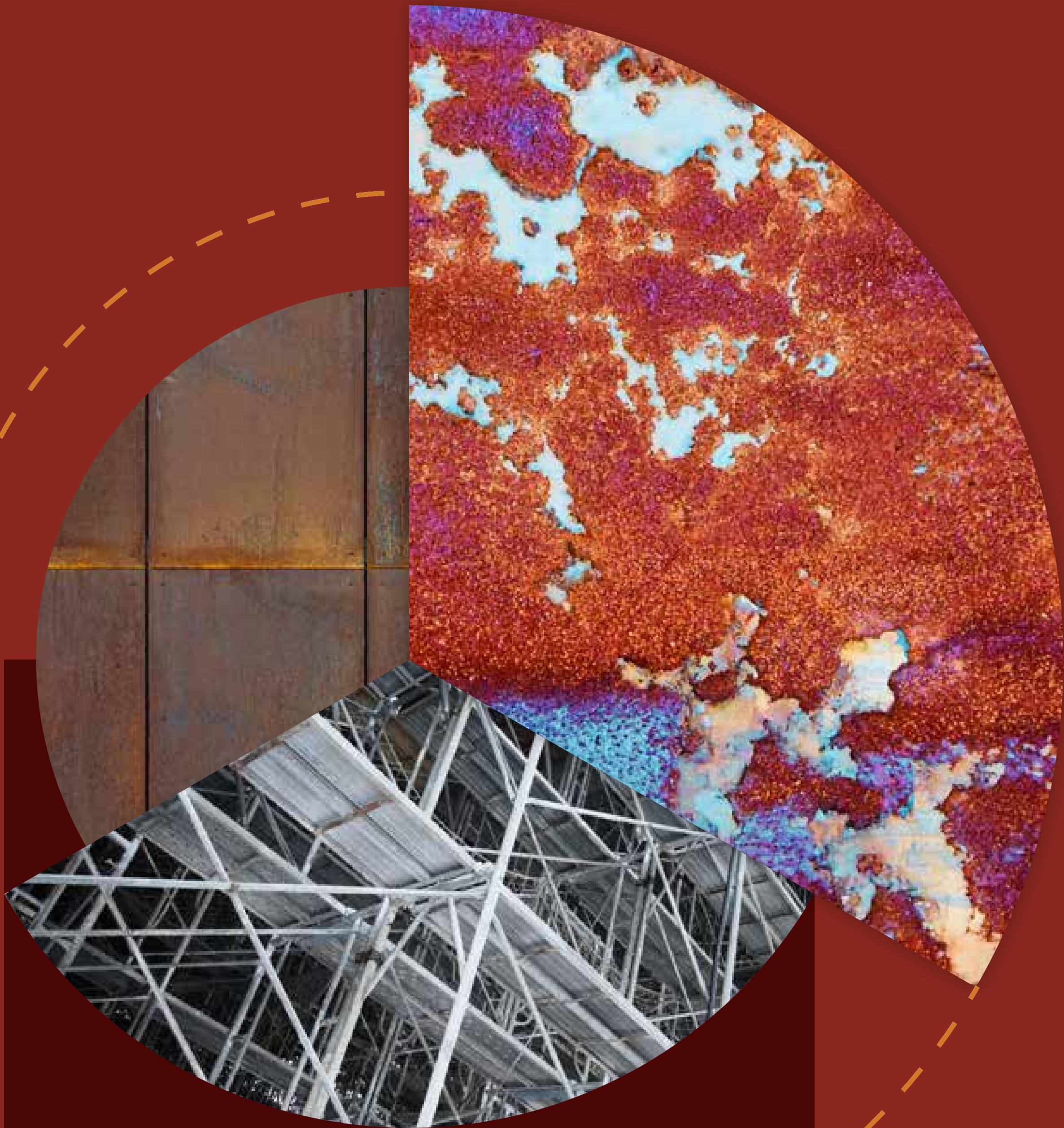
Strengthening Sustainability *in the Steel Industry*



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Acknowledgments

Special thanks to Gary Seidman and Kathy Chen for their involvement in producing this series. In addition, Irina Sarchenko, IFC Communications Analyst, managed the design process, and Aliza Marcus, Senior Communications Officer for Manufacturing, Agribusiness & Services, assisted in the preparation and finalization of the series.

