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Improving energy and climate indicators for the steel industry – the case of Sweden

Johannes Morfeldt [a,*], Semida Silveira [a], Tomas Hirsch [b], Susanne Lindqvist [c], Alena Nordqvist [c], Jan Pettersson [b], Magnus Pettersson [d]

[a] Energy and Climate Studies Unit, KTH Royal Institute of Technology, Stockholm, Sweden
[b] SSAB EMEA AB, Stockholm, Sweden
[c] Sandvik Materials Technology, Sandvik AB, Sandviken, Sweden
[d] Höganäs AB, Höganäs, Sweden

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ABSTRACT

Energy and climate indicators are required for monitoring and controlling the effectiveness of regional as well as national initiatives towards increasing energy efficiency and reducing carbon dioxide (CO_2) emissions. Indicators are also needed for monitoring measures implemented within companies. Recent studies show that traditional energy efficiency indicators do not capture product differentiation or value creation in the steel industry, while observed trends capture structural shifts instead. In this study, methods combining physical and techno-economic perspectives on energy and CO_2 efficiency are proposed for alleviating these problems. The methods were evaluated using data from three Swedish steel producers. The results compensate for structural shifts when focused on physical production. When focused on economic production, the methods represent the value creation of the companies more strongly than traditional indicators. The proposed methods may be useful complements to traditional indicators for monitoring energy and CO_2 efficiency. However, the trends show strong links with the economic climate, which may reduce companies' possibilities of using the indicators for monitoring their own performance. The study confirms the high complexity in monitoring energy and CO_2 efficiency within steel companies focused on high-value market segments. Further research is required in exploring issues related to data confidentiality, product portfolios and processes represented in the method, influence of external factors, and aggregating indicators at sectoral level.

1. Introduction

Energy and climate indicators are required for monitoring and controlling the effectiveness of regional (i.e. European Union – EU) as well as national initiatives to improve energy efficiency and reduce greenhouse gas emissions. Likewise, indicators are needed for monitoring measures implemented within companies. For the case of energy efficiency, the *Odyssee energy efficiency index* (also known as ODEX) has been developed and is recommended by the European Commission as a top-down method for monitoring achievements (European Commission, 2012, 2006, 2003). The *specific energy consumption* (SEC), which is the indicator proposed for iron and steel production (referred to as steel production hereinafter) within the economy-wide ODEX-indicator, has some limitation as it compares total energy use with the production of one specific product, i.e. crude steel in this case (Patterson, 1996; Pérez-Lombard et al., 2013; Schenk and Moll, 2007; Worrell et al., 1997). Previous analysis made by Morfeldt and Silveira (2014a) confirmed that the *specific energy consumption* is not sufficient to capture energy efficiency trends in the European iron and steel sector. Furthermore, Morfeldt et al. (2014b) showed that the *specific energy consumption* is strongly affected by intra-sectoral structural shifts. The Swedish Energy Agency (2011) proposes an indicator to measure the energy intensity based on value added. But also this indicator has proven weak in capturing actions among global companies (Morfeldt et al., 2014b).

In this study, improvements are suggested for energy and climate indicators to better reflect product differentiation, compensate for structural shifts, and capture the value creation of

* Corresponding author. Tel.: +46 8 790 74 41.
E-mail address: johannes.morfeldt@energy.kth.se (J. Morfeldt).
URL: http://www.ecs.kth.se

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the industry. The methodology developed by Farla and Blok (2001) was applied with some adjustments. The implications of the method were evaluated using company-level data from three Swedish steel producers. The methodology was also extended by devising a techno-economic methodology based on the average contribution of each product group to value creation for the industries, which is hypothesized to be more robust than indicators based on the value added as per proposed by the Swedish Energy Agency (2011). More specifically, the paper aims at exploring how sectoral energy efficiency indicators could be improved to better capture the trends of Swedish steel producers.

The main contribution of the study is further development of an established methodology for calculating energy efficiency indicators, so that it can better capture product differentiation and compensate for structural shifts. While the study relies on Swedish evidence, the outcomes and insights should provide useful reference for the development of energy and climate indicators for steel industries in Europe and worldwide.

The following section provides a background, particularly explaining the choice of methodology and its application in Swedish and European settings. The methods considered in the study are then presented in detail in section 3. The results of the case studies are presented in subsequent sections, together with a thorough discussion of the results and the methods applied, highlighting the implications in the Swedish setting. Finally, the last section presents the main conclusions of the study and policy implications.

