IN BRIEF

The iron and steel industry is one of the largest industrial emitters of CO$_2$, accounting for between 6% and 7% of anthropogenic CO$_2$ emissions globally. In the past 40 years there has been a 50% reduction in energy consumption in the industry in Europe. This has mainly been due to the increased use of recycled scrap iron from a 20% share in the 1970s to around 40% today, while the manufacture of iron from iron ore has declined. However, a complete shift to recycling is limited by the availability and quality of scrap.

THE TECHNOLOGY

State of the art

There are two main routes to produce steel. The integrated route is based on the production of iron from iron ore, while the recycling route uses scrap iron as the main iron-bearing raw material in electric arc furnaces. In both cases, the energy consumed comes from fuel (mainly coal and coke) and electricity. The recycling route consumes much less energy (about 80%) than the integrated route.

The integrated route – used for about 60% of production globally – relies on the use of coke ovens, sinter plants, blast furnaces (BF) and Basic Oxygen Furnace (BOF) converters. The fuels used are fully exploited, first for their chemical reaction potential (during which they are converted into process gases) and then for their energy potential, by capturing, cleaning and combusting these process gases in production processes and to generate heat and electricity. However, the increased energy efficiency that comes with the re-use of process gases – so-called cascadic fuel use – does not reduce overall energy consumption, in terms of the primary fuels used for the chemical reactions.

Ongoing research

Alternatives to the two main production routes include direct-reduced iron technology and smelting reduction (which, like the blast furnace, produces hot metal). The advantage of these technologies compared with the integrated route...

Improvements in energy efficiency have led to reductions of about 50% in the energy required to produce a tonne of crude steel since 1975 in most of the top steel producing countries.

OECD

OECD

Energy Efficiency and CO$_2$ emission reductions in the Iron and Steel Industry

Table: Total production of crude steel

<table>
<thead>
<tr>
<th>Year</th>
<th>Integrated Route (IR)</th>
<th>Recyling Route (RR)</th>
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<tbody>
<tr>
<td>2005</td>
<td>185 Mt</td>
<td>108 78</td>
</tr>
<tr>
<td>2030</td>
<td>250 Mt</td>
<td>110 140</td>
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42% 56%

Δ production ~ 34%
Δ CO$_2$ emissions ~ 7%

Source: JRC

The production of crude steel in the EU in 2008 was 198 Mt, representing 14.9% of the total world production (1,327 Mt of crude steel), compared to 24.6% ten years earlier.

In 2009, with the financial crisis, steel production in Europe dropped by 30% compared to the previous three years.

From 1998-2008, Chinese steel production grew more than fourfold (from 114 Mt to 500 Mt of crude steel).

Today, over 40% of steel is traded internationally and over 50% is produced in developing countries.

By 2020 and 2030, the annual consumption of steel in the wind energy industry could amount to 3 Mt and 6.3 Mt respectively, in order to achieve the respective projections of 230 GW and 350 GW of wind energy.

For a steel integrated plant, raw materials represent around 35% of total production costs and energy costs about 25%.

GHG emissions from the iron and steel industry between 2005 and 2008 on average amounted to 252.5 Mt CO₂ equivalent.

In Europe, about 80% of CO₂ emissions from the 'integrated route' originate from waste gases. These waste gases are used within the same industry to produce about 80% of its electricity needs.

During the period 2005 to 2008, direct emissions from the integrated route were on average 2.3 t CO₂/t of rolled products and 0.21 t CO₂/t of rolled products for the recycling route.

The expected increase in the recycling route share of total production, from 42% in 2005 to 56% in 2030, could result in an increase of only 7% in CO₂ emissions. This means an improvement of the CO₂ emissions per tonne of crude steel of around 20%.

Current energy consumption for the integrated route is estimated to lie between 17 and 23 GJ/t of hot-rolled product and for the recycling route, between 3.5 - 4.5 GJ/t of hot-rolled product.

According to the IEA, the savings potential in 2005 for the industry, based on best available technologies, is around 2.12 GJ/t for the European countries of the OECD. This value is around 15% of the average consumption (combined production of both integrated and recycling routes).

The implementation of the Top gas recycling blast furnace with CCS will cost about EUR 590 million for an industrial demonstrator producing 1.2 Mt hot metal per year.

Combined with CCS, the potential reduction of CO₂ emissions of the Hlsarna process is 70 - 80%.

The potential reduction of CO₂ emissions from the ULCORED process is 70 - 80%.

If the body structures of all cars produced worldwide were made of Advanced high-Strength Steel instead of conventional steel, 156 Mt CO₂ eq would be avoided.

Steel is a direct supplier for and part of a value chain representing the best of European industry and contributing annual revenues in excess of EUR 3,000 billion and employing 23 million people.

In the EU, 350,000 people were directly employed in the sector in 2005.

2. The base year of 2008 is often used throughout. More recent data covering all aspects of the statistics for this industry is not readily available. Consequently, in order not to compare data for different years, a common early base had to be taken.
route is that the raw materials do not need to be treated (‘beneficiated’), e.g. by sintering and making coke, and that they can adjust well to low-grade raw materials. On the other hand, more primary fuels are needed, especially natural gas for direct reduced iron technology and coal for smelting reduction.