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Growing global concerns over climate change are putting an increasing focus on sustainability. This report is part of an occasional series on sustainability in industry which examines the opportunities and challenges facing various industrial sectors and the role that the International Finance Corporation can play to support their efforts and contribute to a greener planet.

People have used steel since ancient times, after blacksmiths discovered that iron became harder and stronger after being placed in charcoal furnaces.

Today, steel is present in virtually every aspect of people's lives, from homes and hospitals to roads and other infrastructure that provide the foundation for social and economic development.

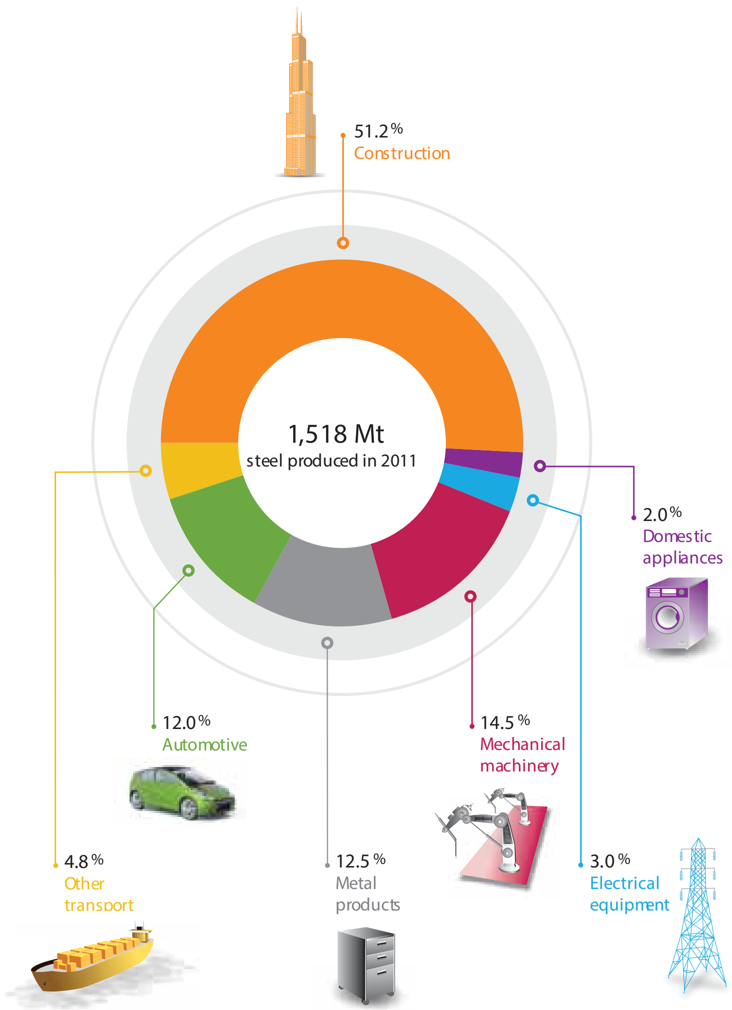
Steel is among the world's most recycled materials, with circular economy practices incorporated into various stages of the production cycle. Yet the high-temperature heat vital to its production process still requires large amount of energy. Hence, the iron and steel sector remains among the largest consumers of energy and emitters of carbon dioxide, accounting for 6 to 7 percent of global greenhouse gas emissions.[1]

With growing global concerns over climate change, regulators, investors, and industrial customers are increasingly pushing steelmakers to increase their sustainability by pursuing decarbonization pathways. To speed up the process will require incremental and breakthrough technologies, and the International Finance Corporation has been exploring opportunities to finance such projects and support steelmakers to become more sustainable.

