Great Lakes Near-Zero-Emissions Steel

Memo Focus: Michigan

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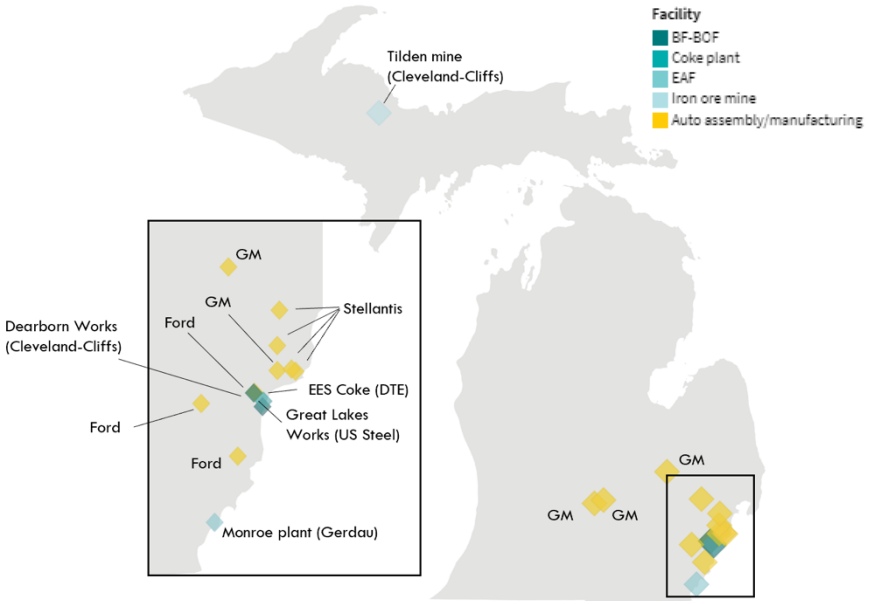
Michigan overview

Figure 1: Michigan steel and related assets



Michigan ranks fifth among the Great Lakes states in terms of crude steel production, with one ore-based production site currently operational and due for reline in 2027: Cleveland-Cliffs' Dearborn Works.[1] Cleveland-Cliffs' Tilden iron ore mine, located in the upper peninsula, supplies pellets to BF-BOFs in the Great Lakes region. The state focuses on reducing emissions from heavy industry and manufacturing by leveraging the Michigan Healthy Climate Plan and Michigan Hydrogen and Fuel Cell Electric Vehicle Deployment Plan, which are supported by a few legislative regulations for transmitting and storing hydrogen and CO_2.[2] Moving forward, these policies will also be supported by the EPA's Climate Pollution Reduction Grant Program, which awarded the state of Michigan and its two largest metropolitan statistical areas with funding for climate action plan development.

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**	6	41
Raw material	Coke	1	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)	3*	36

**Does not include idled Great Lakes Works production capacity.*

*** State and Great Lakes production capacity reflect production volumes for 2022.*

[1] The projected reline date for the Dearborn plant is based on historical investment trends and an expected 20year investment cycle.

[2] Michigan state legislation regulating hydrogen and CO_2 transmission and storage includes HB 5254, HB 5255, and HB 5274.

Current issues and impact

In October 2023, the EPA mandated Cleveland-Cliffs to invest over $100 million to update emissions control systems for particulate matter at the Dearborn facility. The EES coke battery supplies coke to the Dearborn site and is currently in litigation with the Justice Department and EPA over SO_2 permit exceedances. In 2020, Cleveland-Cliffs laid off approximately 200 workers at the Dearborn site when several finishing operations were shifted to Indiana mills. Additionally, US Steel idled its Great Lakes Works in 2020 due to strategic company focus to invest in other assets, leading to a significant decrease in steel production employment (approximately 1,500 employees).[3] With no new production facilities sited in Michigan since 1980 and closure of the Great Lakes Works in 2020, the Michigan steel industry appears to be in decline. Figure 2 indicates the loss of steel manufacturing employment over the last decade, much of which is attributable to the idling of the Great Lakes Works. While steel manufacturing employment has decreased, the other four downstream steel market indicators included in Figure 1 present Michigan as a promising location for future investment. The GDP growth rate associated with durable goods manufacturing (50%) is by far the highest in the region.

