Great Lakes Near-Zero-Emissions Steel

Memo Focus: Minnesota

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November 2023

Minnesota overview

Minnesota has been home to the country's largest iron ore mines since the 1800s. The Minnesota mines owned by US Steel and Cleveland Cliffs supply 87% of the iron ore, feeding more than 85% of the primary steel production in the United States.[1] In conjunction with mining activities, Cleveland-Cliffs and US Steel own and operate pellet-making operations that convert ore into blast furnace and direct reduced iron pellets. Currently, Minnesota does not have steelmaking operations. Most of the state's climate-related policy directives are laid out in Governor Walz's Climate Action Framework, although there is a lack of industrial sector consideration. There will be an opportunity to advance industry decarbonization strategies with the funding Minnesota and the City of Minneapolis recently received from Climate Pollution Reduction Grant Program.

Figure 1: Minnesota steel and related assets

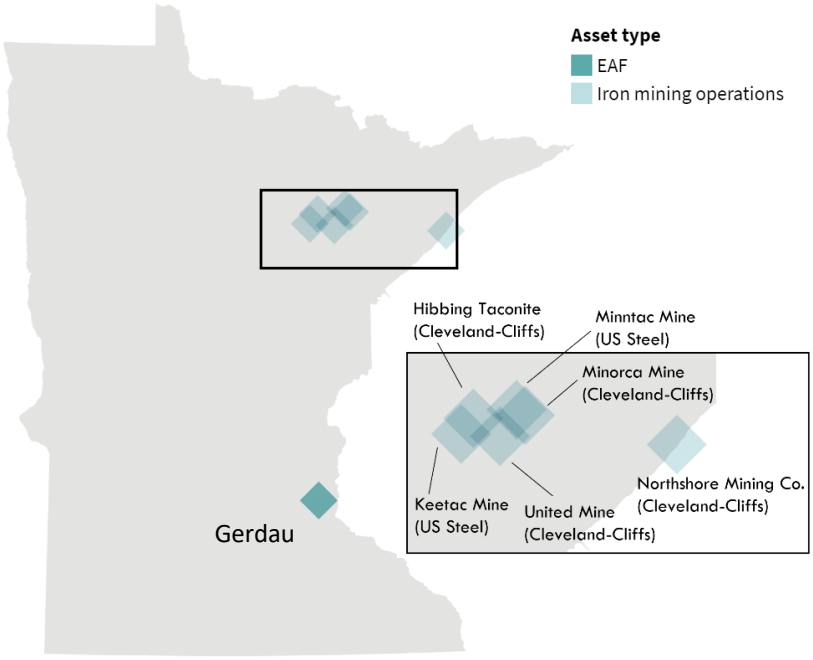


Table 1: Steel supply chain production capacity

Product	Type	State production capacity (million tons)	Great Lakes production capacity (million tons)
Raw material	Iron ore pellets*	35	41
Raw material	Coke	0	11.6
Intermediate material	Direct reduced iron (DRI)	0	1.9
Steel (recycled)	Electric arc furnace (EAF)	0.6**	28
Steel	Blast furnace-basic oxygen furnace (BF-BOF)	0	36

** State and Great Lakes production capacity reflect production volumes for 2022.*
*** 0.6 million tons reflects the historical capacity of the idled Gerdau EAF facility.*

[1] The remaining 13% of the iron ore production for steelmaking comes from Tilden Mine in Michigan.

Current issues and impact

Gerdau owns an electric arc furnace in St. Paul but permanently laid off 222 workers in 2020. The facility once produced 560 TTPA of steel rounds mainly for building and infrastructure, steel packaging, and transport. Prior to its idling, the site was fined for air quality violations and suffered an onsite fire in 2019. Water discharge permits at US Steel's Minntac Mine expired in 1992, but local litigators have worked diligently in recent years to get them reinstated. US Steel was able to operate the facility over the past several decades with the help of administrative continuances granted by the Minnesota Pollution Control Agency.