Sector Background

Steel ranks as the third-most-abundant man-made bulk material after cement and timber, serving as an integral material for virtually all aspects of the built environment. It provides essential inputs to the construction, infrastructure, machinery, transport, and consumer goods sectors. In 2020, the largest end uses for steel were construction and infrastructure (52 percent, for products such as construction beams and plates), mechanical equipment (16 percent, including factory and farm machinery), and automotive (12 percent, for car bodies and parts).[2] The metal also has thousands of other applications, and is present in everything from home appliances to surgical screws to satellites. The raw materials for producing steel—iron ore, coal, and limestone—

Steel's Main Uses, 2011

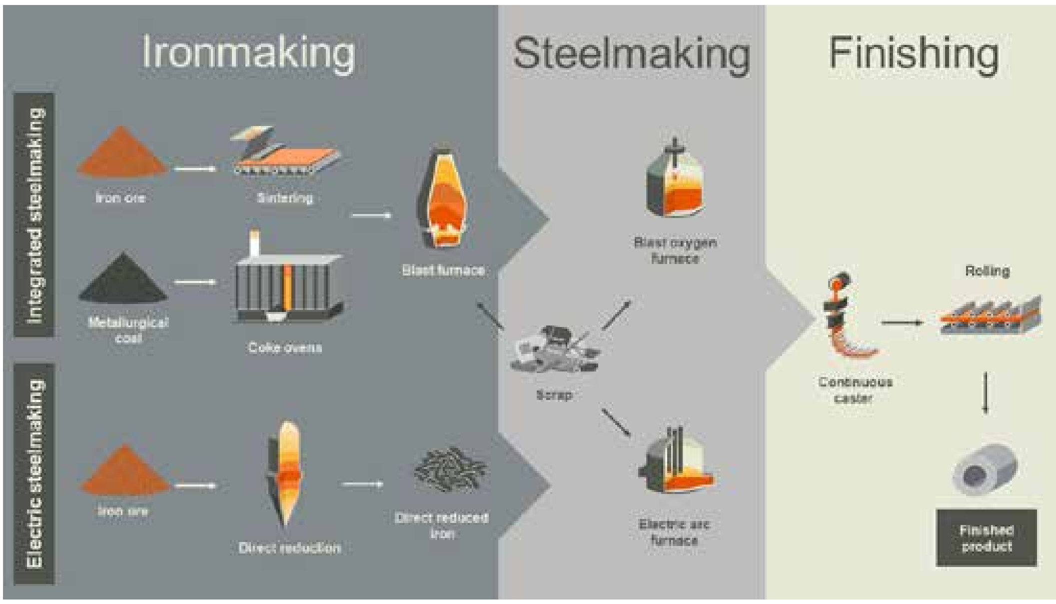


Source: World Steel Association 2012b.

are generally cheap and plentiful. In the primary production process, these ingredients turn into molten steel through a series of chemical reactions that take place under extreme heat. This heat is generated by coke, which is made from coal, or by other energy sources in giant furnaces. The addition of elements such as chromium or titanium can produce alloys that are more able to absorb energy (toughness) or easier to cast (formability), scratch-resistant (hardness) or rust-resistant (corrosion-resistance, such as in stainless steel). Huge rollers and molds help to shape the metal while it is still hot, with further processing potentially incorporating protective coats, color, or other additions.

Global production of crude steel has more than doubled over the last two decades, to 1.86 billion tons in 2020.[3] The main sites of production have shifted over this period, from Europe, the United States, and Japan as the biggest producers accounting for more than half (53 percent) of total production in 2000, to emerging markets, which presently account for more than 70 percent of production. China alone accounts for about 55 percent of global steel production and has generated more than 90 percent of global production growth over the past 20 years. Outside of China, the top steel-producing countries today are India, Japan, Russia, and the United States.[4] Industrialization and urbanization have helped fuel market growth, contributing to global demand for steel that is projected

The Steelmaking Process: Two Major Routes



Source: BHP 2020a.

to increase by more than a third by 2050, according to the Paris-based International Energy Agency (*IEA*).[5] Demand from steel consumers such as automakers has helped make steel one of the world's most widely traded commodities. Approximately one-quarter of global production volume is traded as intermediate steel products. In addition to being integrated in global value chains, the steel industry plays an outsize role in development, accounting for 3.8 percent of global gross domestic product (*GDP*) in 2017, including its direct, indirect, and induced impacts,[6] and supporting 49.3 million direct and indirect jobs.[7] The industry provides an essential material for construction and urbanization and helps countries move up the production value chain. And because steel is used in many "greening" technologies, from wind and solar power generation systems to electric vehicles, it is critical to the global energy transition.

