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Wisconsin's Electric Vehicle/Electrification Supply Chain Strategy

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Table of Contents

Definitions

The following table provides a list of definitions for common terms used in this report. For further detail, please refer to the Methodology section in *Appendix A*: *Methodology*.

Term	*Definition*
Electric Vehicle (EV)	An automobile that is powered entirely or partially by electricity from a battery that requires recharging.
Internal Combustion Engine (ICE)	An engine that generates motive power by the burning of gasoline, oil, or other fuel with air inside the engine. In this report, gas-powered automobiles are referred to as ICE-powered vehicles, and suppliers which predominantly manufacturer parts and components for internal combustion engines are referred to as ICE-dependent suppliers.
Automotive Manufacturer	Manufacturers which produce automobiles or automotive components, parts, and materials for both EV and ICE-powered vehicle markets. In this report, automotive manufacturers are grouped into three categories based on their role in the automotive supply chain: upstream suppliers, parts manufacturers, and original equipment manufacturers.
Upstream Supplier	Manufacturers which supply basic components to firms further down the automotive supply chain. Firms in this category include metal fabrication shops, plastics molding businesses, and iron and steel forgers.
Parts Manufacturer	Manufacturers which assemble basic components from upstream suppliers into more complex automotive parts and systems.
Original Equipment Manufacturer (OEM)	In this report, original equipment manufacturers refer to firms which produce complete automotive vehicles, typically through the assembly of parts and components supplied by manufacturers further upstream on the supply chain.
Tier 1 Supplier	Suppliers of products and components directly to OEMs. In the context of this report, Tier 1 suppliers are a subset of Parts Manufacturers.
Productivity	A measure of the amount of goods produced (output) given the resources used in production (input), such as labor or machinery. Productivity is an important measure of business and industrial competitiveness.
Automation	A term used to describe a wide range of technologies that reduce human intervention in processes.
Upskilling	Workforce training which emphasizes the acquisition of skills related to up-to-date technologies and practices.

Executive Summary

The advent of electric vehicles (EV) is spurring the automotive industry to undergo a profound transformation. In a world where oil is a limited resource and concerns are rising over the environmental impact of its use, demand for EVs is growing. Global carmakers are responding by shifting the focus of their production from traditional automobiles, powered by the internal combustion engine (ICE), to EVs. The implications of this shift will be felt throughout the automotive supply chain, and companies that manufacture and supply ICE components and materials will be significantly affected by this transition.

As a state with a rich manufacturing legacy, Wisconsin is home to a large and diverse automotive sector comprising firms that supply raw materials for the automotive industry, manufacturers that produce automobile parts, and original equipment manufacturers (OEMs) that assemble these parts into complete vehicles. However, with the ongoing transition by carmakers toward EV supply chains, there is a need to understand how the EV transition will affect Wisconsin's automotive sector and to identify the types of companies that will most likely be disrupted by the transition. To develop this understanding and to craft a strategy for Wisconsin's manufacturers to become integral players in the rapidly growing EV market, the Wisconsin Economic Development Corporation hired SRI International to engage with stakeholders throughout industry, academia, and government, conducted extensive quantitative data analysis, and to design a long-term industry transition strategy.

As this report will show, there is a tremendous opportunity for Wisconsin to develop a globally competitive cluster centered on the manufacturing of EVs and EV-related equipment, which in turn can help revitalize Wisconsin's automotive manufacturing industry and drive statewide economic development. However, realizing this goal involves addressing broader challenges in Wisconsin's manufacturing sector, including below-average productivity and a shortage of qualified workers. Concurrently, the state will need to strengthen innovation and entrepreneurship around electrically powered technologies, and it will need to prepare the infrastructure and regulatory framework that enables widespread EV adoption.

Institutional assets in Wisconsin have considerable depth and breadth, and they all play a role in the development of the state's economy and communities. For Wisconsin to develop a thriving and dynamic EV manufacturing cluster, the state will need to mobilize its immense base of assets and coordinate its activities and investments in a way that produces sustainable growth conditions for the industry. Thus, enhanced collaboration between institutions throughout government, industry, and academia to implement the recommendations outlined in this report will be a defining feature of the work ahead. To this end, the vision statement below provides a unifying idea that captures the ambitions of Wisconsin's stakeholders:

To have a dynamic and inclusive manufacturing ecosystem that engages local talent, cultivates innovation, and supports statewide electrification efforts.

The following six strategies and their associated action items will achieve this vision through concrete steps to be taken by stakeholders in Wisconsin's manufacturing and economic development ecosystem. These strategies and actions are discussed in detailed in the section *Wisconsin's Path Forward*.

Strategy 1: Enhance Productivity through Automation and Upskilling

Action Item 1.1: Refocus incentive programs to encourage and support productivity-enhancing capital investments by existing manufacturers.

Action Item 1.2: Strengthen cooperative efforts between the Wisconsin Economic Development Corporation and organizations with technical assistance capabilities, such as the Wisconsin Center for Manufacturing & Productivity, to develop and administer joint programs supporting manufacturers.

Action Item 1.3: Launch a manufacturing accelerator program for small and/or rural manufacturers in partnership with organizations such as the Wisconsin Small Business Development Center, the Wisconsin Center for Manufacturing & Productivity, and other stakeholders.

Action Item 1.4: Establish technology demonstration centers that enable manufacturers to learn about, experiment with, and pilot new technologies and practices.

Action Item 1.5: Mobilize Wisconsin's industrial automation and power electronics providers to boost productivity for under-resourced manufacturers and to accelerate their transition to EV supply chains.

Action Item 1.6: Deepen engagement with rural counties whose economies are highly dependent on manufacturing.

Strategy 2: Scale Up the Middle-Skill Workforce Pipeline

Action Item 2.1: Establish and maintain relationships with technical colleges that (1) boost enrollment in programs that are in high demand by manufacturers and (2) direct talent to fill high demand positions.

Action Item 2.2: Develop and launch a basic mechanical aptitude program to evaluate the skill level of job seekers, based on skills and needs identified by the industry.

Action Item 2.3: Remove barriers to labor force participation and increase job access for individuals who are not currently in the workforce.

Action Item 2.4: Improve perception of manufacturing occupations by launching a Made in Wisconsin marketing campaign.

Action Item 2.5: Incentivize manufacturers implementing automation and other productivity-enhancing measures to invest in workforce upskilling.

Strategy 3: Improve Manufacturers' Access to Regional, National, and Global Markets

Action Item 3.1: Assist manufacturers in obtaining automotive industry certifications.

Action Item 3.2: Develop interoperability standards for EV components and EV charging equipment manufacturing.

Action Item 3.3: Partner with the Wisconsin Supplier Diversity Program to facilitate supplier relationships with Minority-Owned, Service-Disabled-Veteran-Owned, and Woman-Owned businesses in the private sector.

Action Item 3.4: Strengthen supply chain relationships with nearby EV OEM plants through the establishment of an automotive industry liaison.

Strategy 4: Build Connections between Innovators and Industry

Action Item 4.1: Launch a manufacturing innovation consortium of university researchers to work on use-inspired projects alongside industry partners.

Action Item 4.2: Establish a "hard tech" entrepreneurial mentorship network that connects experienced entrepreneurs and investors to promising power electronics, mechanical engineering, and advanced manufacturing startups seeking to commercialize new technologies.

Action Item 4.3: Support international students, workers, and entrepreneurs in contributing to Wisconsin's EV ecosystem.

Strategy 5: Align EV Policymaking with Economic Development Interests

Action Item 5.1: Identify and pursue changes to electric system infrastructure to align with EV adoption increases.

Action Item 5.2 Coordinate EV infrastructure and manufacturing development with other Midwestern states

Strategy 6: Prepare for the Future of Mobility and Sustainability

Action Item 6.1: Explore opportunities to leverage Wisconsin's sand mining industry for novel applications in sustainability and mobility.

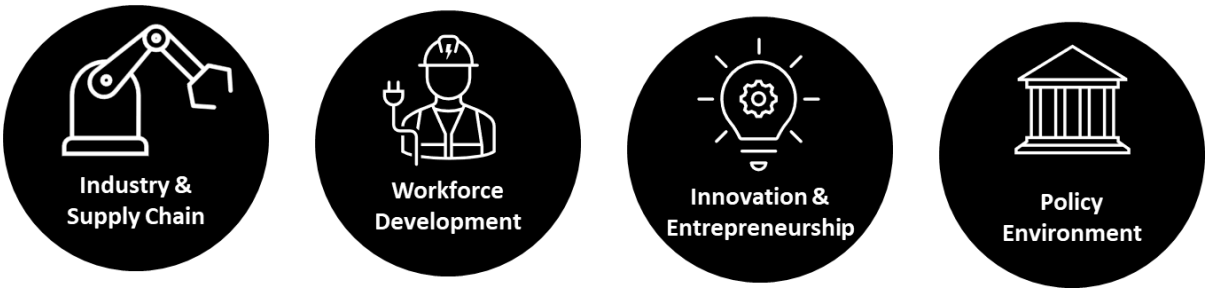
Action Item 6.2: Conduct long-range planning on the integration of emerging clean technologies and trends into Wisconsin's economy and communities.

