

Strengthening Sustainability

Decarbonizing Manufacturing Industries



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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.

Introduction

Manufacturing is essential for economic growth, and its supply chains are pivotal for ensuring the wellbeing and advancement of people and economies. Among the largest and most critical manufacturing industries are steel, cement, glass, and chemicals. These industries are the biggest industrial consumers of energy, helping to make heavy industry responsible for 20 percent of global direct carbon dioxide emissions today.¹ Given the integral role that these industries play in the global economy and in people's lives, it will be critical for them to decarbonize their production processes if the world is to meet emissions-reduction goals and prevent intensifying climate disasters.

McKinsey & Company has identified steel, cement, and two subsectors of the chemicals industry (specifically, ammonia, used to make fertilizer, and ethylene, used in many industrial production chains), as the manufacturing sectors emitting the most CO₂. McKinsey estimates that it would cost over \$21 trillion through 2050 just to decarbonize these sectors.² Despite the costs and technical complexities involved

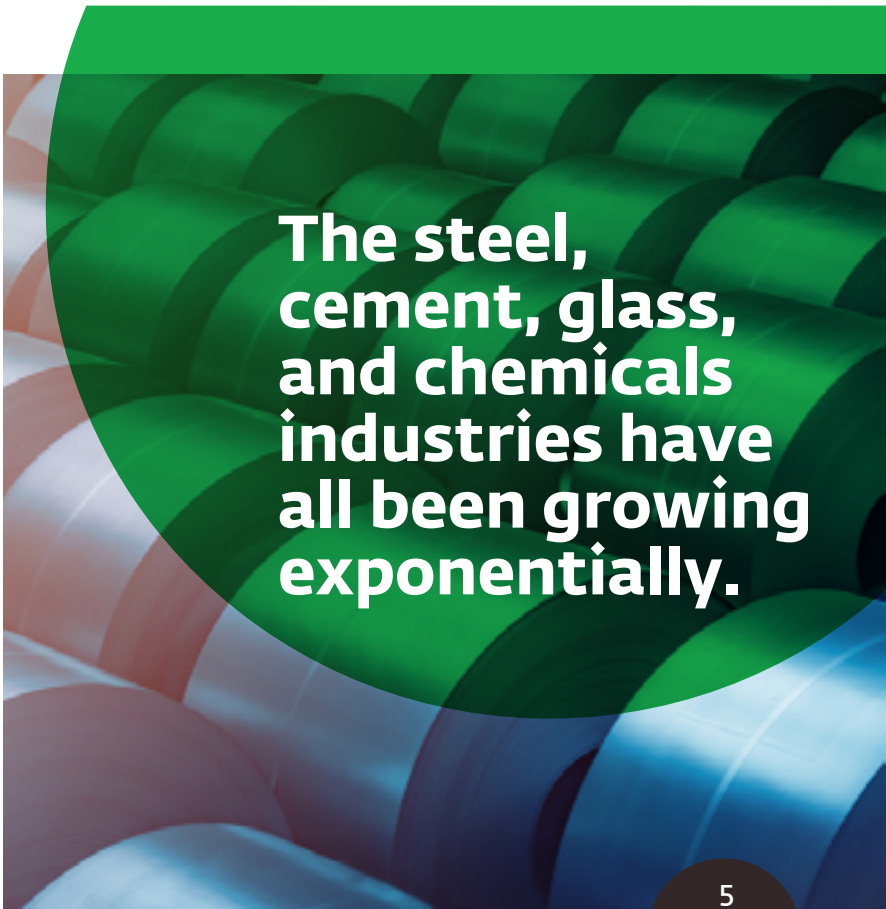
in decarbonizing these industries, the private sector together with governments and a range of other stakeholders are pursuing carbon-abatement strategies to make manufacturing more energy efficient and less harmful to the planet. These strategies involve 1) shifting manufacturers to cleaner energy sources; 2) encouraging more efficient production processes; 3) offsetting the financial costs and risks of decarbonizing; and 4) investing in technologies that can eliminate waste by capturing, recycling, remanufacturing, and reusing spent material.

