Mitigating Iron and Steel Emissions

The iron and steel industry is the largest energy consuming manufacturing sector and the second-largest industrial consumer of energy, after the chemical sector. It produces around 5% of total world greenhouse gas emissions, some 2,165 million tons (Mt) of carbon dioxide (CO₂) per year, and small amounts of sulfur dioxide and nitrogen oxide. This is due to the resource-intensive production process and the massive scale: steel is used in every country and in virtually all sectors. With continued growth in demand, especially from emerging economies, emissions from steelmaking are expected to keep rising. Energy use and emissions depend on the production methods employed. Increased coordination in the industry could ensure the application of more efficient technologies and the development of next generation technologies with the greatest mitigation potential.

Production Processes

The majority of greenhouse gas emissions from steel production are caused by the combustion of fossil fuels, the use of electrical energy, and the use of coal and lime as feedstock. The two main production processes are the primary route of basic oxygen furnace steelmaking (BOF) and the secondary route of electric furnace steelmaking. BOF accounts for 66% of world production. Emissions from BOF result directly from coke manufacture, used as a reducing agent to transform iron ore into the pig iron that is then turned into steel, the oxidation of coke/coal, calcination of carbonate fluxes, and from power consumption. The average total emissions intensity from BOF is 2.8 tCO₂ per ton of steel, almost entirely from fossil fuels. BOF is four times more emissions-intensive than the electric furnace process because of the large amount of heat and reducing materials required. The electric furnace process, which accounts for 24% of global production, uses an electric current to melt scrap metal and produce steel. As the electric furnace process is widespread in developed economies (57% of US steel production), recycling rates within the industry are high (83% in the US in 2008) but there is often not enough scrap to meet demand. The emissions intensity of electric furnace steelmaking is 0.6 tCO₂ per ton of steel, mostly from electricity. Although emissions vary by country and region depending on the reducing materials used, other energy inputs, the source of electricity inputs and plant efficiency, 75% of all CO₂ emissions from the steel industry come from coke and coal in iron making for the BOF process. The remaining 10% of production is in less efficient open hearth furnaces or a production process that utilizes natural gas to produce direct reduced iron (DRI). While the use of open hearth furnaces is being gradually phased out, DRI production is expected to increase because CO₂ emissions can be reduced by up to 50% compared with the BOF method.

Production and Consumption

World crude steel production in 2010, some 1,414 Mt, set a record for the industry. Demand is expected to continue to grow, driven in large part by China and other emerging economies, with the OECD predicting an annual growth rate of 5.1% up to 2030. China’s share of global demand is expected to increase from 17% in 2005 to 26% in 2030. Fueled by the construction and manufacturing sectors, China is now the world’s largest...
steel producer and consumer, producing over 622 Mt in 2010 (44% of the world total) and around half of world steelmaking CO₂ emissions. China’s steel sector is less efficient than those in Japan, South Korea, Europe and North America. This is due to the large proportion of small steelmaking plants, the predominance (87%) of BOF; the limited or inefficient re-use of residual gases, heat and pressure; and production overcapacity.

Abatement Options

There is potential to increase the use of the electric furnace process, as it is not used extensively in developing countries (only 13% of China’s production). Existing technologies, such as coke dry quenching, top-pressure recovery turbines, continuous casting and furnace gas recovery facilities, can improve plant efficiency and lower emissions. Energy consumption per ton of steel produced has been halved since 1975. The potential for reductions in CO₂ emissions vary by region depending on current practice. The largest potential savings are in increased BOF gas recovery, especially in China and India, and in coke dry quenching in China. If the existing and available technologies that cost under 100$/tCO₂ are introduced by 2030, one study has projected the total emissions reduction potential in China to be around 230 MtCO₂ by 2030, and 110 MtCO₂ in India. These two countries alone account for 66% of the world reduction potential in this study.

In the best plants in Europe and the US, efficiency gains and current technology have reached the limits of what is physically possible. The development of breakthrough technologies is thus required. Some of the most promising low-emission breakthrough technologies are Top Gas Recycling, the Hsarna Process, improved DRI and the electrolysis of iron ore. The first three facilitate carbon capture and storage (CCS). While these technologies are in various stages of development and their commercial scale capabilities are not yet known, they are receiving support from industry groups and some national and regional governments.

International Coordination

Despite a trend of consolidation in recent decades, the steel industry still remains highly fragmented. The World Steel Association, whose members represent approximately 85% of world steel production, is working to reduce steel emissions. Its “climate action recognition program” seeks to establish a common measurement and reporting system for steel plant CO₂ emissions that could be used to benchmark and identify priority areas; and its “CO₂ Breakthrough Program” establishes a forum for informational exchange of regional activities around the world. One of the leading such activities is the EU’s Ultra Low CO₂ Steelmaking (ULCOS) initiative, which brings together 48 European companies and is 40% funded by the European Commission. ULCOS recently selected 4 technologies from a long list of 80 for further research and development, including a €20 million pilot Hsarna project aiming to reduce BOF emissions by more than 50%. Notably, the resulting knowledge of these technologies will be shared equally between ULCOS members. These initiatives offer a valuable coordinating role for research and support for public-private ventures to deliver emissions reductions in iron and steel.

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Further resources are available at www.theGNCS.org