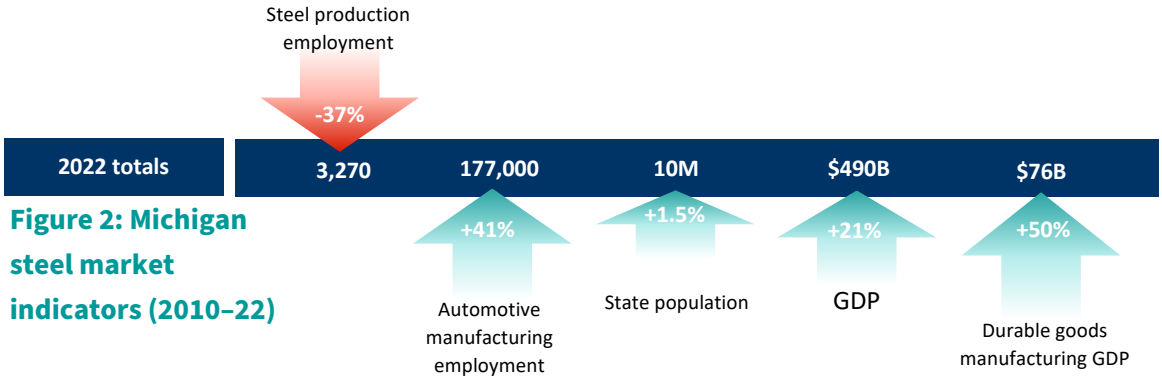


Figure 2: Michigan steel market indicators (2010–22)

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 Michigan

Michigan has long been a leader in automotive manufacturing, and the wave of recent private investments in EV and battery manufacturing in the state since the passage of the Inflation Reduction Act ($19.5 billion) suggest that this trend will continue well into the future. The automotive market represents roughly 25% of US steel demand, with a high percentage of automotive demand specifically for ore-based steel.[4] Automotive companies are leaders in terms of emissions reduction targets and specific commitments for purchasing low-emissions steel. Michigan is highly suitable for ore-based near-zero-emissions steel production given the magnitude of local downstream purchasers in the automotive sector. In May 2023, Michigan secured a $400 million investment from Nel for an electrolyzer manufacturing facility. This site will be one of the largest in the

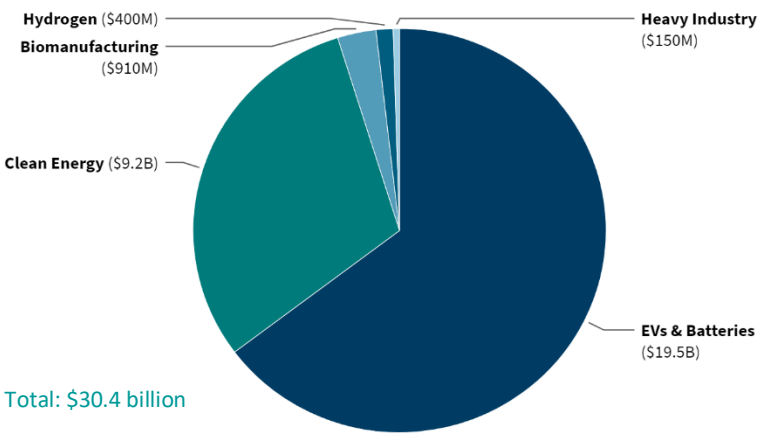
[3] Worker Adjustment and Retraining Act notices were issued to 1,500 individuals.

[4] Ore-based steel, or primary steel, is produced using relatively high percentages of either pig iron or direct reduced iron. Secondary steel is predominantly made from recycled scrap material.

world, producing up to 4GW of PEM and Alkaline electrolyzers. Electrolyzers are required to produce renewable hydrogen, and this investment has positioned Michigan as the leader in this space.