Economic & Supply Chain Assessment

Introduction

Wisconsin's automotive manufacturing sector is one of its greatest economic assets. Composed of a diverse group of brand name original equipment manufacturers (OEMs), Tier 1 manufacturers, and firms further upstream, the sector employs over 92,000 workers and is closely tied to the rich economic and cultural legacy of Wisconsin manufacturing. However, as the world transitions from internal combustion engines to electric vehicles and electrically powered technologies in the coming decades, Wisconsin's automotive manufacturing sector is being challenged to reinvent itself to become part of the growing EV supply chain.

Within this context, the following report presents an economic and supply chain assessment of Wisconsin's automotive sector with a focus on identifying opportunities and challenges for the state as it seeks to transition its legacy automotive sector into a globally competitive EV cluster. While the supply chain portion of this assessment identifies elements within the sector at high risk of disruption due to the EV transition, the overall report establishes a broader understanding of Wisconsin's manufacturing and economic development ecosystem on which the sector's success ultimately depends. This understanding is driven by assessments of statewide dynamics in four key areas:



The analysis in this report uses both quantitative data collected from public and private sources as well as qualitative insights obtained from stakeholder interviews. Together, these data points paint a picture of an automotive manufacturing sector that has the potential to become a key economic development driver for Wisconsin. Yet, the sector also faces headwinds that are consistent with broader challenges in Wisconsin's manufacturing sector. A summary of these opportunities and challenges are presented below.

Upstream Suppliers Have Opportunities to Enter the EV Supply Chain.

Wisconsin's automotive manufacturers are predominantly concentrated in upstream industries. Firms in these industries are less at risk of disruption from the EV transition because the basic components they manufacture are used in both ICE and EV equipment as well as in other industries. Furthermore, many of these upstream suppliers, such as metal fabricators and plastics manufacturers, tend to be smaller businesses that can benefit from greater involvement in the EV supply chain.

Low Manufacturing Productivity Threatens Competitiveness.

Wisconsin's automotive manufacturers are, on average, notably less productive (as measured by output per worker) than the national average. The labor-intensive nature of many manufacturing operations makes the sector more vulnerable to skilled labor shortages and can potentially hinder manufacturers' ability to compete in the advanced manufacturing economy. Consequently, there is a serious need for investments in automation within Wisconsin's automotive sector.

Non-Metropolitan Areas Are More Vulnerable to Disruption from Supply Chain Shift to EV.

In Wisconsin, non-metropolitan and rural economies are more dependent on manufacturing than urban areas, and they are home to a greater share of ICE manufacturers that are more likely to be adversely impacted by the EV transition. As such, non-metropolitan economies are more vulnerable to both the EV transition and to broader changes in the manufacturing sector.

The Workforce Is Aging and There Is a Skilled Labor Shortage.

Wisconsin's automotive manufacturing workforce is aging, and pending retirements may exacerbate the shortage of skilled manufacturing workers in the state. At the same time, skill requirements for new manufacturing workers are becoming more demanding. Though the Wisconsin Technical College System has drastically scaled up enrollment in manufacturing-related certificate programs, training programs in automation and advanced manufacturing are still provided at the associate degree level. Enrollment in these programs, however, is relatively low due to higher costs and the time needed for program completion. To address the manufacturing worker shortage, technical colleges should consider additional strategies to scale up training programs in areas relevant to manufacturers' needs.

EV Innovation and Entrepreneurship Is Nascent but Growing.

Wisconsin's universities have not been as successful as their national peers in translating research and innovation into tangible economic growth. In the EV space, academic labs lack the resources to participate in large-scale collaborative research with industry partners, but stakeholders have recently taken steps to build closer partnerships with industry and to support applied EV research. In entrepreneurship, a lack of professional networks and connections was identified by stakeholders as the greatest challenge to building a critical mass in EV startups.

Opportunities Exist to Align EV Policymaking with Economic Development Interests.

Though Wisconsin policymakers are taking steps to develop a comprehensive EV framework, more can be done to frame EV policymaking in the context of the sector's economic development potential. For instance, there is an opportunity for the state's economic developers to place a greater program focus on incentivizing manufacturing automation and workforce training. At the same time, the state should consider additional actions that enable more businesses to participate in EV-related business activities, such as the operation of charging stations.

Vulnerability Assessment of Wisconsin's Automotive Manufacturers to the EV Transition

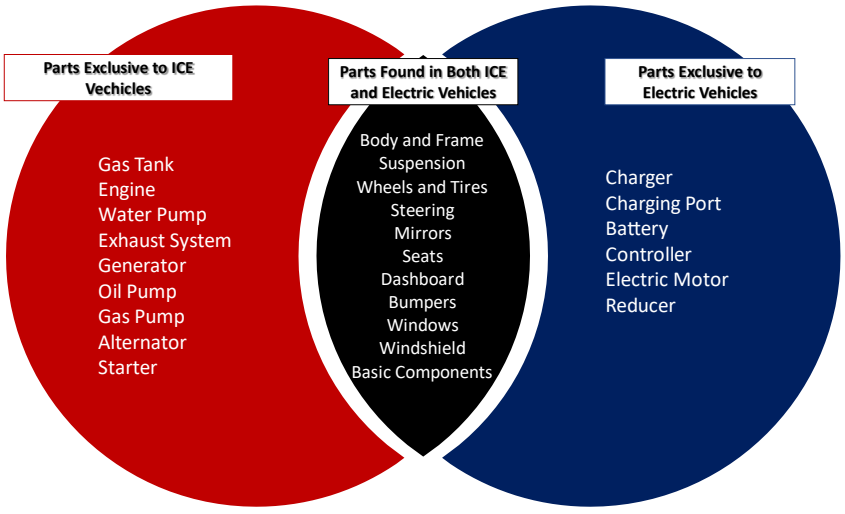
- Manufacturers' vulnerability to disruption from the EV transition is largely determined by dependence on the production of components specific to ICE-powered equipment and the diversification of product portfolios toward non-ICE technologies and industries.
- Because Wisconsin's automotive suppliers are heavily concentrated in industries that manufacture components for both ICE and EV products, the sector is relatively less vulnerable to disruption from the EV transition than downstream ICE-dependent suppliers.
- The overwhelming majority of automotive suppliers is in eastern Wisconsin, with more than half located in the Milwaukee area.
- Wisconsin's non-metropolitan areas are home to a disproportionate share of ICE-oriented manufacturers. As such, non-metropolitan areas are comparatively more vulnerable to the EV transition.

An Overview of ICE and EV Technologies

To assess how different types of automotive manufacturers will likely be affected by the transition to EV, it is necessary to first establish an understanding of how ICE and EV supply chains differ and how they are similar. More specifically, such an assessment requires an understanding of which components are used in both ICE-powered and electric vehicles and which components are used exclusively in one category of vehicles. Such an understanding will enable the identification of manufacturers whose business models depend on the manufacturing of ICE-related components and are therefore highly vulnerable to disruption from the EV transition. Similarly, it will allow for the identification of manufacturers that are well-positioned to capitalize on the EV transition due to their capability to produce EV-related parts and components. Because ICE-powered vehicles and electric vehicles share many of the same parts and components in areas outside of propulsion and powertrain systems, there is also a third category of manufacturers whose businesses are less at risk to the EV transition because their products are used in both types of vehicles.

Manufacturers That Depend on the Production of ICE-related Components Are More Likely to Face Disruption from the EV Transition

Figure 1: Illustration of Automotive Component Groups Commonly Found in ICE-powered and Electric Vehicles. Source: SRI research.

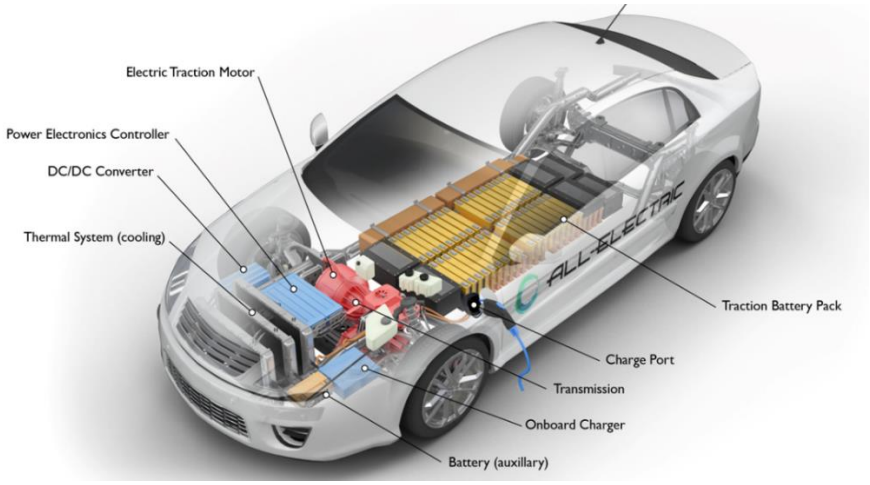


The ICE vehicle has approximately 30,000 parts that can be broken down into eight main categories: engine, fuel supply system, transmission system, chassis, cooling system, electrical system, braking system, and axles. These parts are supported by a complex chassis system and main frame that are often designed for a specific parts configuration, depending on the make and model. In addition to the complex chassis and main frame, an ICE-powered vehicle must house a fuel tank, exhaust system, smog controls, and other minor components.

