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Working Paper

The Political Economy of Steel Decarbonization

Prospects and
Challenges of a Green
Steel Transition in
Dearborn, Michigan

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About the Roosevelt Institute

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Table of Contents

| | |
|--|----|
| Executive Summary | 5 |
| Introduction | 6 |
| I. The Green Steel Transition | 8 |
| Economic Benefits of Steel | 8 |
| Environmental and Health Costs | 10 |
| Greening Steel Production | 11 |
| II. Prospects and Challenges of the Green Steel Transition in Dearborn, MI | 15 |
| Dearborn and the Steel Industry | 15 |
| Community Fears of Economic Insecurity Arising from Techno-Economic Shifts | 20 |
| Green Hydrogen: The Supply Chain Bottleneck for Green Steel | 23 |
| Community Fears of Pollution Associated with New Technologies | 25 |
| Breaking Corporate Path-Dependency | 28 |
| III. Conclusions and Policy Recommendations | 34 |
| Appendix I. Partial List of Industrial Facilities in Dearborn, MI | 37 |
| Appendix II. Ownership Structure of Cleveland-Cliffs | 39 |
| References | 41 |

Tables

[Table 1.](#) Available Industrial Policy Tools for a Green Steel Transition

[Table 2.](#) Partial List of Industrial Facilities in Dearborn, MI

[Box 1.](#) Testimony from Hebah Kassem

[Map 1.](#) Dearborn Works and Other Industrial Facilities in Dearborn



Executive Summary

“Steel decarbonization”—the transformation of the steel industry to reduce its carbon footprint—is an emerging US industrial policy priority. Several factors suggest momentum for a rapid transition to greener steel production: Viable technological pathways are available, demand for greener steel is increasing, and there appears to be broad support from social actors, including the labor movement; federal, state, and local governments; climate groups; and environmental justice communities impacted by steel pollution. However, despite these favorable conditions, the green steel transition in the US has stalled in comparison to European competitors, imperiling the long-term survival of the US steel sector. This paper delves into the economic and political forces influencing the shift toward more sustainable steel production, focusing on one case: the Dearborn Works facility in Dearborn, MI, owned by steel giant Cleveland-Cliffs.

Our analysis identifies four primary challenges impeding progress toward greener steel production: (i) community fears of increased economic insecurity arising from techno-economic shifts; (ii) the supply bottleneck created by a lack of renewable energy infrastructure to produce green hydrogen; (iii) community fears about the health and climate impacts of new technologies; and (iv) corporate inertia and focus on short-term shareholder value over long-term public value and competitiveness. We conclude with a set of policy recommendations that can help surmount those challenges to accelerate a transition to cleaner steel production.



Introduction

"Steel decarbonization"—the transformation of the steel industry to reduce its carbon footprint—is an emerging priority in US industrial policy. From the historic decarbonization funds authorized by the Inflation Reduction Act (IRA), to the Biden administration's [Buy Clean procurement initiative targeting](#) heavy industry products, to a host of administrative and congressional green trade proposals (Table 1), support for industrial decarbonization—and steel decarbonization in particular—continues to build. And there is good reason for this growing sense of urgency: The global steel industry emits 3.5 billion tons of [CO₂-e](#) each year—more than any country in the world, except China and the United States ([Dell 2022](#)). The US steel sector alone is responsible for 86 million metric tons of CO₂ per year ([Cresko et al. 2022](#)).

Despite all this momentum, the transition to greener steel production in the US has stalled in comparison to European competitors. While industry leaders in Sweden and Finland are pioneering first-in-kind steel facilities with the potential to all but eliminate greenhouse gas emissions, US steelmakers have at best planned minimal investments in marginal emissions reductions, in some cases locking in some of the most polluting production methods available.

This paper examines the reasons for these setbacks by delving into the economic, technological, and political forces at play.

Part I provides a backdrop for our analysis by unpacking the problem of steel decarbonization—and the "greening" of the steel industry more broadly. We analyze the useful material and economic functions of steel, examine available technological and policy pathways for decarbonization, and explain how a fuller understanding of the societal benefits and costs of steel production could inform more holistic policies for industrial transformation. In Part II, we zone in on the complexities of steel industrial transformation, with a focus on Dearborn, MI—a community once emblematic of US industrial prosperity, home to Ford Rouge Complex and the Dearborn Works steel plant—the latter of which is



owned by steel giant Cleveland-Cliffs. Our analysis¹ identifies four critical challenges impeding progress toward greener steel production:

1. **Community fears of increased economic insecurity that could arise from further techno-economic shifts.** Today, steel production in Dearborn supports 1,290 high-quality jobs at the community's last remaining plant, Dearborn Works—represented by the United Auto Workers (UAW). But just three years ago, it supported almost twice as many. For a community pummeled by the decline of the auto and steel industries, the uncertainty inherent in the prospect of deep industrial transformation can raise fears about economic insecurity—even for those who bear the costs of the current model. At the same time, growing evidence on the economic opportunities of green steel, and emerging leadership from the labor movement in the green transition, point to a potential shift in the identity of organized labor from "managers of industrial decline" to "leaders of the green transformation."
2. **The supply bottleneck created by a lack of renewable energy infrastructure to produce the green hydrogen required for an immediate transition to the cleanest available methods of steel production.** No available steel production method is perfect, and even the most advanced low-carbon production methods have not been closely examined from the perspective of broader pollution and health impacts. However, with the commercial introduction of green hydrogen—based steel production, it has become possible to produce steel with almost no greenhouse gas emissions. The viability of this energy-hungry technology depends on the availability of abundant renewable energy, which is currently in short supply, encouraging hydrogen production that uses fossil fuel—dependent methods like "blue" hydrogen, which relies on natural gas combined with carbon capture and storage. This points to a need for swift government action to ensure renewables capacity as a basic condition for the production of green hydrogen, and to prevent additional harms to impacted communities.
3. **Community fears about pollution associated with new technologies.** Some nascent steel decarbonization pathways rely on production methods, like using blue hydrogen, that rely on continued consumption of fossil fuels and may even worsen pollution. Without adequate guardrails, planning, and foresight to ensure sufficient production

¹ To prepare this analysis, we traveled to Dearborn, Michigan on September 11 and 12, 2023 to participate in a guided tour of Dearborn's industrial facilities and fenceline communities featuring community members, advocates, and steel experts (*Guided Tour: A Sustainable Future for Steel & Cars in Detroit & Dearborn*), organized by Industrious Labs. On that visit, and over the period between August 2023 to February 2024, we conducted interviews and consultations with members of the Dearborn community, environmental justice advocates, specialists in steel technologies, current and former labor union members, decarbonization advocates, and academic researchers. We also conducted policy, academic, archival, and media research.



of renewable energy and green hydrogen, a “blue” transition could fuel opposition and mistrust from environmental groups and from environmental justice communities. These groups have experienced many past disappointments with the enforcement of pollution controls, harmful zoning decisions that led to polluting facilities being sited immediately next to people's homes, and general failure to keep industry accountable to community demands.

4. **Corporate inertia and focus on short-term shareholder value over long-term public value and competitiveness.** Support for a green steel transition comes from a range of stakeholders: community members and environmental justice organizations seeking a reduction of health-harming pollution, climate advocates seeking to reduce greenhouse gas emissions, and workers who suffer the health impacts of pollution, as well as organized labor, which is increasingly taking a leading role in the green transition. Moreover, federal and state governments have authorized new resources to enable the financial viability of a green steel transition, and are actively contemplating still more. Yet Cleveland-Cliffs has remained on the sidelines, making no plans to transition to the cleanest commercially viable production model—either in Dearborn or elsewhere. Instead, it appears committed to maintaining much of its current production model, while making minimal capital investments to charge its customers “green” premiums—and pursuing an aggressive agenda of share buybacks.

Following our analysis of these challenges, Part III concludes with an overview of possible solutions and policy recommendations—some of which speak to national industrial policy challenges and some of which are generalizable to other industrial communities struggling to solve trade-offs and balance power among stakeholders in pursuit of a rapid, equitable green transition.

I. The Green Steel Transition

To drive a successful decarbonization of the steel industry we have to start with an understanding of (i) why steel is important to local and national economies; (ii) how existing steel production has affected communities; and (iii) the technological and social challenges and opportunities involved in the decarbonization of the industry.

Economic Benefits of Steel

The value of steel stems from its unique combination of material properties: durability, strength, and versatility. Composed primarily of iron and carbon—almost all iron by weight ([Dell 2022](#))—the alloy is used across a wide range of economic sectors, from housing and



infrastructure to manufacturing and technological innovation, each of which satisfy a range of human needs and enable us to live full lives. The robustness of steel makes it a useful input in the construction of long-lasting and resilient housing, bridges, and tunnels. As a significant input in the construction of transportation networks and in the production of cars, trucks, trains, ships, and airplanes, steel provides mobility and safety; due to its strength and ability to withstand impact, it is used in the body, chassis, engine, and almost all other components of vehicles. In the manufacturing sector, steel is used as a component in machinery, tools, and industrial equipment, underpinning operations in key sectors like heavy machinery, mining, and energy. Steel also plays a key role in the renewable energy transition as a major component in almost every major renewable energy technology ([Igogo 2022](#)). Finally, steel is used in the production of a variety of consumer goods, from appliances like refrigerators and washing machines to everyday items like utensils and cutlery. In short, steel plays a key role in providing a range of essential human needs, like shelter and energy, as well as the ability to move from place to place and even to cook and eat.

The useful functions of steel also extend beyond its direct uses in the material economy. Industry associations estimate the direct and indirect economic impact of the US iron and steel industry at over \$500 billion ([Eash-Gates et al. 2023a](#); [AISI 2018](#)). Historically, the development of capabilities for steel production have been a marker of "development," with steel being viewed as an "industrializing industry" that could trigger the development of sophisticated productive capabilities in other economic sectors. Even today, steel continues to play a role in technological innovation, including in robotics, aerospace, and other national security functions.