BOX I: ***COVID-19 Impact on the Steel Industry***

The COVID-19 pandemic and resulting lockdowns dampened global steel production and demand in 2020 although China's strong and quick recovery muted the overall impact. Global steel production declined -0.9 percent in 2020 year-over-year, with China's 5.2 percent growth mostly offsetting a -7.7 percent decline in output in the rest of the world.[a] Similarly, global steel consumption fell -1.0 percent, as China saw a 9.0 percent rise in 2020 while the rest of the world registered a decline of -11.0 percent.[b]

The automotive sector was the hardest hit among major steel-consuming sectors, but demand has improved as lockdown measures have eased. As steel-consuming sectors have rebounded, steel inventory levels have tightened globally, and steelmakers have restarted production that they idled when the pandemic began. The recovery is projected to continue in 2021, with global steel consumption forecast to increase 4.5 to 5.5 percent year-over-year.[c]

In the medium term, the extent to which stimulus packages across the world support infrastructure projects will be a key factor for the steel industry, given that construction and infrastructure account for about half of global steel use.

a. World Steel Association 2021b.
b. ArcelorMittal 2021.
c. Ibid.

Sustainability

Although energy intensity per ton of steel has declined over the past two decades, production growth has led to absolute increases in energy consumption and greenhouse gas emissions.[8] A number of steelmakers are piloting new technologies to address these challenges, and Luxembourg-based ArcelorMittal and Japan's Nippon Steel, two of the world's largest steelmakers, have committed to becoming carbon neutral by 2050.[9] Currently, steelmakers are promoting sustainability in the following ways:

Recyclability

Steel scrap can be collected from the mill, during manufacturing of steel products, and through recycling of goods at end of life, such as a bridge that is being demolished. By end-use sector, global steel recovery rates are estimated at 90 percent each for automotive and machinery, 85 percent for construction, and 50 percent for electrical and domestic appliances.[10] The metal can be recycled continually without any degradation in performance, saving on raw material and energy consumption and reducing emissions. Globally, the recycled content in steel production could rise as more steel products in China and other countries reach the end of their life cycle. Still, scrap-based production alone is unlikely to satisfy the industry's need for raw material due to demand growth and the lag in turnover, given that products often remain in service for decades.

Fully realizing steel's recycling potential requires effective collection systems and infrastructure as well as the appropriate manufacturing process equipment, namely electric arc furnaces (as explained below).

By-product reuse

The sector generates by-products that are essential to other industries as raw materials. These include blast furnace slag, which is formed when the impurities from the steel-manufacture process are mixed with limestone and which serves as a binding material in concrete; and water and processing liquids, which are filtered for reuse by the steel plant. Hot flue gases are collected and cleaned before being channeled to heat the air blast in the furnace. And steelmaking using electric arc furnaces produces dust and sludges that are processed to recover other metals, such as zinc, for reuse.

Shifting production processes

The majority of steel is produced in blast furnaces/basic oxygen furnaces (BF-BOF), which require the use of iron ore and coal, in the form of coke, in an emissions- and energy-intensive production process. The BF-BOF production route is especially widespread among European steelmakers, though an increasing number of producers are shifting to Direct Reduced Iron (DRI) and electric arc furnaces (EAF). These furnaces primarily rely on natural gas and electricity and use DRI, scrap steel, or their combination as the main raw material to make steel. The DRI-EAF production route has emissions intensity and energy intensity that is approximately one-third and one-fifth less, respectively, than in the BF-BOF production route. The intensity rates are even lower for EAF scrap-based steel production, averaging 85 percent and 90 percent less, respectively, compared to the BF-BOF route.[11] But, as previously noted, steel scrap has a limited supply, and it is not fit to make all grades of steel, constricting its potential to serve as the sole method for reducing emissions. Steel companies are also experimenting with carbon capture and hydrogen to reduce or eliminate carbon emissions (see Box II). If these technologies can be applied successfully on a large scale, they could prove transformational for other industries as well.