Compared to ICE-powered vehicles, battery-powered electric vehicles (BEV) have a relatively simple design that consists of fewer components. While ICE powertrains typically use 2,000 moving parts to propel a vehicle forward, approximately 17 moving parts are required for an EV powertrain. However, BEV components tend to be much more technologically complex—and require a greater level of engineering, manufacturing, and software expertise—than traditional ICE-powered vehicles. Though other types of EVs such as hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) have varying designs, BEV components are generally divided into six main categories: electric motor, reducer, battery, on-board charger, the electric power control unit (EPCU), and the charge port (see *Figure 2)*. The battery consists of three additional parts: the battery cells, the battery management system, and the battery heating system. The EPCU can also be broken down into three constituent parts: the power inverter, the low voltage DC-DC converter (LDC), and the vehicle control unit (VCU).

Electric Vehicles Require Fewer Components to Assemble Than ICE-Powered Vehicles, but Components Are More Technologically Complex

Figure 2: Components of a Battery Electric Vehicle (BEV) Source: afdc.energy.gov



Although ICE-powered and electric vehicles vastly differ on components related to their respective propulsion and powertrain systems, the two platforms share similar suspension systems, steering mechanics, body frames, and interior components. Components in these categories can therefore be interchanged more easily, and manufacturers that supply these components are likely to experience less disruption from the EV transition. On the other hand, manufacturers that heavily depend on the production of ignition, transmission, fuel, exhaust, braking, and engine components are much more exposed to disruption risks as ICE vehicles lose market share to EVs.

Vulnerability of Wisconsin's Automotive Manufacturers to the EV Transition

The impact of the electric vehicle transition on Wisconsin's automotive manufacturers varies depending on the parts and components that these manufacturers produce. Some automotive manufacturers, especially those that supply raw materials or provide services such as machining,

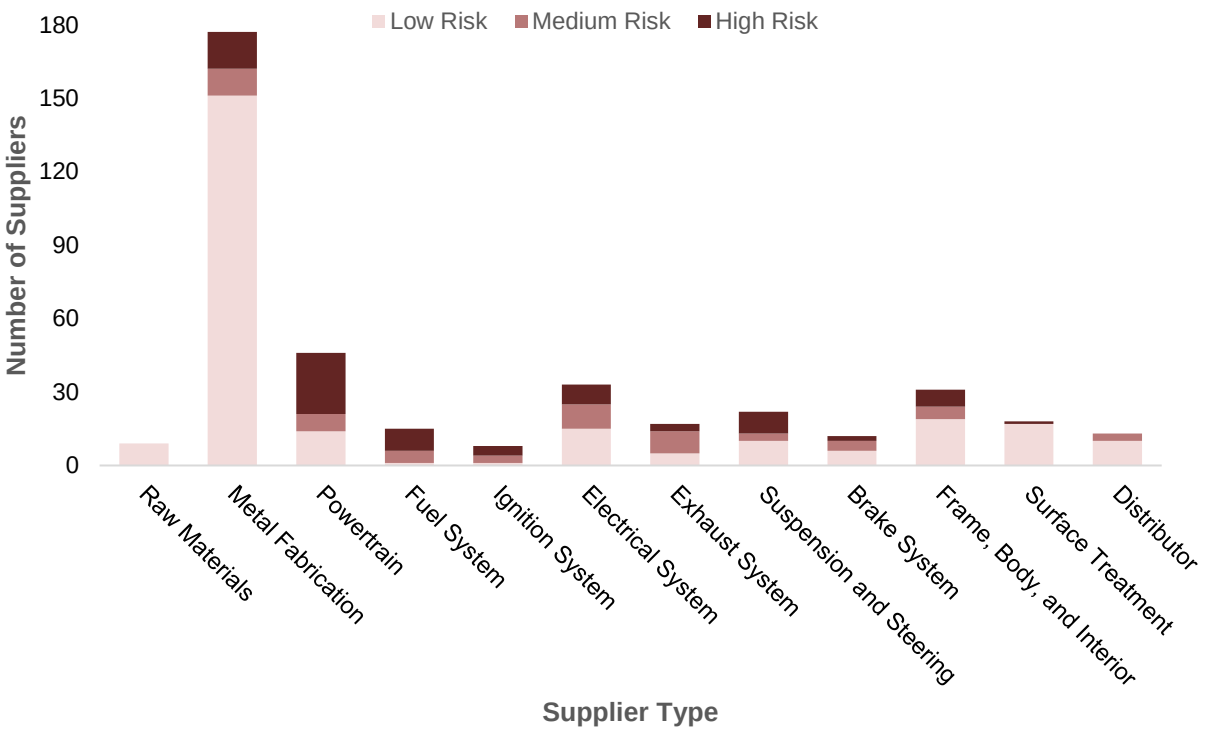
tooling, casting, stamping, and fabrication, are relatively less affected by the EV transition. On the other hand, manufacturers that produce parts for fuel, ignition, exhaust, and powertrain systems are at higher risk of being adversely impacted as automotive supply chains transition to EV. To measure this risk, SRI developed a classification system that places each automotive manufacturer at "low risk," "medium risk," or "high risk" to the EV transition based on the type of components produced as well as the diversity of the manufacturer's product portfolio. For instance, if a manufacturer supplies ICE-specific components but is well-diversified toward other industries, such a manufacturer would be considered less vulnerable to the transition (refer to *Appendix A: Methodology* for SRI's technical approach to assessing manufacturers' vulnerability).

Figure 3 shows the distribution of vulnerability categories, by the type of components produced, among the 253 Wisconsin automotive manufacturers and suppliers identified by SRI. Unsurprisingly, firms which produce fuel system parts and ignition system parts demonstrated the highest vulnerability to the EV transition. Other high-risk part categories include powertrain parts, exhaust system parts, electrical system parts, and suspension and steering system parts.

Upstream suppliers that provide machining, tooling, casting, stamping, and fabrication services are generally less at risk because they can more easily transition their product lines to support EV manufacturing. Raw materials suppliers, firms which provide surface treatment services, and wholesale automotive parts distributors are also at relatively low risk, as their products and services are applicable to EV manufacturing. Because most automotive manufacturers and suppliers in Wisconsin are located in upstream industries that are capable of serving both ICE and EV markets, Wisconsin's vulnerability to the EV transition is relatively low.

Upstream Suppliers Have Lower Risk of Being Adversely Impacted by the EV Transition Than Downstream Part Manufacturers

Figure 3: Distribution of Risk Scores by Manufacturer Type in Wisconsin, 2022. Source: SRI analysis of Marklines and ThomasNet data.



This assessment of automotive suppliers' vulnerability to the EV transition aligns with insights obtained from stakeholder interviews. While the similarities between ICE and EV vehicles may vary, downstream suppliers that specialize in parts manufacturing for ICE propulsion systems are at higher risk of disruption from the EV transition. For upstream suppliers that produce basic components out of raw materials, the EV market will likely represent new business opportunities as usage of ICE vehicles declines. However, it should be noted that this assessment only considers the risk of disruption to manufacturers and does not include an analysis of industries that service ICE vehicles, such as automotive repair and maintenance establishments.

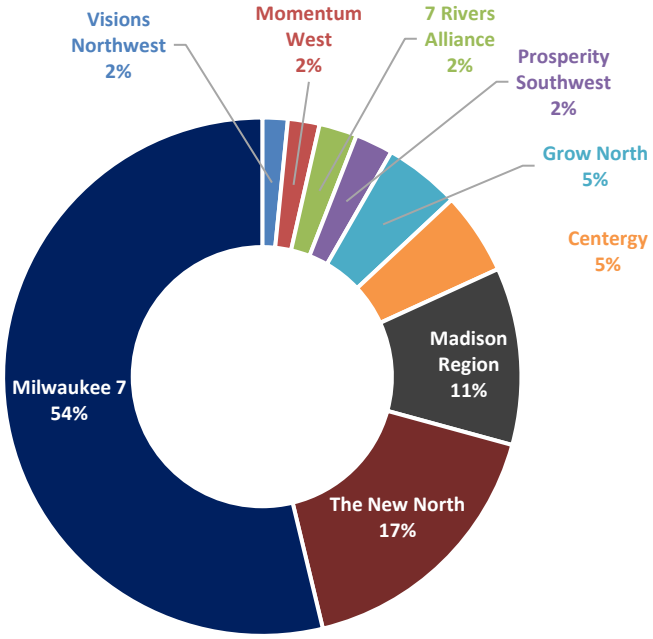
Geographic Distribution of Wisconsin's Automotive Suppliers

A geographic analysis of manufacturer locations within Wisconsin reveals additional insights about concentrated clusters of automotive manufacturing activity, disparities between metropolitan and non-metropolitan areas, and regions in which firms at high risk to the EV transition are located. These locational insights highlight the different roles that automotive manufacturing plays in various regions of the state and raises important equity and socioeconomic implications as Wisconsin develops its EV transition strategy.