Sector Background

The steel, cement, glass, and chemicals industries have all been growing exponentially to keep up with the world's increasing population and the associated demand for building and infrastructure materials. Global demand for steel—the world's most traded commodity after oil—has increased by a factor of three since 1971.³ Today, steel manufacturers use 8 percent of the world's energy, mostly coal,⁴ and emit 6 to 7 percent of the world's greenhouse gases.⁵

Cement production, meanwhile, has tripled from just 1995,⁶ and now generates about 7 percent of the world's total emissions,⁷ while global sales for chemicals have increased 2.4 times over the last two decades, with the industry accounting for about 5 to 6 percent of the world's emissions.⁸ Global consumption of glass is forecast to grow by a compounded annual rate of 3.5 percent between 2019 and 2027, driven by both traditional uses and the material's incorporation into new technologies, including renewable energy systems.⁹ While the glass industry only generates 0.3 percent of worldwide CO₂ emissions, the energy intensity of glass production surpasses that of cement. The production process also emits combustion byproducts that contribute to climate change.

Oil, gas, and coal remain the principal energy sources for manufacturers operating in a wide range of sectors, including steel, cement, glass, and chemicals. This has helped to make these industries among the most difficult to decarbonize. The production of steel, cement, and glass all require extremely high temperatures and thus large amounts of fossil fuels. To make virgin steel, the first step is to break the chemical bond between iron and oxygen in a blast furnace at a temperature of 1000°C or hotter. To produce cement, limestone must be heated in a kiln to at least 1400°C.



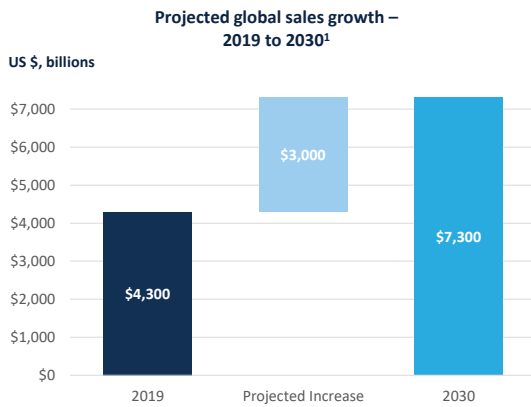
The steel, cement, glass, and chemicals industries have all been growing exponentially.

The primary way to achieve these extreme temperatures is by combusting fossil fuels—mostly coal, which emits large amounts of carbon dioxide. More CO₂ is released later in the production cycles for steel and cement through process emissions, which are the result of chemical reactions in the manufacturing operation.

