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Trends and prospects of energy efficiency development in Slovenian industry

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ABSTRACT

Energy efficiency measures and the utilisation of renewable energy sources have been consistently incorporated into the energy strategy documents of the EU Member States in various sectors. Industry, as the backbone of the European economy, is still not sufficiently addressed, since its development is almost exclusively market driven. The importance of the industrial sector for the economy is not questionable, nor is its impact on the environment. More than a quarter of all final energy consumption in Europe can be attributed to the industrial sector, representing one third of the final energy consumption of natural gas and one third of electricity use, with more than three quarters of all final energy consumption of solid fuels. The paper presents an overview of the energy efficiency development trends in Slovenian industry. To assess the development of energy efficiency, an energy efficiency index (ODEX) is applied, also highlighting some of the non-technical, structural changes. Furthermore, the future development prospects of energy-intensive industry in Slovenia are addressed in compliance with the national legislative framework and energy efficiency targets.

1. Introduction

Improving energy efficiency in industry is one of the more important objectives of the energy policy and strategy of all developed countries. Recently, a number of modelling approaches and methods have been designed that provide an appropriate and accurate background and assessment of the potential energy efficiency and renewable energy sources in industry [1–6]. Al-Mansour presented top-down and bottom-up approaches to energy efficiency assessment in Slovenia [7], highlighting energy efficiency as one of the most potent and cost-effective ways of meeting the demands of sustainable development and lowering fossil fuel dependency. According to Peng et al., the energy consumption structure of industry requires optimisation, which can be achieved by reducing the proportion of coal and oil and using clean and renewable energy as a substitute [8]. Interesting research has been carried out by Ozkara and Atak [9] that analysed the energy efficiency and electricity savings potential in the manufacturing industry in Turkey. The study reports a 29% electricity savings potential for 2017. In general, as reported by Meng et al. in [10], there are two types of factors that can promote improvements in energy efficiency, namely technological innovation and consumption share adjustment. Structural changes in Chinese industry were addressed in Ref. [11]. The study concluded that the adjustment of the industrial structure has played a positive role in the reduction of Chinese carbon emissions, although weakened by the influence of economic growth.

More technical, process-specific methods are usually applied in energy-intensive branches of industry. A study on the use of a fuzzy data envelopment analysis cross model in the chemical industry provides information on energy consumption factors for policy utilisation [12]. Furthermore, Shaohui et al. [13] assessed the possibility of energy efficiency and technologies improving resource efficiency and reducing air pollutants in the Chinese iron and steel industry. The paper industry was addressed in Ref. [14], where several options to decrease heat use in the drying phase were analysed. Energy savings potentials in the German pulp and paper industry were investigated in Ref. [15]; the study concluded that the savings potentials in the paper and pulp sector are limited under the assumption that the production process is not radically changed. Research on improving energy efficiency and CO_2 emissions reduction potentials in the Chinese iron and steel industry [16] reports that effective energy efficiency policies and programmes are needed to realise cost-effective energy savings and

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emissions reduction potentials in industry. According to [17], more efforts are required to improve the quality of national and international energy statistics in the chemical sector. The steel industry is addressed in [18] and the results demonstrate that there is still room for further implementation of energy efficient technologies in the steel production sector, even though they were first introduced over 30 years ago. According to [19], the energy indicators used today, e.g. specific energy consumption, do not fully capture the trends of the iron and steel sector. A comparison of different methods of assessing energy efficiency was carried out by Kohl et al. [20]. The factors influencing energy efficiency on the national level are discussed in [21,22], which concludes that each country has a different reason (basis) for having a different energy efficiency index.

This paper presents trends in the development of energy efficiency in Slovenian industry, the impact of its structural changes, followed by future development prospects regarding Slovenian energy-intensive branches. The research described in this paper addresses the following question: How successful was the transition of Slovenian industry to sustainability?

1.1. Final energy use in the Slovenian industry sector

Slovenian industry accounts for almost 25% of the total final energy use in Slovenia. According to the Statistical Office of the Republic of Slovenia, the final energy consumption in the industrial sector was 1.20 Mtoe in 2013. Final energy consumption in industry has decreased by 6% relative to the year 2010 and by more than 18% relative to the year 2000. The trends for final energy consumption in the Slovenian industry sector are presented in Fig. 1.

In 2013 the GDP of Slovenia amounted to 23,825 million EUR_{2000}. Value added (at constant market prices) for industry represented 6952 million EUR_{2000}.

