Iron & Steel

3.3 Iron & Steel

Crude steel is commonly manufactured in two ways: via a blast oxygen furnace (BOF) or the use of an electric arc furnace (EAF). Both processes involve reducing iron ore into iron and converting iron into steel in a furnace. They differ, however, in that the BOF pathway uses coal, blast furnaces, and pig iron, while the EAF pathway uses syngas, shaft furnaces, direct reduced iron (DRI), and recycled iron scrap. The EAF process is less carbon intensive than the BOF process. Most iron and steel sector decarbonization efforts are centered around policies that support:

- The transition of BOFs to EAFs (dependent on the availability of high-quality scrap and low-carbon electricity to be an effective GHG reducing measure) in producing crude steel

- The use of more DRI, especially coupled with the production of low-carbon, electrolytic hydrogen to convert iron ore and scrap going into EAFs [335]

The U.S. steel industry produced an estimated 87 million tons of crude steel in 2021. [336] Thirty-three percent was produced by steelmaking facilities using BOF at eleven steel mills owned by three companies. The remaining 67 percent was produced by EAF at 101 mills owned by 50 companies. The United States also imported 25 million tons of steel. In 2018, steel plants employed approximately 81,000 people, while iron and steel foundries employed another 64,000. [337] Construction accounts for the most steel consumption in the United States, followed by transportation, machinery and equipment, appliances and energy, and other applications. Indiana accounted for the highest percentages of total crude steel production with 27 percent, followed by Ohio, Pennsylvania, Illinois, Texas, and Michigan. [338]

Iron and steel manufacturing is both energy and carbon intensive. The use of coal as a primary feedstock leads to high carbon dioxide emissions–approximately five percent of total industrial GHG emissions. The need for decarbonization is exacerbated by the fact that global demand for steel is projected to increase by approximately 30 percent by 2070. [339] Natural gas, coal, and coke and breeze products comprise the majority of the sector’s fuel and non-fuel use of energy ***(Figure 16)***. [340]

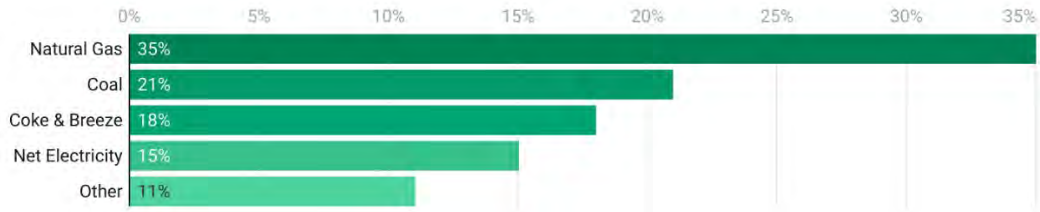


Figure 16: Iron and steel sector fuel and non-fuel uses of energy in 2018 (as a percentage of total trillion Btu). Source: U.S. EIA, MECS 2018, Table 1.2.

The iron and steel sector emits around 100 MMT CO_2e/year (including emissions from offsite generation), with process emissions and process heating accounting for the most direct emissions (***Figure 17***).[341]

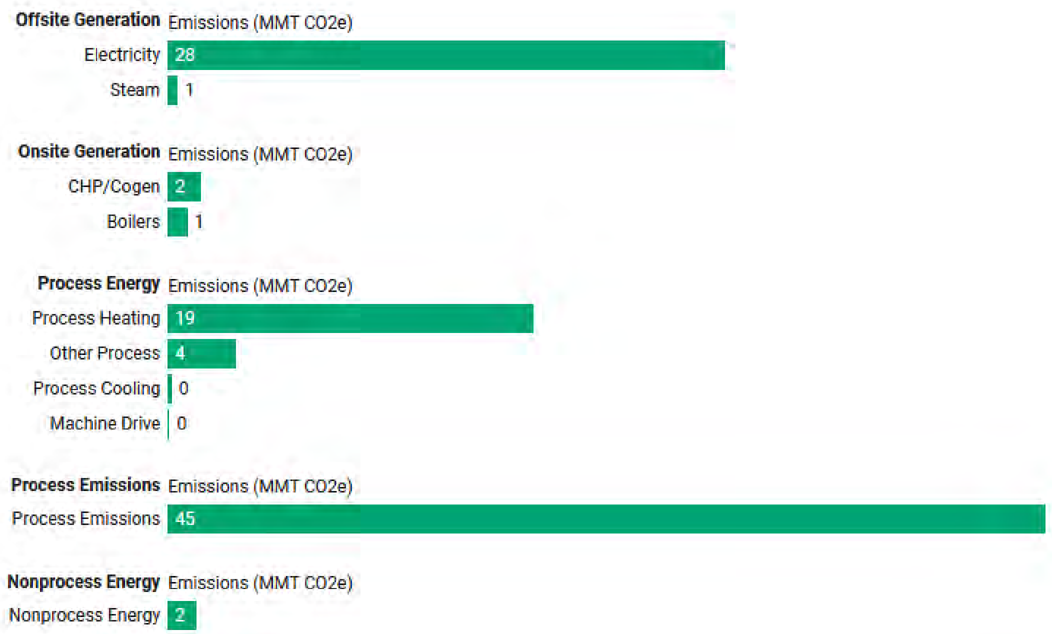
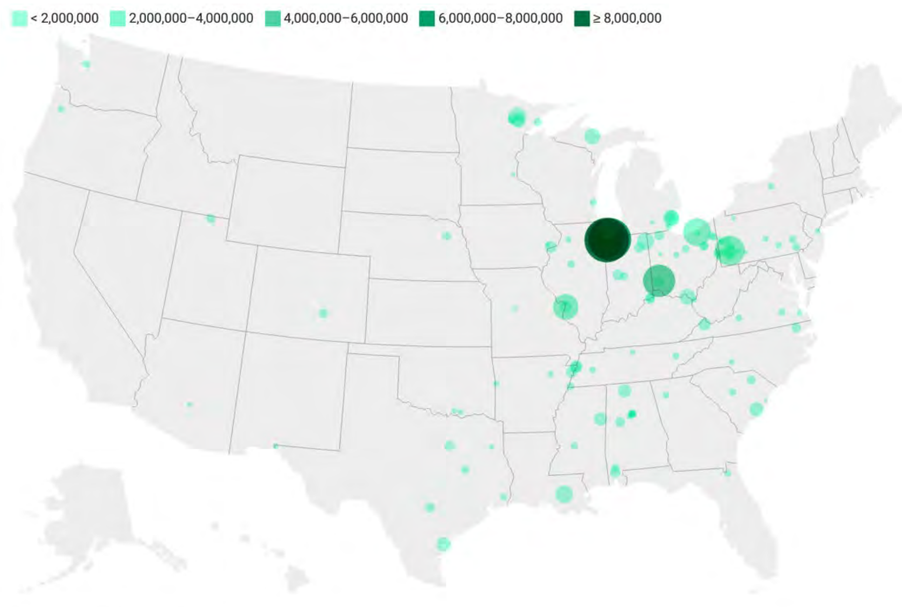


