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Gap analysis of industrial energy management systems in Slovenia

Matevz Pusnik [a], Fouad Al-Mansour [a, *], Boris Sucic [a], A.F. Gubina [b]

[a] Energy Efficiency Centre, Jozef Stefan Institute, Jamova cesta 39, 1000 Ljubljana, Slovenia
[b] Laboratory of Energy Policy, Faculty of Electrical Engineering, University of Ljubljana, Slovenia

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ABSTRACT

Industrial energy management systems, which comprise software solutions, upfront services, and ongoing monitoring and management, enable industrial companies to actively manage their energy consumption and energy procurement activities. Energy management systems are usually tailored to the specific industrial needs but may offer limited functionalities, mostly as a result of different identified gaps (process simplifications, improper measurement points, a lack of motivation, etc.). A survey was conducted in order to analyse the gaps and use of energy management systems in Slovenian industry. The results of the survey presented in this paper demonstrate that the use of energy management systems in industry is recognised as a potential competitive advantage by most of the addressed companies. Furthermore, motivation was highlighted as an important prerequisite for process and structural improvements and reported to be thus far insufficiently addressed. Furthermore, the importance of strong cooperation with actors at different levels of industry, namely the executive and shop floor levels, is addressed. In the conclusion, possibilities for new opportunities in the exploitation of energy efficiency through the use of industrial energy management systems are discussed.

1. Introduction

Energy efficiency measures and the utilisation of renewable energy sources have been consistently incorporated into the energy-related strategic documents of EU member states that address various sectors and facilitate research. Extensive research has been done in the field of the utilisation of renewable energy sources, overall efficiency, and environmental management [1–7]. Energy and environmental management is becoming an essential aspect of the daily operations of industrial companies and is supported by several international standards or schemes, such as ISO 14001 and/or ISO 50001. A number of modelling approaches and methods have been designed in order to provide an appropriate and accurate background for energy and/or environmental management systems in industry.

Energy management practices in steel production companies are presented in Ref. [8] and the importance of prioritisation and awareness within the given organisation is highlighted. Cagno and Trianni [9] analysed barriers to industrial energy efficiency through various case studies in Italian SMEs (small and medium-sized enterprises). Furthermore, fuzzy logic process control systems and rule-based EMSs (energy management systems) have been used in the cement industry [10]. Numbi and Xia [11] reported a daily cost saving of more than 40% when using an optimisation model for energy management regarding the crushing process in the mining industry. Interesting research is presented in Ref. [12], where a system dynamics model for analysing energy consumption in the Iranian cement industry is introduced. The use of an integrated approach to energy optimisation in the cement industry is analysed in Ref. [13], leading to a 7% energy costs savings. Dorr et al. [14] proposed a methodology for energy efficiency on a process level. The proposed methodology is the basis for continuous improvement of industrial energy efficiency. As reported by Gordic et al. [15], EMSs used in the Serbian automotive industry enabled a 25% energy savings. Continuous focus on energy efficiency at all hierarchical levels of a chemical plant enabled a specific energy consumption reduction of 26% [16]. In order to reduce energy consumption and related costs, it is essential to integrate different management concepts and systems while considering energy efficiency as a strategic factor alongside technical measures, as stated in Ref. [17]. Technologies that support the real-time and large-scale handling of energy data are provided in Ref. [18], where the need for assessing the impact of energy-aware information systems is

* Corresponding author. Tel.: +386 (0)1 588 53 29.
E-mail addresses: matevz.pusnik@ijs.si (M. Pusnik), fouad.al-mansour@ijs.si (F. Al-Mansour), boris.sucic@ijs.si (B. Sucic), andrej.gubina@fe.uni-lj.si (A.F. Gubina).

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addressed. The case study presented in Ref. [19] shows that the strategic importance of energy management in industry is neglected to a large extent. In Ref. [20] the energy manager's influence on the adoption of energy efficiency practices is examined. It is reported that the most effective managers implement 13.4% more of the recommended savings.

Energy efficiency challenges and barriers in the shipping industry were explored in Ref. [21]. The study concludes that using accurate measurement instruments and providing suitable and vivid feedback with regard to energy consumption is of vital importance for bridging the energy efficiency gap in the addressed industry. Furthermore, the energy savings potentials in Taiwan's pulp and paper industry are presented in Ref. [22]. It is reported that an energy reduction of 30–40% can be achieved using high-concentration preparation pulp systems. An advanced model of domestic load scheduling is addressed in Ref. [23], stating that the robustness of the proposed model could be enhanced using neural-network-based forecasting that is based on historical data and weather information. The energy intensity in Thai manufacturing industries is analysed in Ref. [24]. The findings provide evidence that implies the importance of balancing industrial policies with energy intensity reduction policies. Advanced application of energy saving technologies in the data storage industry is presented in Ref. [25], where an energy savings potential of 75% is reported when implementing the proposed free cooling heat pipe solution. A quantitative analysis of strategic energy management in the Austrian paper and pulp industry concludes that economic (cost-related) factors dominate over environmental concerns, the main driver being the perceived need to minimise energy costs through reduced energy consumption [26]. In Ref. [27] a survey was carried out as a multiple case study of the Turkish iron, steel, cement, paper, ceramics, and textile industries. The study reports that the main identified barriers to proper energy management implementation were the lack of synergy between the stakeholders, the extent and scope of courses for energy managers, and the lack of financial support for energy management activities. A big step forward was made in Sweden, where energy audits in SMEs are part of a publicly financed programme, achieving a 53% implementation rate of the suggested measures, as reported by Backlund and Thollander in Ref. [28]. Such incentives are paving the way for wider implementation of EMSs.