Fig. 2 shows the correlation of final energy consumption in Slovenian industry and the GDP trends in the period from 2000 to 2013. The impact of the economic crisis in 2008 is clearly shown by the decrease in GDP as well as in energy consumption.

After several years of growth of final energy consumption in the period from 2002 to 2006, the trend declined in 2007, as shown in Fig. 2. The decrease continued in 2008 and 2009 at an annual rate of nearly 12%. The turning point in 2007 was a consequence of a decrease in energy intensity, in particular due to the termination of certain energy-intensive production processes due to environmental requirements (cellulose production), while value added increased. The decrease in 2008 and especially in 2009 correlates with the start of the economic crisis. A slight increase can be observed in 2010, mostly due to economic stimulus measures. Due to the reduction in industrial activity, energy consumption decreased in 2012.

According to Slovenian national statistics, electricity use accounted for 42% of final energy consumption in industry. Natural gas accounted for 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%).

1.2. The energy intensity of the Slovenian industrial sector

Energy intensity is a measure of the energy efficiency of a nation's economy. It is calculated as units of energy per monetary unit of GDP. High energy intensity indicates a high price or cost of converting energy into GDP. Low energy intensity indicates a lower price or cost of converting energy into GDP.

The energy intensity of Slovenian industry in the period from 2000 to 2013 is presented in Fig. 3. The intensity decreased by 33%, relative to 2000. Slovenian energy intensity in 2013 was 27% higher than the energy intensity of the industrial sector in EU. For reference, German energy intensity in 2013 was 0.09 koe/EUR2000, which is 19% lower than the EU average.

1.3. Unit consumption in energy-intensive industries in Slovenia

Unit consumption is most commonly highlighted through the following three energy-intensive industrial sectors, i.e. the production of steel, paper and pulp, and cement. Due to the lack of data on cement production (i.e. due to data sensitivity), only data on steel and paper production is provided in Table 1. Unit consumption is calculated as the ratio between the final energy consumption of the sectors and their output measured in tons. Regarding the unit consumption of the paper and pulp sector, it has to be emphasised that in 2007 the production of cellulose ceased, resulting in a significant decrease in the trend from 2006 onwards.

1.4. The CO_2 intensity of Slovenian industry

Industry emits two types of CO_2 emissions, namely emissions related to energy use and process-related emissions. Process emissions in industry are emissions that occur primarily in the chemical processes of certain production procedures (i.e. when

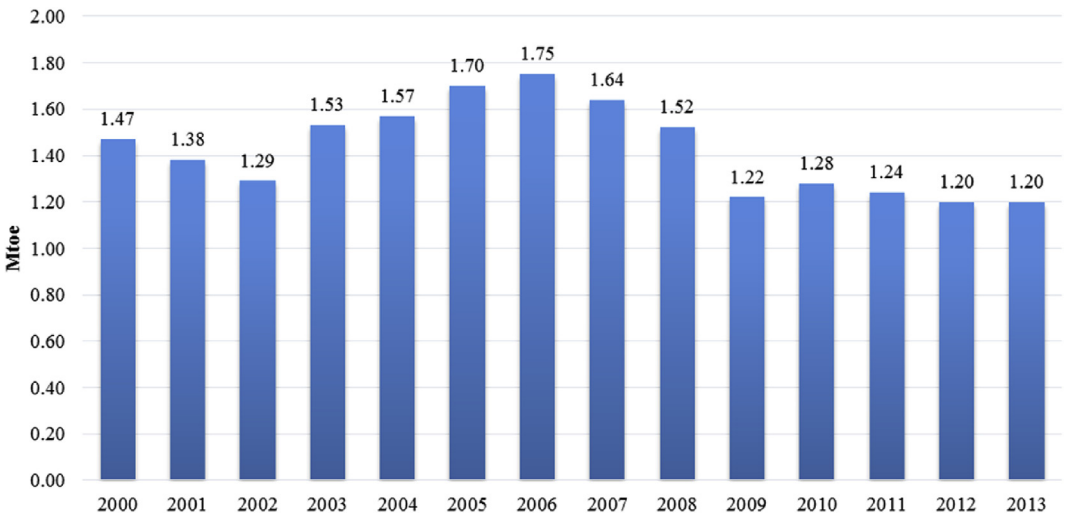

Fig. 1. Final energy consumption in Slovenian industry in the period 2000–2013.

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