Figure 4 shows the automotive manufacturing supplier distribution based on the nine regional economic development locations that are outlined by the Wisconsin Economic Development Corporation.[1] The name of each regional economic development location represents the name of the associated regional economic development partner organization. The majority of identified automotive manufacturers are in eastern Wisconsin, as represented by Milwaukee 7, New North, and the Madison Region Economic Partnership. The six remaining economic development regions represent just 18% of automotive manufacturing locations.

Majority of Automotive Manufacturing Suppliers Are Located in Eastern Wisconsin

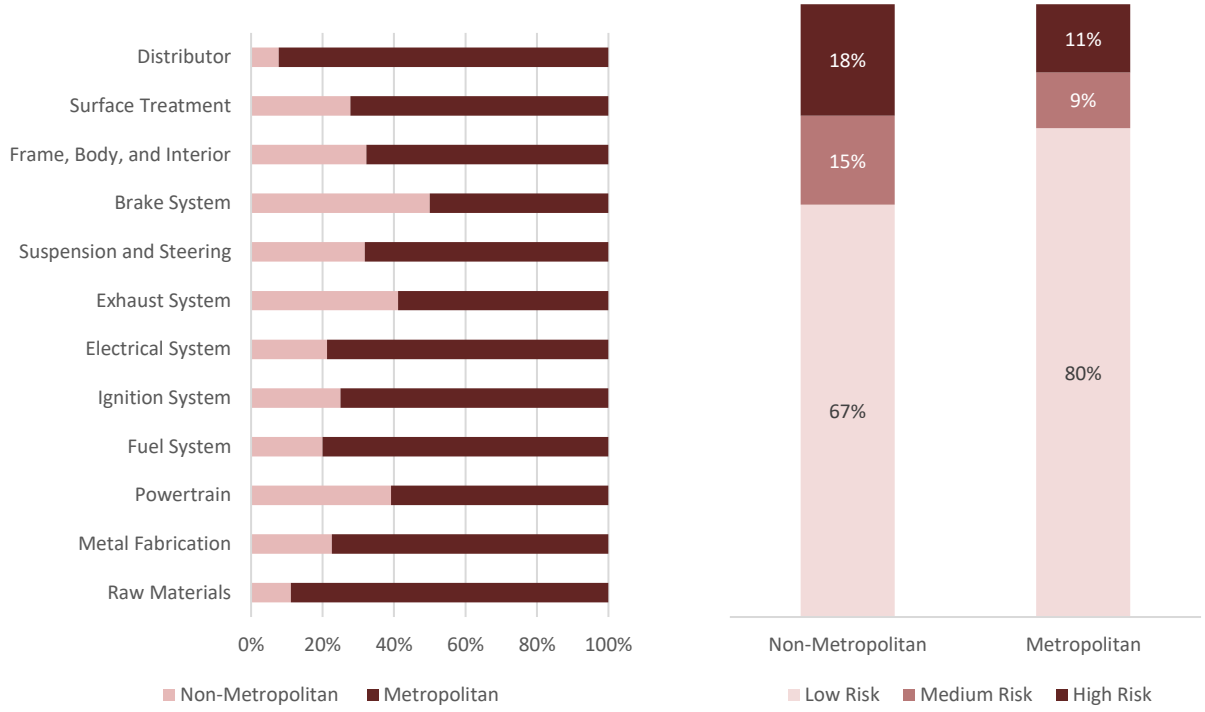
Figure 4: Wisconsin Automotive Manufacturers by Economic Development Region, 2022. Source: SRI analysis of Marklines and ThomasNet data.



Additionally, while it appears that most manufacturers across all parts categories are in metropolitan areas, some categories hold a greater presence in non-metropolitan areas. As *Figure 5* shows, there are large variations in the ratio of metropolitan to non-metropolitan areas across parts categories, with parts manufacturers of brake, exhaust, and powertrain systems being more heavily represented in non-metropolitan areas. Consequently, the share of medium- and high-risk manufacturers is also greater in the non-metropolitan areas—33% of automotive manufacturers in non-metropolitan areas are determined to be at medium- or high-risk compared with 20% of those in metropolitan areas. These findings suggest that more rural areas in Wisconsin may face a higher level of disruption from the EV transition relative to the state's urban centers.

Non-Metropolitan Areas Hold an Outsized Presence of ICE Parts Manufacturers That Face Greater Disruption Risk Due to the EV Transition

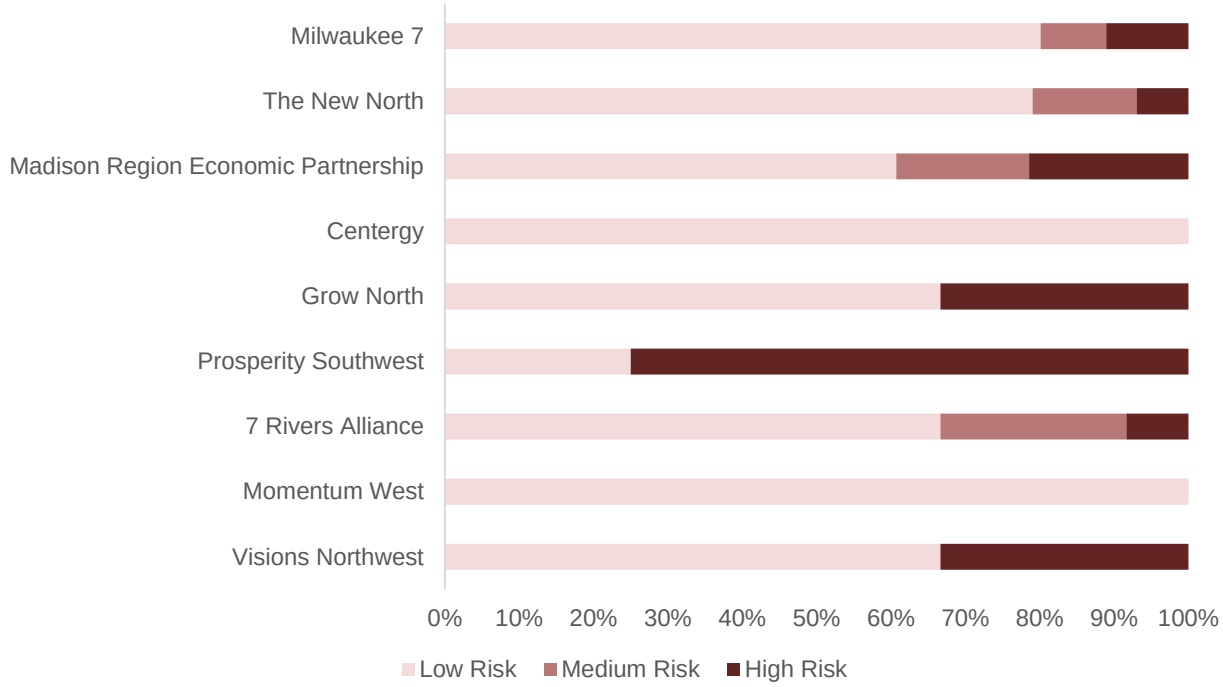
Figure 5: Distribution of Automotive Manufacturers by Parts Category and Metropolitan Status (Left); Manufacturer Vulnerability by Metropolitan Status (Right). Source: SRI analysis of Marklines and ThomasNet data.



Indeed, *Figure 6* shows that less urbanized regions hold an outsized share of manufacturers at medium- or high-risk to disruption from the EV transition. High-risk manufacturers account for a particularly large portion of automotive manufacturers in southwest Wisconsin and, to a lesser extent, in north central and northwest Wisconsin.

The Southwest Region Has the Highest Percentage of Automotive Manufacturing Suppliers That Are at High Risk

Figure 6: Distribution of Vulnerability Scores by Regional Economic Development Locations (2022). Source: SRI analysis of Marklines and ThomasNet data.[2]



The State of Wisconsin's Automotive Manufacturing

- Wisconsin's automotive suppliers and manufacturers are concentrated in the upstream portion of the supply chain. For example, metals fabricators and plastics product manufacturers hold an outsized presence in Wisconsin compared with other states. Many upstream suppliers are small- and mid-sized businesses that employ fewer than 50 workers.
- Employment growth in Wisconsin's automotive sector has been modest, having grown by 0.8% year-over-year from 2010 to 2021.
- Wisconsin's automotive manufacturing is noticeably less productive and more labor-intensive than the U.S. average, thus highlighting the need for industrial automation across the sector. However, opportunities exist to better utilize Wisconsin's strong industrial machinery industry to accelerate capital upgrades of its automotive manufacturers.
- Non-metropolitan areas are on average more specialized in automotive manufacturing than urbanized regions, and their economies are more sensitive to changes in the manufacturing sector.