Figure 1 displays steel industry market indicators in Minnesota. Relative to other Great Lakes states, Minnesota has a smaller share of automotive manufacturing employment, which decreased by roughly 5% from 2010 to 2022. Automotive manufacturing represents 25% of the steel demand in the United States, which is the second largest end-use market after construction (approximately 46%). Minnesota had the fastest growing population (8% from 2010 to 2022) among Great Lakes states, indicating the potential for steel demand in the construction sector to increase as additional homes and businesses take shape. Durable goods manufacturing in Minnesota was responsible for $31 billion of state GDP, this is the lowest total among all Great Lakes states.

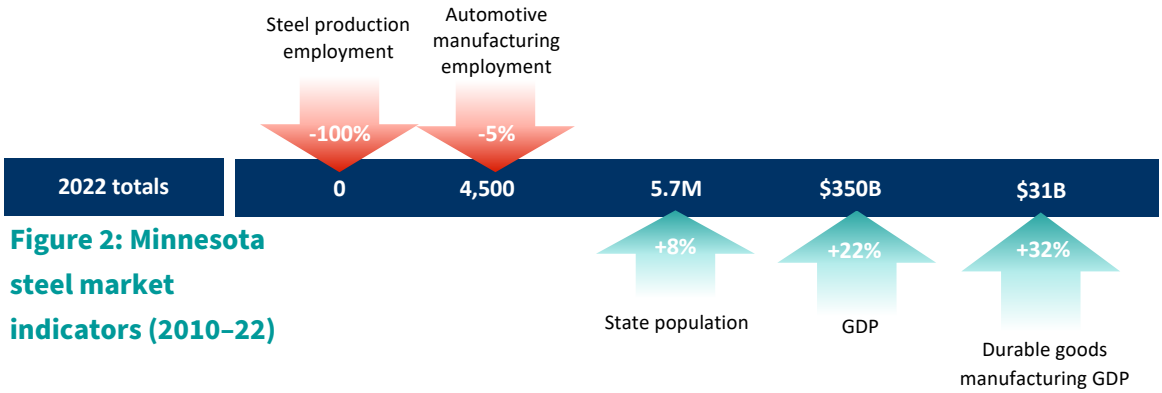


Figure 2: Minnesota steel market indicators (2010–22)

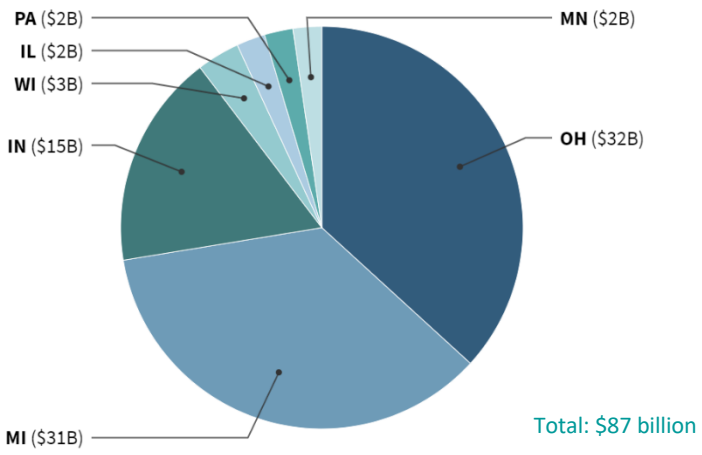
Note: GDP metrics are measured in 2012 chained dollars

Data source: Bureau of Economic Analysis, United States Census Bureau. United States Regional Economic Analysis Project

Steel development opportunities in Minnesota

Since the passing of the Inflation Reduction Act (IRA) and other recent federal policies incentivizing domestic clean manufacturing, Minnesota has recorded roughly $2 billion of private investment in clean manufacturing, the vast majority of which ($1.7 billion) has been in the clean energy sector. As Figure 2 indicates, $2 billion is among the lowest private investment totals across the Great Lakes states. The investment of $36 billion in EV and battery manufacturing in the region has eluded Minnesota in favor of other states such as Michigan, Indiana, and Ohio. Although not directly cited in Minnesota these new facilities in Ohio, Indiana and Michigan will help bolster regional steel demand and facilitate regional economic growth in tangential upstream and downstream sectors. On the supply side, there may not be a place more enticing than Minnesota to produce