Near-zero-emissions steel production in Michigan can be materialized via a handful of potential pathways, they are listed in Table 2. Of these, constructing a direct reduced iron (DRI) facility on the Great Lakes Works footprint may be the most attractive option for investors and developers. With all iron and steelmaking activities suspended, the mill undertakes finishing activities and employs approximately 500 individuals. Selecting this location for DRI-EAF investment may reduce costs associated with permitting, siting, and local infrastructure. Such a redevelopment project would also be eligible for funding from the DOE's Loan Program Office through the Title 17 Clean Energy Financing Program. Carbon capture and storage (CCS) implementation at the Dearborn site is feasible but requires navigating several barriers and will not meet the currently developing emissions intensity thresholds for near-zero-emissions steel production. CCS implementation at Dearborn would require individual capture systems to be applied to multiple flue gas streams, including those at the nearby EES coke battery, to reach the maximum abatement potential. Aggregating these streams on-site poses a potentially expensive infrastructural challenge.

Figure 3: Post-IRA clean manufacturing investments in Michigan



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

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

Production pathway (2 mt/year)	Investment capital ($billion)		Emissions reduction potential		Projected Timeline (years)
	H_2	CCS	H_2	CCS	
DRI-EAF construction at Great Lakes Works	1.9	2.1	68–86%	57–79%	3
CCS development at Dearborn Works	N/A	1.3	N/A	46–59%*	2
BF-BOF → DRI-EAF asset conversion at Dearborn Works	1.9	2.1	68–86%	57–79%	3+
DRI-EAF development at new site	2.1	2.4	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.

** BF-BOF with CCS range reflects the option of applying capture technology to the adjacent EES coke battery.*

Converting either the Dearborn or Great Lake Works sites to a hydrogen-ready DRI-EAF configuration requires lesser capital investment and offers more certain emissions reduction potential than CCS options. Incorporating hydrogen production on-site will help employment levels remain consistent with the standard threshold for BF-BOF facilities. As for greenfield projects, the greater Detroit area provides available workforce, material transport infrastructure, and proximity to auto manufacturing facilities. Although a greenfield project can 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.

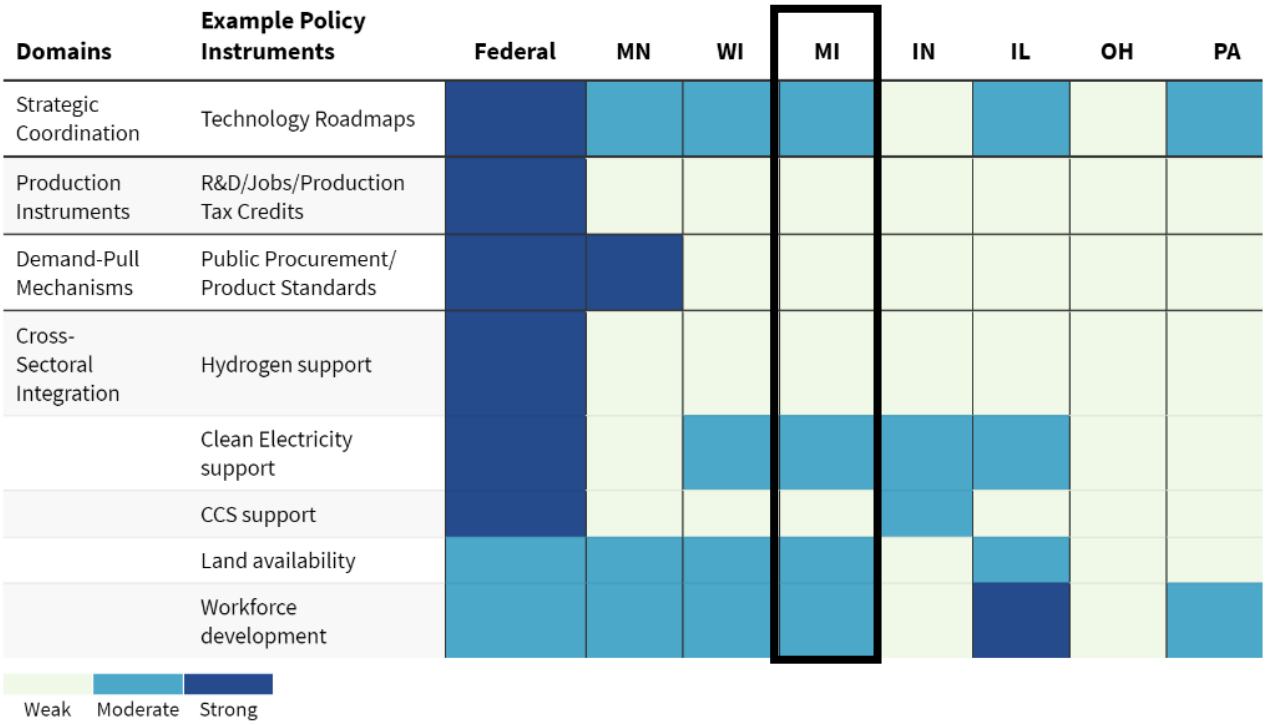
Developing hydrogen and CCS infrastructure

