers the case of a Finnish facility management organisation providing a remote energy management service. Energy consumption data from two Finnish retailers with locations throughout the country is used to evaluate the effectiveness of the service. The study shows how value is increased and waste diminished through a service concept aimed at reducing costs and producing positive environmental impacts.

The remainder of the paper is structured, as follows. The next chapter will present the theory of lean management, focusing on the concept of waste. Section 3 describes the Study Design, informing the reader of e.g. data collection methods. Results of both the empirical case study and the theoretical literature review are introduced in Section 4. Finally, the last chapter discusses the results, draws conclusions and provides ideas for future research.

2 LEAN MANAGEMENT AND THE DEFINITON OF WASTE

Lean is known as a management theory, in which everything is done with less of everything (Morgan & Liker 2006). Lean management is a way of thinking initiated by the successful CEO of Toyota Taiichi Ohno. According to lean management, the end customer is willing to pay only for those activities of the value creation process that increase the value of the product/service from the perspective of the end customer (Womack & Jones, 1996; Liker 2004). Therefore, the core idea of lean management is to minimise the non-value adding activities, that are called waste (*muda* in Japanese), of the processes. In addition to value adding activities and non-value adding activities, there are activities that do not create value for the end customer but are necessary or otherwise challenging to eliminate for example due to legislative issues (Liker 2004). According to Hines et al. (2008) in an information flow environment such as the office environment, only 1% of the process activities create value, while 50% do not create value but are necessary and 49% do not create value and, thus, are pure waste. Unlike in the Western thinking, in which productivity is typically increased by focusing on the value adding activities of the processes, in lean management the productivity gains are achieved by continual minimising the non value adding activities of the processes (Morgan & Liker 2006).

As stated above, the key idea of lean management is to eliminate the non-value adding parts of the process and, thus, increase productivity (Liker 2004). However, waste prevention is at least as important (Bicheno 2004). Waste should be minimised through the entire process, i.e., from the moment the order is received to the point the cash is collected (Ohno 1988). In addition to product and service delivery, waste should be also minimised from other activities, such as, product development (Morgan & Liker 2006) and administration (Rother & Shook 2003). In practise all waste can never be eliminated, hence the processes should be optimised in accordance with the principles of lean management (Liker 2004).

Waste of resources such as energy, water, and materials have traditionally been considered poor environmental practice. However, they are also considered waste from the lean management perspective. Human behaviour has a significant role in reducing energy (Bicheno 2004) for instance by activities such as switching off the lights, shutting down machines, car pooling, etc. after the work day. Lean management encourages the optimization of the use of materials from design to manufacturing and from customer usage to remanufacturing, i.e., throughout the whole life cycle of the product or service (Bicheno 2004).

The 12 types of waste found from literature (Ohno 1988; Liker 2004; Bicheno 2004; Morgan & Liker 2006; Hines et al. 2008) are listed and described below:

1) Waiting and delays
2) Overproduction
3) Unnecessary inventories
4) Incorrect processing e.g. duplications, inappropriate systems
5) Unnecessary transport
6) Unnecessary motion and movements
7) Defects and errors
8) Unclear communication

9) Making a wrong product or service efficiently
10) Untapped employee potential
11) Opportunity lost

According to lean principles, waiting and delays (1) do not create value for the customer. All process parts that do not create value to the customer but require time generate delays and waiting for the end customer. Although it might be difficult to eliminate all waiting and delays, elimination has to remain the aim (Bicheno 2004), since time on hand produces waste for the end-customer.

Overproduction (2) is considered to be a fundamental waste because it is a source of many other waste types (Bicheno 2004; Liker 2004). Whenever too many products or product parts are produced, or they are produced earlier than needed (Morgan & Liker 2006; Hines et al. 2008), other types of waste, such as unnecessary inventories, transportation and motion, is also generated. Furthermore, unnecessary inventories (3) tend to require more space and increase lead times (Bicheno 2004). To tackle overproduction is a great challenge in the production industry but causes fewer challenges in the service sector due to the intangible nature of the services.

In an incorrect process (4) the product or service can either be damaged (Bicheno 2004; Liker 2004) or unneeded steps are taken (Liker 2004), in other words, the product or service is over processed. For example, in the current ICT era, improper software systems cause incorrect processing and increase the overburden and unevenness of work.

Unnecessary transport (5) results in wasted time, effort and cost (Hines et al. 2008). Moving materials or information from one place to another does not create value for the end-customer (Bicheno 2004; Hines et al. 2008). Unnecessary motion and movements (6) of employees are also considered waste (Ohno 1988; Liker 2004; Morgan & Liker 2006; Hines et al. 2008). Employees' movements can be decreased by optimising both the workstation layout (Bicheno 2004) and the overall layout of the office.