Demand for Heavy Industry Products is Expected to Grow Significantly by 2030

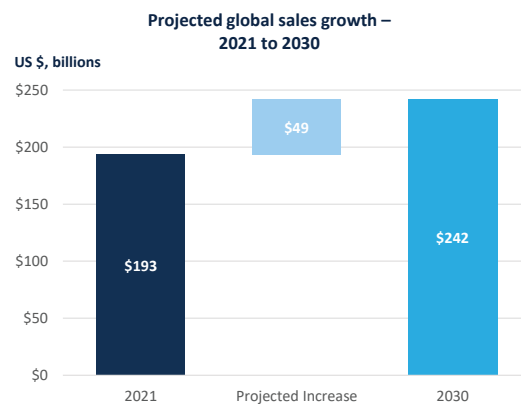
Chemicals

Projected investment over next 10 years:
\$3,000 bn



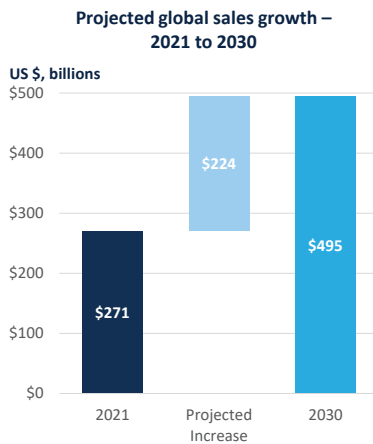
Fertilizers

Projected investment over next 10 years:
\$49 bn



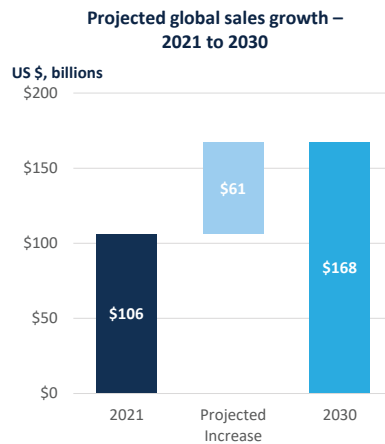
Cement

Projected investment over next 10 years:
\$224 bn



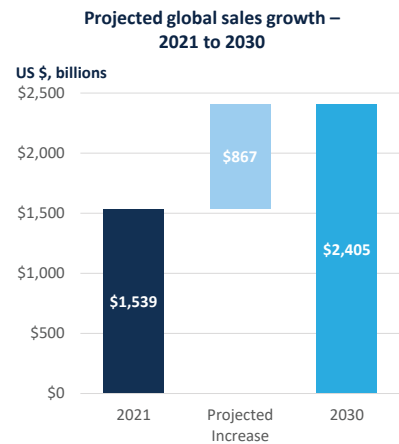
Glass

Projected investment over next 10 years:
\$61 bn



Steel

Projected investment over next 10 years:
\$867 bn



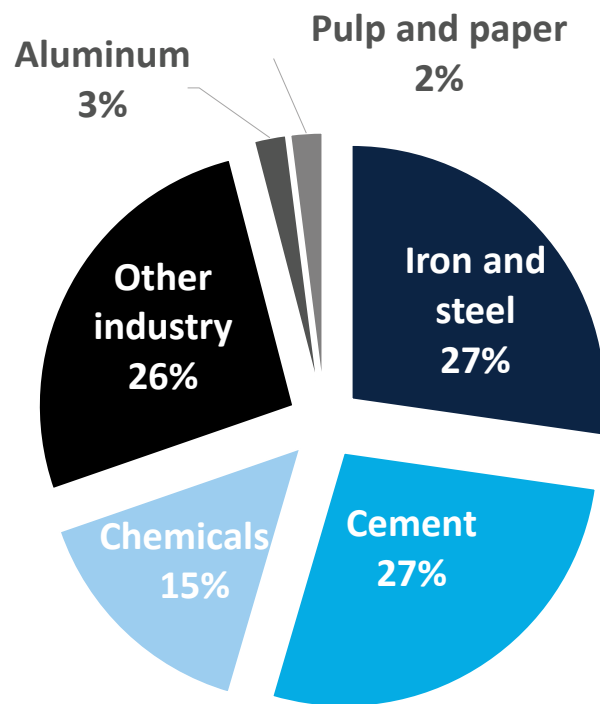
Source: CEFIC, 2021 Facts and Figures of the European Chemical Industry, 2021. Projections assume current regulatory and consumption patterns continue. <https://www.statista.com/statistics/1266004/global-fertilizer-market-size/>. Note: ¹ Values converted from Euros to US dollars (March 26, 2021 exchange rates)

Heavy industry is responsible for ~20% of global direct CO₂ emissions.

The chemicals industry uses as much fossil fuel as the steel and cement industries combined,¹⁰ but it emits less carbon dioxide.¹¹ This is because some fossil fuels are used as feedstocks, or raw materials that are processed into the end products (such as natural gas for producing ammonia), and because the manufacturing processes have fewer CO₂ emissions.¹²

Clearly, decarbonizing heavy industries will take decades of work, trillions in investments for capital and operational expenses, and global coordination. Besides adequate supplies of renewable energy, countries and companies, particularly in developing markets, will need support for capital expenditures to retool production. Many old-line factories were built to function for 50 years or more and could be emitting CO₂ for decades to come if they aren't retrofitted or replaced. Global regulation will also be key. For example, because steel is traded globally, regulating emissions unevenly could shift production to areas where costs are lower and emission standards—if they even exist—are lax or unregulated.

Distribution of CO₂ Emissions by Industry



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Source: Center for Strategic & International Studies, Climate Solutions Series – Decarbonizing Heavy Industry, 2020. Raimund Malischek, Adam Baylin-Stern, and Samantha McCulloch, Transforming Industry Through CCUS (Paris: International Energy Agency, 2019), <https://www.iea.org/reports/transforming-industry-through-ccus> <https://ourworldindata.org/ghg-emissions-by-sector>

Sustainability

Manufacturers over the last few decades have substantially improved their energy efficiency and reduced emissions per output. In the steel industry, a growing number of producers are switching to Direct Reduced Iron (DRI) and electric arc furnaces (EAF). These methods rely on natural gas and electricity and use DRI, scrap steel, or their combination, to make steel, resulting in lower emissions and energy-intensity production. In the United States, two-thirds of steel production involves recycled steel from electric arc furnaces.¹³