Throughout much of the 20th century in the US, the steel industry also provided high-wage union jobs to workers around the country (Part II). For workers without college degrees, the steel industry represented an accessible pathway to the middle class and economic security. The decline of the steel industry,² due in part to competition from suppliers in emerging economies like Korea and China, led to significant losses of jobs and tax revenue for steel communities, which continue to struggle with the consequences of economic decline ([Lee and Ki 2017](#)).

² See [Tarr 1988](#) for a granular study.



Environmental and Health Costs³

The benefits associated with the steel industry, however, also come with costs—in the form of climate impact, ecosystem harms, and harms to human health. Moreover, these costs are neither equitably distributed nor captured in the price of steel, but rather externalized to society as a whole, and especially to impacted communities living near the fence line of the steel value chain—from the extraction of raw material inputs, to production and transportation. Consequently, steel-sector policies that maximize benefits, minimize harms, and equitably manage the distribution of benefits and harms have to start from an understanding of the trade-offs implicit in steel production.

The "greening" of the steel industry is currently understood primarily as a climate challenge, in which the objective of steel industrial transformation is to mitigate greenhouse gas emissions. The steel sector is, in fact, a significant contributor to the climate crisis: The global steel industry emits 3.5 billion tons of CO₂-equivalent each year—more than any country in the world except the United States and China—and consumes 7 to 8 percent of global energy ([Dell 2022](#)). The US steel sector alone is responsible for 86 million metric tons of CO₂-e per year ([Cresko et al. 2022](#)).

However, the environmental side effects of the steel value chain extend beyond climate change. Pollutants released into waterways and soils can affect other living organisms, the life-sustaining capabilities of ecosystems, and even the built environment, and, while some of the emerging steel production technologies are able to mitigate certain pollutants, the reduction of many of the environmental byproducts of steel production along the rest of the value chain remains elusive. Iron ore mining, for example, almost by definition entails land degradation, deforestation, destruction of habitats, and water pollution. Mining and onsite processing create persistent water quality issues, like acidic drainage and release of heavy metals ([Baeten, Langston, and Lafreniere 2018](#)).

Beyond environmental impact, the iron and steel sector is also responsible for large amounts of air, water, and soil pollution that seriously harms human health. Source-point air pollution from iron and steel facilities, for example, includes nitrogen oxides (NO_x). Studies have demonstrated that exposure to NO_x damages the pulmonary system ([WHO 2021](#)), particularly in already vulnerable populations like children and people with respiratory conditions ([ATSDR n.d.](#)). And NO_x is hardly the only pollutant produced by the steel industry that has significant potential harm to human health ([Hasanbeigi, Bhadbhade, and Ghosh](#)

³ A similar section appears in the authors' previous work, *Using Trade Tools for Industrial Transformation* ([Estevez, Kwon, and Paul 2023](#))



[2022](#)): Other toxics, including highly harmful ones like [lead](#) and other heavy metals, can also contaminate air, land, and water ([EPA 2015](#)).

The impacts of these pollutants on the health and well-being of frontline communities is further examined in Section II.

Greening Steel Production

The US steel industry produced 87 million metric tons of crude steel in 2018 using two predominant production models: secondary (or recycled) steelmaking or primary steelmaking ([Cresko et al. 2022](#)).

About two-thirds of this domestic steel production takes place in electric arc furnaces (EAF), in a process that does not require onsite combustion of any fossil fuels, but relies on recycled steel scrap from consumer products and pig iron or direct reduced iron from other metallurgical facilities. Because of its use of scrap, this process is sometimes referred to as "secondary" steel production ([Cresko et al. 2022](#)).

The remaining third of domestically produced steel comes almost entirely from integrated steel mills where blast furnaces (BF) combust coal-derived metallurgical coke to transform the iron ore into an intermediate carbon-rich pig iron, which is then converted into steel in a basic oxygen furnace (BOF). This production model is the most polluting model currently available—and the most pervasive worldwide ([Cresko et al. 2022](#)).

Another method to produce primary steel is the direct reduced iron (DRI) furnace. In the US, DRIs currently employ methane gas (CH₄, or "natural gas") instead of metallurgical coke to prepare the iron ore. Only a small fraction of the intermediate iron in the US is currently produced at a DRI facility, and these facilities rely on off-site EAFs or BOFs to complete the steelmaking process ([Gallucci 2023](#)).

No US steelmakers currently employ the least carbon-intensive process currently available: DRI-EAF production that uses green hydrogen—hydrogen made with electricity generated from renewable sources—to transform ("reduce") iron ore into iron in a DRI, combined with an EAF powered by renewable energy to make steel. The feasibility of this pathway has been proved by a demonstration plant (HYBRIT) built by Swedish steelmaker SSAB, Swedish state utility Vattenfall, and Finnish iron ore producer LKAB ([Reuters in Stockholm 2021](#)). One ton of steel made at this pilot facility released 25kg of CO₂-equivalent ([Pei et al. 2020](#)). For comparison, the Cleveland-Cliffs facility in Burns Harbor, IN emitted approximately 2.07 metric tons of CO₂-equivalent onsite for every ton of steel ([Eash-Gates et al. 2023a](#)). Building



on this milestone, the Swedish H2 Green Steel project raised \$1.6 billion in September 2023 to build a new large-scale DRI-EAF steel mill in Boden, Sweden with hydrogen production onsite using renewable electricity ([Solvik and Johnson 2023](#); [H2 Green Steel n.d.](#)).

The transition from BF-BOF to DRI-EAF is gaining momentum more broadly in Europe, where a majority of the steelmaking currently takes place at BF-BOF integrated facilities—a reverse of the composition of US steel production. While the US has yet to announce any green iron facilities, Europe has awarded \$5.5 billion in public subsidies across six major green steel projects ([Industrious Labs and Public Citizen 2024](#)). Steel producer ArcelorMittal already operates a DRI-EAF facility in Hamburg, Germany (but still utilizes methane gas as the feedstock). ArcelorMittal looks to retire its BFs and BOFs at the integrated steel mills in Bremen and Eisenhüttenstadt in Germany ([Evans and Langner 2021](#)). The German steelmaker ThyssenKrupp announced a similar transition plan to replace blast furnaces with Hydrogen-DRIs ([Stagge 2022](#)). Tata Steel Nederland also plans to develop a DRI-EAF facility at its integrated steel mill at IJmuiden, Netherlands ([Agarwal 2022](#)). Rising demand from automakers has played a role in accelerating the transition: Both Tata Steel and ThyssenKrupp have secured a memorandum of understanding with Ford Motors Europe to supply the steel made from the new DRI-EAF sites ([Ford Media Center 2022](#)).

However, all the transitions mentioned above that are taking place at existing industrial sites are managing risk by making sure that they could fall back on using methane gas. Some current efforts to decarbonize the iron and steel industry also include pathways that would increase non-greenhouse gas pollutants, like NO_x. This includes ongoing efforts to use a blend of fossil gas and hydrogen as a heat source in steel forging with the aim of reducing the burning of fossil fuels ([Tena 2021](#)) (note that this model is distinct from ones that use (green) hydrogen as a reductant rather than a heat source). Recent studies suggest that burning hydrogen-enriched fossil gas—even if we assume that hydrogen is produced from renewable sources—could increase NO_x emissions up to six times that of directly burning natural gas ([Dabbs 2023](#), [Cellek & Pınarbaşı 2018](#)).

These risks point to the urgent need to eliminate the bottleneck of green hydrogen production to ensure the viability of a green steel transition. Hydrogen is a clean alternative to methane in a DRI process, but the production of hydrogen from water (electrolysis) is energy intensive. Analogous to an electric vehicle running on charge from coal-fired power plants, a facility that relies on a fossil fuel—powered grid for electrolysis to produce hydrogen would still carry a climate impact and could potentially worsen pollution.

In other words, planning for a green steel transition entails actionable steps to secure the full range of necessary productive capabilities—from clean energy production to DRI-EAF



physical infrastructure. And, while European competitors are making concrete progress in that transition, US producers of primary steel have instead opted to retain their existing coke-dependent blast furnaces, while pursuing only marginal reductions in emissions intensity by adopting measures that utilize industrial heat more efficiently (see, for example, the proposal for the Cleveland-Cliffs integrated mill in Indiana Harbor, further discussed in Part II, which includes the injection of hydrogen into blast furnaces to reduce the total amount of fossil fuels consumed in the steelmaking process). Such solutions carry an inherent limit to their greenhouse gas emissions reduction potential because they still rely on inputs made from fossil fuels in the ironmaking process. In addition to onsite releases of climate and toxic pollution, this also means that coal mining and the production of metallurgical coke remain essential components of the steel supply chain. As a consequence, they do not offer a pathway that could one day achieve near-zero emissions.

The path-dependency from corporate actors in the US is striking in the context of the new and contemplated public resources and policy frameworks that have emerged in recent years to enable the transition of the steel industry toward more sustainable models. While US public resources for steel decarbonization still fall short of Europe's (Industrious Labs and Public Citizen [2024] estimate that the Department of Energy's Industrial Demonstrations Program subsidies are 35 percent lower than what has been awarded in Europe), they are nonetheless substantial. Table 1 provides an overview of current and possible industrial policies for steel industrial transformation and related upstream investments, featuring public funding streams for steel decarbonization and pollution reduction recently made available by the Inflation Reduction Act (2022) and the Infrastructure Investment and Jobs Act (IIJA) (2021).