Figure 3: Post-IRA clean manufacturing investments in the Great Lakes

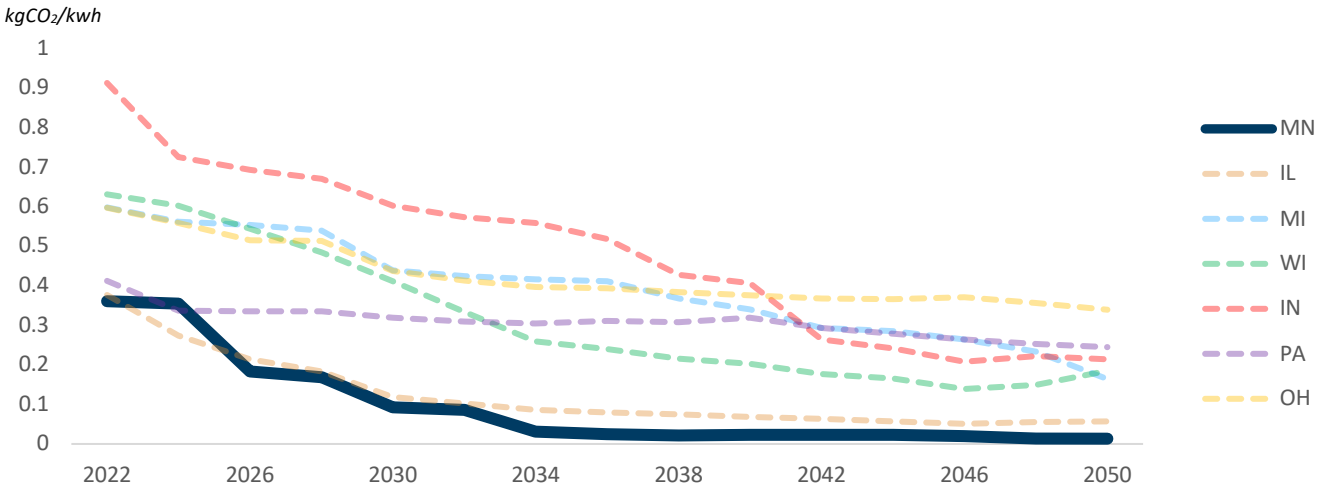


Data source: Climate Power, US White House.
Note: data sources leverage information form public announcements, investment totals may not be comprehensive

near-zero-emissions steel products. For starters, no state in the country offers the kind of proximity to raw iron materials as Minnesota. In recent years, both Cleveland-Cliffs and US Steel invested $100 million or more to upgrade existing pellet-making operations to produce direct reduction grade (DR) pellets. Active domestic supply of DR pellets is significant for US producers, which would otherwise have to import these critical raw materials.

The success of all near-zero-emissions steel production technologies will rely to some extent on access to cost-competitive renewable energy sources. Figure 3 highlights Minnesota's projected emissions intensity of power generating assets between now and 2050. Minnesota currently has one of the cleanest grids in the region and expects rapid decarbonization between now and 2034. In addition to renewable energy, steel producers need to leverage either hydrogen or carbon capture and sequestration (CCS) technologies to reach near-zero-emissions steel production. Minnesota is one of the only two Great Lakes states to receive a large private investment in electrolyzer manufacturing following the IRA.[2] Cummins invested $10 million to retrofit its existing facility near Fridley for electrolyzer production, making Minnesota a leader in hydrogen production technology. Two potential near-zero-emissions production pathways for Minnesota are listed in Table 2.

Figure 4: Emissions intensity projections for generating assets in Great Lakes states



Data source: NREL Cambium Tool – Low cost RE scenario.

[2] Nel invested $400 million in an electrolyzer manufacturing facility in Michigan.

