Energy xxx (2014) 1–6

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Methodological differences behind energy statistics for steel production – Implications when monitoring energy efficiency

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A R T I C L E I N F O

Article history:
Received 25 June 2014
Received in revised form
4 September 2014
Accepted 6 September 2014
Available online xxx

Keywords:
Energy and resource efficiency
Iron and steel sector
Energy use statistics

A B S T R A C T

Energy efficiency indicators used for evaluating industrial activities at the national level are often based on statistics reported in international databases. In the case of the Swedish iron and steel sector, energy consumption statistics published by Odyssee, Eurostat, the IEA (International Energy Agency), and the United Nations differ, resulting in diverging energy efficiency indicators. For certain years, the *specific energy consumption* for steel is twice as high if based on Odyssee statistics instead of statistics from the IEA. The analysis revealed that the assumptions behind the allocation of coal and coke used in blast furnaces as energy consumption or energy transformation are the major cause for these differences. Furthermore, the differences are also related to errors in the statistical data resulting from two different surveys that support the data. The allocation of coal and coke has implications when promoting resource as well as energy efficiency at the systems level. Eurostat's definition of energy consumption is more robust compared to the definitions proposed by other organisations. Nevertheless, additional data and improved energy efficiency indicators are needed to fully monitor the iron and steel sector's energy system and promote improvements towards a greener economy at large.

1. Introduction

Energy efficiency is an important means for reducing resource utilization as well as CO_2 emissions. Energy efficiency indicators are used for monitoring and controlling the effectiveness of regional (i.e. EU (European Union)) as well as national initiatives towards increasing energy efficiency. The recently adopted Energy Efficiency Directive of the EU aims at addressing these challenges while also improving European energy security and industrial competitiveness [1]. Key energy efficiency indicators are essential to capture the effects of policies and investments designed to achieve these goals and monitor improvements. The ODEX (Odyssee Energy Efficiency Index) has been developed by the European Commission as a top-down method for evaluating and monitoring efficiency improvements [1,2]. The Odyssee database provides statistics on energy use as well as indicators derived from these data [3]. The Odyssee database is recommended by the European Commission and is already used at national level, for example in Sweden, for monitoring trends in energy efficiency e.g. [4,5]. However, close observations reveal that the statistics on energy use in Odyssee diverge from the statistics reported in other international databases provided by European Commission (Eurostat), IEA (International Energy Agency) and UN (United Nations). The diverging energy statistics lead to different measures of *specific energy consumption*. Depending on the database used, a doubling of the *specific energy consumption* can be observed for some years.

Various authors have pointed out problems with the statistics on energy use for the iron and steel industry. Farla and Blok provided a thorough review of energy use statistics for steel production in four international databases maintained by (i) IEA, (ii) the European Commission (Eurostat), (iii) International Iron and Steel Institute (now World Steel Association) and (iv) Lawrence Berkley National Laboratory. The authors identified several errors in the reported statistics on energy use such as double counting of self-generated gases for some years (i.e. blast furnace gas and basic oxygen furnace gas) [6]. Tanaka discussed the reliability of energy efficiency indicators in the case of the iron and steel sector and pointed to the fact that statistics diverge in different international databases (comparing data from the FAO (Food and Agriculture Organization of the United Nations) and the IEA) [7].

Tanaka also found that published indicators sometimes are simply incorrect [7]. The IEA presented indicators for the energy intensity of pig iron production well below the theoretical

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http://dx.doi.org/10.1016/j.energy.2014.09.020
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minimum for the processes (pig iron is the intermediary product produced using the blast furnace process). The reason behind this incorrect estimation by the IEA is explained later in this paper. While Tanaka provided insight about problems with different system boundaries, the implications of using different definitions when allocating energy used for generation of gases as energy transformation was not properly discussed. Furthermore, neither Farla and Blok nor Tanaka covered the recently published database, Odyssee, in their studies [6,7].

In this study, we analyse available statistics on *final energy use* and *final energy consumption* in four international databases for the Swedish iron and steel sector to (i) scrutinize the reasons behind the diverging datasets and (ii) highlight the implications of using specific definitions over others for evaluating the energy efficiency of iron and steel production activities. The focus is on the allocation between energy consumption and energy transformation of the energy use in the processes rather than the system boundaries of the raw data. The latter have already been discussed in depth by Tanaka, in the case of energy statistics in international databases, as well as Morfeldt et al. and Siitonen et al., in the case of company-specific energy statistics [7–9].

The next section presents the methods used in this study. The subsequent sections present the results of the database comparisons, followed by a discussion on the implications of choosing one database over the other as statistical source in energy efficiency analyses. We have used Sweden as the case for analysis and exemplification. In the final section, the major findings and their policy implications are presented.