| Table 1. Available Industrial Policy Tools for a Green Steel Transition | | |
|---|--|---|
| Carrots | | |
| Public Investment: Grants, Loans, Tax Credits, and Procurement | IRA & IIJA grants, rebates, and cooperative agreements | The IRA included \$5.812 billion in grants, rebates, and/or cooperative agreements for retrofits, upgrades, installation, or implementation of advanced industrial technologies for industrial decarbonization (recipients shoulder at least 50 percent of the cost) (Sec. 50161: Advanced Industrial Facilities Deployment Program). This funding was bundled with \$500 million from the Infrastructure Investment and Jobs Act (Sec. 41008 for demonstrations in the Industrial Emissions Reduction Technology Development Program) into a Department of Energy (DOE) funding opportunity: DE-FOA-0002936 (7/21/2023). |
| | Department of Energy (DOE) Loans Program | The IRA gave the DOE's Loan Programs Office (LPO) loan guarantee authority of \$250 billion and \$5 billion in Credit Subsidy Cost (to be committed by September 2026) (under Title 17 of the Energy Policy Act of 2005). Steel decarbonization projects are eligible. Title 17 can be used to facilitate federal debt and debt from third party |



| | | |
|--|--------------------------------|--|
| | Office (LPO) lending authority | commercial lenders. Federal loan applicants can work with LPO to receive a direct loan from US Treasury's Federal Financing Bank (FFB) backed by a 100 percent "full faith and credit" DOE guarantee (through LPO). Commercial loan applicants can apply for an LPO partial guarantee of that commercial debt. LPO can guarantee up to 90 percent of loans made by other financial institutions. |
| | Greenhouse Gas Reduction Fund | Steelmakers could benefit from the IRA's Greenhouse Gas Reduction Fund , which encompasses \$27 billion in grants and loans for a range of clean energy and clean technology projects. |
| | Government procurement | The Biden administration's "Buy Clean" initiative uses public purchasing power to drive demand for lower-emissions products, including steel. |
| | Various tax credits | Many of the IRA's vast tax credits can be used to support decarbonization or address supply chain bottlenecks, such as the availability of green hydrogen for steel production (Section 45V). 45V credits can be combined or "stacked" with the 45Y clean electricity production credit for zero-carbon generation, and with the 48E investment tax credit for storage/other zero-carbon technologies. |
| | Defense Production Act (DPA) | The IRA appropriated \$500 million to use for DOE to make clean energy investments under the DPA (Datta et al. 2022). While these efforts are currently focused on heat pumps and minerals, the DPA is a wide-ranging and flexible tool that could be deployed to promote the green steel transition (Tucker 2022). |
| | Trade tools | Tools like Carbon Border Adjustments, if well designed , can prevent unfair competition at the international level arising from environmental and social dumping (Estevez, Kwon, and Paul 2023). |

Sticks

| | | |
|---|---|---|
| Pollution Regulation | Clean Air Act, Clean Water Act & Occupational Health and Safety Act | These legal frameworks allow for industry-specific air, water, and soil pollution standards. Current regulations and enforcement are not commensurate with the magnitude of the health and environmental impacts of industrial pollution. More robust regulation and enforcement would likely constitute a strong motivation for steel producers to invest in decarbonization. |
| Nationalization Creation of New Public or Worker-Owned Enterprises | Various national and international precedents | The US has a long history of public ownership and nationalizations. Over the past century, the US government has nationalized railways, coal mines, and steel mills, and has taken a controlling interest in banks when that was deemed to be in the national interest (Aronoff 2024; Lohr 2008). Due to the strategic importance of steel, many leading steel producers today are state-owned companies. In terms of crude steel production, in 2016, 22 of the world's largest 100 companies were directly or indirectly owned by states. Although relatively small in numbers, state enterprises represented no less than 32 percent of global crude steel output in 2016, and 45 percent of total crude output among the largest 100 steelmaking companies (Mattera and Silva 2018). |



II. Prospects and Challenges of the Green Steel Transition in Dearborn, MI

Immediately adjacent to Detroit and just across the bridge from Canada, the community of Dearborn, Michigan, illustrates the urgency of a green steel transition—both as a means of resolving tensions between the costs and benefits of steel production and as a means of ensuring the long-term survival of the local steel industry.

Dearborn's steel industry has been intimately intertwined with the rise of the automotive industry and the Ford Motor Company in the early 20th century, and has long contributed to the community's tax base and supported high-wage jobs for thousands of workers represented by the United Auto Workers. At the same time, the relationship between local industries and the community has a dark side: dangerous working conditions, harmful zoning decisions, and the cumulative impacts of pollution from steel and many other industrial facilities, which contribute to a panoply of health problems, including high rates of asthma, cancer, developmental problems, reduced quality of life, and, of course, climate change. Moreover, these harms have been predominantly borne by a historically marginalized community: Dearborn is 54 percent Arab according to 2020 census data—and closer to 70 percent according to other estimates based on reporting from public records ([Anderson 2023](#)).

Dearborn's experience illustrates how power asymmetries—and the historic inability of governments to balance power between corporations, communities, and workers—have held back progress toward healthier and more equitable industrial production. In the sections that follow, we examine the place of steel in Dearborn's history and unpack the challenges that policymakers seeking to usher in a new industrial policy paradigm face.

Dearborn and the Steel Industry

The steel industry in Dearborn is part of a broader constellation of industrial facilities deeply integrated into the century-old automotive industry value chain (Table 2). Dearborn Works, the last remaining steel facility in Dearborn, was originally built as an essential piece of the Detroit auto value chain. After founding the Ford Motor Company in 1903, Henry Ford began construction of his Ford Rouge Complex in 1917 with the aim of integrating all aspects of the automotive manufacturing process in one location (a significant innovation in manufacturing efficiency at the time). The facility's steel mill began operations in 1926,



enabling Ford to produce steel for its automobiles on site and realizing his “ore to assembly” vision for fully vertically integrated production ([The Henry Ford n.d.a](#)).

For over a century, the steel industry in Dearborn has provided inputs primarily for the automotive sector, as well as for other useful products including those for heating, cooling, ventilation, and converters (Table 3).⁴ The Dearborn Works plant is also likely linked downstream with DTE Energy's EES coke plant in Detroit, MI and the Edw. C. Levy Co., which transports and processes slag from Dearborn Works to make other products, such as concrete⁵ (Appendix I, Table 2).

Beyond their contributions to the material economy, the auto and steel industries in Dearborn have contributed to the economic sustenance of the community, providing a tax base for the local government to provide public services for a population of about 108,000. Since at least 1941—when Ford became the last major auto company to sign a contract with the UAW (represented by UAW Local 600)—the auto industry and its value chain has also provided access to union jobs ([The Henry Ford n.d.a](#)). The economic opportunities provided by the Ford Motor Company have long attracted workers from across the world (Box 1).

However, the local and societal benefits of steel production in Dearborn have come at significant cost to the health and well-being of the community, including low-income, predominantly Arab families, many of whom are immigrants and refugees, living on the fenceline and in the vicinity of industrial facilities for decades (not to mention those affected by the production of inputs along the rest of the supply chain, including the mining of metallurgical coke).

Dearborn is located in Wayne County, where children are hospitalized for asthma at nearly twice the rate of the Michigan state average and adult asthma hospitalizations are more than double the statewide rate ([Altavena 2022](#)). At least as early as the 1990s, researchers have pointed to health risk factors arising from industrial pollution of Dearborn's water, land, and air. These include cancer, genetic or chromosomal mutations, reproductive defects, and damages to the nervous system ([Berry n.d.](#)). For years, residents have raised awareness and

⁴ While US industrial policy choices over the past century have supported the entrenchment of a transportation model that privileges personal vehicles, the steel produced in Dearborn could just as easily be deployed to expand material and immaterial benefits to millions of Americans across the country in the form of cost-efficient housing, solar arrays providing more affordable energy, and increased mobility through trains, trams, buses, and other forms of mass transit—including access to public transit for Dearborn residents, which is currently sparse and inconvenient.

⁵ The Levy Co. transports this slag from Dearborn Works through residential neighborhoods and stores it in uncovered mountains at their Dix Avenue location. It is a significant source of particulate matter and fugitive dust emissions (Industrious Labs 2023).



organized to protect their children from being exposed to the pollution. At one recent event to raise awareness in 2023, Dearborn resident and advocate Samra'a Luqman explained:

We live in a cancer cluster. My family and neighbors are impacted and dying. Within six months of birth, my son developed a tumor and had it removed. My mom is in remission. When COVID came to our area, it cleaned out our grandmothers, our grandfathers, and our parents. We were severely impacted because the steel industry refuses to clean up its mess. ([Criste n.d.](#))⁶

Map 1. Dearborn Works and Other Industrial Facilities in Dearborn⁷



Author: Adriana DiSivestro

Recent environmental advocacy efforts have also highlighted the climate impacts from the facility: In 2020, the facility emitted 832 thousand metric tons (or 0.84 million metric tons) in

⁶ Samra'a Luqman was a featured speaker in "Guided Tour: A Sustainable Future for Steel & Cars in Detroit & Dearborn," organized by Industrious Labs in September 2023.

⁷ "Not applicable" denotes nonresidential areas. All other areas are residential.



scope 1 emissions and 1.03 million metric tons for scope 1+2 emissions ([Eash-Gates et al. 2023b](#)). This is equivalent to 2.6 natural gas–fired power plants running for one year, or 2.8 million barrels of oil combusted (EPA Greenhouse Gas Equivalencies Calculator). In dollar terms, Dearborn Works' greenhouse gas emissions from 2020 alone are responsible for over \$200 million in climate damages.⁸

Box 1. Testimony from Hebah Kassem

One of the coauthors of this study, Hebah Kassem was born and raised in Dearborn and has experienced the impacts of the steel and auto industry firsthand. Her testimony points to the tensions that many community members hold as they seek to protect themselves from harms of pollution while preserving economic security.

I am proud to have been born and raised in Dearborn, Michigan. Dearborn is home to the highest concentration of Arabs outside of the Middle East, and is one of the best cities in America. It will always be a home, where Arab American [culture, traditions, food, and community are prioritized](#), and is a place that helped shape who I am today. You can find the largest mosque in the United States—the [Islamic Center of America](#)—in Dearborn, alongside hundreds of community centers, schools, faith-based organizations, and businesses, such as restaurants and supermarkets attracting people from all over the country and other parts of the world, built by [the diverse and thriving](#) Arab American community.

In the late 1880's, Arab migrants, primarily from Lebanon, started to make their way to the Detroit metro area, and in the second decade of the 20th century, Palestinians started to arrive, followed by Iraqis and Yemenis in the 1920s ([Leech 2017](#)). Many of those families came to Dearborn from war-torn countries and other dire circumstances in search of better opportunities, such as jobs in the auto industry. By the 1920s, Ford Motor Company attracted workers from across the world, including my parents. I am the daughter of Palestinian Muslim refugees who made their way to Dearborn for a chance at a better life.