Table 2: Potential near-zero-emissions steel production pathways in Minnesota

Production pathway (2 mt/year)	Investment capital ($billion)		Emissions reduction potential		Projected Timeline (years)
	H_2	*CCS*	*H_2*	*CCS*	
DRI construction at idled Gerdau St. Paul EAF*	0.8	1.2	68–86%	57–79%	2
DRI-EAF (inc of new casting & rolling)	1.8	2.3	68-86%	57–79%	3+

Note: Emissions reduction potential relative to unabated BF-BOF steel production. Emissions reduction potential based on scope 1, 2, and 3 emissions for hot rolled coil production. Range is a product of varying scope 2 emissions from US grid average (0.37 tCO2/MWh) to dedicated renewable energy, varying pellet-making fuel from natural gas to pyrolysis oil and varying natural gas methane leakage rate from 1.2% to 2.5%. Assumed capture rate for all CCS technology is 90%, conservative figure yet to be proven at scale. Capital for hydrogen production pathways do not include upstream renewable energy or hydrogen assets.. Classification as near-zero-emissions production is dependent on actual system configuration and realized emissions abatement.

**This pathway includes investment in a DRI and a $100 million investment to increase EAF production capacity to 1.8mt per year.*

DRI construction at the Gerdau St. Paul EAF facility is an attractive possibility for investors and developers. Leveraging the existing EAF production capacity on-site will help reduce investment costs. Near-zero-emissions DRI pathways can operate on natural gas with CCS or hydrogen, each carrying risks and benefits. A hydrogen-based DRI-EAF configuration requires lesser capital investment than CCS options and offers more certain emissions reduction potential. A natural gas DRI with CCS would need to achieve high capture rates (90% or greater) and certified low upstream methane leakage to meet many of the new industry standards for near-zero-emissions steel. Furthermore, according to multiple Minnesota Geological Survey studies, options for traditional subsurface geologic storage of CO_2 are extremely limited, with the only potential option being mineral carbonation in rock formations near Duluth. This implies any steel facility pursuing carbon capture would likely need to find a market partner for the captured CO_2 or be forced to transport out of state.

For greenfield projects, the greater Minneapolis or Duluth appears to be the most logical given the available workforce and material transport infrastructure. Colocation with iron ore mines can help save barge transport costs of shipping raw material to other states. Although a greenfield location helps design and incorporate infrastructure for CCS and hydrogen systems from scratch, the additional costs and time for permitting and siting may be less attractive for developers.

Developing hydrogen and CCS infrastructure

In October 2023, the Heartland Hydrogen Hub (HH2H) was announced as one of the seven awardees of the Regional Clean Hydrogen Hubs Program. The hub has an opportunity to receive up to $925 million for development activities. It covers three states: Minnesota, North Dakota, and South Dakota. The hydrogen production methods proposed include natural gas with carbon capture and electrolysis leveraging nuclear energy. The primary off takers will be in the agriculture/fertilizer, power, and ammonia sectors. However, steel producers will have an opportunity to leverage hub infrastructure for hydrogen supply, storage and transmission following the initial phase of development.

