worldsteel ASSOCIATION

FACT SHEET

Addressing climate change through technology transfer and research

Steelmakers are involved in many programmes to transfer technologies thereby improving or replacing existing processes or process steps. Steel producers are also researching and investing in new production technologies that would radically reduce their environmental impact.

The steel industry has identified climate change as a major challenge for more than two decades. The steel industry has been very effective in improving energy use and efficiency, thereby reducing CO_2 emissions but recognises that breakthrough technologies are needed to further tackle CO_2.

Modern steel plants are now limited by the laws of thermodynamics on how much they can still improve their energy efficiency and intensity.

Advanced technologies maximise the efficiency of production and minimise emissions of CO_2 to atmosphere. CO_2 generated in the steel industry results mostly from the chemical interaction between coal and coke (carbon) and iron ore in a blast furnace. This process is called ore reduction and produces hot metal which is then converted into steel. There is no large-scale commercially available substitute for replacing all the carbon in iron and steel making. Modern integrated iron and steel mills feed all their generated gases back into the production processes, to generate power and heat, thus increasing carbon efficiency, reducing external energy needs and reducing greenhouse gas emissions to a minimum.

An increasing number of countries around the world are taking measures to reduce their CO_2 emissions, through emission trading schemes (for example: EU and South Korea), carbon taxes and energy efficiency initiatives.

Technology transfer

worldsteel member companies see technology transfer as part of the solution – bringing all the major steel-producing companies up to the industry best practices as quickly as possible. The objective is to encourage developing countries to use the hard lessons learned in the developed world to improve their steel industry, without compromising the drive to improve their social and economic well-being or competitiveness.

worldsteel members regularly exchange information through projects, workshops, conferences, and expert groups on technology, environment, LCA, safety committees and also by benchmarking energy intensity, emission intensity, reliability and safe practices. worldsteel also produces technical reports on major subjects impacting the steel industry. These reports form the basis for internal online benchmarking systems and aim to contribute effectively to improving the economic and environmental performance of the steel industry. Examples of topics dealt with in recent technical publications are air quality, by-products, energy use, maintenance and reliability, raw materials and water management in the steel industry. worldsteel is also recognised as a world leader in life cycle assessment which uses the data from steel companies to determine the overall environmental impact of steel products.

The CO_2 breakthrough programme

Modern steel plants operate very close to the limits of the laws of thermodynamics. With most major energy savings already achieved, further large reductions in CO_2 emissions are not possible using present technologies. Further reductions called for by governments and international bodies require the invention and implementation of new production technologies.

worldsteel provides an expert or R&D forum in which seven national and regional programmes on breakthrough technologies exchange information on their projects, share improvements and identify gaps or overlaps in research. Table 1 shows an overview of the programmes.

The various regional programmes call on a range of industrial expertise from steel producers, energy generators, plant designers and equipment manufacturers. They also call on scientific expertise from research laboratories, universities and academic research institutions the world over.

The programmes identify steelmaking technologies that hold the promise of significant reductions in CO_2 emissions. They explore their feasibility on various scales, from lab work only to small pilot plant developments and eventually commercial sized implementation or using existing plants to test the improvement. As part of the worldsteel CO2 Breakthrough Programme, participants keep each other updated to avoid unnecessary duplication and to learn from each other, during the pre-competitive stage of the projects.

There are no restrictions placed on the scope of the projects, and the output is intended to be breakthrough technologies that can reduce the GHG emission intensity to atmosphere by at least 50% potentially revolutionising the way steel is made. Each regional initiative explores the solutions that seem best suited to local constraints and cultures.

Four possible directions are under examination:

- CCS – use of carbon capture and storage technology (CCS) is a necessary pre-condition to the continued use of fossil fuel based reducing agents in steel production. This emerging technology could be based on various capture and storage options, some of which only need to be adapted to the steelmaking context, while others still need basic research. Storage can be in deep saline aquifers, depleted oil or gas fields, in coal mines as geological storage, or turned back into carbonates (mineralogical storage). Waste-gas from steel production differs from that of other industries by its CO_2 content (usually higher), dust content, composition of minor gases (CO2, CO, etc.), temperature and pressure. Specific studies are therefore actively being carried out in the various initiatives. This has been developed in detail in the EU, Japan, China and USA. Many uses for the CO_2 have also been developed such as gaseous cement used as reef replacement or building water barriers. Emirates Steel in the United Arab Emirates is currently taking part in an innovative and ambitious project whose aim is to capture, reuse and store 800,000 tonnes of carbon dioxide (CO_2) from its steel plant annually[1]. The project is scheduled to be completed by 2016. The goal is to produce steel with lower CO_2 emissions to the atmosphere by capturing the CO_2 produced in the iron and steel making process, injecting it into existing oil fields for enhanced oil recovery (EOR) while at the same time storing it.
- Coal – would continue to be used as a reducing agent but the ensuing CO_2 would have to be captured and stored. The approach is similar to the power industry's effort to cut emissions from fossil fuel power plants, although the steel production solutions propose oxygen operation and in-process CO_2 capture rather than oxyfuel combustion and pre- or post-combustion capture. Ironmaking solutions range from the blast furnace, modified to accommodate CCS as in the ULCOS 'top gas recycling blast furnace', to smelting reduction processes such as HIsarna, Finex, etc., also similarly re-designed.
- Hydrogen – could be used as a reducing agent, as its oxidation produces only water. Hydrogen, either pure, as a synthesis gas (syngas) produced by reforming methane or as natural gas, can be used in conventional direct-reduction reactors or in more futuristic flash reactors. This hydrogen needs to be produced using carbon-lean processes: water electrolysis or natural gas reforming (both need high pressure steam or carbon free electricity otherwise it would defeat the purpose). Both may include CCS at their own level.
- Biomass – can be used to generate the reducing agent, either from charcoal for example or syngas. Biomass in such a scheme would need to be grown effectively near the place of use and in sufficient quantities to make it economically usable and repeatable. Interest in biomass is strong in Brazil, Australia, Canada and Europe. Biomass can be added as charcoal in the blast furnaces, added to the coke oven charge, burned as fuel in steelmaking reactors or used in direct reduction as syngas etc.

The various exploratory programmes have already identified more than 40 technologies of which seven programmes show promise. The more ambitious projects in terms of CO_2 reduction are now going through various steps with few technologies progressing from laboratory stage to pilot plant. Their potential, constraints and technical limits are being evaluated.

The coal-based ironmaking technologies associated with CCS are the most likely candidates for early maturity. Hydrogen technology is further into the future, as it will require re-engineering of steel production and the development of new processes from first principles. Biomass solutions are probably in the intermediate future.

In the even longer term, new avenues of research are likely to emerge. These include the integration of steelmaking with solar power generation, with new energy technologies and with new, fourth or even fifth generation nuclear power plants. Such solutions are not yet part of the ongoing programme, but could be added in the near future.

Energy intensity project

worldsteel completed the energy intensity project in 2013. The project included a global survey of the current energy-efficient technologies that are used in the steel industry today. Some are mature and widely used while some are still under development. Out of the 190 technologies reviewed, a pattern emerged that approximately 30% are commonly used, the ones saving the most energy. These technologies when fully utilised allow steel producers to potentially reach the lowest energy levels possible. Adding additional technologies would not create extra energy savings.[2]