Despite these opportunities, my family and our community faced many challenges. Growing up in a predominantly immigrant community, language and existing systems were a barrier for us. Like many of the children from Dearborn, I am a first-generation American whose parents did their best to provide for us while trying to live and thrive in a place very different from their homeland. That came at great cost when we were breathing in air from the neighborhood factories, drinking contaminated water, and consuming toxins from industrial pollution that have resulted in serious health issues for myself and my relatives, including asthma, lung cancer, high blood pressure, Crohn's disease, and more. I distinctly remember the foul odor we smelled every time we drove past the River Rouge plants on the way to visit my grandparents or the black dew we'd wake up to on our cars on colder days. Like many of our families in

⁸ Using EPA's 2024 estimates at a 2 percent discount rate.



Dearborn, my parents used every opportunity given to us, including organized labor, to try to overcome these barriers.

I was raised by proud union workers. My father was a UAW factory worker at Ford and my mother was a Head Start teacher who led efforts to unionize her workplace with the American Federation of Teachers (AFT). Many of these unionized jobs gave families like mine better wages, benefits, and opportunities, and I have experienced firsthand the strength and importance of labor unions such as the UAW. For example, in the most recent and historic contract negotiations between UAW and General Motors, Ford, and Stellantis, workers walked away with the biggest victory in decades. UAW was successful in securing an increased contribution to their members' 401ks, pay increases as well as cost-of-living increases that are tied to inflation, and securing guarantees that at least some battery plants making EV batteries will be unionized ([Domonoske 2023](#)). This is huge for UAW members and even retirees such as my father, who received an increase to his monthly pension in 2024 and beyond as a part of the new contract. And because of this, years after my father retired, my family still feels the benefits of unionized labor.

Although we are grateful for the jobs and opportunities, my community has unfortunately had to bear the brunt of corporate and industrial pollution. Dearborn is a neighbor to Detroit, and has grown into a vital industrial center, with a steel plant, auto factories, oil refineries, and other industrial facilities. Most of my relatives, including my parents, late grandparents, aunts and uncles, their children, and now grandchildren lived for many years and continue to live across the street from the Cleveland-Cliffs Dearborn Works—one of Michigan's most notorious polluters. My aunt has worked at Salina School for years, which was first opened in 1918. The current Salina intermediate was built in 1920 and today is located directly across from Cleveland-Cliffs Dearborn Works ([Arab American News 2018](#)). Some of my other family members continue to live and work in the area, including on the assembly line at the neighboring Ford plant. Consequently, my family is still experiencing a variety of health issues and I have lost family members due to these illnesses.

As I went on to college and graduate school, I learned that our health issues were not an accident, but by design. They were likely the result of corporate-driven zoning decisions that led to siting industrial sites next to where communities of color like ours live and work—polluting our air, land, and water.

I've dedicated my career to become an advocate for climate and environmental justice, and for creating family-sustaining jobs, because communities like mine depend on it—and we deserve so much better.



Community complaints and legal actions⁹ to address the health impacts of industrial pollution have historically not achieved the desired results, leading some community members to advocate for a shutdown of the facility because the impacts on their children and well-being outweighed the economic benefits. As Theresa Landrum, a lifelong Detroit resident and retired auto worker explains, many industrial plants in Dearborn are surrounded by homes and parks where children play.¹⁰

Today, however, the new state and federal funding streams for decarbonization discussed in Section I (Table 1) have ushered in an opportunity to eliminate this trade-off by making it possible to keep steel production in Dearborn, while significantly reducing its health and environmental impacts. The sections that follow examine the prospects and challenges of realizing that transformative vision.

Community Fears of Economic Insecurity Arising from Techno-Economic Shifts

One way to think about industrial transformation at an industry-specific level is in terms of how that industry needs to change to minimize—and ideally eliminate—undesired side effects while simultaneously maintaining existing benefits and achieving as many societal goals as possible (i.e., "[multi-solving](#)").¹¹ When eliminating undesired side effects is not possible (as is currently the case with steel production), smart industrial policy should endeavor to not only minimize "overall" costs but also assess who will bear those costs, and make principled judgment calls about who should and should not bear them. This is especially important for industries like steel, where costs have historically been borne by specific communities—in the case of Dearborn, predominantly Arab residents living on the fenceline of production, due to over a century of harmful zoning decisions and lack of regulatory enforcement, intertwined with racism (Barrow 2018). At the same time, a smart steel industrial policy has to preserve the industry's benefits—namely its contributions to the material economy, the local tax base, and workers.

Prescriptive judgment calls about who bears costs, who is entitled to benefits, and how these can be fairly (re)distributed through a process of industrial transformation should be founded on empirical understanding of existing economic realities and their rigidities. Productive structures—the collection of technological-productive capabilities in a particular

⁹ See, for example, [Ferretti 2021](#).

¹⁰ Theresa Landrum was a featured speaker in "Guided Tour: A Sustainable Future for Steel & Cars in Detroit & Dearborn" organized by Industrious Labs in September 2023. She is quoted in [Gallucci 2023](#).

¹¹ For a longer discussion on multi-solving, see [Estevez 2023a](#) ("Multi-Solving, Trade-Offs and Conditionality in Industrial Policy")



place—are generally slow to evolve and are often significantly shaped by dynamics beyond the direct control of local actors (see [Estevez 2023b](#)¹² for a longer discussion). Dearborn's pattern of productive specialization is no exception.

By virtue of its status as a component of the global automotive industry, Dearborn's local steel industry dynamics have been deeply marked by national and international economic trends. In other words, the story of Dearborn's economy is part of a larger story about the rise and decline of the automotive industry in the United States; the rise of emerging economies in the 20th century—namely the industrial development of Russia, China, India, Korea, Taiwan, and Japan and their growing role in the steel and automotive sectors; and finally, competitive pressures from highly industrialized European economies currently outpacing the US in the quest for cleaner steel as offtaker and consumer preferences shift to prioritize more sustainable production (Part I).

This global evolution of the steel and automotive markets over the past century is reflected in the story of Dearborn's steel industry. In 1989, after gradual decline over the course of the 20th century,¹³ Ford divested its steel mill assets. The early 21st century marked another pivotal change, with the 2004 acquisition of the bankrupt Rouge Steel by Russian steel giant Severstal. The plant saw substantial investments following the acquisitions, including the inauguration of a new blast furnace in 2007. The plant's ownership changed again in 2014, when AK Steel Holding acquired Severstal's Dearborn steelmaking assets for \$700 million in a deal that also encompassed a coke-making facility and interests in three joint ventures processing flat-rolled steel products (concurrently, Severstal announced the sale of a separate steelmaking facility in Columbus, Mississippi, to Steel Dynamics for \$1.63 billion). The evolution of the plant continued with US steelmaker Cleveland-Cliffs acquiring AK Steel Dearborn Works in 2020 ([Noble, Hall, and Ferretti 2020](#); [Kurane, Banerjee, and Pramanick 2014](#)).

The decline of the industry has taken its toll on Dearborn, with job loss and the attrition of the city's tax base leading to marked declines in the community's physical and social infrastructure. The impacts of overflowing sewage systems ([Cwiek 2023](#)) have been concentrated in the city's poorest neighborhoods, where there is a high concentration of Yemeni residents—one of Dearborn's most vulnerable populations. The most recent closure of a steel factory in the area is also fresh in the community's memory—founded in 1902, US Steel's Great Lakes Works closed in 2020, leaving 1,000 workers without jobs after decades of gradual attrition ([Rubin 2020](#)).

¹² [Estevez 2023b](#) (“Using Industrial Policy for Productive Transformation: Three Lessons from Development Economics for US Industrial Strategy”)

¹³ Ford's Rouge complex employed over 100,000 workers in 1929 and 60,000 by 1953 ([The Henry Ford n.d.a](#))



This is only the most recent event in a long and steady history of decline: After climbing to 103,000 in 1929, employment at the Rouge Complex had declined to 75,000 by 1946 and to 60,000 by 1953. Today, about 6,000 people ([The Henry Ford n.d.b](#)) work at the River Rouge complex, of which 1,290 work at the last remaining steel plant in the city—Dearborn Works (Table 3) ([The Henry Ford n.d.a](#); [SHOT 2013](#)).

In a context of nearly a century of deindustrialization and economic decline, it is not surprising that the prospects of further techno-economic change would arouse fears of further economic insecurity. In fact, as we discuss in the following sections, workers have been emphatic about their fears that the mismanagement of the technological shifts associated with a green transition in the auto sector could translate into fewer jobs, worse wages, and declining benefits—and they have organized to attempt to ensure that the green transition avoids such outcomes.

In the steel sector, however, the evolution of the industry suggests that a transition to cleaner production is not only unlikely to cause further economic insecurity, but may in fact be the only medium-term survival strategy for the industry. While maintaining the Blast-BOF model could lead Dearborn Works to the same fate of Great Lakes Works and to surrender the green steel market to international competitors that have already achieved a competitive edge (Part I), evidence suggests that a transition to a greener model could expand the total number of jobs supported by the steel industry. A 2023 report by the Ohio River Valley Institute found that, in a scenario that maintains the Blast-BOF model, jobs in the region are expected to fall by 30 percent by 2031 as a result of outsourcing and automation ([Ebner et al. 2023](#)). Conversely, in a scenario in which companies shift to the green hydrogen—powered DRI-EAF model that decarbonization advocates have championed, the region could experience job growth of 27 to 43 percent over the same period ([Ebner et al. 2023](#); [Gallucci 2023](#)).

