Energy Policy 98 (2016) 459–469

Contents lists available at ScienceDirect

Energy Policy

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

Paying the full price of steel – Perspectives on the cost of reducing carbon dioxide emissions from the steel industry

Johan Rootzén*, Filip Johnsson

Department of Energy and Environment, Energy Technology, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

HIGHLIGHTS

- Examines impacts downstream of investments in CO_2 abatement in the steel industry.
- Show how investing in low-CO_2 processes have marginal impacts in end-user stage.
- Increase in the retail price of a mid-sized passenger car would be well below 1%.
- Open up for complementary policies, financing mechanisms or new business models.

ARTICLE INFO

Article history:
Received 29 April 2016
Received in revised form
9 September 2016
Accepted 10 September 2016

Keywords:
Abatement costs
Steel industry
Emission reductions
Material flows
Value chains
Car manufacturing

ABSTRACT

This study examines the impacts felt downstream of carbon pricing and investments made in CO_2 abatement within the steel industry. Using the supply of steel to a passenger car as a case study, the effects of a steel price increase on cost structures and price at each step of the supply chain were assessed. Since the prices of emission allowances under the European Union Emissions Trading System fall well below those required to unlock investments in low-CO_2 production processes in the integrated steelmaking industry this paper seeks to pave the way for a discussion on complementary policy options. The results of the analysis suggest that passing on the compliance costs of the steel industry would have only marginal impacts on costs and prices for the end-use sectors (e.g., on the production cost or selling price of the passenger car). Under the assumptions made herein, at a carbon price of 100 €/tCO_2, the retail price of a mid-sized European passenger car would have to be increased by approximately 100–125 €/car (< 0.5%) to cover the projected increases in steel production costs.

1. Introduction

The Nordic countries have adopted an offensive stance to addressing the challenge of mitigating global climate change. Nonetheless, the Nordic climate policy targeting the industrial sectors continues to rely almost exclusively on the price signal imposed through the EU Emissions Trading System (EU ETS). However, in the case of carbon-intensive industries, as long as there exists a need to balance competitiveness and environmental effectiveness without additional policy measures, reliance on the trading system alone may lead to under-investment in the high-abatement, long-lead-time measures required to reach the long-term targets for emissions reductions (Vogt-Schilb et al., 2014; Bennett and Heidug, 2014).

In the case of iron and steel production from virgin iron ores, which is the focus of this paper, achieving significant decarbonisation up to Year 2050 will require substantial changes in the steelmaking process (Daniëls, 2002; Fischedick et al., 2014; Wörtler et al., 2013). While several alternative low-CO_2 processes have been investigated at the laboratory scale, moving from the laboratory or pilot plant to larger-scale operation will involve substantial costs (Birat et al., 2008; IEAGHG, 2013; Ho et al., 2013; Hooey et al., 2013). Given the long investment cycles associated with a capital-intensive industry like the steel industry and the fact that CO_2 emissions have to be reduced by some 80% up to Year 2050, there is an urgent need to find ways to unlock investments in the development and implementation of breakthrough technologies. While the existing literature typically focuses solely on the impacts of cost on primary production and the primary product of investing in high-abatement, long-lead-time measures, the present paper examines how cost increases in the steel industry affect both costs and prices further up the product chain.

Skelton and Allwood (2013) have shown that even in steel-

* Corresponding author.
E-mail address: johan.rootzen@chalmers.se (J. Rootzén).

http://dx.doi.org/10.1016/j.enpol.2016.09.021
0301-4215/

intensive sectors, such as the construction and vehicle-manufacturing industries, the actual expenditure on steel is relatively small compared to the expenditure on other inputs. Their results also indicate that including carbon costs in the steel price would have a limited effect on the cost structure for downstream consumers. There are few other examples of attempts to quantify the impact downstream of CO_2 pricing and abatement in the steel industry. Neuhoff et al. (2014) used a rough estimate of the carbon cost impact on an average car to report the additional cost as being in the order of 9–221 €/car using different assumptions with regards to the specific emissions from steel manufacturing (1.3–2.3 tCO_2/t steel) and the carbon price (5–100 €/tCO_2). Similarly, PwC (2011) estimated that the Australian vehicle manufacturing industry faced an additional cost, in the absence of government assistance for companies in the supply chain, in the order of 222–412 AUD per vehicle produced, based on a carbon price of 20–30 AUD/tCO_2.

Our investigation differs from these previous studies in that it takes as its point of departure the preconditions and costs of investments in low-CO_2 processes in the steel industry, and, by accounting for changes in reference conditions across the supply chain of steel. Using the supply of steel to a passenger car as a case study, this paper seeks to pave the way for broadening the discussion as to how best to allocate the costs required to develop and deploy new low-carbon steel-making processes. The ambition has been to explore the magnitude of the cost increases that may occur downstream if and when the steel industry shift to low-CO_2, but high-cost, production processes. We do this by looking beyond current market conditions (bleak) and the existing climate policy environment (weak) as if mechanisms that would allow steel producer to pass on parts or all of the added costs were in place.

