

Energy efficiency potentials for different motor system levels – an empirical study of PFE implemented energy efficiency measures

Svetlana Paramonova
 Linköping University
 SE-581 83 Linköping
svetlana.paramonova@liu.se

Patrik Thollander
 Linköping University
 SE-581 83 Linköping
patrik.thollander@liu.se

Introduction

Improved industrial energy efficiency (IEE) is a cornerstone in reducing greenhouse gas emissions. The implementation of Energy Efficiency Measures (EEMs) is the primary means of improving IEE. However, EEMs are not always, as many measures in the building sector, stand-alone measures. Rather, EEMs are intertwined in the production system and various other sub-systems calling for a systems approach to be applied. In industry, nearly 70 percent of the power use emanates from motor systems (Waide & Brunner, 2011). Electric motor systems can be categorized into three system levels; motor, core motor system, and whole system, where Waide and Brunner (2011) state the large energy efficiency potential to be found in the upper system levels. Backlund et al. (2012) state that a large unexploited potential also lies in measures related to management and operation of the energy system. However, previous research has been scarce in showing on which system levels that the highest potential for improved IEE is found. Based on a large dataset of electric motor system measures from the Swedish energy policy program PFE (Program for improving energy efficiency in energy-intensive companies) consisting of about 1250 EEMs saving 900 GWh/year, the aim of this study was to analyze, using an extended version of the system level categorization, on which system levels the implemented measures were found.

Methodology

The basis for the categorization of the measures was motor system levels defined by Waide and Brunner (2011). They define three levels of motor system to make energy efficiency improvements: Level 1 (Electric motor), Level 2 (Core motor system) and Level 3 (Total motor system). In the current study, an additional category, Level 4 (Extended motor system), was introduced in order to include measures related to energy management and operative actions, which lie outside the total motor system. The most obvious here would be when a measure clearly involves a person to do something, demand-based adjustment, switching off, regulation or optimization we define as level 4.

Only measures that are related to motor systems and with estimated energy saving potential were selected from the PFE data and assigned a respective motor system level. Example of measures found in PFE and divided by motor systems levels are presented in Table 1.

Table 1. Examples of measures from PFE classified into the motor systems levels.

Motor system level	Example from PFE
Level 1: Electric motor	Replace pump motor, Change to more efficient electric motors, Removal of motor, Change of fan motor in washing machine
Level 2: Core motor system	Replacement of backwater pump, Replacement of fan, VFD on green liquor pump, VFD on backwater pump
Level 3: Total motor systems	Replacement of mixer, Replacement of chips' conveyer, Reduce consumption of compressed air, New cooling tower
Level 4: Extended motor system	Adjust ventilation, Automatic stop, Change of operative time on paper machine, More efficient production of compressed air, Decrease specific electricity consumption

Results

In total around 850 measures were categorized from the total 1250 measures as motor related with the total energy saving potential of approximately 600 GWh/year (compared to all EEMs in the PFE amounting to savings of 900 GWh/year). Results show that implemented EEMs found in the upper system levels (Level 3, Total motor system, and Level 4, Extended motor system) present almost half of the total number of measures (Figure 1).

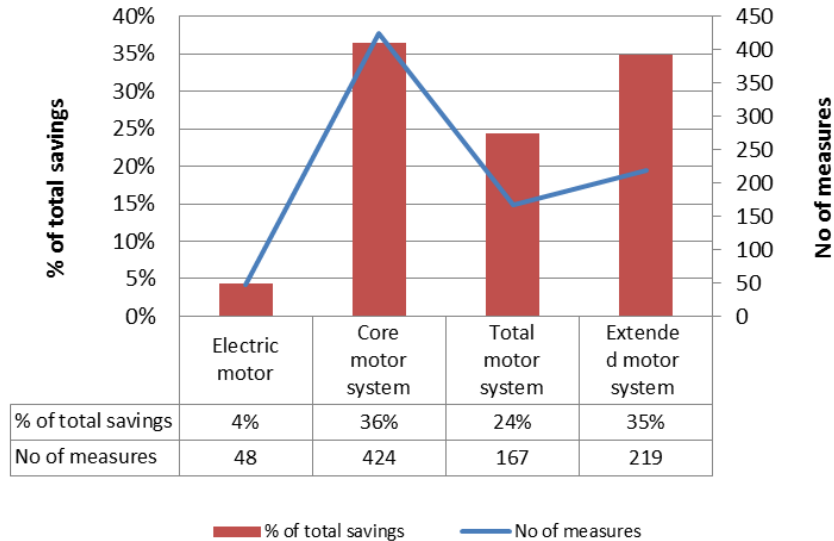


Figure 1: Number of measures and % of total energy savings for different system levels

The number of measures belonging to Level 2 (Core motor system) is approximately the same as sum for Level 3 (Total motor systems) and 4 (Extended motor system). However, despite the number of measures on Level 4 is approximately half of the Level 2, the energy saving potential for Level 4 is close to the potential for Level 2. Thus, the specific energy saving potential (kWh per measure) increases with higher system levels.

From the preliminary results of categorization, it is clear that the large potential for energy saving is achievable by not only replacing of existing motors with the most efficient ones (Level 1, Electric motor). The companies participating in the PFE program has found both a greater number of measures and a greater potential in all the other three levels. It is important to emphasize that these measures have been detected by the companies which have implemented energy management systems and thus were actively working on improving energy efficiency in their organizations. One conclusion that can be drawn from this is that energy efficiency requirements in the whole motor system thus become more powerful than the mere requirements on energy-efficient motors.

The work on energy efficiency is and will be a critical success factor to increase awareness and knowledge of system effectiveness and propose the actions that take into account the entire system, rather than individual components. That so far remains scarcely studied, calling for new and more innovative approaches to energy end-use policies than for example administrative.

References

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