2. Energy efficiency in a context of structural shifts

As a result of increased global competition, the steel sector has undergone privatisation as well as consolidation since the 1990s. A range of different producers has emerged while, in Sweden, steel producers have become niche specialists as a way to retain their position in the global market. However, several niche products — though not all — require higher levels of refinement, which lead to increased energy demand (Deforche et al., 2007; Sandberg et al., 2001). Fig. 1 indicates the point of crude steel production in relation to the boundary of energy use measured in the steel sector, which is reflected in the *specific energy consumption* indicator. Although the *specific energy consumption* may be useful at low levels of aggregation (e.g. a specific process), it does not properly capture product differentiation and its contribution to value creation for products downstream of crude steel production (Morfeldt and Silveira, 2014a; Morfeldt et al., 2014b; Swedish Energy Agency, 2011).

An indicator based on *value added* could be more accurate for representing production of the Swedish steel sector than the *specific energy consumption* since the former theoretically could consider more steps in the value chain. Furthermore, the aspect of value creation is especially interesting for ex-post energy efficiency policy evaluation due to its connection with the gross domestic product (GDP). The GDP is defined as the aggregate of the *value added* of each economic sector (Statistics Sweden, 2013; Swedish Energy Agency, 2011).

On the other hand, the *value added* is not a robust indicator for measuring the value creation of production. In many cases, large companies operate in international markets and the value of production is not fully obtained until the product is sold by their subsidiary in foreign markets. Hence, while the final contribution to the *value added* is computed within one national boundary, the energy for refining the product may have been used and accounted for elsewhere (Morfeldt et al., 2014b). In addition, economic indicators fail to capture technical improvements which may lay behind changing levels of energy demand (Patterson, 1996; Schenk and Moll, 2007; Worrell et al., 1997).

Morfeldt et al. (2014b) showed that traditional sectoral energy efficiency indicators (based on crude steel production as well as *value added*) capture structural shifts within the production chains that may veil other efficiency improvements. In this context, structural shifts are defined as shifts from one process route to another. For example, a company may use several routes for producing their products. A decrease in the *specific energy consumption* for the whole company may therefore be related to the shift from one production route to a less energy intensive one. While structural shifts may also be considered a means towards improving energy efficiency, it is useful to distinguish them from other types of energy efficiency improvements to be able to design proper incentives to the industrial sector.

Farla and Blok (2001) previously developed a method for compensating for such effects by representing different product groups in an energy efficiency index. The approach was applied on national data for steel production in selected countries. The index used the *specific energy consumption* of best-practice for each specific process as statistical weight. In the Swedish case, the steel producers use several processes not included in best-practice documents (i.e. European Commission, 2010), particularly when it comes to refinement of steel products. Nanduri et al. (2002) consider the use of best-practice as a weighting factor a drawback of the method since it may be difficult to estimate the *specific energy consumption* of best-practice processes, and properly define the processes. Products impose specific requirements on the processes, which further aggravates the definition of best-practice for the processes in question. However, best-practice may be a good reference if comparison with an optimum is sought for a specific process, under the assumption that the requirements are similar for all products considered and the system boundary of the process is strictly followed.

Wu et al. (2007) propose another methodology for minimizing the effects of structural shifts where the production and energy use of each process is compared with benchmark values, as per defined at the design stage of the process in question. This approach provides information whether the processes are run at their optimum compared to the intended level, but does not capture increased

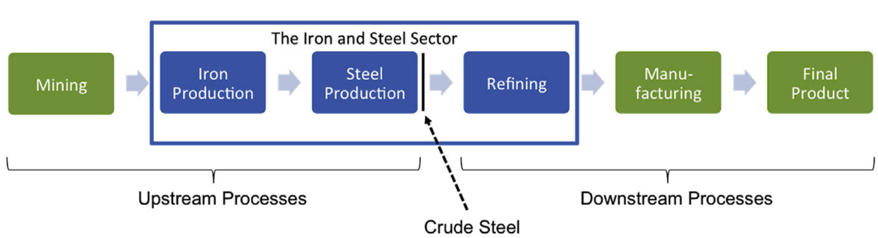

Fig. 1. Simplified graphical representation of the value chain of a steel product (adopted from Morfeldt and Silveira (2014b)). The *specific energy consumption* relates energy use, marked as the blue box, to crude steel production, marked as a black line. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)