Defects and errors (7) can occur in product or service quality, paper work, or poor delivery performance (Hines et al. 2008). Because of defects and errors, inspections, rework, and corrections need to be done (Liker 2004). The longer the defects remain undetected, the more the defects tend to cost. Lean management sees defects and errors an opportunity to improve the performance (Bicheno 2004) and, consequently, increase the productivity of processes and product and service quality. Similar to defects and errors, unclear communication (8) often results in rework of searching for clarifications, wasted time, misunderstanding the use of product or service, to name but a few (Bicheno 2004). Albeit defect-free products and services are essential, producing a defect-free but wrong product or service (9) efficiently is also considered waste.

The overall aim of lean management is to create thinking people (Bicheno 2004). Therefore, not using the potential of employees is another waste type. According to Ohno (1988) instead of automation companies should aim at *autonomation*, meaning automation with human touch. Untapped employee potential (10) refers to e.g., lost ideas, employees' low commitment to their work, low trust in the workplace (Bicheno 2004). Lean management deems it essential to empower the employees to use their potential, since not only managers have great ideas (Bicheno 2004).

Whenever an organisation cannot retain or win customers, it will suffer an opportunity lost (11) which can be a consequence of for example defect products, long waiting times, or poor service experience (Bicheno 2004). A company that does not have customers only creates waste.

3 STUDY DESIGN

The case under review is a remote energy management service operating under the service portfolio of a global commercial facility service provider. Active energy management is conducted from a centralized building automation system control centre. While the energy management provider has not formally adopted lean management, their policies and practices bear a clear resemblance to lean principles. The service comprises continuous and regular control and monitoring of building systems in order to minimize the end-customers' energy consumption levels and consequently, greenhouse gas emissions and costs. Using the terminology of lean, the principle idea is to minimize waste. Furthermore, the monitoring schedule and scope are based on the end-customers' needs. Control systems for all equipment, including the building automation system, ventilation, air-conditioning, heating, cooling, lighting and refrigeration, can be centralized. The service provides energy consumption, deviation and maintenance reports, as well as proposals for action. It is worth noting that the remote energy management service acts as a supporting tool for onsite property maintenance and technical property services, not as a separate service.

Energy consumption data from two Finnish retailers with locations throughout the country is used to evaluate the effectiveness of the energy management service. A sample of 44 retail facilities was chosen for analysis. The sample comprised a variation of different retail types including department stores, grocery and hardware stores, car dealers, hypermarkets and wholesalers. The volume of the facilities varied from 1,600 m^3 to 150,600 m^3. Energy and electricity consumption data was collected from an 18-month period, starting on the date the facilities were connected to the energy management service. The comparison period is the 12-month period before connecting to the service. Furthermore, the authors familiarized themselves with the operations of the energy management service via interviews with the customer service manager and director of energy management.

4 RESULTS

The results of the study are divided in two chapters. The results of the quantitative analysis are presented first, followed by the results of the literature review a qualitative analysis of the energy management service

4.1 Reduced Energy Consumption

Conducting quantitative analysis of the retail facility data sample enabled numeric evaluation of the amount of waste reduced. For the analyzed facilities, electricity consumption decreased 4.85% and heating energy 6.73% on the average, during the reference period. The respective decrease in CO2 emissions was 2,458 ton in total. The reduction in CO2 emissions was calculated using the average carbon intensity values of Finnish energy production. The carbon intensity values used were 280 kg (CO2)/MWh for electricity and 219 kg (CO2)/MWh for district heating, respectively (ERA 17 2010).

Furthermore, when examining the last six month period and comparing it to the consumption levels of the previous calendar year, i.e., when the properties were already connected to the remote control centre, the results show that the consumption levels continue to decrease. Total electricity consumption decrease during the last six months of the reference period was 4.26% and heating energy decrease 5.34% on the average. The results suggest that energy management continues to affect the energy efficiency of the retail facilities even after the initial improvements. This supports the idea that lean and energy management share the common goal of continuous improvement.

4.2 Waste in Energy Management

Based on the interviews and observance of the energy management service 11 non-value adding parts of energy consumption, corresponding to the 11 types of lean waste found in literature (see Section 2), were identified. The wastes hindering energy-efficiency, as well as the respective lean waste types, are presented in Table 1. The waste types are then described in more detail in the following chapter.