Industry Composition and Change

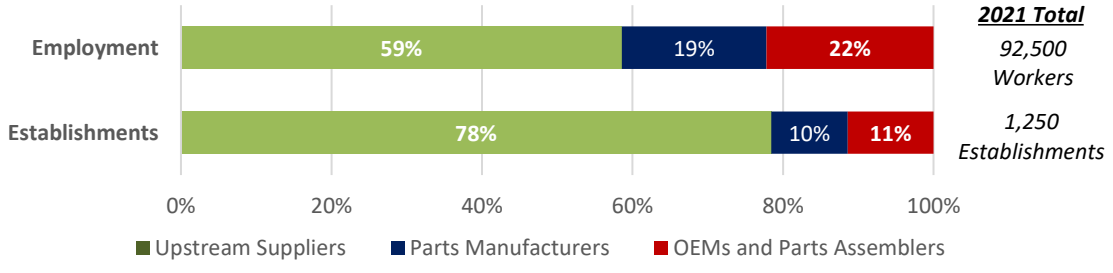
To properly assess Wisconsin's potential to develop a competitive EV manufacturing cluster, it is necessary to move beyond the vulnerability assessment toward a broader analysis of Wisconsin's automotive manufacturing sector. Such an analysis reveals insights about the sector's current composition and change over time and will identify challenges that Wisconsin manufacturers should address to become integral players in the EV supply chain.

In Wisconsin, the automotive manufacturing sector is heavily weighted toward the upstream portion of the automotive supply chain. Of the sector's 92,500 workers, 59% are employed in upstream industries, such as plastics product manufacturing and metals forging and fabrication, that supply basic components to firms further down the supply chain. These downstream firms include vehicle and engine parts manufacturers, which produce more complex components for assembly by OEMs. Parts manufacturers and OEMs employ 19% and 22% of the workforce, respectively.

In addition to employment, the distribution of establishments across the supply chain can yield further insights into its composition.[3] Of the 1,250 establishments in Wisconsin's automotive supply chain, more than 75% are located in upstream industries, 10% are involved in parts manufacturing, and 11% are operated by OEMs (see *Figure* 7). These figures indicate that the average establishment in upstream industries is much smaller, in terms of workers employed, than that of parts manufacturers and OEMs.

Upstream Suppliers Comprise the Majority of Workers and Establishments in Wisconsin's Automotive Manufacturing Sector

Figure 7: Employment and Establishments in Wisconsin's Automotive Sector, by Supply Chain Segment. Source: SRI analysis of Lightcast data.

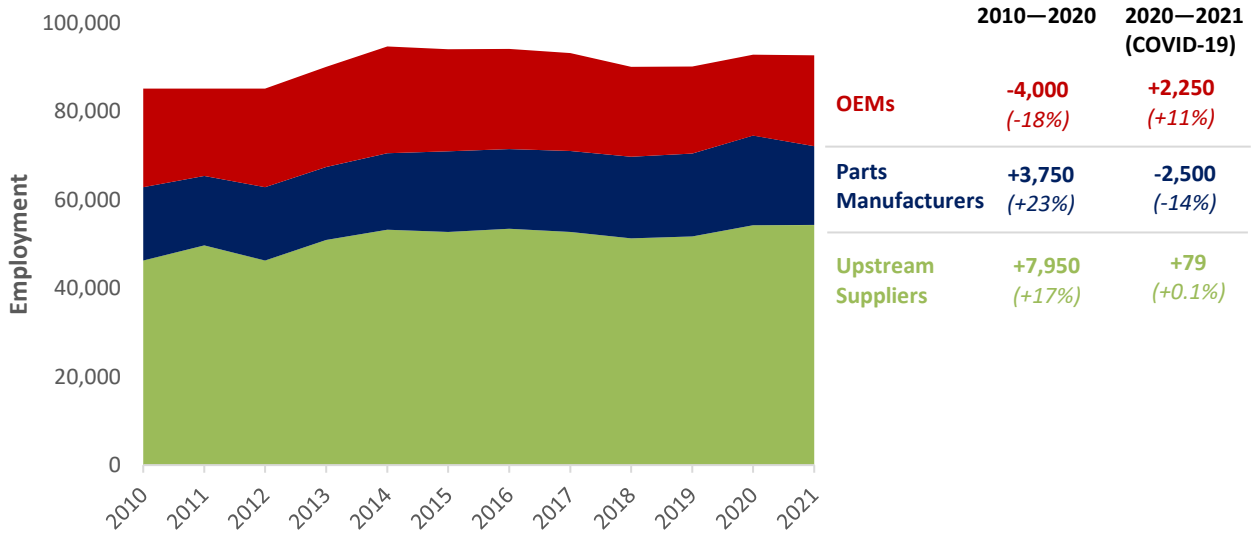


From 2010 to 2021, Wisconsin's automotive sector experienced modest growth. Sector employment increased by 8.8% during this period (0.8% annually), with much of this growth driven by employment gains in upstream suppliers (see *Figure 8*). On the other hand, OEM employment has declined, while parts manufacturing employment experienced marginal growth.

It is worth noting, however, that parts manufacturers in Wisconsin experienced a significant employment downturn in 2020, during the COVID-19 pandemic, while employment levels in upstream industries and OEMs appear to be less affected.

Employment Growth in Industries Related to the Automotive Supply Chain Has Been Modest, with Much of This Growth Driven by Upstream Suppliers

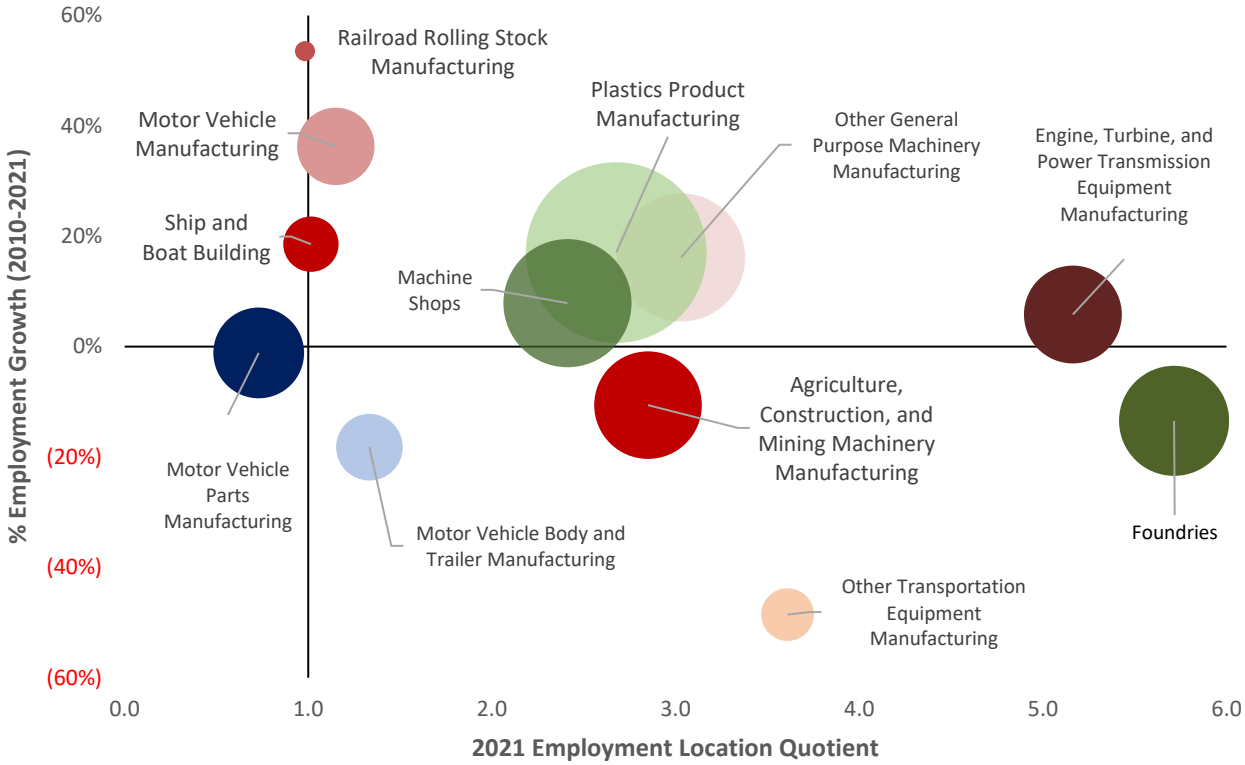
Figure 8: Employment in Automotive-related Industries in Wisconsin, 2010-2021. Source: SRI analysis of Lightcast data.



To provide a more comprehensive picture of composition and change in Wisconsin's automotive supply chain, *Figure 9* breaks down this supply chain into a select group of constituent 4-digit NAICS industries and plots each industry's employment growth (y-axis) against its relative specialization in Wisconsin (x-axis) and its current employment size (size of the bubble).[4] Industries are also categorized by their role in the supply chain—upstream suppliers in shades of green, parts manufacturers in shades of blue, and OEMs in shades of red.

Wisconsin's Strength in Industrial Machinery, Metalworking, and Plastics Production Overshadows Its Vehicle and Vehicle Parts Manufacturing

Figure 9: Select Industries in Wisconsin's Automotive Supply Chain by Employment Location Quotient and Growth. NOTE: Size of bubbles denote employment in 2021. Source: SRI analysis of Lightcast data.



Industries in the upper right quadrant are those that both exhibit strong growth potential and encompass areas in which Wisconsin is more specialized relative to the United States. As *Figure 9* shows, Wisconsin enjoys a clear competitive advantage in Plastics Product Manufacturing and Machine Shops in the upstream segment. Further downstream, it is OEMs of non-motor vehicle engines and industrial machinery that are competitive in Wisconsin, while the state's specialization in vehicle manufacturing and ship building is only marginally above that of the United States.