The realization of those benefits hinges on the ability of industry, labor, community, and government actors to manage the transition: In the same 2023 study, the Ohio River Valley Institute Study found that much of its predicted job growth would come from building and operating new wind and solar farms and electrolyzers, which would entail retraining for current steel workers to redeploy their skills to new sectors—a feat that requires strong multi-actor coordination ([Ebner et al. 2023](#)). As a 2023 industry study by Synapse Energy Economics ([Eash-Gates et al. 2023a](#)) points out, poorly managed transitions in the manufacturing sector risk squandering such opportunities:

Even when new manufacturing jobs have been created, they have often remained inaccessible to individuals with lower levels of education. Job



postings for highly educated roles such as “engineer” have increased, while other more accessible roles have disappeared. For communities with high proportions of manufacturing workers, a decrease in manufacturing roles has correlated with higher rates of unemployment, fewer hours worked, and lower wages. Studies have also found correlations between decreased manufacturing employment and negative impacts such as increased opioid usage and overdoses in affected communities; opioid usage has also been attributed to decreased length of employment. (21–22)

To realize the job-growth potential of the green transition, the study goes on to recommend the development pathways to ensure that newly created positions are accessible to local communities, including legacy workers, environmental justice communities,¹⁴ and other historically excluded groups. This includes retraining, affordable new educational programs, and complementary policies to ensure access to high-quality jobs and long-term career pathways.

With adequate cooperation from stakeholders, a green steel transition presents Dearborn with the opportunity to not only reduce the industry's harms to community health and the climate, but also to save it from the terminal decline to which it may otherwise be pushed by long-standing economic trends.

Green Hydrogen: The Supply Chain Bottleneck for Green Steel

The green steel transition in Dearborn also faces technological challenges.

Decarbonization advocates have called on Cleveland-Cliffs to transition to DRI-EAF production that substitutes green hydrogen for coal ([Criste n.d.](#)), and community advocates have similarly called for measures to mitigate toxic pollutants. Though not enough is known about the impacts of emerging decarbonization technologies on non–greenhouse gas emissions, the green hydrogen–based DRI-EAF model does present a promising decarbonization pathway, and its viability has been proven by European competitors.

However, with the successful demonstration of iron reduction using green hydrogen at HYBRIT in Sweden (see Part I), some of the concerns around the feasibility of a green hydrogen steelmaking pathway shifted upstream to two key concerns: (i) how to increase the cost

¹⁴ For a discussion about the targeting of environmental justice communities in public investments, see [Daly 2022](#).



efficiency of electrolysis; and (ii) how to increase the generation of electricity from renewable sources.

These challenges are interrelated, as both the efficiency of large-scale conversion of water into hydrogen through electrolysis ([Office of Energy Efficiency & Renewable Energy n.d.](#))¹⁵ and the accessibility and cost of renewable energy represent the two largest factors in determining the cost of this key input for the future of steelmaking. According to the European Commission, in July 2020 hydrogen produced from electrolysis with water and renewable energy cost between \$3/kg and \$6.55/kg, while hydrogen made using methane gas as the principal feedstock cost about \$2.40/kg ([DiChristopher 2021](#)). If this difference in price persists, it will discourage DRI operators from making the final transition from methane gas to green hydrogen as a feedstock in the DRI furnace. Recognizing that the current cost differential rendered the cleanest available steelmaking pathway unattractive to industry, the Department of Energy has set the goal of promoting the creation of \$1/kg hydrogen by 2030. The current view is that this may be achieved by: (i) reducing the capital cost of electrolyzer units; (ii) improving energy efficiency in converting electricity to hydrogen over a wide range of operating conditions; and (iii) increasing the operational life of electrolyzers by mitigating their degradation ([Office of Energy Efficiency & Renewable Energy n.d.](#)).

Given the energy-hungry nature of hydrogen production, the availability of renewable energy infrastructure constitutes one of the key bottlenecks in the transition. Analysts estimate that if Sweden's HYBRIT operated as a large-scale green hydrogen steelmaking facility, it would consume over 12 percent of Sweden's existing wind power ([Albuquerque 2021](#)). In a context of growing demand for renewable energy elsewhere in the economy, the industrial consumption of this power risks crowding out everyday people or leading to price spikes and increased consumption of nonrenewable energy.

The failure to achieve either electrolyzer efficiency or an increase in renewable power generation thus risks deepening the hold of methane gas over the global economy. Currently, [the hydrogen hubs program](#) funded by the US government promotes a diversity of hydrogen production methods—many reliant on fossil fuels. These have raised fears of locking in new fossil fuel—based path-dependencies and production methods that may yield even worse health outcomes than current methods. This is why, as discussed below, advocacy groups and scientists have called for hydrogen producers to add renewables capacity and other

¹⁵ Water is converted into hydrogen primarily through a process called electrolysis. In this method, an electric current is passed through water, splitting it into hydrogen and oxygen gases. This process requires a significant amount of electrical energy, and its environmental impact largely depends on the source of the electricity used (whether it's derived from renewable sources or fossil fuels) (see Section I).



guardrails as a condition for receiving public funds ([Black Labor Week Project et al. 2024](#); [Stokes 2023](#)).

Community Fears of Pollution Associated with New Technologies

After the Department of Energy's October 2023 [announcement](#) of support for seven hydrogen hubs around the country, including the MachH2 hub that will serve midwestern markets and Cleveland-Cliffs experiments with hydrogen (discussed below), advocates voiced both support for green hydrogen—based steel production and opposition to the types of hydrogen that appeared to be planned at many of the sites that could result in harmful impacts on communities (also lamenting a lack of transparency about the specifics) ([van Deelen 2023](#)).

The industrial decarbonization group Industrious Labs stressed the importance of hydrogen for decarbonization,¹⁶ but also went on to explain, "As proposed today, the Hydrogen Hubs with the greatest potential to clean up the primary steelmaking industry fall short of the opportunity to eliminate fossil-fuels and their climate and health-harming impacts on communities . . . As the Department of Energy negotiates funding it must listen to workers and communities, and prioritize a full commitment to green hydrogen" ([Industrious Labs n.d.](#)). Even more forceful reactions came from organizations like Just Transition Northwest Indiana, which stated that "Fossil fuel-produced hydrogen and carbon capture and storage will irrevocably endanger the Great Lakes ecosystem while further harming the region's already overburdened communities . . . These Hydrogen Hub announcements are more of the same carbon schemes from corporate polluters." Other organizations, such as the Ohio River Valley Institute and SteelWatch, ([Industrious Labs n.d.](#)), echoed those sentiments—and they were recently reinforced in a technical environmental justice analysis of hydrogen production ([Flores et al. 2024](#)).¹⁷

Nonetheless, the DOE's original announcement ([Office of Clean Energy Demonstrations n.d.](#)) of the MachH2 hub included fossil fuel—based hydrogen: "The Midwest Hydrogen Hub plans to produce hydrogen by leveraging diverse and abundant energy sources, including renewable energy, natural gas, and low-cost nuclear energy." To date, the MachH2 website

¹⁶ "Hydrogen is a key ingredient in the most commercially advanced [pathway](#) to cleaning up primary steelmaking [the process of making new steel from iron ore]. Green hydrogen, produced through electrolysis powered by new renewable energy resources, can be used to make iron in a direct reduced iron (DRI) furnace. When combined with an electric arc furnace (EAF) powered by renewable energy, steel production can reach near zero emissions" ([Industrious Labs n.d.](#)).

¹⁷ These statements build on long-standing advocacy against the use of "blue" and "gray" hydrogen ([Fogler 2022](#)).



offers few details about the specific technologies planned but affirms that it will include "blue hydrogen utilizing carbon capture and sequestration" ([MachH2 n.d.](#)).

When it comes to green hydrogen specifically, the DOE is seeking to uphold guardrails embedded into the IRA to ensure that hydrogen tax credits meets three criteria: additionality (electrolysis must have clean electricity supplied by new resources), deliverability (electrolytic H₂ production occurs nearby qualifying electricity generation); and hourly temporal matching. Without those three guardrails, studies have shown that the IRA's hydrogen tax credits will generally increase economy-wide CO₂ emissions ([EPRI 2023](#)).

However, according to advocates, industry groups appear to be pushing back. In a recent letter to the CEO of MachH2, dozens of environmental, environmental justice, consumer advocate, public health, and community groups from Illinois, Indiana, and Michigan state that they "have learned that MachH2 may be coordinating with other hydrogen hubs to try to undermine the 45V rules proposed by Treasury" and voice their concern about "efforts from participants in MachH2 to eliminate [those] common sense, legally required rules" ([Black Labor Week Project et al. 2024](#)).

As guardrails for hydrogen production crystalize, it remains to be seen whether industry groups will prevail over health and environmental justice concerns. For the moment, the close association of nascent steel decarbonization pathways with varieties of hydrogen that may worsen pollution adds to community skepticism grounded in past disappointments with government enforcement of pollution controls, harmful zoning decisions that led to polluting facilities being sited immediately next to people's homes, and general failure to keep industry accountable to community demands.

Moreover, the focus of green steel policies on "decarbonization" over broader "pollution reduction" appears to be a challenge for building momentum for a green steel transition. In interviews conducted with environmental justice advocates and scientists, the concept of "decarbonization" was seen as overly technical jargon, disconnected from the immediate concerns of communities, highlighting a gap in policy framing that also reflects the narrowness of policy substance—currently, industrial decarbonization funding targets greenhouse gas mitigation, overlooking the broader universe of health-harming air, water, and soil toxic pollutants, which have been the subject of long-standing community advocacy.

The importance of working toward a broader framework for green industrial transformation aligned with community priorities has also been identified in government research, like the Department of Energy's Industrial Decarbonization Roadmap ([Cresko et al. 2022](#)), which highlights that:



[I]t is also important to consider reductions of non-GHG emissions (e.g., carbon monoxide, sulfur oxides (SO_x), nitrogen oxides (NO_x)). New technologies should be developed with the goal of being fully sustainable, considering the full range of possible emissions, in addition to addressing GHG emissions. Sustainable manufacturing (or circular economy) approaches, which consider the full life cycle of a product from material extraction to reuse, are essential to ensuring sustainability of technologies.¹⁸

In Dearborn, community leadership can be a valuable asset in the design of a more holistic green steel transition. Collective action from community members has long reflected the centrality of pollution mitigation as a local well-being objective. Local efforts have included raising awareness in community forums and in the media, organizing town halls and events to provide a space for the community to discuss and strategize; working with local and national organizations, agencies, and labor unions; and supporting elected officials who prioritized environmental justice and the community's well-being in their campaign platform.