Figure 17: Iron and steel sector sources of GHG emissions in 2018, by major end use. Source: U.S. DOE, Manufacturing Energy and Carbon Footprint: Iron and Steel Sector.

Iron and steel plants are located largely in Ohio, Illinois, Pennsylvania, and Michigan, consistent with the states responsible for the most emissions from iron and steel manufacturing (***Figure 18***).[342]



State	Total GHG Emissions	Facilities
IN	26,757,113	11
OH	9,532,641	15
PA	5,660,326	20
IL	3,473,264	9
MI	2,714,139	8
MN	2,467,679	8
AL	1,918,839	9
TX	1,523,394	7
AR	1,312,598	5
LA	1,068,285	2

Source: EPA Flight 2020 • Created with Datawrapper

Figure 18: Location and total reported emissions (metric tons CO_2e) of iron and steel manufacturing plants in the United States (left). Top 10 states by total GHG emissions from iron and steel facilities (right table). Size and darkness of bubbles scale with level of emissions. Source: U.S. EPA, FLIGHT.

Several large iron and steel manufacturers have established sustainability targets or made significant efforts in improving energy efficiency aimed towards reducing emissions in their manufacturing processes. ArcelorMittal, one of the largest steel manufacturers in the world, has a target of 25 percent global carbon emissions reduction by 2030. [343] U.S. Steel, the eighth-largest steel producer in the world, has a roadmap to help achieve net-zero GHG emissions by 2050. [344]

Steel companies plan to pursue these targets by taking actions like:

- Transitioning from coal to natural gas in the blast furnace
- Process optimization and clean energy procurement
- Energy transformation fostered by green and blue hydrogen, CCUS, and electrification
- Increased use of scrap
- Sourcing lower-carbon electricity
- Offsetting residual emissions not addressed by other strategies

Decarbonization of iron and steel manufacturing will require policies and programs at the state and federal level, and alignment between such policies. The summary in ***Table 10*** highlights the connections between challenges and state policy opportunities.

Table 10: Decarbonization barriers and policy opportunities for the iron and steel industry.

Challenge / Barrier	State Opportunities	Policy Connections
Lack of new energy efficiency options in highly integrated iron and steel manufacturing makes high-temperature processes difficult to decarbonize	• Information and systems efficiency approaches may yield additional gains • States can support the proliferation and use of these approaches / technologies	• Support studies on applications of process control, machine learning, and automation • Incentivize the further development and application of these technologies • Incentivize the uptake and integration of such technologies
Lack of resource management, waste heat management means untapped savings potential	• Strategic energy management (SEM) can help save energy, emissions • Significant opportunity for waste heat recovery	• Statewide support for SEM managers and programs can yield substantial energy and GHG reductions, in particular for small- and medium-sized companies • Increased support for energy audits and capital to pursue projects is needed
R&D is needed to improve the economics and integration aspects of multiple low-carbon technology options	• Electrification of reheating furnaces, CCUS in post combustion, electrolysis of iron ore, hydrogen in smelting to improve viability at scale	• State funds coupled with federal funds in R&D can help bridge the gap between innovative options and commercial viability in industrial facilities
Circularity and recyclability of steel scrap needs continual improvement	• Using steel scrap in the steel production process reduces carbon dioxide emissions by 58 percent and air pollution by 86 percent[345]	• Procurement of recycled steel for state infrastructure projects • Incentives for steel mills that do onsite recycling or use recycled steel pellets

Roadmaps for the Iron and Steel Industry

- European Steel Industry Decarbonization Roadmap (2019)
- International Energy Agency, Iron and Steel Decarbonization Roadmap (2020)
- Japan Roadmap for Iron and Steel (2021)
- UK Roadmap for Iron and Steel (2015)
- UK Roadmap for Iron and Steel (Appendices) (2015)

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