"Green" contribution to other sectors

Steel contributes to key industries that are helping to drive the shift to a green economy. It is a key material used in the construction of equipment needed to supply the world with renewable energy such as hydroelectric, wind, and solar power. An average wind turbine, for instance, is comprised of 80 percent steel, used in the tower, nacelle, and rotor.[12] Steel is also critical in the construction of energy-efficient buildings and factories, and electric vehicles, and can help improve the sustainability of traditional goods. For example, the use of advanced high-strength steel can reduce a car's structural weight by as much as 25 percent and help lower its total life cycle carbon dioxide emissions.[13]

Challenges & Opportunities

Steelmakers have reduced energy use and carbon emissions mostly through technological innovations to existing production processes, but they will have to do much more to reduce their carbon footprint going forward. For the steel sector to be on a pathway that is aligned with the temperature goals of the Paris Agreement, its direct carbon emissions must decline by more than half by 2050, according to the IEA, with continued reductions towards zero emissions thereafter.[14] Shifting expectations from downstream industries and customers are putting additional pressure on the steel industry. In the auto industry, Toyota is aiming for zero carbon emissions from vehicle lifecycle and plants by 2050, while BMW is including suppliers' carbon footprints as a criterion in deciding contract awards.[15] Government regulation is likely to accelerate these trends. The European Green Deal requires companies to gradually pay higher prices to cover carbon emissions, and starting in 2023, will impose a carbon tax on certain imports into the EU. Additionally, the state of California, through the Buy Clean California Act, has created a public procurement program that aims to curb emissions. The state has established a benchmark for the emissions intensity of building materials, including steel products, that can be used in state-funded projects. In the near term, steelmakers using blast furnaces could reap energy savings of about 20 percent per ton of crude steel by improving operational efficiency and adopting new technology.[16] Beneficial technology modifications include deploying waste heat recovery systems, either in new builds or through retrofits of existing plants, and equipping blast furnaces with top-pressure recovery turbines, which use the heat and pressure of blast furnace gas for electricity generation. Promoting greater use of scrap alongside iron ore in BF-BOF production can also enhance energy efficiency.

Nonetheless, further decarbonization of primary production will be critical in the long term. This will require potentially expensive scale-up of new manufacturing technologies, such as carbon capture and hydrogen (see Box II).

BOX II: *Hydrogen and Other Innovations Towards Carbon-Free Production*

Hydrogen is needed in steel production as a reductant, but it requires a large amount of energy to produce. Today, most hydrogen is produced from natural gas using a carbon-intensive process called steam methane reforming. Hydrogen can also be produced by splitting water molecules in an electrochemical reactor, with oxygen as the sole by-product. Using electrolysis powered by renewable energy to isolate hydrogen renders the process carbon-free, but this requires a reliable and affordable source of renewable energy to be economically viable at scale. Incorporating green hydrogen offers a solution for achieving low-carbon steelmaking.

Hydrogen can be used in blast furnaces to replace coke, which can lower emissions by up to about 20 percent.[a] More transformational, hydrogen can be used as an alternative reductant in making direct reduced iron, which is then processed into steel in an electric arc furnace. Using green hydrogen in this process would enable nearly carbon-neutral steel production.

The first direct reduced iron facility based solely on green hydrogen is being developed under Sweden's HYBRIT initiative with steelmaker SSAB, state-owned utility Vattenfall, and miner LKAB, with hopes of launching fossil-free steel products by 2026.[b]

Other initiatives are harnessing different technologies to develop very low-emission steelmaking, including carbon capture, use, and storage *(CCUS)*, which entails capturing carbon emissions and reusing or storing them. Such systems can be integrated in existing plants but require carbon transport and storage infrastructure. The first commercial steel CCUS project has been launched by CCUS company Al Reyadah and Emirates Steel at a gas-based, direct reduced iron plant in Abu Dhabi, United Arab Emirates.

a. Hoffman, Van Hoey, and Zeumer 2020.
b. Hybrit 2021.

