Steel and energy

The steel industry actively manages the use of energy. Energy conservation in steelmaking is crucial, to ensure the competitiveness of the industry and to minimise environmental impacts, such as greenhouse gas emissions. Steel is also essential for energy production and transmission and saves energy over product life cycles through its light-weight potential, durability and 100% recyclability.

In 2007, 1.3 billion tonnes of steel were produced. Production levels are expected to double by 2050 to meet the growing demand for steel around the world.[1]

Energy use in steelmaking

Steel production is energy intensive. However, sophisticated energy management systems ensure efficient use and recovery of energy throughout the steelmaking process for reuse, wherever possible. Improvements in energy efficiency have led to reductions of about 50% in energy required to produce a tonne of crude steel since 1975 in most of the top steel producing countries, as shown in Figure 1.[1]

Energy inputs and associated costs

- Energy constitutes a significant portion of the cost of steel production, from 20% to 40% in some countries.[2,3] Thus, improvements in energy efficiency result in reduced production costs and thereby improved competitiveness.
- The energy efficiency of steelmaking facilities vary depending on production route, type of iron ore and coal used, the steel product mix, operation control technology, and material efficiency.
- Energy is also consumed indirectly for the mining, preparation, and transportation of raw materials, including: coal, iron ore, recycled steel and limestone (about 8% of the total life cycle energy required to produce the steel[1]).
- About 95% of an integrated facility's energy input comes from solid fuel (mainly coal), 3-4% from gaseous fuels and 1-2% from liquid fuels.[4]

Energy inputs as reducing agents

- The production of primary steel is more energy intensive than the production of secondary steel (see Figure 2) due to the chemical energy required to reduce iron ore to iron using reducing agents.
- Table 1 shows the main energy inputs of steel production and their applications as energy and reducing agents.[3]
- Because reduction does not take place at room temperature, reducing agents such as coal, coke and natural gas also function as the heat supply.
- Coke, made by carburising the coal (i.e. heating in the absence of oxygen at high temperatures), is the primary reducing agent of iron ore, and most other fuels are used to substitute a portion of coke. If a plant doesn't produce its own coke and/or electricity on-site, these must be purchased externally.
- Up to 75% of the energy content of the coal at an integrated facility is consumed in the blast furnace, where in the form of coke it serves multiple roles including chemical reductant, furnace burden support, and fuel. The remainder provides heat at the sinter and coking plants and, in the form of by-product gas, serves as an energy source displacing other fuels to various downstream process stages.[4]

FIGURE 1

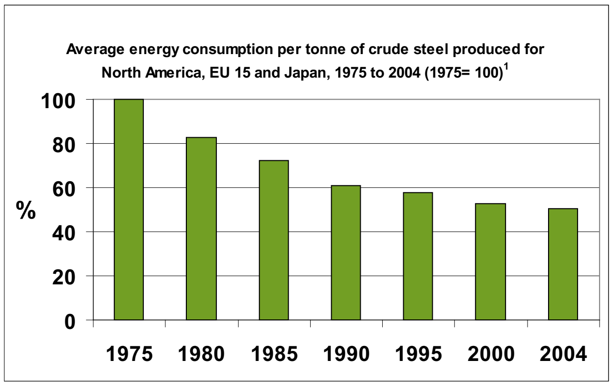


TABLE 1: APPLICATIONS OF ENERGY INPUTS IN STEEL PRODUCTION[3]

Energy input	Application as energy	Application as energy and reducing agent
Coal	-	Coke production, BF pulverised coal injection, DRI production
Electricity	EAF, rolling mills and motors	-
Natural gas	Furnaces	BF injection, DRI production
Oil	Steam production	Blast furnace (BF) injection

By-product gases

- By-product gases from the coke oven, blast furnace and basic oxygen furnace (BOF) can be fully reused, saving additional fossil fuel resources. They typically contribute 40% to total energy and are used either as a direct fuel substitute or for the internal generation of electricity.[4]
- In Germany, for example, BOF by-product gas recovery saves the equivalent of 300 million cubic meters of natural gas per year, which would otherwise have to be obtained from natural resources.[4]
- Innovative technology now exists that allows CO_2 to be recaptured and remarketed, such as a steelmaking plant that is supplying a nearby gas facility with 50,000 tonnes of CO_2 per year. In turn, the gas is cleaned up and used to make carbonated drinks.[1]

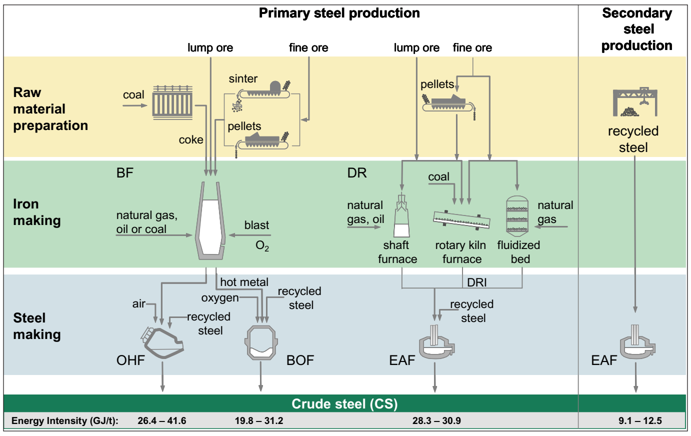
Future improvements in energy efficiency