The bottom right quadrant, which encompasses four industries, represents areas in which Wisconsin has a strong competitive position but faces growth challenges. Foundries—one of the industries that is furthest upstream in the automotive supply chain—is also one of the most competitive in Wisconsin's manufacturing sector. Yet, it is part of an industry that is experiencing decline across the United States. Similarly, employment in Other Transportation Equipment Manufacturing, which in Wisconsin consists almost entirely of Motorcycle, Bicycle, and Parts Manufacturing, experienced the greatest decline, but Wisconsin remains 3.5 times as competitive in this industry compared to the United States average.

The industry in the upper left quadrant—Railroad Rolling Stock Manufacturing—exhibits strong growth potential but is currently in a weaker competitive position. Generally, industries in this quadrant have a smaller presence in Wisconsin than in the rest of the nation, but they are rapidly growing. They should, therefore, be viewed as opportunities for the state to leverage their ongoing growth to cultivate competitive clusters.

Industries in the bottom left quadrant signify challenge areas for Wisconsin due to their negative growth and relatively weak competitive position. Unfortunately, Motor Vehicle Parts Manufacturing falls in this quadrant, as its presence in Wisconsin is smaller relative to its national footprint and industry jobs were fewer in 2021 than in 2010. It is worth noting that this job loss is driven by a 33% decline of the Motor Vehicle Gasoline Engine and Engine Parts Manufacturing workforce, which was partially offset by employment growth in Motor Vehicle Electrical and Electronic Equipment Manufacturing. As will be discussed later in this report, these trends suggest that Wisconsin's automotive parts industry is already diversifying into electrically powered technologies.

While *Figure 9* illustrates changes within Wisconsin's automotive sector over time, *Figure 10 and Figure 11* provide a view of the sector's geographic distribution and identify clusters of high industry specialization. Counties that are highly specialized in automotive manufacturing are overwhelmingly concentrated in eastern Wisconsin, with isolated clusters in the northwest (Polk and St. Croix), north central (Price, Lincoln, and Marathon), and southwest (Richland, Crawford, Grant, and Saulk). In measuring a county's relative specialization, SRI developed an index based on the county's location quotient percentile in each of the three supply chain categories. The percentiles are then normalized from 0 to 1 and added together to form the combined competitiveness index (see Appendix B for the location quotients for each of the three supply chain categories).

Automotive Manufacturing Specialization Is Largely Concentrated in Eastern Wisconsin

Figure 10: Automotive Manufacturing Specialization Index by County, 2021. Source: SRI analysis of Lightcast data. NOTE: Index calculated by summing the percentile of county location quotients of all three supply chain categories (upstream suppliers, parts manufacturers, and OEMs).

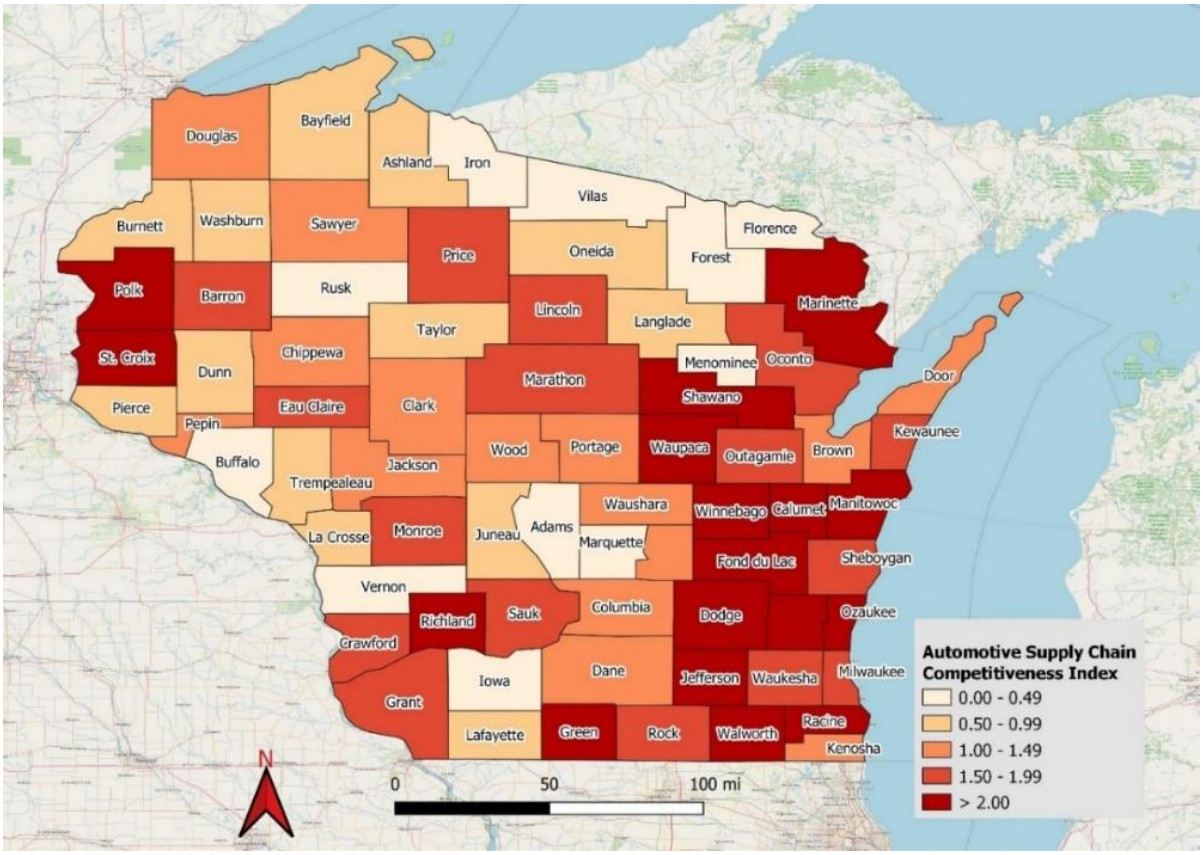
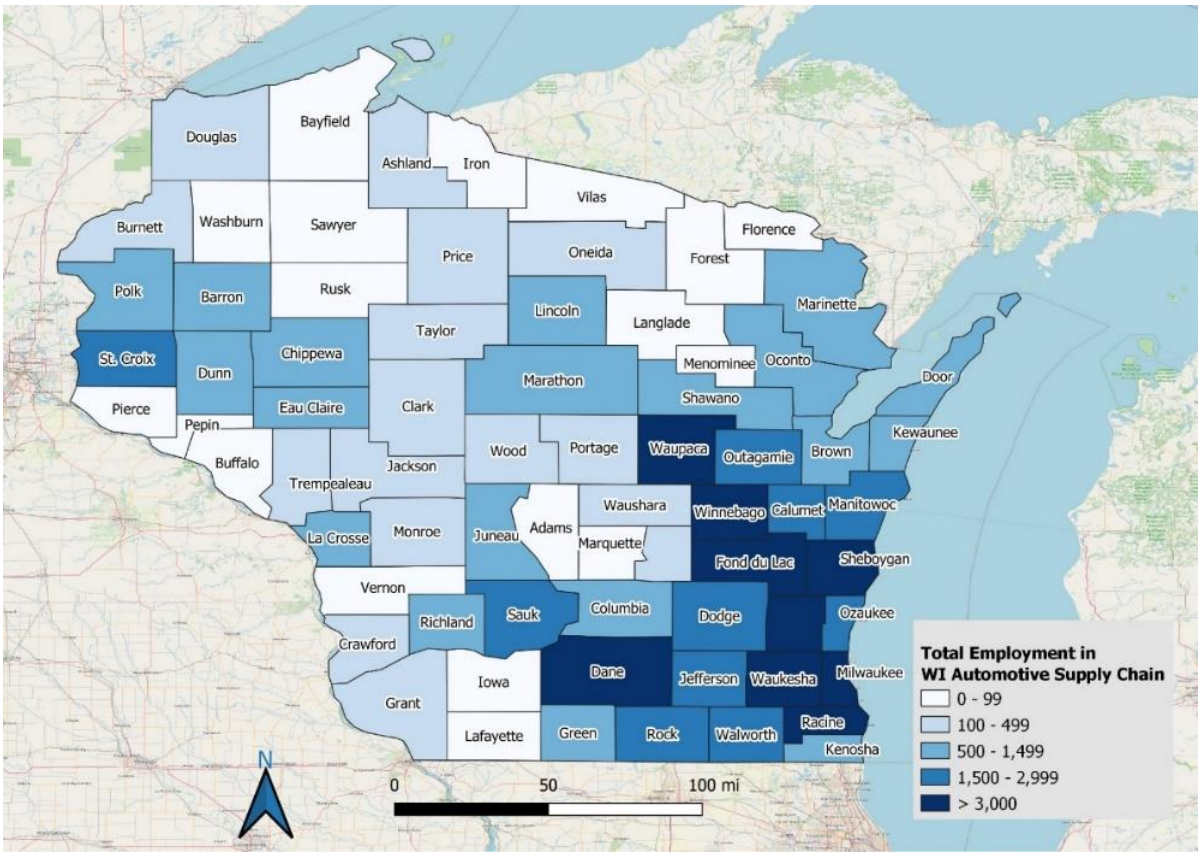