The cement industry uses waste as a fuel, and substitutes clinker with industrial waste, such as fly ash from power-generation plants; the glass industry has increased its use of cullet, which is made from crushed glass and requires approximately 40 percent less energy than when using raw materials. The chemical industry has secured reductions through process and energy improvements, but it faces a unique challenge, since half of its products use carbon, such as from crude oil, for feedstock.¹⁴

However, process improvements and equipment retrofits alone won't achieve the deep cuts that are required for heavy industries to meet the goals set under the Paris Agreement.¹⁵ To guide further reforms, the steel,¹⁶ cement,¹⁷ glass,¹⁸ and chemical¹⁹ industries have drawn up their own roadmaps for achieving net zero by 2050.

Many of the innovative technologies needed to achieve these goals already exist, and some are being piloted. In the steel sector, the Al Reyadah Carbon Capture, Use, and Storage Project in the United Arab Emirates is capturing CO₂ from the flue gas of an Emirates Steel production facility and injecting it to conduct enhanced oil recovery in the Abu Dhabi National Oil Company's oil fields nearby. The project includes capture, transport, and injection of up to 800,000 tons of CO₂ annually and is part of a bigger potential plan to create a CO₂ hub to manage carbon dioxide supply and injection requirements in the UAE.²⁰ The cement sector is also exploring the use of carbon capture, use, and storage, with the LEILAC 2 project testing the technology at HeidelbergCement's plant in Hanover, Germany, with a slated 2023 operational date.²¹

To roll out these cutting-edge solutions at scale, however, will require huge capital investments at attractive commercial terms as well as additional research and development for heavy industry to decarbonize coupled with a supportive ecosystem.

Challenges & Opportunities

Coal makes up 75 percent of the fuel used to produce iron and steel, and 60 percent of the fuel used to make cement. Natural gas and oil are the dominant fuels used in the manufacturing of petrochemicals. Finding substitutes for old fossil fuel-powered blast furnaces and factories is a significant challenge. Old equipment is expensive to replace, and it's difficult to find enough renewable capacity capable of generating industrial-grade heat on a 24/7 basis.

Various strategies can drive behavioral change among companies and their consumers and investors. Governments and other stakeholders including the International Finance Corporation (IFC) are working with the private sector on a range of such strategies to help manufacturers in heavy industries achieve greener production—plus financial savings and a competitive edge.

Shifting to Cleaner Energy

Capacity for wind and solar power is growing, and policies announced by the U.S.²² and EU²³ in 2022 should accelerate this trend. The International Energy Agency estimates that renewable's share must double from 30 percent in 2021 to more than 60 percent by 2030 to meet the green energy needs required for the world to achieve net zero by 2050.²⁴ Heavy industries will require four to nine times as much clean energy to decarbonize, compared to the status quo.²⁵

Using biocarbons as replacement fuel or feedstock in some heavy manufacturing provides another way to reduce emissions. This change typically could be implemented without expensive retrofits to blast furnaces; the challenge is finding enough sustainably produced biofuels. And biofuels still emit CO₂, though their net emissions are lower.

Green hydrogen offers one of the most promising long-term solutions. Hydrogen exists in abundance in nature and is used in some production processes including for feedstock. It also has the potential to power manufacturing processes and to store and transport energy. But production of carbon-neutral hydrogen requires renewable power—and enough of it— to break apart hydrogen's bonds and release energy through electrolysis.

Hydrogen is also used in other ways in the production process, including as a lower emission reduction agent in steel production. Used to make ammonia, green hydrogen could help to decarbonize the agricultural food supply chain.

Improving Efficiency

Trillions of dollars of investment will be required to phase out the thousands of existing coal-combusting steel,²⁶ cement,²⁷ and chemical plants around the world that are responsible for most industrial emissions. Investing in more efficient production offers one of the fastest ways to reduce manufacturers' carbon footprint, while also boosting their bottom line through reduced energy and raw material use.

A wide range of options for improving efficiency is available to hard-to-abate industries, and IFC can advise companies on what works best for them.

IFC supports a number of strategies aimed at decarbonizing heavy industries, with a focus on promoting energy efficiency, renewable and alternative energy, emerging technologies, and resource efficiency.