- Today's best-available steelmaking processes have optimised energy use.
- Medium-term energy efficiency improvements in the steel industry are expected through Technology Transfer, or applying best-available technology to out-dated steel plants worldwide.
- Breakthrough technologies are expected to lead to major changes in the way steel is made, with a time frame of 2020 and beyond.[1]

Steel production basics

Steel is produced using primary or secondary methods, as shown in Figure 2.

FIGURE 2



Steel production routes and energy intensity per route (in units of GJ per tonne of crude steel produced). This figure is for illustrative purposes only, as the steelmaking process can vary from one facility to another. Energy intensity is shown as a range because it varies depending on steel grade produced and technology used. Energy intensity values are based on CO_2 intensity values from worldsteel 2007 data. The CO_2 intensity values include direct and indirect emissions from coke making, sintering, iron making, casting and rolling. Mining is not included.

Primary steel currently accounts for about 75% of world steel production and is produced by reducing iron ores to iron and converting iron to steel. The main inputs are iron ore, coal, limestone, and recycled steel. The main primary production routes are:

- Blast furnace (BF) – basic oxygen furnace (BOF): 66%[1]
- BF – open hearth furnace (OHF): 3%[1]
- Direct reduction (DR) – electric arc furnace (EAF): 6%

Secondary steel accounts for about 25% of steel and is produced by recycling steel in an electric arc furnace (EAF). The main inputs are recycled steel and electricity.

Most steel products remain in use for decades before they can be recycled. Therefore, there is not enough recycled steel to meet growing demand using the secondary steelmaking method alone. Demand is met through a combined use of the primary and secondary production methods. Open Hearth Furnace (OHF) technology use continues to decline owing to its environmental and economic disadvantages.

Steel's role in energy production and transmission

Steel is indispensable for energy production and transmission. It is used to manufacture:

- mining equipment and offshore oil platforms
- equipment for oil and gas extraction and production
- natural gas and oil pipelines and storage tanks
- ships, trucks and trains used to transport many forms of energy
- transformers (magnetic steel core)
- generators and electric motors
- power transmission towers and cables.

Steel also plays an important role in renewable energy technologies. For example:

- Solar: stainless steels play a key role in converting solar energy into electricity or hot water. They are used as a base for solar thermal-panels and in pumps, tanks and heat exchangers.[5]
- Wave and tidal: a steel pile is the main component of a tidal turbine in tidal energy systems. Steel is also used to fabricate wave energy devices. The steel used is formulated to withstand the harsh marine environment.
- Wind: steel is the main material used in onshore and off-shore wind turbines. Almost every component of a wind turbine is made of steel, from the foundation, to the tower, gears and casings.

Steel saves energy over product life cycles

While steel products require energy to produce, they can also offer savings over the life cycle of the product, sometimes greater than the energy used during their production.

For example, over 20 years, a three-megawatt wind turbine can deliver 80 times more energy than is used in its production and maintenance.[6]

Steel also reduces product life cycle energy use and emissions in other ways, including through:

- Light-weighting – advanced high-strength steels (AHSS) allow for less steel to be used in cars, reducing their weight by 9%, fuel consumption during the use phase by 5.1%, and greenhouse gas emissions by 5.7%, without compromising safety.[1]
- Long product life cycle – steel's strength and durability allow for long product life cycles. For example, buildings and bridges made with steel last 40 to 100 years, or longer with proper maintenance. Zinc coating on steel framing can provide corrosion resistance and thereby an average life expectancy of 377 years.[7]
- Recycling – steel is easily recovered with magnets and is 100% recyclable. It can be infinitely recycled without loss of quality. Recycling reduces the use of energy & other raw materials in the making of new steel. In 2006, about 459 million metric tons (mmt) of steel were recycled worldwide, saving the equivalent of 242 mmt of anthracite coal.[1]

Last updated: October 2008

Footnotes

1. From World Steel Association data or publications (worldsteel.org)
2. "The State-of-the-Art Clean Technologies (SOACT) for Steelmaking Handbook." Asia Pacific Partnership for Clean Development and Climate, December 2007.
3. "Saving One Barrel of Oil per Ton (SOBOT)." American Iron and Steel Institute, 2005.
4. "Steel Industry and the Environment, Technical and Management Issues." IISI and United Nations Environment Programme (UNEP) Technical Report No. 38. Copyright 1997.
5. "Stainless steel in solar energy use. " International Stainless Steel Forum (ISSF), 2008.
6. Danish Wind Industry Association (www.windpower.org)
7. "Galvanized Steel Framing for Residential Buildings," American Iron & Steel Institute and Steel Framing Alliance, 2006