THE GNCS FACTSHEETS

Mitigating Iron and Steel Emissions

The iron and steel industry is the largest energy consuming manufacturing sector[1] and the second-largest industrial consumer of energy, after the chemical sector.[2] It produces around 5% of total world greenhouse gas emissions, some 2,165 million tons (Mt) of carbon dioxide (CO_2) per year, and small amounts of sulfur dioxide and nitrogen oxide.[3] 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.[4] 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.[5] 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.[6] 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 oxidization of coke/coal, calcination of carbonate fluxes, and from power consumption.[7] The average total emissions intensity from BOF is 2.8 tCO_2 per ton of steel, almost entirely from fossil fuels.[8] BOF is four times more emissions-intensive than the electric furnace process because of the large amount of heat and reducing materials required.[9] 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.[10] The emissions intensity of electric furnace steelmaking is 0.6 tCO_2 per ton of steel, mostly from electricity.[11] 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 CO_2 emissions from the steel industry come from coke and coal in iron making for the BOF process.[12] 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 CO_2 emissions can be reduced by up to 50% compared with the BOF method.[13]

Production and Consumption

World crude steel production in 2010, some 1,414 Mt, set a record for the industry.[14] 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.[15] China's share of global demand is expected to increase from 17% in 2005 to 26% in 2030.[16] Fueled by the construction and manufacturing sectors, China is now the world's largest

[1] Watson, C. *et al.* (2003). "Can Transnational Sectorial Agreements Help Reduce Greenhouse Gas Emissions?" Organization for Economic Cooperation and Development. Paris: OECD.
[2] ETSAP. (2010). *Iron and Steel Technology Brief 102*. International Energy Association Energy Technology Systems Analysis Programme.
[3] This is taking into account all onsite emissions and the indirect emissions from electricity use. Watson (2003).
[4] Worrell, E. *et al.* (2009). *Industrial Energy Efficiency and Climate Change Mitigation*. Berkeley National Laboratory.
[5] *Ibid*.
[6] Watson *et al*. (2003).
[7] IPCC. (2007). *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report*. Intergovernmental Panel on Climate Change. Section 7.4.1: Iron and Steel.
[8] Watson *et al*. (2003).
[9] *Ibid*.
[10] See American Iron and Steel Institute.
[11] Watson *et al*. (2003).
[12] OECD. (2008). *Environmental Outlook to 2030*. Organization for Economic Cooperation and Development. Paris: OECD.
[13] IPCC (2007). Section 7.4.1: Iron and Steel.
[14] See World Steel Association, www.worldsteel.org.
[15] OECD (2008).
[16] *Ibid*..

steel producer and consumer, producing over 622 Mt in 2010 (44% of the world total) and around half of world steelmaking CO_2 emissions.[17] 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;[18] the predominance (87%) of BOF; the limited or inefficient re-use of residual gases, heat and pressure; and production overcapacity.[19]

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).[20] 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.[21] The potential for reductions in CO_2 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.[22] If the existing and available technologies that cost under 100\$/tCO_2 are introduced by 2030, one study has projected the total emissions reduction potential in China to be around 230 MtCO_2 by 2030, and 110 MtCO_2 in India.[23] These two countries alone account for 66% of the world reduction potential in this study.[24]

In the best plants in Europe and the US, efficiency gains and current technology have reached the limits of what is physically possible.[25] The development of breakthrough technologies is thus required.[26] Some of the most promising low-emission breakthrough technologies are Top Gas Recycling, the HIsarna Process, improved DRI and the electrolysis of iron ore.[27] The first three facilitate carbon capture and storage (CCS).[28] 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.[29]

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.[30] Its "climate action recognition program" seeks to establish a common measurement and reporting system for steel plant CO_2 emissions that could be used to benchmark and identify priority areas; and its "CO_2 Breakthrough Program" establishes a forum for informational exchange of regional activities around the world.[31] One of the leading such activities is the EU's Ultra Low CO_2 Steelmaking (ULCOS) initiative, which brings together 48 European companies and is 40% funded by the European Commission.[32] ULCOS recently selected 4 technologies from a long list of 80 for further research and development, including a €20 million pilot HIsarna project aiming to reduce BOF emissions by more than 50%.[33] Notably, the resulting knowledge of these technologies will be shared equally between ULCOS members.[34] 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**

[17] Murray, R. *et al.* (2010). "Beyond Copenhagen: mechanisms to finance and deliver GHG emissions reductions in the iron and steel sector in China." Camco.
[18] Smaller steel plants are less efficient and more carbon intensive. Recent efforts by China's government set a target to close all furnaces below 300 m^3 by 2010, 400 m^3 by 2011 and 500 m^3 by 2012. *Ibid.*
[19] In July 2009, a three-year moratorium was enforced limiting construction of new plants and expansion to address production overcapacity, which stood at 24% in 2008. Murray *et al*. (2010).
[20] Akashi, O. *et al.* (2011). "A projection for global CO2 emissions from the industrial sector through 2030 based on activity level and technology changes." *Energy* 36(4): 1855-1867.
[21] Birat, J.P. (2009). "CO_2 Capture in the Steel Industry." *Presentation to ULCOS 3rd Colloquium.* 5-6 November 2009.
[22] Akashi *et al.* (2011).
[23] *Ibid*. This analysis is based on realistic and currently available technologies; some potential technologies, which may appear by 2030, are not taken into account. For example, CCS technology is not included.
[24] They have large reduction potentials because their absolute amounts of emissions are quite large and energy efficiency in 2005 was relatively low.
[25] WSA. (2010). "Steel's contribution to a low-carbon future." *Position Paper*. World Steel Association.
[26] WSA. (2009). "Breaking through the technology barriers." *Position Paper*. World Steel Association.
[27] See ULCOS Research for more information on these technologies.
[28] While these technologies also decrease reliance on coke and coal, their highest emissions reduction potential relies on the successful implementation of CCS technology.
[29] Birat (2009).
[30] The WSA represents approximately 170 steel producers (including 19 of the world's 20 largest steel companies), national and regional steel industry associations, and steel research institutes.
[31] The reporting framework uses a common agreed methodology. WSA is working to have this methodology recognized as an ISO Standard.
[32] See ULCOS, www.ulcos.org.
[33] See ULCOS Research, www.ulcos.org/en/research/home.php.
[34] Birat (2009).