Chemicals and Fertilizers

Potential energy-related strategies include installing emission-abatement facilities and new furnace and waste-heat recovery steam generators, and adopting renewable and alternative energy systems such as solar and wind.

In terms of emerging technologies, the industry could in the near term incorporate biomaterials, biodegradable materials, or biochemical processes, and power-to-fertilizer technology; in the longer term, it could use green hydrogen and carbon, capture, utilization, and storage (CCUS).

To improve resource efficiency, the industry could substitute virgin materials with recycled materials, such as PET and other plastics, and use local waste in the production process.

Construction Materials (Cement, Steel, Glass)

Potential energy-related strategies include adopting modern kiln technology and vertical roller mills (for cement); optimizing blast furnace operations (steel); upgrading furnaces such as by installing waste-heat boilers (glass); and employing electric arc furnaces (steel and glass). The three industries could employ waste-heat recovery and power cogeneration systems, adopt solar and wind power, and incorporate biomass or biogas as alternative reductants or fuels.

Emerging technologies that could help all three industries include green hydrogen and CCUS, while the cement industry could also increase its use of blended and green cement.

To improve resource efficiency, industries could alter designs to lightweight products or change the production process (such as using the narrow neck press and blow approach to produce glass bottles), saving on raw materials and energy. They could increase the use of recycled content, including recycled concrete, cullet or waste glass, and scrap steel.



Offsetting Costs and Risks

Governments can help offset the costs and risks of decarbonization by providing tax breaks and subsidies for businesses that shrink their carbon footprint. Regulations can also help to make the enabling environment more conducive to decarbonization, such as through cap-and-trade programs. Policy makers can assist in creating a supportive ecosystem through such measures as clean energy standards and investment in infrastructure supporting recycling and reuse. Meanwhile, development organizations such as IFC can help mitigate the financial risk by extending risk-sharing lending arrangements or by anchoring investments.

In the longer term, decarbonizing operations can help manufacturers maintain their competitive edge. Companies are not only facing growing pressure to become more sustainable from consumers, investors, and corporate boards, but must also consider how best to protect their operations from a changing climate and potential future shortages in essential inputs, from water to rare earth minerals.

Investing in Technology

Technologies are capable of eliminating waste by capturing, recycling, remanufacturing, and reusing spent material. One proven method for limiting CO₂ emissions is carbon capture, utilization, and storage (CCUS), with the gas then stored or used for other purposes. Widespread adoption will depend in part on the economic viability of sequestering carbon. Currently, technologies are in the early stage, with years of development needed before they become commercially viable. Broad use of CCUS will also require the development of transportation and storage infrastructure. Another decarbonizing strategy is to simply reduce demand for certain manufactured products. Significant research and development is going into finding more sustainably manufactured products such as building materials that can replace steel, cement, and glass.

The Role of IFC

IFC's strategy is aimed at helping emerging markets accelerate development through manufacturing, and an increasingly important aspect of this strategy is to help industries find ways to reduce their carbon footprint.

Modern heavy industry plants with the latest process technologies use significantly less fossil fuels and have lower costs of production. Across emerging markets, IFC will help to drive the financing and crowding in of capital to promote restructuring of global industry toward a more efficient production.

Under its decarbonization strategy, IFC seeks to focus on four of the world's most carbon-intensive industries: steel, cement, glass, and chemicals, including those used for fertilizers. Partnering with governments and private companies in these sectors, it seeks to:

- Create greener supply chains
- Promote materials conservation and circulation to reduce waste
- Boost economic and technological complexity
- Offset financial risks associated with decarbonization
- Develop manufacturing clusters and partnerships to optimize resource, energy, and labor efficiency

Besides financing, IFC offers advisory services to clients, for example, helping them to assess their carbon footprint and create their own decarbonization roadmap with complementary cost-benefit analysis; and providing support in early-stage project development (or upstream), including piloting business models and helping to fund preinvestment studies.



IFC Green Partnerships

Below are examples of how IFC has partnered with companies in hard-to-abate industries to achieve green victories.

Rider Iron and Steel Ghana Limited

IFC provided a loan to Rider Iron and Steel Ghana Limited to help finance the construction of a greenfield steel plant in Ghana that will use mostly locally sourced scrap steel and operate with an energy-efficient induction furnace. By sourcing scrap steel locally, the project is projected to result in a gross avoidance of import-related greenhouse gas emissions of 330,000 tons of CO₂ equivalent per year, roughly comparable to the total carbon emissions from 34,000 U.S. homes' annual energy use.