IFC Role

The iron and steel sector is estimated to need approximately $1.4 trillion of capital investment between 2021 and 2050 to be on a trajectory that is compatible with the goals of the Paris Agreement.[17] The International Finance Corporation invests in steel as part of its broader strategy to increase economic complexity in emerging markets and to support the industry's decarbonization pathway. Since 2005, it has invested in iron and steel projects across more than 15 countries. IFC applies strong performance thresholds in the assessment of iron and steel investments, with all projects required to adhere to the World Bank Group's Environmental, Health, and Safety Guidelines. IFC supports the industry in decarbonization through the adoption of leading technologies and pathways that can help plants reduce energy and emissions intensities. And it offers advisory services to manufacturing clients on how to improve energy and resource efficiency, mitigate climate risks, and minimize their climate footprint. The following is a sampling of IFC's recent engagements with steel manufacturers.

Rider Iron and Steel Ghana Limited (RSK)

IFC provided a $12 million loan to RSK to help finance the construction of a steel manufacturing plant in Ghana that will use mostly locally sourced scrap steel and operate with an energy-efficient induction furnace. The new plant will produce 240,000 tons of steel annually, increasing Ghana's current production by more than 75 percent. The use of scrap steel will result in lower carbon emissions than manufacturing steel from iron ore. And by sourcing scrap locally, the project will result in a gross avoidance of import-related greenhouse gas emissions of 330,000 tons of CO_2 equivalent per year, approximately equivalent to the CO_2 emissions from 34,000 U.S. homes' annual energy use.[18]

Blue Nile Rolling Mills

IFC has committed an $8 million loan to Blue Nile Rolling Mills, a locally owned, leading steel manufacturer in Kenya which uses solar power to fuel some of its operations. The loan will fund the company's backward integration into galvanized iron wire, establishing the country's first galvanized iron wire manufacturing plant. With IFC's funding, the company is able to commission additional solar power capacity as part of its decarbonization solution. Additionally, IFC will assist the company to develop environmental, health and safety, and social practices in line with international standards.

Conclusion

The steel industry has a critical role to play as the world steps up efforts to combat climate change. The sector is among the biggest industrial consumers of energy and emitters of greenhouse gases; at the same time, steel constitutes an essential material in economic development, in the global transition to green energy, and in other industries' efforts to make their products more sustainable.

Transforming the traditionally energy- and emissions-intensive process of steelmaking will require fast scale-up of new technologies and decarbonization pathways, such as carbon capture and use of hydrogen where possible. Bringing these technologies to the commercial stage, in turn, will require major financial commitment, strong regulatory support, and a broader enabling environment that includes access to stable, affordable sources of renewable energy and supporting infrastructure.

If the steel industry succeeds in this challenge, it would not only vastly reduce its own carbon footprint, but it could also help downstream industries improve their sustainability and provide a path forward for other heavy industries seeking to reduce their energy use and emissions.

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1. Kock Blank 2019.
2. World Steel Association 2020a.
3. Ibid 2021b.
4. Ibid 2021b.
5. IEA 2020.
6. Oxford Economics 2019.
7. World Steel Association 2020b.
8. Energy intensity represents energy consumption per ton of steel produced.
   (Likewise, greenhouse gas intensity represents GHG emissions per ton of steel produced.)
9. ArcelorMittal 2020a; Nikkei 2020.
10. World Steel Association 2021a.
11. IEA 2020. Emissions intensity represents direct and indirect CO2 emissions.
12. World Steel Association 2020b.
13. American Iron and Steel Institute 2020.
14. IEA 2020.
15. Van Hoey and Mareels 2020.
16. IEA 2020.
17. Ibid.
18. U.S. Environmental Protection Agency 2020.

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July 2021

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