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An analytical model for identifying and addressing energy efficiency improvement opportunities in industrial production systems – model development and testing experiences from Sweden

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Keywords: industrial energy efficiency, improving energy efficiency, behavioural changes, system approach, production system, continuous improvement

Abstract

Improved energy efficiency is one of the most effective strategies for achieving energy sustainability and independence locally, regionally and globally. Industry accounts for 40% of global energy usage each year, which suggests its potentially significant impact on overall energy use. The rapid development of standards for more efficient equipment and components are pushing manufacturers towards further improvements on a component level. However, it has been shown that the largest efficiency potential is actually found in higher system levels in which components serve, such as production processes, ventilation or hydraulic systems. Even though the importance of increasing energy efficiency at a systemic level has been widely acknowledged in recent years, practical approaches are seldom discussed in the literature. This gap between aspiration and achievement calls for the development of new approaches to foster system efficiency in industrial systems. This paper presents a systems analysis and corresponding model to increase the energy efficiency of industrial processes that involve intensive usage of electric motor systems. The model originates from traditional value stream mapping. Three case studies representing three different industrial processes were conducted to develop and validate the model. In total, 31 energy efficiency measures were identified, 29 of which address actions beyond component levels. Alongside identifications of energy efficiency measures, the model promotes the creation of conditions for cross-functional worker participation. By applying this model, the knowledge and skills gained by industrial personnel working with improved energy efficiency, maintenance and production processes can be used immediately to generate improvement suggestions. The paper concludes that this model, based on a simplified energy-focused value stream mapping, could broaden the scope of energy efficiency actions, engage a larger group of workers within the organisation and increase systems efficiency. This can be further used as a practical tool for finding continuous improvement possibilities that will result in strengthened competitiveness and more cost-effective and sustainable manufacturing.

1. Introduction

The ability to assure customer satisfaction with fewer resources is always important and often crucial for industrial competitiveness. Historically, Swedish industry has remained competitive due to innovation and optimisation practices; i.e. the development of its ability to adapt products and their related costs to the needs of the market (Swedish Government, 2016). Improving energy efficiency in industry is considered to be an important means for increased competitiveness that will also help reduce global warming and achieve sustainable production (IPCC, 2014). Additionally, improving industrial energy efficiency is a pivotal means of achieving energy independence locally, regionally and globally.

Energy audits performed by external energy experts can be used to identify areas for industrial energy efficiency improvements (Bunse et al., 2011; Caffal, 1995). According to Article 8 of Sweden's Energy Efficiency Directive, since June 2014 all energy-intensive industries in Sweden have been obliged to perform energy audits every four years (EC, 2012). These audits result in lists of energy efficiency

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