Kioo Limited

IFC extended a \$10 million loan to Kioo Limited, East Africa's largest glass-packaging manufacturer based in Tanzania, to replace and upgrade its machinery, including the addition of a narrow neck press and blow machine that produces lightweight containers. By reducing the average bottle weight by one-fifth, Kioo has been able to decrease its energy consumption by 10 percent and carbon emissions by over 3,000 tons each year. The company uses 40 percent cullet, or waste glass, in its production, which also saves on energy consumption and emissions.

Indorama Eleme Petrochemicals Limited

Indorama Eleme Petrochemicals Limited, a Nigerian integrated petrochemical company, secured a \$64 million loan from IFC to install a new furnace and two new heat recovery generators to reduce its gas consumption. The improvements reduced emissions at the plant by 1.2 million tons of CO₂ equivalent.

Sococim Industries

In Senegal, IFC is supporting the country's largest cement manufacturer, Sococim Industries, as it creates a modernized facility and aims to manufacture cement with one of the lowest emissions levels in the world. As part of IFC's strategy to help Senegal decarbonize its manufacturing sector, it will provide a 120 million euro loan to Sococim, a subsidiary of French cement maker Vicat S.A. Sococim will use the funds to boost energy efficiency and maximize alternative fuels in its clinker-production plant in Dakar, reducing greenhouse gas emissions by more than 300,000 tons of CO₂ equivalent per year by 2030.

Conclusion

Decarbonizing heavy industry will require deploying new technologies and substituting fossil fuels with greener energy sources such as biomass, municipal solid waste, and solar and wind energy. IFC's clients such as Dangote Cement in Africa and Indorama Ventures, the world's largest PET resin producer, are already making the transition by developing cheaper, cleaner, and more efficient ways to power their factories and conserve natural resources. Other companies are investing in carbon capture initiatives and technologies that will allow green hydrogen to be deployed on an industrial scale.

Bringing modern, sustainable technologies to the commercial stage will require a significant financial commitment and robust regulatory support, but it can usher in a new industrial age where businesses flourish, green jobs are created, and carbonless technologies drive development.

IFC, as the largest multilateral finance organization operating in emerging markets today, is well placed to help lead this effort, working with the private sector, governments, and the vast range of players who can together meet this challenge.

REFERENCES

- American Iron and Steel Institute. n.d. "Facts about American Steel Sustainability." American Iron and Steel Institute website article. https://www.steel.org/wp-content/uploads/2021/11/AISI_FactSheet_SteelSustainability-11-3-21.pdf.
- Backlin, Asa. 2022. "HYBRIT: New Research Shows Hydrogen-Reduced Iron Has Superior Properties." Hybrit.com news article, October 12, 2022. <https://www.hybritdevelopment.se/en/hybrit-new-research-shows-hydrogen-reduced-iron-has-superior-properties>.
- Bojek, Piotr. 2022. "Renewable Electricity: More Efforts Needed." IEA report. <https://www.iea.org/reports/renewable-electricity>.
- Brudermuller, Martin. 2020. "How to Build a More Climate-Friendly Chemical Industry." World Economic Forum Annual Meeting, January 21, 2020. <https://www.weforum.org/agenda/2020/01/how-to-build-a-more-climate-friendly-chemical-industry/>.
- Carbon Sequestration Leadership Forum. n.d. "Al Reyadah Carbon Capture, Use, and Storage (CCUS) Project." <https://www.cslforum.org/cslf/Projects/AlReyadah>.
- CEFIC. n.d. "Profile: Europe Is the Second Largest Chemical Producer in the World." The European Chemical Industry Council, Brussels, Belgium. <https://cefic.org/a-pillar-of-the-european-economy/facts-and-figures-of-the-european-chemical-industry/profile/>.
- CemNet. n.d. "The Global Cement Report—Online Database of Cement Plants." <https://www.cemnet.com/global-cement-report/>.
- Chemical Industries Association. n.d. "Navigating Net Zero." <https://www.cia.org.uk/Portals/0/Documents/Policy%20Position%20Statements/Navigating%20Net%20Zero.pdf?ver=2022-07-22-093042-183>.
- Climate Trace. 2022. "Our Story." <https://climatetrace.org/our-story>.
- de Pee, Arnout, Dickon Pinner, Occo Roelofsen, Ken Somers, Eveline Speelman, and Maaike Witteveen. 2018a. "Decarbonization of Industrial Sectors: The Next Frontier." McKinsey & Company report. https://www.mckinsey.com/~/_media/mckinsey/business%20ofunctions/sustainability/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.pdf.
- _____. 2018b. "How Industry Can Move to a Low-Carbon Future." McKinsey Sustainability article, July 13, 2018. <https://www.mckinsey.com/capabilities/sustainability/our-insights/how-industry-can-move-toward-a-low-carbon-future>.
- European Commission. 2022. "REPowerEU: Commission Steps Up Green Transition Away From Russian Gas by Accelerating Renewables Permitting." Press release, November 9, 2022. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_6657.
- _____. n.d. "European Climate Law." Climate Action website. https://climate.ec.europa.eu/eu-action/european-green-deal/european-climate-law_en.
- FEVE. 2022. "Furnace for the Future: A Fundamental Milestone Towards Climate-Neutral Glass Packaging." European Container Glass Federation, March 14, 2022. <https://feve.org/glass-industry/projects/furnace-future/>.