2. Method

To place the analysis in context, we begin by providing an overview of the material and value flows involved in the supply chain of steel. Then, based on performance data for the Nordic iron ore-based steel industry, we assess how compliance costs, i.e., the combined cost of buying emission allowances and investing in new low-carbon process technology affects the break-even costs for primary production. Finally, we estimate the magnitude of the cost increases that may occur in the auto industry due to increases in the acquisition costs for steel products.

2.1. Material flows and value chains

The study reported herein relies on an approach similar to that used in a previous study by the authors in which the focus was on the cement industry and the supply chain of cement (Rootzén and Johnsson, 2016; Rootzén, 2015). Steel and cement are both intermediates in the supply chain of a large range of final goods, and both our present and previous studies build on the recognition that as these basic materials are transformed and passed along the chain of production their shares of the total input expenditures gradually diminish (Dahlström and Ekins, 2006; Allwood et al., 2011; Skelton and Allwood, 2013). However, the fact that the markets for cement and concrete are mostly regional meant that the material flows involved in the Nordic cement supply chain could be traced with fairly good accuracy. This is not the case for the steel industry, in that steel and semi-finished steel products are traded globally. In addition, there are other characteristics that complicate the mapping of the material and value flows involved in the chain of production, fabrication, and end-uses of steel. These characteristics include: the range and variation of the steel product portfolio with a significant span between low- and high-value-added products; the fact that for many applications, primary and secondary steel are nearly perfect substitutes; and the number of, and in some cases the complex network of, intermediate parties involved (steel service centres, distributors, and components manufacturers) before the steel reaches the end-user. Nevertheless, to provide a context for the subsequent analysis, we give a basic overview of the flows of steel that link the Nordic iron ore-based steel industry with the final consumers of the steel or steel-containing products (Fig. 1). Following Dahlström and Ekins (2006) and Cullen et al. (2012), the production chain and the associated material flows can be subdivided into four production steps: (1) iron and steel making (including reduction of the iron ore, steelmaking, and casting); (2) finishing (including rolling, forming, and coating); (3) fabrication and manufacturing (including the intermediate processing of semi-finished steel products by various manufacturing sectors); and (4) eventual consumption (divided into four main sectors and ten subsectors). The flows of steel were traced from the bottom up using the three Nordic integrated iron and steel production plants currently in production (with an overall average annual production capacity of approximately 7.5 Mt crude steel/year), as the point of departure. The classification of the different steel products into categories (1) and (2) were made based on data from SSAB (2005), Rautaruukki (2008), and WSA, (2013). Since there are no public records of the subsequent flow of semi-finished steel, the splitting of the flow of intermediate steel products is approximate. Thus, the estimates of the categories of final consumption of primary steel across end-use sectors (4) rely on data that describe European and global conditions (Cullen et al., 2012; Eurofer, 2015).

2.2. Carbon cost impacts from steel to car manufacturing

In the subsequent analysis, the supply of steel to produce a passenger car was used as a case study. Using a stylised representation, the supply chain can be described as: (1) the production of automotive steel in a hypothetical integrated steel plant; via (2) further preparation of steel and steel-containing automotive parts in the components manufacturing industry; to eventual use (3) in the assembly of a mid-sized passenger car. The set-up of the production process (three options) at the steel works and market price for emissions allowances (three price levels) decide the price of the steel. Specifications of the material compositions of the passenger cars considered (four functionally equivalent versions of a European mid-sized passenger car) define the amount and mix of steel required. Based on descriptions of the cost structure in each step of the supply chain, the actual expenditure on steel is compared to the expenditure on other inputs (Fig. 2). All flat steel products used in the car are assumed to be sourced from the same hypothetical average Nordic integrated steel plant, and in the reference case, the steel plant is operating with existing units and with the price of emissions allowances under the EU ETS (EUA) set at zero. We assume that industry pass-through of cost is complete, in other words that the intermediate and final consumers of the steel-containing products bear the full costs of CO_2 trading and investments in CO_2 abatement. As in the study conducted by Skelton and Allwood (2013), the analysis of the impact downstream of steel price increases attributable to CO_2 trading and investments in CO_2 abatement measures at the steel plant has been carried out under *ceteris paribus* assumptions. All the additional costs in the steel industry are assumed to be passed through completely along the supply chain. Furthermore, for the components and car manufacturers, it is only the steel acquisition costs that change; all the other costs are kept constant. Finally, whereas the impact of carbon cost on two light-weight versions of the reference car, in which aluminium replaces steel, have been investigated, increases in the selling price of steel are not assumed