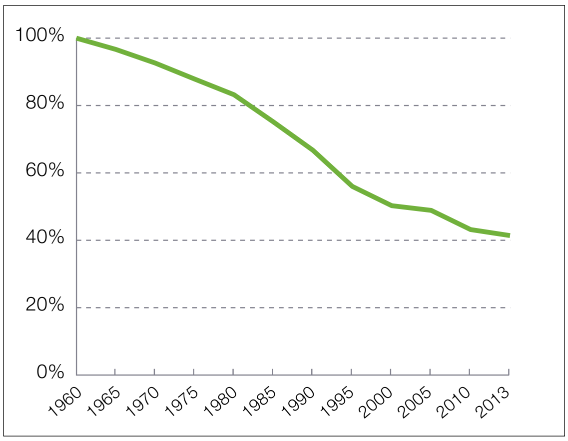

Figure 1: Indexed global energy consumption/tonne of crude steel production

Programme	Involving	Purpose	Best results
AISI - technology roadmap programme	Public-private partnership between AISI and the US Department of Energy's (DOE), Office of Industrial Technology)	Joint DOE/AISI collaborative programme designed to (1) increase energy efficiency, (2) increase competitiveness of the North American steel industry, (3) improve the environment. Different to other programmes because steel programme is required to pay back the federal cost sharing.	(1) Suspension hydrogen reduction of Iron oxide concentrate; (2) Molten oxide electrolysis.
Baosteel programme	Baosteel (China)	Objective is to reduce emissions from flares.	(1) Photovoltaic cells (2) Ethanol production from BOF gas (LanzaTech).
Australian programme	BlueScope Steel and OneSteel, CSIRO coordination (Australia)	In Australia, CSIRO is working with BlueScope and OneSteel on two projects aimed at cutting CO_2 emissions: biomass, which uses renewable carbon derived from biomass in steel manufacturing and heat recovery from molten slags through dry granulation, which captures the waste heat released from slag cooling, thus reducing CO2 emissions. These programmes have received large support from the Australian government.	(1) Cut CO_2 emissions through the use of biomass and by-products.
COURSE50	Japan Iron and Steel Federation (JISF), Japanese Ministry of Economy, Trade and Industry	Objective is to develop innovative technologies to help solve global environmental problems. Includes R&D projects, public relations activities and promotes industry/institute cooperation.	(1) Scenario-making for global warming mitigation; (2) CO_2 separation, capture and storage; (3) CO_2 fixation by plants and its effective use (4) Hydrogen reduction has been tested with interesting results, limits have been identified as well.
China Steel Corporation (CSC)	Taiwan CCS Alliance coordination (Taiwan)	The Alliance is focusing their research activities on two main technologies: the oxy fuel burner technology which aims at purifying CO_2 by burning without nitrogen content and the chemical absorption pilot plant which seeks to further decrease energy consumption per unit of CO_2 captured. Additionally, academic cooperation projects in CSC include BOF slag carbonation and microalgae carbon fixation.	(1) CO_2 purification; (2) Energy use reduction; (3) BOF slag carbonation and microalgae carbon fixation.
POSCO CO_2 breakthrough framework	POSCO, RIST, POSLAB, POSTECH	Objective is to find new solutions for CO_2 emission reduction in the steel industry, and climate change adaptation using steelmaking by-proudcts. The framework consists of six projects: (1) Pre-reduction & heat recovery of hot sinter, (2) CO_2 absorption using ammonia solution, (3) Bio-slag utilisation for the restoration of marine envionments, (4) Hydrogen production using coke oven gas and wastes, (5) Iron ore reduction using hydrogen-enriched syngas, and (6) Carbon-lean FINEX process.	(1) CO2 absorption using ammonia solution; (2) Carbon-lean FINEX process.
ULCOS - Ultra-low carbon dioxide steelmaking (EU)	All major EU steel companies, energy and engineering partners, research in-stitutes and universities. Also supported by the European Commission	Cooperative R&D intitiative to research radical reductions in carbon dioxide (CO_2) emissions from steel production. Includes process science, engineering, economics and foresight studies in climate change.	Top gas recycling blast furnace with CO_2 capture and storage (CCS); (2) HIsarna with CCS; (3) Advanced direct reduction with CCS; (4) Electrolysis.

Table 1: Breakthrough programmes (past and ongoing)

Breakthrough technologies have been developed, however, some funding has stopped and very few of the technologies have progressed to reduce emissions by more than 20-25%. The ULCOS programme in Europe has been halted apart from the HIsarna and ULCO-Red project which are now being privately funded by industry partners. The funding for the US programme has been reduced and the Australian project has stopped altogether.

On the other hand, the COURSE 50 research programme in Japan, the POSCO programme in Korea, the China Steel Corporation programme in Taiwan and the Baosteel programme continue as planned.

It is important to note that although some programmes may have been reduced for lack of funding, the technology researched is still valid and useful for future generations.

Importance of raw materials

The quality of raw materials has an impact on the energy consumed and subsequently on emissions produced. Demanding quality raw materials at an economic level is necessary for an efficient operation. Iron ore beneficiation equipment at the mine is significantly less capital intensive than investing in additional steelmaking capacity to meet demand. Using quality raw materials reduces the use of coal, energy and by-products at the steelmaking site. Good quality iron ore has an Fe content of 60-80% and low levels of contaminants. Coal products should have low ash content.[3]

Importance of recycling

Steel is a material which is 100% recyclable and can be reused indefinitely. This recyclability contributes significantly to the sustainability of steel, as the need for virgin resources is reduced significantly.

Recycled steel also entails much lower energy consumption – manufacturing steel from recycled steel scrap requires about a third of the amount of energy needed to produce steel from the raw material of iron ore.

Using recycled material is encouraged as much as possible across all regions. Scrap-based steel accounts for about 30% of the global steel production. However, due to the long life of steel products and the high demand for steel, today there is not enough available steel scrap to produce all steel from recycled material. As markets get saturated with steel products, they will return to a recycling path depending on products made from steel, from a few weeks ago in steel packaging, to vehicles which may last up to 15 to 20 years or infrastructure and buildings which may last up to 50 to 100 years. The economics of recovering material is usually aligned with the price of raw materials, if they reduce in price they are used more and scrap prices drop as well, if scrap is scarce the prices increase.

The industry must continuously balance energy requirements and costs as well as the quantity of iron ore, coal, and scrap needed in order to minimise energy and by-products while providing the best quality material to suit the customers' demand.

Last updated: AE, CB, HR, VR, October 2014

Footnotes:

1. www.esi-steel.com: Success stories: Reducing the Carbon Footprint.
2. Energy use in the steel industry, worldsteel, 2014.
3. Raw materials improvement report, worldsteel, 2013.