- GlassOnline. 2020. "Furnace of the Future: A Vision for Climate Neutral Packaging." GlassOnline.com focus article, April 14, 2020. <https://www.glassonline.com/the-furnace-of-the-future-a-vision-for-climate-neutral-packaging/>.
- Global Cement and Concrete Association. 2021. "Concrete Future: The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete." Report. <https://gccassociation.org/concretefuture/wp-content/uploads/2021/10/GCCA-Concrete-Future-Roadmap-Document-AW.pdf>.
- Global Energy Monitor. n.d. "Global Steel Plant Tracker." <https://globalenergymonitor.org/projects/global-steel-plant-tracker/>.
- Gross, Samantha. 2021. "The Challenge of Decarbonizing Heavy Industry." Foreign Policy at Brookings, Brookings Institution, Washington, DC. https://www.brookings.edu/wp-content/uploads/2021/06/FP_20210623_industrial_gross_v2.pdf.
- IFC (International Finance Corporation). 2022. "IFC Manufacturing Toolkit for Scaling Up Decarbonization and Circularity Projects." PowerPoint Presentation, International Finance Corporation, Washington, DC.
- _____. n.d. "IFC Global Manufacturing: Decarbonizing Heavy Industry in Emerging Markets." PowerPoint Presentation, International Finance Corporation, Washington, DC.
- Kamau, Peter Kamicha, Marek Stec, Li Tu, and Sabine Schlorke. 2020. *Strengthening Sustainability in the Glass Industry*. Washington, DC: International Finance Corporation. https://www.ifc.org/wps/wcm/connect/5b253a67-c583-46a6-90bb-886a5a9b5838/FINAL_IFC_Glass_7-26-21.pdf?MOD=AJPERES&CVID=nldwExK.
- Ladislav, Sarah. 2020. "Climate Solutions Series: Decarbonizing Heavy Industry." CSIS Briefs, October 5, 2020, Center for Strategic & International Studies, Washington, DC.
- Leilac. n.d. "The LEILAC2 Project." Low Emissions Intensity Lime & Cement (LEILAC) Projects website. <https://www.project-leilac.eu/leilac2-project>.
- Lim, Xiao Zhi. 2021. "How the Chemicals Industry's Pollution Slipped under the Radar." *The Guardian*, November 22, 2021. <https://www.theguardian.com/environment/2021/nov/22/chemicals-industry-pollution-emissions-climate>.
- Mallagray, Juan Villar, John Anagnostou, Marek Stec, Li Tu, and Sabine Schlorke. 2020. *Strengthening Sustainability in the Cement Industry*. Washington, DC: International Finance Corporation. <https://www.ifc.org/wps/wcm/connect/242c9ecd-3c4e-4201-839f-of392a25b41b/IFC-StrengtheningSustainability-Cement-WEB.pdf?MOD=AJPERES&CVID=nQGkUn7>.
- McKinsey Sustainability. n.d. "Decarbonizing the World's Industries: A Net-Zero Guide for 9 Sectors." McKinsey & Company Our Insights Collection. <https://www.mckinsey.com/capabilities/sustainability/our-insights/decarbonizing-the-world-industries-a-net-zero-guide-for-nine-key-sectors>.
- Mission Possible Partnership. 2021. "Net-Zero Steel Sector Transition Strategy." Energy Transitions Commission Net-Zero Steel Initiative report. <https://www.energy-transitions.org/publications/the-net-zero-steel-sector-transition-strategy/#download-form>.