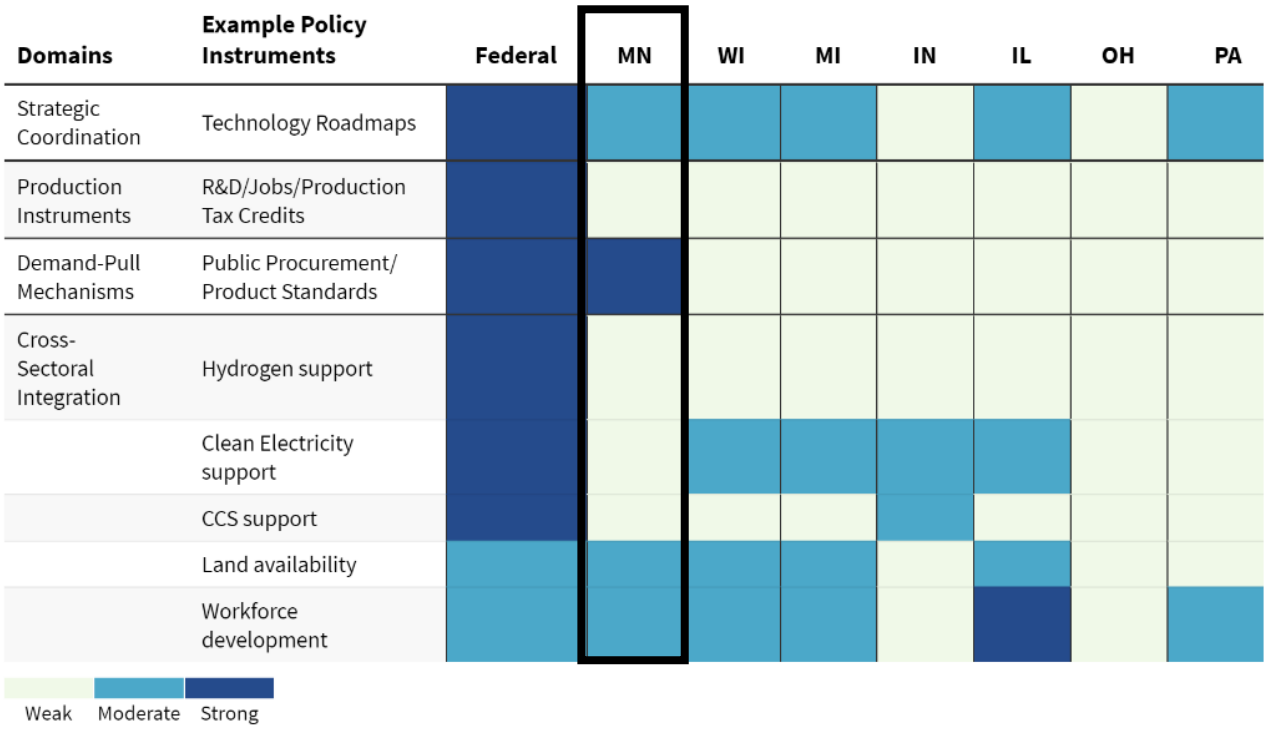
Summit Carbon Solutions is currently developing an interstate CCS network set to capture CO_2 from ethanol facilities and store it in geologic formations in North Dakota. The network has multiple planned nodes in Minnesota but remains dedicated to ethanol facilities. The potential for a new steel facility to leverage the developing infrastructure seems feasible given the projected annual sequestration volume (12 million tons) and the storage capacity (250 billion tons).

Supporting policy

Policy and investor support will be critical for each pathway. Minnesota's 2023 Energy and Climate Omnibus bill includes the Buy Clean/Buy Fair Act that applies to steel rebar and structural steel for construction projects. However, like many of the Great Lakes states, Minnesota lacks specific and targeted policy support for hydrogen and CCS industries. Although Minnesota has set a 100% carbon-free electricity goal for 2040, local balancing authority MISO is struggling to manage interconnection timelines for new renewable energy resources. Grid decarbonization is essential for facilitating clean hydrogen production for those not pursuing behind-the-meter options and for supplying low-emissions energy to EAFs that are restarted or added. Minnesota ordered state agencies to evaluate their regulatory preparedness for hydrogen, which is a good first step and should be supplemented by more support.

Thus far, major investments in near-zero-emissions steel production in Europe and Canada have received public funding support from national and local governments. The US federal government has provided multiple subsidy and tax incentive programs targeted at near-zero-emissions steel production, but further incentives and infrastructural support from states can expedite asset development. Looking ahead, Minnesota has a unique opportunity to capitalize on its rapidly decarbonizing grid and iron ore resources to construct the first near-zero-emissions steel production facility in the United States. A DRI-EAF steel production facility leveraging renewably produced hydrogen and an accompanying renewably powered EAF could manufacture near-zero-emissions products that could easily be shipped to the multitude of new clean manufacturing facilities receiving investment the region.

Figure 5: Great Lakes near-zero-emissions steel policy gap



In the immediate future, Minnesota policymakers, economic development offices, and industrial developers can consider the following to attract steel producers to site clean production assets in Minnesota.

1. **Redeveloping the existing EAF infrastructure at the St. Paul plant for hydrogen-based DRI-EAF steel production.**
2. **Increase production of hydrogen in the HH2H by including new priority sectors such as steel, through long term offtake agreements or additional government de-risking mechanisms.**
3. **Continue to advance policies that facilitate industrial access to cost-competitive renewable energy resources.**