20-25 % savings in CO₂ emissions in the smelting reduction process can be achieved if the additional coal is transformed into process gases, which are then captured and used to produce heat and electricity. At present in EU-27, only one plant uses direct-reduced iron technology (in Germany), while none of the eight operational facilities for smelting reduction in the world are in Europe.

TECHNOLOGY OBJECTIVES AND ACTIONS

There is potential for reducing direct CO₂ emissions by about 27 Mt per year by applying best practice, including the retro-fitting of existing equipment. This potential however relies strongly on a substitution of local raw materials with increased imports of best performance raw materials from outside the EU (especially ores and coal).

The industry’s flagship ULCOS programme (Ultra–Low Carbon dioxide (CO₂) Steelmaking)⁴, supported by the European Commission and involving a consortium of 48 leading players in industry and research, aims to reduce the CO₂ emissions of today’s best routes by at least 50%. The first phase of ULCOS had a budget of EUR 75 million.

As a result of the first phase of ULCOS, four main processes have been earmarked for further development. The top gas recycling blast furnace is based on the separation of the off-gases so that the useful components can be recycled back into the furnace and used as a reducing agent. Meanwhile, oxygen is injected into the furnace instead of preheated air to facilitate CO₂ capture and storage (CCS). The timeline to complete the demonstration programme is about 10 years, allowing further market roll-out after 2020.

The Hisarna technology combines preheating of coal and partial pyrolysis in a reactor, a melting cyclone for ore melting and a smelter vessel for final ore reduction and iron production. Market roll-out is scheduled for 2030. The ULCORED (advanced Direct Reduction with CCS) involves the direct reduction of iron ore by a reducing gas produced from natural gas. The reduced iron is in a solid state and will need an electric arc furnace to melt the iron. An experimental pilot plant is planned in Sweden, with market roll-out foreseen for 2030. The experimental processes, known as ULCOWIN and ULCSYS, are electrolysis processes to be tested on a laboratory scale.

In thermal power plants, the development of new steel grades will increase temperature and pressure and will contribute to the improvement of energy efficiency. In advanced supercritical plants with steam conditions up to 600ºC and 30 MPa, net efficiencies between 46 and 49% could be reached whereas older pulverised coal plants, with subcritical steam parameters, operate with efficiencies between 32 - 40 %.

The development of new grades (lightweight alloys) for the automotive industry can decrease steel consumption (energy consumption) and at the

“Since 2001, CO₂ emissions from iron and steel production have been relatively stable while steel production from electric processing has been steadily increasing and steel production from integrated steelworks has been stable. This indicates a decoupling between steel production from electric processing and related CO₂ emissions, due to efficiency improvements in the steel production process and in electricity generation by the steel industry.⁴”

European Environment Agency²

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same time improve the efficiency of the final products – lighter cars will be more efficient.

**THE INDUSTRY**

The production of crude steel in the EU in 2008 represented about 14.9% of total world production (1 327 Mt of crude steel), compared to a 24.6% share ten years earlier, even with a slightly lower production. The main difference is that the Chinese production has grown more than fourfold over this period.

The growth of iron and steel production in the EU-27 is estimated at about 1.18% per year up to 2030. The increase in the production would be covered mainly by an increase in the recycling route. Production from the integrated route is expected to stay around its current values.

**Barriers**

Further increases in the recycling rate beyond the 60% in 2030 will be hampered by the availability of scrap. Such high recycling rates will increase the impurities and reduce overall steel quality. Recycling is associated with high emissions of heavy metals and organic pollutants due to the impurities of scrap.

Meanwhile, the thermochemical efficiency of current blast furnaces is almost optimal. As CO₂ emissions are linked to the chemical reaction for the reduction of iron ore, there can be no significant decrease in CO₂ emissions without the development of breakthrough technologies, as proposed by ULCOS.

The industry is also facing a social challenge due to the increasing average age of its workforce: more that 20% will retire from 2005 to 2015 and close to 30% during the following 10 years. The industry will therefore need to attract, educate and secure more qualified people.

**Needs**

There is a clear need to support the ULCOS research effort with a high share of public funds and to encourage the deployment of these breakthrough technologies.

One important synergy in the quest to curb prospective CO₂ emissions through the ULCOS project is by sharing innovation initiatives within the power sector or with other (energy-intensive) manufacturing industries that could launch CCS initiatives (e.g. the cement industry).

Not all the European operators are performing as well as they could, so there is still potential to save energy by bringing them up to the level of the best performers.

**INSTALLED CAPACITY**

The EU is the second leading manufacturer of iron and steel products in the world, China being the largest. The main EU steel producers are Germany, Italy, France, Spain, UK, Belgium and Poland. The USA is the main importer and the EU, Japan, Russia and Ukraine are the main steel exporting countries.

In 2008, the total EU iron and steel production was 198 million tonnes, accounting for 15% of the world steel production. The annual turnover in the EU steel sector is approximately €150 billion and employs approximately 440,000 people.

The EU-25 iron and steel production sector employed about 598,000 people in 2003, having seen about 64,657 job losses between 1999 and 2003. Worldwide consumption of steel increased by 70% over 1982-2004. Despite this world increase, the EU has decreased its share by 20%. In the rest of the world, consumption has almost doubled.

**For further information:**