These efforts have also yielded results—albeit often after long delays. In response to a 2023 agreement between Cleveland-Cliffs Dearborn Works and the EPA to replace the facility's nearly 60-year-old pollution control technology, Dearborn resident Samra'a Luqman commented: “The [pollution controls] should have been replaced in the last consent decree almost 10 years ago . . . We could have been breathing clean air for the last 10 years.” During the decade-long delay, Luqman gave birth to a son who had to have a tumor removed and suffered from asthma and high lead levels in his blood ([Brooker 2023](#)).¹⁹

In 2022, the community elected former State Representative and Dearborn native Abdullah H. Hammoud as mayor—Hammoud is the first Arab and Muslim American to represent the city as mayor and campaigned on his track record on public health and safety, climate and environmental justice, and economic development. As mayor, Hammoud revamped the Dearborn Health Department with a focus on equity and environmental justice ([Warikoo 2022](#)). In early 2023, the city of Dearborn sued a local scrap yard and trucking company due to

¹⁸ The DOE's report also points to a crucial knowledge gap in the quest for more comprehensive strategies that encompass a wide range of pollutants: thorough Life Cycle Assessment (LCA) and Technology and Economic Assessment (TEA) analyses. The development of that knowledge base is urgent to avoid creating new technological path-dependencies that entrench low-carbon technologies that might not address other forms of pollution effectively, or may even exacerbate them.

¹⁹ This followed a 2015 agreement between the facility, Michigan environmental regulators, and the EPA to address 42 state environmental violations, reduce pollution from their operations, and prevent future violations. An additional violation was issued within six months of that agreement ([Brooker 2023](#)).



concerns about the health impacts of poorly controlled fugitive dust ([Mackay 2023](#); [Allnutt 2023](#); [Washington 2023](#)).

Building on the Dearborn community's leadership, the resources made available by recent industrial policy legislation have the potential to catalyze a green steel transition rooted in community priorities.

Breaking Corporate Path-Dependency

The alignment of interests from environmental advocates, community health advocates, and workers—coupled with new public resources—suggests strong potential to disrupt corporate inertia in favor of a green steel transition.

Whereas advocates' efforts to "decarbonize" the energy sector encouraged a brand of activism laser focused on shutting down coal plants, sometimes in tension with workers and communities, the nature of the technological challenges of the green steel transition has meant that "decarbonization" activism is not about shutting down steel plants: It is about transforming the industry by building greener alternatives. And, as we've discussed, advocates have been precise about the technical details of what "green steel production" means. This vision has also enabled the emergence of coalitions that increasingly bring together climate groups with environmental justice advocates and local communities and workers. The mobilization of environmental groups in support of the UAW strike in 2023 recently added to that momentum.²⁰

Some people we interviewed also pointed to a similar ideational shift underway in the labor movement. Labor's role in the green transition has often been perceived as one of either antagonism to environmental causes or "managing the decline" of polluting industries—and in some cases the very real and consequential decline of the steel industry has forced union leadership to prioritize, and thereby internalize, the role of "managers of decline." However, there is increasing awareness that workers have often been at the vanguard of environmental causes and even see themselves as agents of industrial transformation. As labor journalist Alex Press describes, workers are often on the front lines of whistleblowing about environmental concerns and bring critical know-how to the green transition: "Those workers [at an Erie, PA plant] want to build green locomotives. They know the technology is there. They're the people along the assembly line sick of breathing in the pollution from

²⁰ See, for example, [UAW Solidarity Letter - Labor Network for Sustainability \(n.d.\)](#).



polluting locomotives. They are the ones that kind of have the leverage and the knowledge to talk about how to transition" ([Vicente 2023](#)).²¹

The labor movement has also played a leading role in recent efforts to green steel production. The [BlueGreen Alliance](#), composed of labor and environmental groups whose members include the United Steelworkers (USW) and the UAW, has been an active advocate for Buy Clean government procurement standards for steel, cement, and other heavy industry products. And in southeast Michigan, workers facing the cumulative impacts of pollution firsthand, as both workers and residents, have become vocal advocates for cleaner steel. As retired auto worker, advocate, and resident of Southeast Detroit²² Theresa Landrum explains, "When we talk about pollution, we need to talk about the pollution inside and outside of these facilities that impacts workers and residents . . . My father worked on Zug Island²³ and brought chemicals and dust from work on his uniform into our family home. My mother and father both passed from cancer, and my sister and I are both cancer survivors. You can connect the cancer rates in our community to the pollution from these industries."²⁴

Beyond advocacy efforts driven by immediate health concerns at the local level, at the national level the labor movement has echoed support for the green transition as a matter of industrial and climate strategy.

The UAW, which represents Dearborn's steel workers due to their direct integration into the auto supply chain, has voiced its support for a green transition in the automotive sector more broadly, while making it clear that support is contingent on government action to guarantee strong labor standards—a demand shared by Dearborn residents. In the midst of contentious contract negotiations with the Big Three automakers in 2023, Dan Vicente, director of UAW Region 9, explained UAW's position on the green transition as follows:

We're not naïve. Transitioning to electric vehicles is going to be absolutely necessary. The climate is warming. Our members run a huge range of political positions, but whether we like it or not, the transition is happening . . . We firmly believe that there does need to be a transition to electric vehicles, but we're concerned that that transition is going to be a continuation of this endless race

²¹Transcribed from *Odd Lots*, "What the UAW wants from its fight with the Big Three." August 7th, 2023 (40:20): <https://omny.fm/shows/odd-lots/what-the-uaw-wants-from-its-fight-with-the-big-thr>.

²² Southwest Detroit neighbors Dearborn.

²³ Zug Island has long supplied purified coal to furnaces run by Cleveland-Cliffs and US Steel. The Biden administration sued the operator in 2022 for allegedly violating the federal Clean Air Act ([Singer 2022](#); [Gallucci 2023](#)).

²⁴ Quoted in [Criste n.d.](#)



to the bottom of wages. So, it's going to require less jobs. We know that. What we want to see . . . as we transition into electric vehicle manufacturing is that these jobs fall under UAW master agreements, which gives us job security, which allows our more senior members, if they so desire, to transfer into these jobs, and that the wages . . . mirror the wages that we make in the internal combustion engine manufacturing.

Where we have concerns is that there is massive investment going into these facilities—taxpayer dollars and investment . . . The Energy Department just loaned \$9.2 billion to Ford to build battery plants in the South—in right-to-work states—and the Biden administration didn't require any sort of guarantees that those jobs be UAW jobs or be any union jobs at all . . . They basically just said 'Hey Ford please be nice to these workers and let them have a vote if you feel like it' . . . We don't find that acceptable. We're willing and ready to work with these companies to assist in the transition to an electric future, as long as there is equity in those jobs and they allow us wages that we can maintain middle-class lifestyles. I don't think anything about that is a huge ask. (Vicente 2023)²⁵

While the UAW has not made similar explicit statements about the green *steel* transition, it is not unreasonable to infer from this message about the automotive industry that UAW's vision for steel would follow a similar logic: realistic acceptance and support for a green transition—provided strong labor standards and opportunities are guaranteed. Labor support for steel decarbonization also appears to extend beyond national boundaries: In October 2023, workers from the steel and aluminum industries in the US and Europe joined forces to demand a successful conclusion of the Global Arrangement on Sustainable Steel and Aluminum (GASSA) (IndustriALL 2023). Indeed, restricting the US market to clean steel products could offer a major incentive for Cleveland-Cliffs and other producers to decarbonize (Stiglitz, Tucker, and Estevez 2022).

However, the concurrence of viable technological pathways, government support, community demands, and labor support has not yet proven powerful enough to persuade the most critical actors—Cleveland-Cliffs' leadership and owners²⁶ (Appendix II), and what are likely the most influential purchasers of steel from Dearborn Works: the Big Three Detroit automakers—Ford Motor Company, General Motors, and Stellantis N.V.²⁷

²⁵ Transcribed from *Odd Lots*, "What the UAW wants from its fight with the Big Three." August 7th, 2023 (36:16-44:15): <https://omny.fm/shows/odd-lots/what-the-uaw-wants-from-its-fight-with-the-big-thr>.

²⁶ Its owners include major institutional investors like Vanguard and Blackrock, which own 20 percent of the company (Appendix II).

²⁷ Formerly Fiat Chrysler Automobiles.



Due to the auto sector's influence over the steel sector (over a third of Cleveland-Cliffs' revenue comes from direct automotive sales ([Cleveland-Cliffs, Inc. 2023](#)), the Big Three have come under increasing scrutiny and pressure from activists to decarbonize their supply chain, including steel inputs. This includes the formation of a [coalition](#) of environmental, human rights, and other public interest groups that have sought to secure commitments for disclosures and target setting. As of October 2023, advocates continued to view the automakers' steel decarbonization commitments with dissatisfaction. According to Erika Thi Patterson of Public Citizen's auto supply chain campaign, "What we really need automakers to do is start setting steel-specific decarbonization goals and disclosing those goals, so we can hold them accountable" ([Gallucci 2023](#)). In their campaigns, advocates have often made the case for the economic viability of a transition to green steel, pointing both to the soaring profits of the Big Three ("From 2013 to 2022, the automakers [collectively raked in \\$250 billion](#) of profit, and in the last four years alone, workers watched CEO pay at Ford, GM, and Stellantis [shoot up](#) by 40%" [[Thi Patterson 2023](#)]), and to the minimal impact of a green steel premium on production costs: According to BloombergNEF, even a 25 percent increase in the price of steel would raise vehicle production costs by only 1 percent ([Gallucci 2023](#)).