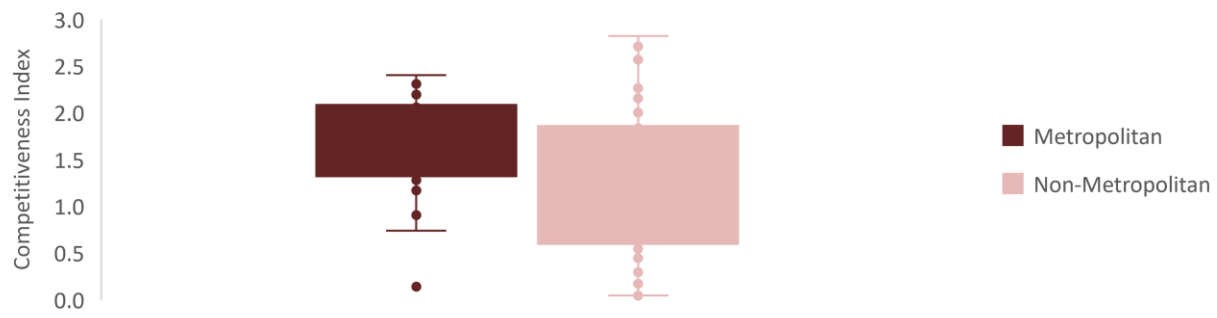
Figure 11: Automotive Manufacturing Employment by County, 2021. Source: SRI analysis of Lightcast data.



A comparison of industry specialization between Wisconsin's metropolitan and non-metropolitan areas reveals that metropolitan areas generally enjoy a greater degree of specialization in automotive manufacturing (see *Figure 12*). On average, the specialization index for metropolitan counties is 1.66 compared to 1.24 for non-metropolitan counties. However, non-metropolitan counties exhibit wider variation in this index, and two non-metropolitan counties—Waupaca and Polk—exhibit the highest measures of automotive manufacturing specialization among all Wisconsin counties.

Metropolitan Areas Are Generally More Specialized in Automotive Manufacturing

Figure 12: Automotive Manufacturing Specialization Index by Metropolitan Status, 2021. Source: SRI analysis of Lightcast data.

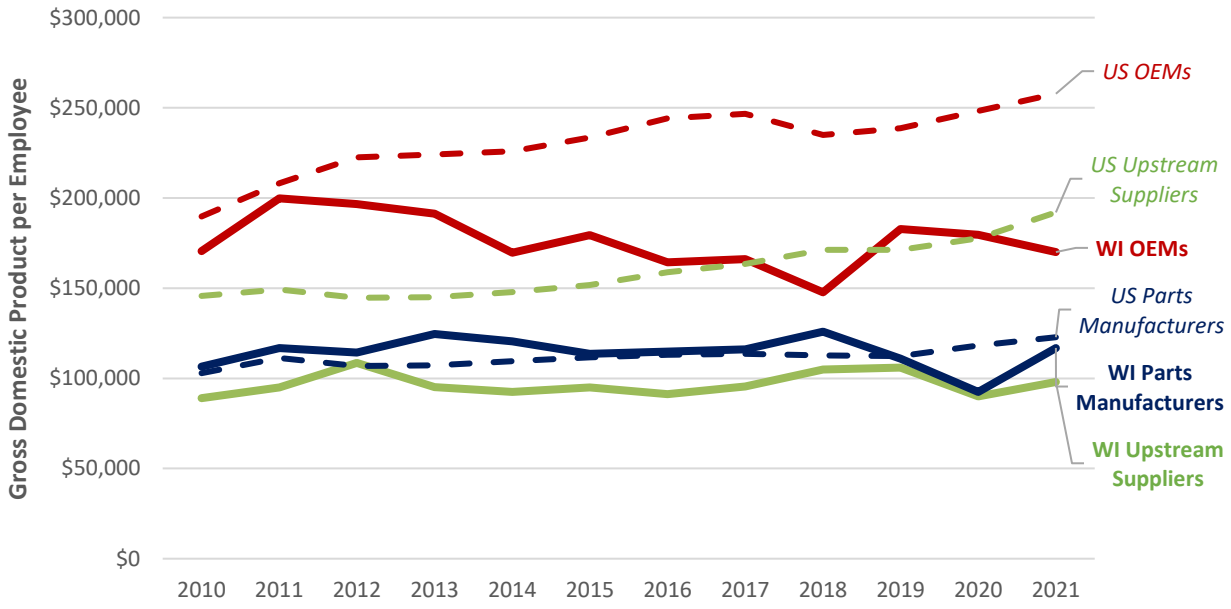


To obtain a comprehensive understanding of Wisconsin's automotive supply chain, one must look beyond employment trends. Growth in U.S. manufacturing output has far outpaced growth in manufacturing employment in recent decades as technological advancement has enabled workers to become more productive. Today, many manufacturers are adopting automation technologies that reduce the need for lower-skilled workers.[5] Despite these trends, Wisconsin has historically trailed neighboring Midwestern states and the United States in manufacturing productivity.[6]

As *Figure 13* shows, the productivity of Wisconsin's automotive manufacturing firms is, on average, lower than the national average across all three supply chain segments. Of particular concern is the widening productivity gap for OEMs and, to a lesser extent, upstream suppliers. In 2010, nationwide OEM productivity was 11% higher than in Wisconsin; this gap increased to 52% in 2021. Similarly, U.S. upstream suppliers in 2010 were 64% more productive than those in Wisconsin; they were 96% more productive in 2021. While Wisconsin's parts manufacturers were slightly more productive than the national average for most of the 2010s, productivity declined sharply in 2018 and remains 5% below the national average.

Productivity in Wisconsin's Automotive Manufacturing Lags Behind That of the United States

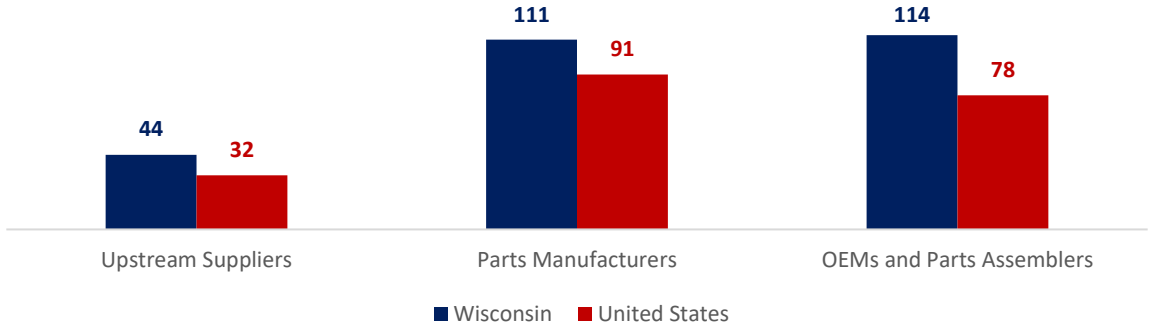
Figure 13: Gross Domestic Product per Employee in Wisconsin and the United States, by Supply Chain Segment. Source: SRI analysis of Lightcast data.



An analysis of average establishment size further confirms the labor-intensive nature of Wisconsin's automotive manufacturers. The average Wisconsin establishment employs significantly more workers than the average U.S. establishment in all three supply chain segments, with Wisconsin OEMs employing 45% more workers, parts manufacturers 22% more workers, and upstream suppliers 38% more workers. Given the existing shortage in manufacturing workers in the state, the high labor intensity of Wisconsin's automotive manufacturing sector may exacerbate its vulnerability to additional labor market shocks.

On Average, Manufacturing Establishments in Wisconsin Employ Significantly More Workers Than Those in the United States

Figure 14: Number of Employees per Establishment in Wisconsin and the United States, by Automotive Supply Chain Segment. Source: SRI analysis of Lightcast data.