2. Methods

In this study, energy use is seen as the energy input to an industrial activity. Energy consumption is the amount of energy that is used for performing the activity after which no more energy is available for other purposes. Energy transformation (or conversion) is the amount of energy that is used for performing the activity of generating a new energy carrier (e.g. a refinery producing petrol from crude oil). The transformation efficiency may be below 100%, resulting in the energy transformation input being higher than the energy transformation output. While energy consumption is allocated to the end-user (i.e. the iron and steel sector in this case), energy transformation – and transformation losses in the case of transformation efficiencies below 100% – is allocated to the energy sector. Final energy use has been considered throughout the study.

Statistics from four international databases were compared: Eurostat [10], Odyssee [3], IEA [11] and United Nations Statistics Division [12]. The differences between the databases were scrutinized in relation to the national statistics provided by Statistics Sweden [13] and the reasons behind the differences were discussed with experts from Statistics Sweden, the Swedish Energy Agency and the IEA.

The four international databases considered in this study aggregate final energy use in the iron and steel sector according to the economic sub-sectors 24.1–24.3 and 24.51–24.52 in NACE 2.0 statistical classifications (*Nomenclature statistique des activités économiques dans la Communauté européenne*). This means that all iron and steel production processes including crude steel production (blast furnaces/basic oxygen furnaces and electric arc furnaces), rolling mills etc. (warm and cold rolling as well as warm and cold drawing), refinement processes (annealing and coating) as well as iron and steel foundries are covered. However, coke ovens are not included since they are considered an energy transformation activity (i.e. 19.1 in NACE 2.0 statistical classifications). Coke ovens produce coke and coke oven gas from hard coal. Also, sintering and pelletizing processes are outside the iron and steel sector boundary as they are counted as part of the iron ore mining sector (i.e. 7.10 in NACE 2.0 statistical classifications) [14].

2.1. Indicators on energy use and energy intensity

Two indicators were used for comparing the differences between the databases. The *final energy use* sums all transformation inputs and consumption of all energy carriers except consumption of self-generated gases and electricity (i.e. electricity generated by autoproducers) to avoid double counting. Electricity generated by autoproducers is not reported separately in UN data and, hence, the indicator could not be adjusted for this. The *final energy consumption* sums all statistics reported as energy consumption for all energy carriers in the iron and steel sector. Conversion factors were used to convert statistics published in *tonnes of oil equivalent* to *megawatt-hours* [15].

The indicator *specific energy consumption* was used to highlight the implications of the statistical differences of the databases when used in energy efficiency analyses. The *specific energy consumption* was calculated based on:

$$\textit{Specific energy consumption} = \frac{\textit{final energy consumption}}{\textit{crude steel production}}. \tag{1}$$

The *final energy consumption* is provided by each analysed database, as defined above. The *crude steel production* statistics were provided by World Steel Association (2014) which are identical the ones in Odyssee [3,16].

While previous studies criticise the use of *specific energy consumption* [4,8,17], there is currently no other indicator available for monitoring energy efficiency in steel production. The *specific energy consumption* should suffice for the purpose of comparing databases. However, the authors would like to stress that conclusions on the energy efficiency development drawn from the trends seen in the *specific energy consumption* are likely to be misleading [17].

3. Results from the comparison of databases

Significant differences were observed when comparing the statistics reported as *final energy consumption* for the iron and steel sector in Sweden (see Fig. 1). The statistics provided by the Odyssee database shows levels of *final energy consumption* that are almost two times as high as the statistics provided by IEA and UN for certain years.

Two major reasons have been identified that explain these differences: (i) the assumptions made when allocating coal and coke either as energy consumption or energy transformation, and (ii)

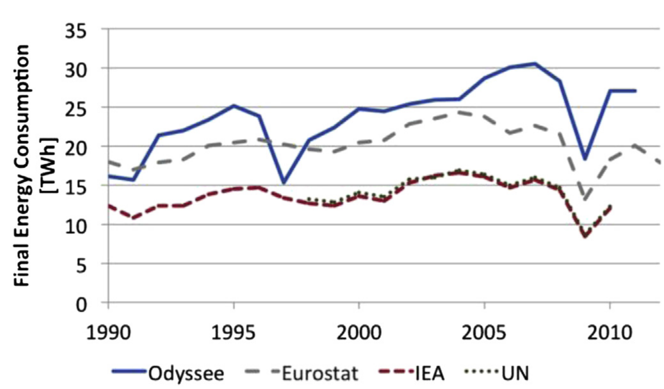

Fig. 1. Final energy consumption in the Swedish iron and steel sector, as defined in each database.

Please cite this article in press as: Morfeldt J, Silveira S, Methodological differences behind energy statistics for steel production – Implications when monitoring energy efficiency, Energy (2014), http://dx.doi.org/10.1016/j.energy.2014.09.020