In Dearborn, residents and advocates have called on Cleveland-Cliffs to refrain from relining its blast furnace—a relining would extend its life by an estimated 18 years—and instead commit to a robust plan for green industrial transformation, including a transition from to DRI and EAF—based production to achieve near-zero CO₂ emissions ([Criste n.d.](#)). Though no such commitments have been made at either Dearborn Works or other facilities, their absence has not prevented Cleveland-Cliffs from charging green premiums. As CEO Lourenco Goncalves explained in the company's October 2023 earnings call, Cleveland-Cliffs has already successfully implemented one "green" surcharge and has plans to introduce another:

As for our annual automotive negotiations, our October 1st renewals, which represent about 30% of our total annualized auto volumes, were another success. We held onto important volumes and did not take any price decreases. In fact, in these negotiations, we're successful in implementing the "Cliffs H" surcharge that we discussed last quarter. As a reminder, "Cliffs H" represents the premium we charge for supplying our customers in the United States with steel produced with close to 30% scrap in our base oxygen furnaces and using HBI [hot briquetted iron] in our blast furnaces . . . While "Cliffs H" is a very important first step in decarbonizing the production of sophisticated grades of steel, earlier this month we saw the most consequential step forward in advancing to the "Cliffs H2" phase in which we will implement the use of hydrogen as reductant in our blast furnaces. ([Goncalves 2023](#))



Goncalves went on to explain that the "CliffsH2"²⁸ phase involved the introduction of hydrogen into the iron reduction process, while sticking to the Blast-BOF model. Specifically, the plan involves procuring hydrogen from the Midwest Hydrogen Hub led by the [Department of Energy—backed](#) Midwest Alliance for Clean Hydrogen (MachH2), which counts Cleveland-Cliffs among its key members (according to Goncalves, "Cliffs' commitment to buy a large portion of the output from the Midwest hub helped get this location selected by the Department of Energy . . . [O]ur commitment of a significant offtake ultimately makes the hub viable, as we solved the chicken and egg dilemma").

Cleveland-Cliffs plans to begin displacing coke with hydrogen in the reduction process in two trial sites: Middletown (where a trial is already ongoing) and Indiana Harbor 7. However, although according to Goncalves the company does not yet know the extent of emissions reductions made possible by these changes, it is clear that "EAFs will continue to generate less CO₂ than the current route" and the extent of the potential to replace coke with hydrogen remains unclear.²⁹ He nonetheless suggests that EAF production is unable to produce certain high-quality steel "that comes with blast furnace/basic oxygen furnace steel making" ([Goncalves 2023](#))—a statement that others have contested. High-grade steel, free from impurities, is very likely necessary for certain applications—like automotive, which require high predictability of performance in adverse circumstances—and currently EAF facilities in the US that use recycled steel as input cannot guarantee that quality. But there is no reason to think that DRI-EAF production of primary steel would be subject to the same limitations, since it would allow for quality control of iron inputs. In fact, according to the International Iron Metallurgy Association, direct reduced iron facilities are able to produce iron with the low levels of residuals needed for automotive applications ([International Iron Metallurgy Association 2017](#)).³⁰

Cleveland-Cliffs' resistance to ambitious decarbonization commitments is difficult to justify in the context of new government support for decarbonization (Table 1) and what appears to

²⁸ Speaking of the \$9 million capital expenditure needed to pipe hydrogen into the Indiana Harbor 7 plant, Lourenco Goncalves stressed, "Don't forget, we are not doing this for free. We are going to pass this cost to the clients in the form of the 'Cliffs H2,' like we're doing the 'Cliffs H.' If clients really want green steel, and I believe they do, they should be willing to pay, and they should be willing to pass along to the consumer or their end users, whatever. We can't just keep talking about this thing as a theoretical exercise. It sounds like everybody's praying for this thing to just go away. This thing is not going away" ([Goncalves 2023](#)).

²⁹ "Carlos De Alba: Sure. It is just, what is the technical level or limit to which you can replace coke with hydrogen? Lourenco Goncalves: Yeah. That's a question I don't have an answer yet" ([Goncalves 2023](#)).

³⁰ The IIMA is a global industry association whose members account for over 80 percent of production and international trade in ore-based metallurgy (pig iron, hot briquetted iron, direct reduced iron, granulated pig iron).



be a moment of unprecedented financial prosperity for the company. Publicly available information does not allow for the identification of revenues specific to Dearborn Works, but the value captured by Cleveland-Cliffs overall is public—and substantial. An October 2023 assessment of the company's financials by CFO Celso Goncalves is revealing:

In Q3, we generated revenues of \$5.6 billion, adjusted EBITDA³¹ of \$614 million . . . During the quarter, we generated free cash flow of \$605 million . . . [W]e used the majority of that cash to pay down our ABL,³² bringing our net debt down to \$3.4 billion and boosting our total liquidity up to an all-time high of \$4.4 billion. We also returned approximately \$60 million to shareholders by buying back 3.9 million shares, during the quarter. ([Goncalves 2023](#))

In January 2024, after losing to Nippon Steel in its bid to acquire US Steel, Celso Goncalves announced Cleveland-Cliffs' intention to engage in more aggressive share buybacks, alluding to \$600 million remaining in its existing share repurchase program: "Going forward, share buybacks are now the number one priority . . . [O]ur current liquidity [is] above \$4.5 billion, the highest level in our company's history" ([Goncalves 2024](#)).

Viewed from a public interest perspective, the benefits accruing to Cleveland-Cliffs' shareholders in the planned shared buybacks represent enormous opportunity costs³³: The liquidity used for share buybacks could instead be used for investments in decarbonization and pollution reduction to mitigate the negative impacts of the industry on the community and the climate. For comparison, the construction on the DRI-EAF HYBRIT facility in Sweden is being financed with a loan of 3.1 billion SEK (around \$300 million [[Algers 2024](#)]), which is half the remaining amount of Cleveland-Cliffs' share repurchase program of \$600 million and a fraction of the company's historic liquidity of \$4.5 billion—resources that could also be combined with the billions of decarbonization dollars made available by the IRA and IIJA (Table 1).

Cleveland-Cliffs' enduring reluctance to set the course for a green steel transition despite existing government support and pressure from civil society actors suggests that governments should explore more aggressive policy actions. Measures like nationalization or the creation of new public or worker-owned enterprises may be an efficient means of driving steel decarbonization forward. And as federal, state, and local governments consider policy measures to expedite a green steel transition, they can learn from the historical and comparative experiences. The US has a long track record of nationalizations and public

³¹ Earnings Before Interest, Taxes, Depreciation and Amortization.

³² Asset-based lending.

³³ See [Palladino and Estevez 2022](#) for a longer discussion about risks of shareholder primacy.



ownership—including in the steel sector (Aronoff 2024; [Lohr 2008](#))—and, due to the strategic importance of steel, many leading producers today are state owned companies (Table 1). As development economist Ha-Joon Chang points out, after WWII European countries contributed to their industrial development by transferring certain industrial properties from a "non dynamic industrial capitalist class to professional public-sector managers with a penchant for modern technology and aggressive investments" (Chang 2002, 83). Today the Swedish state's ownership in key firms has been a key enabler of its leadership in iron and steel decarbonization ([Algers 2024](#)). Growing leadership of workers and organized labor in the green transition also points to what may be an unprecedented opportunity to develop innovative governance and ownership structures that depart from historical precedents and create the conditions for a steel policy more rooted in worker and community demands and priorities.

III. Conclusions and Policy Recommendations

As we've shown in the preceding analysis, the prospect of a green steel transition in Dearborn faces several challenges: Community fears of economic instability; the lack of renewable energy infrastructure to produce green hydrogen; community fears about pollution associated with new technologies; and corporate inertia, evidenced in Cleveland-Cliffs' reluctance to adopt the cleanest available production methods and its preference for marginal changes over the significant shifts embraced by European competitors.

At the same time, our analysis also points to several opportunities to surmount those obstacles. These obstacles are far from particular to Dearborn and its decarbonization prospects, and many of the solutions are likewise generalizable to broader industrial policy goals and to other communities seeking to solve trade-offs and balance power among stakeholders in the pursuit of a rapid, equitable green transition.

Community fears of increased economic insecurity pose an opportunity as much as a challenge. Deindustrialization has taken its toll on Dearborn and uncertainty about the implications of a green steel transition has understandably raised concerns about the potential for further loss of high-wage jobs and tax revenue. However, research suggests that a green steel transition is likely to bring more, rather than less, economic security. And, to the extent that governments guarantee the maintenance of jobs and labor standards in a green transition (which they have struggled to do in the automotive sector), concerns about economic security are likely to be significantly mitigated. Furthermore, governments at all levels have the opportunity to play a transformative role by going beyond industry-specific



"green steel" policies to enable the development of a broader worker- and community-led industrial policy for economic revitalization.

The supply bottleneck created by a lack of renewable energy infrastructure can likewise be solved with activist industrial policy that matches the scale of the problem. Without sufficient renewable energy at hand it is not possible to produce the green hydrogen required for an immediate transition to the cleanest available methods of steel production. State and federal governments can correct this bottleneck by ensuring the availability of resources, planning capabilities, and productive capacity for a swift renewable energy build-out. There are various pathways for achieving this, ranging from clear conditionalities that require the owners of federally backed hydrogen hubs to build renewables capacity and greater use of the Defense Production Act, to deploying existing government productive capabilities to build renewable capacity directly, at warp speed—whether by deploying the Army Corps of Engineers or creating new public companies that provide attractive job training and transition programs and guarantee access to family-sustaining union jobs building renewable energy capacity.

Solving the renewable energy bottleneck and upholding guardrails can also assuage community fears about pollution associated with new steel technologies. The close association of some nascent steel decarbonization pathways with hydrogen production that may worsen pollution has added to skepticism stemming from past disappointments with enforcement of pollution controls, harmful zoning decisions that led to polluting facilities being sited immediately next to people's homes, and general failure to keep industry accountable to community demands. To build trust with community members, governments at all levels will have to uphold environmental and equity guardrails to ensure that the steel transition is lowering emissions and considering environmental justice concerns on par with decarbonization objectives. Ensuring that the green steel transition is, in fact, green can help increase community buy-in and build momentum.

Perhaps the most critical opportunity to expedite a green steel transition lies in increased collaboration between social actors to create an effective counterweight to Cleveland Cliffs' corporate inertia and its prioritization of short-term private gain over the public interest. Despite its historic levels of liquidity and the availability of new public funding for decarbonization, Cleveland-Cliffs appears to be committed to maintaining current production methods, making only minor decarbonization investments while charging "green premiums" for marginal changes and engaging in aggressive share buybacks. Soon, the company will have to decide whether to reline its Dearborn Works blast furnace, prolonging its model for an estimated 18 years, or to transition to the hydrogen-based DRI-EAF model preferred by community and climate advocates. To date, there is no indication that the company will opt for the latter. This suggests that breaking Cleveland-Cliffs' corporate



path-dependency will require greater collaboration between social actors that favor a green steel transition and more aggressive action from governments to tip the scales. Measures like the nationalization of facilities like Dearborn Works, transfer of ownership to workers, or construction of new, state-of-the-art or first-in-kind public or worker-owned green steel facilities, could also be used to speed up the transition and better align the trajectory of the steel industry with the public interest, rather than short-term private gain.