In October 2023, the Midwest Alliance for Clean Hydrogen (MachH2) was announced as one of the seven awardees of the Regional Clean Hydrogen Hubs Program. The hub has the opportunity to receive up to $1 billion in cost share funding for development activities. It covers three states (Michigan, Indiana, and Illinois) and includes two major steel companies as lead members of the coalition (ArcelorMittal and Cleveland-Cliffs). Two Michigan-based hydrogen production facilities in Flint and Ypsilanti are included in the hub proposal. These are slated for small production volumes and specifically target transportation initiatives. The new Ypsilanti production facility will rely on hydrogen production from natural gas, while the project in Flint will be an expansion of the electrolytic production facility supporting the local bus transit system. Carbon capture feasibility relies on finding a long-term storage option for CO_2. Underneath Michigan lies the Michigan Basin, a sub-surface region deemed viable by the United States Geological Survey for long-term CO_2 storage. To date, there has only been one commercial CCS project in the state.

Supporting policy

Like the other Great Lakes states, Michigan has yet to produce specific and targeted goals for CCS and hydrogen industries beyond exploring their potential. Moreover, regional transmission authorities PJM and MISO struggle to manage interconnection timelines for new renewable energy generation resources. Grid decarbonization is essential to facilitate clean hydrogen production for those not pursuing behind-the-meter options and to supply low-emissions energy to the Monroe plant and other EAFs that may be added. In November of 2023, Michigan passed a collection of new legislative initiatives building on the framework laid out in the MI Healthy Climate Plan. They include a new clean energy standard, more ambitious than most in the country, and worker protections for those in the clean energy sector. So 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 cost share, tax incentive, and loan-based programs targeted at near-zero-emissions steel production, but further incentives and infrastructural support from states is needed to expedite asset development. States should look to fill the policy gaps highlighted in Figure 4. For example, permitting and regulatory frameworks for CCS and hydrogen infrastructure will be essential for expediting projects and ensuring the health and safety of workers and community members.

Figure 4: Great Lakes near-zero-emissions steel policy gap analysis



In the immediate future, the Dearborn site will require a reline investment (expected in 2027). Relining and installing a comprehensive CCS system will lock the Dearborn asset into coal-based production for decades to come. Alternative clean technologies provide an opportunity to maintain and expand steel production and its related supply chain in Michigan, creating robust economic development pathways. Policymakers, economic development offices, and developers should focus on the following to bring near-zero-emissions steel production to Michigan:

1. **Leverage existing BF-BOF infrastructure for DRI-EAF development.**
2. **Include steel production as the prioritized offtake sector for hydrogen development projects.**
3. **Avoid large capital investments that extend the life of the Dearborn BF-BOF facility (reline, CCS, expanded capacity, etc.).**
4. **Advance policies facilitating industrial access to cost-competitive renewable energy resources.**