- Morgan Stanley. 2019. "Decarbonization: The Race to Zero Emissions." Research report. <https://www.morganstanley.com/ideas/investing-in-decarbonization>.
- Morris, Greg. 2021. "British Glass Publishes Industry-Wide Net Zero Strategy." Glass International Industry News, July 19, 2021. <https://www.glass-international.com/news/british-glass-publishes-industry-wide-net-zero-strategy>.
- Paragamian, Matthew, John Anagnostou, Li Tu, and Sabine Schlorke. 2021. *Strengthening Sustainability in the Steel Industry*. Washington, DC: International Finance Corporation. <https://openknowledge.worldbank.org/handle/10986/37145#:~:text=Hence%2C%20the%20iron%20and%20steel,of%20global%20greenhouse%20gas%20emissions>.
- Pinner, Dickon. 2018. "Decarbonizing Industry Will Take Time and Money—But Here's How to Get a Head Start." McKinsey Sustainability Our Insights article, December 14, 2018. <https://www.mckinsey.com/capabilities/sustainability/our-insights/sustainability-blog/decarbonizing-industry-will-take-time-and-money-but-heres-how-to-get-a-head-start>.
- UNEP (United Nations Environment Programme). 2022. "Emissions Gap Report 2022." UNEP report, October 27, 2022. UN Environment Programme, Nairobi, Kenya. <https://www.unep.org/resources/emissions-gap-report-2022>.
- UNFCCC (United Nations Framework Convention on Climate Change). n.d. "The Paris Agreement: What Is the Paris Agreement?" UNFCCC article. United Nations Framework Convention on Climate Change, Bonn, Germany. <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>.
- WEF (World Economic Forum). 2022. "Towards a Net-Zero Chemical Industry: A Global Policy Landscape for Low-Carbon Emitting Technologies." World Economic Forum white paper, May 2022. World Economic Forum, Davos, Switzerland. https://missionpossiblepartnership.org/wp-content/uploads/2022/05/WEF_Towards_a_Net_Zero_Chemical_Industry_2022.pdf.
- West, Darrell M., and Christian Lansang. 2018. "Global Manufacturing Scorecards: How the U.S. Compares to 18 Other Nations." Brookings Institution report executive summary. Brookings Institution, Washington, DC. <https://www.brookings.edu/research/global-manufacturing-scorecard-how-the-us-compares-to-18-other-nations/>.
- White House, U.S. 2022. "Executive Order on the Implementation of the Energy and Infrastructure Provisions of the Inflation Reduction Act of 2022." Executive order, September 12, 2022. The White House, Washington, DC. <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-the-implementation-of-the-energy-and-infrastructure-provisions-of-the-inflation-reduction-act-of-2022/>.

ENDNOTES

- 1 Ladislaw 2020.
- 2 de Pee et al. 2018a.
- 3 Gross 2021.
- 4 Ibid.
- 5 Paragamian et al. n.d.
- 6 WEF 2022.
- 7 Mallagray et al. 2020.
- 8 CEFIC n.d.
- 9 Kamau et al. 2020.
- 10 Gross 2021.
- 11 WEF 2022.
- 12 Gross 2021.
- 13 Ibid.
- 14 Brudermuller 2020.
- 15 For details about the Paris Agreement, see <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>.
- 16 Mission Possible Partnership 2021.
- 17 Global Cement and Concrete Association 2021.
- 18 Morris 2021.
- 19 Chemical Industries Association n.d.
- 20 Carbon Sequestration Leadership Forum n.d.
- 21 Leilac n.d.
- 22 For details, see <https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-the-implementation-of-the-energy-and-infrastructure-provisions-of-the-inflation-reduction-act-of-2022/>.
- 23 See, for example: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_6657.
- 24 Bojek 2022.
- 25 IFC n.d.
- 26 Global Energy Monitor n.d.
- 27 CemNet n.d.