None of this is unrealistic. The government already has a wide range of tools at its disposal to equitably decarbonize the steel sector (Table 1). And, although Europe continues to outcompete the US in terms of public investment in steel decarbonization ([Industrious Labs and Public Citizen 2024](#)), the Inflation Reduction Act, the Infrastructure Investment and Jobs Act, the federal government's Buy Clean initiative, and the Clean Air Act, to name a few, constitute a powerful toolbox. This means that—with the support of local, state, and federal governments—an equitable green steel transition is within reach for communities like Dearborn, in which local leadership has already built the foundation for transformative change.



Appendix I. Partial List of Industrial Facilities in Dearborn, MI

| Table 2. Partial List of Industrial Facilities in Dearborn, MI | |
|--|---|
| Dearborn Works Steel Mill | <p>Cleveland-Cliffs bought the plant from AK Steel in 2020 (AK Steel had bought it from Severstal in 2014). It was previously owned by Rouge Steel (1989–2004) and Ford, which built the plant and began operations in 1926.</p> <p>Dearborn Works has one blast furnace, which was fully rebuilt in 2007. The mill is one of the only operational US steel plants with a single blast furnace.</p> <p>Dearborn Works operations include carbon steel melting, casting, cold-rolling, and finishing operations for carbon steel. In addition to the blast furnace and basic oxygen furnaces, the facility includes two ladle metallurgy furnaces, a vacuum degasser, two slab casters, a pickling line tandem cold mill and a hot-dipped galvanizing line.</p> <p>Markets served: automotive, heating, ventilation, air conditioning, converters, and distribution</p> <p>Estimated blast furnace production vs. capacity: 1.84 mtpa to 2.5 mtpa (74 percent of capacity).</p> <p>Estimated crude steel production vs. capacity: 2.0 mtpa to 3.0 mtpa (67 percent of capacity).</p> <p>Likely Coke Source: DTE Energy's EES Coke on Zug Island.</p> <p>Estimated workforce size: 1,290.</p> <p>Products: carbon slabs, hot-dipped galvanized (HDG) steel, and advanced high-strength steels (AHSS).</p> |
| EES Coke on Zug Island | <p>EES Coke, a subsidiary of DTE Energy, processes metallurgical coal into coke, a fuel used to make steel in blast furnaces. Coke ovens release known health-harming carcinogens and hazardous air pollutants, including lead, mercury, and benzene. According to available data, coke ovens are responsible for more than 40 percent of carcinogens in the blast furnace steelmaking process.</p> <p>EES Coke ranks second in Michigan for sulfur dioxide and particulate matter emissions among industrial emitters, excluding power plants. The Biden administration filed a lawsuit against the company in 2022 because it violated the Clean Air Act by increasing sulfur dioxide emissions by 1,000 tons above the allowed baseline without applying for permits or installing pollution controls.</p> |
| Carmeuse Lime | <p>Carmeuse Lime makes lime, one of the three primary inputs into a blast furnace for steelmaking. This facility is owned by a privately held Belgian company, a global lime and limestone product manufacturer.</p> <p>It is the state's 11th-highest emitter of SO₂ and NO_x.</p> |
| Great Lakes Steel | <p>Great Lakes Steel, owned by US Steel, permanently idled its blast furnace and basic oxygen furnaces in 2020. It is estimated that around 1,000 workers lost their jobs in this shutdown. The plant still does steel finishing work, such as cold-rolling.</p> |



| | |
|--|--|
| | Before the furnaces were idled, Great Lakes Steel was one of the worst environmental offenders in the region. From 2003 to 2007, US Steel violated the National Pollutant Discharge Elimination System permits at its Great Lakes Works facility over 170 times. |
| Dearborn Industrial Generation | Dearborn Industrial Generation (DIG) is a 770-megawatt (MW) methane gas power plant across the street from Ford Motor Company's Rouge Complex. DIG fulfills heating and processing needs for Ford Motor Company, Cleveland-Cliffs, and other nearby industrial facilities. It is Wayne County, MI's #1 source of CO ₂ -e emissions. |
| Ford Rouge Complex | The Ford Rouge Complex is an industrial park that houses Ford Motor Company's largest factory, employing approximately 6,000 workers . This is where Ford manufactures its F-150 Lightning electric truck. In addition to Ford's auto manufacturing operations, the Ford Rouge Complex houses Cleveland-Cliffs Dearborn Works. |
| Dearborn Engine and Fuel Tank Plant | This plant, opened in 1941 , currently employs approximately 445 employees and focuses on producing 2.0-liter I4 GDI engines. |
| Dearborn Tool and Die ³⁴ Plant | Established in 1938 , this facility currently has about 271 employees and is involved in tooling, without direct production. |
| Dearborn Diversified Manufacturing Plant | With approximately 773 employees, this plant, operational since 1942 , produces suspension parts, truck axles, stampings, tires and wheels, frames, and more for F-series and Super Duty trucks. The site is 27 acres large. |
| Dearborn Stamping | This plant, which opened in 1939 , has around 1,658 employees and is involved in stamping outer and inner commodities.. |
| Edw. C. Levy Co. | The Edw. C. Levy Co. transports and processes slag from Dearborn Works to make other products, such as concrete. The Levy Co. transports this slag from Dearborn Works through residential neighborhoods and stores it in uncovered mountains at their Dix Avenue location. It's a significant source of particulate matter and fugitive dust emissions. |
| Sources: Industrious Labs 2023; Cleveland-Cliffs n.d. ; UAW Local 600 n.d. ; Ford n.d. | |

³⁴ A "die" is a machine used to shape materials.



Appendix II. Ownership Structure of Cleveland-Cliffs³⁵

Top Institutional Holders

| Holder | Shares | Date Reported | Percent Out | Value |
|-------------------------------------|------------|---------------|-------------|-------------|
| Vanguard Group Inc | 50,822,378 | Jun 29, 2023 | 10.07% | 855,340,617 |
| Blackrock Inc. | 50,139,345 | Sep 29, 2023 | 9.93% | 843,845,172 |
| State Street Corporation | 21,773,942 | Jun 29, 2023 | 4.31% | 366,455,442 |
| Fisher Asset Management, LLC | 7,992,483 | Jun 29, 2023 | 1.58% | 134,513,488 |
| Geode Capital Management, LLC | 7,813,265 | Sep 29, 2023 | 1.55% | 131,497,249 |
| FMR, LLC | 6,817,729 | Jun 29, 2023 | 1.35% | 114,742,378 |
| Dimensional Fund Advisors LP | 6,561,842 | Sep 29, 2023 | 1.30% | 110,435,800 |
| Morgan Stanley | 6,310,013 | Jun 29, 2023 | 1.25% | 106,197,518 |
| Bank Of New York Mellon Corporation | 5,146,344 | Sep 29, 2023 | 1.02% | 86,612,969 |
| Neuberger Berman Group, LLC | 4,051,028 | Jun 29, 2023 | 0.80% | 68,178,800 |

Top Mutual Fund Holders

| Holder | Shares | Date Reported | Percent Out | Value |
|--|------------|---------------|-------------|-------------|
| Vanguard Total Stock Market Index Fund | 16,085,586 | Jun 29, 2023 | 3.19% | 270,720,411 |
| iShares Core S&P Midcap ETF | 15,909,151 | Sep 29, 2023 | 3.15% | 267,751,010 |
| Vanguard Small-Cap Index Fund | 13,297,964 | Jun 29, 2023 | 2.63% | 223,804,733 |
| Vanguard Small Cap Value Index Fund | 9,214,709 | Jun 29, 2023 | 1.83% | 155,083,551 |
| Vanguard Extended Market Index Fund | 7,111,278 | Jun 29, 2023 | 1.41% | 119,682,808 |
| SPDR (R) Ser Tr-SPDR (R) S&P (R) Metals & Mining ETF | 4,989,531 | Sep 29, 2023 | 0.99% | 83,973,806 |
| SPDR S&P Mid Cap 400 ETF Trust | 4,168,208 | Sep 29, 2023 | 0.83% | 70,150,940 |
| Pacer US Cash Cows 100 ETF | 3,971,807 | Jul 30, 2023 | 0.79% | 66,845,511 |
| IShares S&P Midcap 400 Value ETF | 3,180,753 | Sep 29, 2023 | 0.63% | 53,532,072 |
| Fidelity Extended Market Index Fund | 2,668,951 | Aug 30, 2023 | 0.53% | 44,918,445 |

³⁵ Source: Yahoo!Finance (2023).



Insider Roster

| Individual or Entity | Most Recent Transaction | Date | Shares Owned as of Transaction Date |
|---|-------------------------|--------------|-------------------------------------|
| Robert P. Fischer , Director | Stock Award(Grant) | Oct 01, 2023 | 189,026 |
| William K. Gerber , Director | Stock Award(Grant) | Apr 25, 2023 | 137,578 |
| Celso Goncalves Jr. , CFO | Purchase | Apr 30, 2023 | 237,727 |
| Lourenco Celso Goncalves , CEO | Purchase | Apr 26, 2023 | 5,464,880 |
| Susan Miranda Green , Director | Stock Award(Grant) | Apr 25, 2023 | 96,786 |
| Keith Koci , Officer | Purchase | Apr 26, 2023 | 383,358 |
| Ralph S. Michael III , Director | Purchase | May 01, 2023 | 171,840 |
| Janet L. Miller , Director | Stock Award(Grant) | Oct 01, 2023 | 93,185 |
| Gabriel Stoliar , Director | Stock Award(Grant) | Oct 01, 2023 | 250,002 |
| Arlene M. Yocum , Director | Purchase | Apr 27, 2023 | 83,454 |



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