Table 1 Types of Waste

Lean	**Energy-efficiency**
1) Waiting and delays	1) Time-lag in optimization
2) Overproduction	2) Lack of scheduling
3) Unnecessary inventories	3) Excess space
4) Incorrect processing	4) Random monitoring
5) Unnecessary transport	5) Infrastructure
6) Unnecessary motion and movements	6) Separated systems
7) Defects and errors	7) Deviations
8) Unclear communication	8) Poor communication
9) Making a wrong product or service effectively	9) Overheating and/or cooling
10) Untapped employee potential	10) Incompetent staff
11) Opportunity lost	11) Unwillingness to make changes or invest in repairs

Time-lag in optimization (1) occurs when there is no active or formalized energy management. However, time-lag can be avoided with quick reaction to problems and, more importantly, a proactive approach to weather changes or changes in occupancy levels. Furthermore, quick reaction to problems prevents the matter form escalating into more serious problems, which could lead to decreased energy-efficiency. One of the main reasons for wasting energy in buildings is the lack of scheduling (2) with regard to heating, cooling, or lighting facilities. In other words, facilities are unnecessarily heated, cooled, or lighted because the operating schedules have not been optimized for building occupancy, indoor air quality, or climate conditions.

The use of space naturally has a major impact on building energy consumption. Lean management considers unnecessary inventory waste, mainly due to the extra space required to

store the stock. The parallel between lean and environmental management is clear and excess space (3) was identified as a waste.

The lack of systematic, real time, continuous monitoring and leakage watch can result in energy loss. By providing random monitoring (4), the energy management service provides an incorrect, possibly harmful service.

The energy management service is operated as a remote service from a single location for nationwide locations. Besides reducing unnecessary transport and motion, this allows for consistent monitoring and reporting. The use of unnecessary infrastructure (5) and separated systems (6) is avoided. Deviations (7), such as leaking valves can be first detected and then recorded and documented by the energy management service. All equipment alarms leave a paper trail that can be tracked later, if needed.

Poor communication (8) between the facility manager or facility maintenance and the end-customer can also hinder energy efficiency. With the help of a centralized energy management service, communication can be improved and misunderstandings avoided. Energy management facilitates the flow of information from service provider to onsite property management, and on to the end-customer.

A surprisingly common problem with building energy use is the simultaneous heating and cooling of facilities. A good example is a situation, where thermal occupant comfort requires the occupant to open windows, while the heating system is adjusted to a high level. When comparing to lean waste types, overheating and/or cooling (9) essentially correspond producing the wrong service to the end-customer, albeit effectively.

Energy management is provided by professionals, with the latest technology in use, which ensures that incompetent staff (10) or the lack of training does not conflict with the energy-efficiency goal. The energy management service also provided recommendations for actions and investment suggestions to enhance the energy-efficiency. The unwillingness of the end-customer to make changes or invest in repairs (11) represents a lost opportunity in adding value to the process.

5 DISCUSSION AND CONCLUSION

Building energy consumption is considered one of the main culprits of the most significant environmental challenge of our times, the anthropogenic climate change. Mitigating the climate impacts of the built environment requires, among other measures, systematic energy management. Almost simultaneously with the rise of environmental, or green, consciousness, lean thinking has penetrated various sectors of industry. Lean management is a philosophy that aims at eliminating the non-value adding parts - referred to as waste - of a value stream. As previous research has shown, both green and lean philosophies strive towards efficient use of resources, reducing waste, as well as promoting human health and well-being.

The motivation for this study was to illustrate similarities between lean management principles and energy management. In particular, it was of interest to adapt the different types of waste typically found in lean management theories into energy management. It was observed that while the energy management provider has not formally adopted lean management, their policies and practices bear a clear resemblance to lean principles. In summary, the practices promoting efficient use of energy include:

1) quick reaction to problems, a proactive approach to weather changes or changes in occupancy levels;
2) adequate scheduling;
3) efficient use of space;
4) systematic, real time, continuous monitoring and leakage watch;
5) appropriate infrastructure;
6) use of a centralized energy management system;
7) detecting, recording and documenting any deviations;
8) efficient communication between facility manager, maintenance and the end-customer;
9) always providing the right service;
10) high level of professionalism; and
11) providing recommendations for actions and investment suggestions.

The study shows that many parallels exist between the types of lean waste and the non-value adding parts of energy consumption, i.e. waste energy. Furthermore, eliminating waste from the energy management service will automatically conserve energy, as well as reduce greenhouse gases. Minimizing the use of resources, such as energy, is an essential part of the lean management philosophy. It can even be argued that incorporating lean thinking into energy management innately generates greener energy management practices, and vice versa.

Future research on the linkage between lean and green could focus on other aspects of green and facility management, such as greenhouse gases from other sources, waste management, material use, as well as occupant comfort and well-being

ACKNOWLEDGMENTS

The authors wish to thank the facility management organization ISS for providing the empirical data for the study. Additionally, Ms. Luoma wishes to thank the Finnish Foundation for Technology Promotion for a scholarship in support of her PhD studies.

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