This paper presents a gap analysis of industrial energy management systems in Slovenia, with an emphasis on the investigation of business and implementation potential. The analysis was conducted using the 3EMT tool, which is a tool developed in the scope of the CEEM project (Central Environmental and Energy Management as a Kit for Survival) funded by the EU Central Europe Programme. The research described in this paper was inspired by the recommendations proposed by Backlund and Thollander in Ref. [29], where future research should focus on determining the reasons for the implementation gap with regard to wider implementation of energy efficiency measures in the manufacturing industry. A very important challenge that lies ahead for Slovenian industry is how to stimulate further growth of the industrial sector without jeopardising the achievement of national and European climate and energy goals. The real research question that arises in this context is: “What is the potential for the improvement of energy management practices in Slovenian industry?”

1.1. Energy use in Slovenian industry

Slovenian industry accounts for approximately 25% of all final energy use in Slovenia. According to the Statistical Office of the Republic of Slovenia, the final energy consumption in industry was 1195 ktoe in 2013. The importance (impact) of industry in terms of final energy consumption in Slovenia is presented in Fig. 1. With a 13% share of renewables and waste, a 46% share of final electricity consumption, a 72% share of total natural gas final energy consumption, and a nearly 90% share of all solid fuel final energy consumption, it is evident that the industrial sector is vital as regards achieving sustainable development goals.

According to Slovenian national statistics, 42% of final energy consumption in industry is accounted for by electricity use. Natural gas represents 33% of final energy consumption in industry, followed by other fossil fuels at 14% (solid fuels 4%, petroleum products 10%), heat (4%), and renewables and waste (7%). Fig. 2, shows the final energy consumption for industry in 2013 by fuel used.

The breakdown of costs for final energy consumption in industry in 2013 by type of fuel is presented in Fig. 3. Almost 65% of all energy costs in Slovenian industry can be attributed to electricity use, followed by the costs for natural gas (26%), petroleum products (3%), district heat (4%), renewables and waste (1%), and solid fuel (also 1%). When comparing the prices for electricity in industry, the Slovenian price is at 89% of the EU-28 average, according to Eurostat. The price for natural gas for industrial use in Slovenia is significantly higher than the EU-28 average, namely 21% higher.

In the Slovenian industry sector, two-thirds of industrial final energy is consumed by only 55 companies in 5 industry branches, as presented in Fig. 4. Namely (in descending order), C24 – manufacture of basic metals, C17 – manufacture of paper and paper products, C23 – manufacture of other non-metallic mineral products, C20 – manufacture of chemicals and chemical products, and C22 – manufacture of rubber and plastic products. Furthermore, in 2012, only 120 industrial companies accounted for 80% of total industrial final energy consumption. Taking the current situation into account, it should emphasised that the Slovenian industrial sector needs a healthy environment for further development and only a strong and active partnership between government and industry representatives could provide such conditions.

The sectorial structure of final energy consumption in Slovenian industry by company size is presented in Fig. 5. Nearly half of Slovenian industry energy use (49.8%) is attributed to companies that have 250 or more employees (labelled as large), followed by medium-sized (50–249 employees) companies (43.9%), and small companies (6.4%).

According to the national statistics, 96.7% of manufacturing companies are small (up to 50 employees), of which 88.5% are micro companies (fewer than 10 employees), medium-sized companies (from 50 to 249 employees) represent 2.7%, and large companies represent only 0.6% (more than 250 employees). Large companies, representing less than 1% of all Slovenian companies, consume approximately 50% of all energy in industry. Medium-sized companies consume 44%, and small companies 6%.

1.2. The savings potential in Slovenian industry

Significant energy savings in industry are possible through the implementation of energy efficiency measures that need to be supported by the sector specific national energy efficiency policies. Energy efficiency in Slovenian industry is improving as a result of new investments in the development of core business, as well as investments to improve the energy efficiency of production processes. In accordance with the national energy efficiency policy documents [29,30], both branch-specific and horizontal energy efficiency potentials have been analysed. Energy efficiency measures and future development assumptions specific to the industrial sector are presented in Table 1.

When assessing energy efficiency in industry, the peculiarities of energy-intensive branches must be taken into account (i.e. electrolysis in aluminium, electric arc furnaces in steel, and thermal