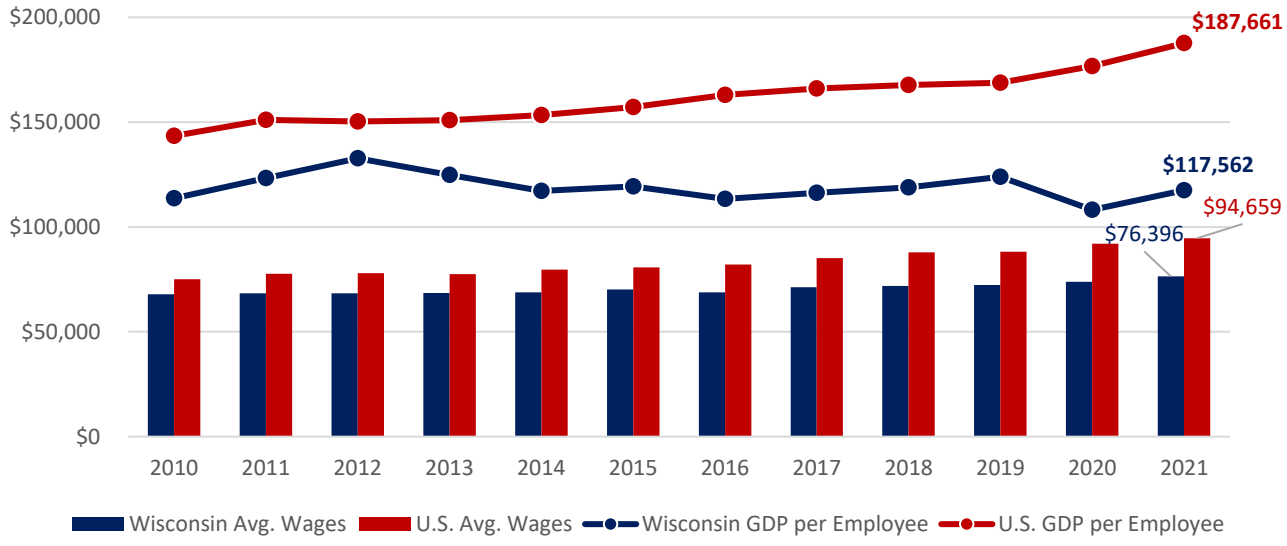


Far from being an isolated issue, low manufacturing productivity—especially in a manufacturing-heavy state such as Wisconsin—poses broad socioeconomic implications for workers, firms, and residents. Traditional microeconomics posits that workers' wages are determined by how productive they are in the workplace. Given Wisconsin's relatively low productivity growth in automotive manufacturing, wage growth among manufacturing workers is also expected to be modest.[7]

Figure 15 shows that this is indeed the case. While the average worker in Wisconsin's automotive manufacturing sector enjoyed a 12% increase in wages and a 3% increase in productivity from 2010 to 2021, that of the United States enjoyed a 26% increase in wages and a 31% increase in productivity. If productivity growth continues to remain stagnant among Wisconsin's automotive manufacturers, labor costs will likely take up a growing share of output. Consequently, a diminishing share of profits available for capital upgrades can potentially create a negative cycle that further decreases the relative productivity of Wisconsin's manufacturers.

Low Productivity Growth in Wisconsin's Automotive Manufacturing Supply Chain May Have Contributed to Modest Wage Growth

Figure 15: Gross Domestic Product per Employee and Average Annual Wages in the Automotive Supply Chain: Wisconsin and the United States. Source: SRI analysis of Lightcast data.



Wisconsin's Automotive Workforce

***Occupational susceptibility to displacement**: The risk faced by workers in an occupation to displacement from automation*

- The EV transition will likely decrease labor demand in lower-skill manufacturing occupations, especially those involved in machining and casting engine components. Conversely, workers skilled in electrical engineering and software programming are expected to be in high demand as more manufacturers transition to the EV supply chain.
- Since 2010, the fastest-growing occupations within Wisconsin's automotive manufacturing workforce are commonly associated with advanced manufacturing.
- The aging of Wisconsin's automotive manufacturing workforce, in which a significant share of workers is over 55 years old, underscores the need for greater automation and skilled workforce training.
- Hiring by Wisconsin's automotive manufacturers has declined even before the COVID-19 pandemic, only to rebound as demand for goods surged in the latter half of 2020.
- Skill requirements have become more demanding across the manufacturing sector to keep pace with changing technologies, thereby placing pressure on Wisconsin's manufacturers and training providers to upskill their workers. More specifically, workers are increasingly expected to demonstrate programming, communication, and critical thinking skills to become successful on the manufacturing floor.
- In recent years, Wisconsin's technical colleges have significantly increased enrollment in manufacturing-related certificate programs to meet employers' workforce needs. More advanced training in fields related to automation and advanced manufacturing, however, usually requires an associate degree, which is less accessible to students than certificate programs.

Workforce Impact of the EV Transition

At a broad level, the total labor hours required to produce an EV is comparable to those needed to produce an ICE-powered vehicle.[8] This similarity, however, belies significant differences in the distribution of labor requirements between EV and ICE supply chains that have far-reaching implications for Wisconsin's automotive manufacturers.

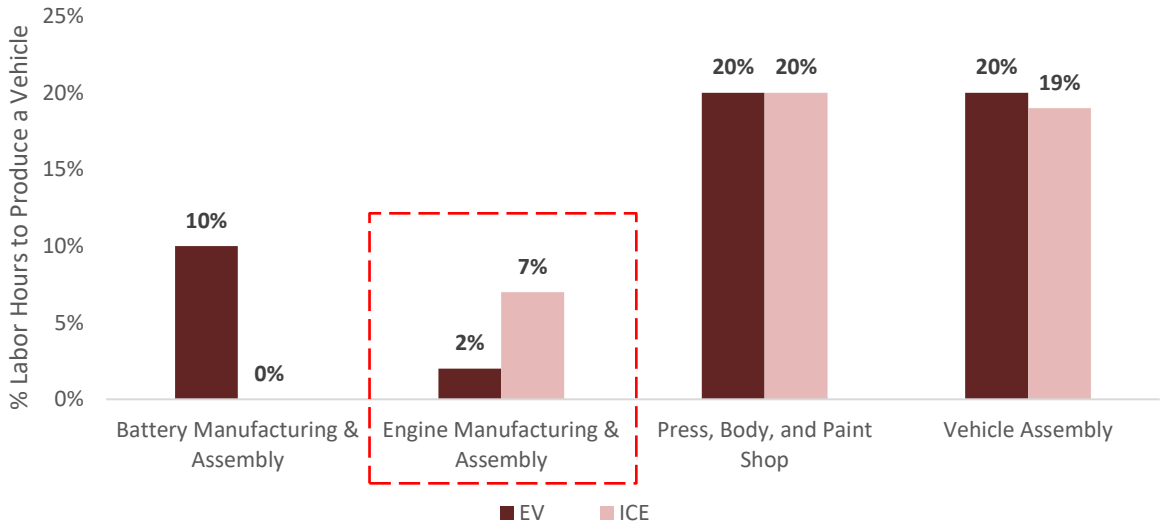
Because electric motors employ fewer and simpler components than internal combustion engines, they require less machining and casting. Rather than using complex machining and casting methods to make camshafts, crankcases, and cylinders for ICE vehicles, EV manufacturers employ smaller and simpler processes to make electric motor components, which include bearings, magnets, and rotor hubs. The elimination of exhaust and fuel systems further cuts back on the amount of work required by traditional machine operators and technicians. However, EV component manufacturing itself involves highly manual processes, such as wiring harness production and software implementation, which requires electrical engineering and programming skills that are lacking in most traditional automotive workers. Nevertheless, the labor hours required to produce EV engine components are approximately 70% less than that of ICE, and workers employed in Wisconsin's engine parts manufacturers—especially those with few transferrable skills—are at greater risk of being affected by the EV transition.[9]

Figure 16 compares the share of labor hours required in certain stages of the manufacturing process between EV and ICE-powered vehicles. While engine manufacturing and assembly accounts for 7% of total labor involved for ICE vehicle production, only 2% of labor hours are dedicated to the manufacturing of electric motors and its components. However, because both EVs and ICE-powered

vehicles possess similar exterior designs and are assembled through roughly similar processes, labor hours required are comparable during these stages.[10]

The Reduction in Labor Hours Required to Produce Electric Motors Poses a Threat to Workers Employed in Manufacturing Traditional Engine Parts

Figure 16: Share of Labor Hours Required to Produce a Vehicle, ICE vs. EV, by Stage in the Manufacturing Process. Source: Boston Consulting Group.



In Wisconsin, the EV transition will likely decrease labor demand for lower-skill manufacturing workers who are involved in machining and casting internal combustion engine components. Conversely, workers skilled in electrical engineering and software programming are expected to be in higher demand as more manufacturers transition to the EV supply chain. These trends underscore the need for the state to retrain its automotive manufacturing workforce toward skills more relevant to the EV manufacturing process and, more generally, to the automation and process innovation taking place in the manufacturing sector.

Broader Trends in Wisconsin's Manufacturing Occupations and Labor Market

Beyond EV's potential impact on Wisconsin's workforce, there are implications that broader trends in Wisconsin's manufacturing workforce may have on manufacturers' ability to make the EV transition. Since 2010, the mix of occupations in Wisconsin's automotive manufacturing workforce has undergone a significant shift toward occupations associated with industrial automation. While traditional manufacturing occupations such as Assemblers and Fabricators, Machinists, and Welders still comprise a notable share of the workforce, growth in these occupations has been outpaced by the rest of country. On the other hand, the number of workers in occupations associated with industrial automation—namely Computer Numerical Control (CNC) Tool Operators, Industrial Engineers, and Industrial Mechanics—nearly doubled over the past decade (see *Table 1*).

The shift in Wisconsin's automotive workforce toward occupations related to advanced manufacturing indicates that the state's educators and workforce developers have had some success in upskilling workers over the past decade. Manufacturers themselves, moreover, likely provided much of the impetus toward industrial automation training as most of these occupations require moderate on-the-job training.

Table 2 also includes estimates of an occupation's susceptibility to displacement due to future automation based on a detailed analysis by Frey & Osborn (2017).[11] Occupations that require leadership and planning skills typically exhibit very low susceptibility to automation, while occupations whose most important skills include basic math, lifting ability, and attention to detail are generally more susceptible.

Fast-Growing Occupations Are Associated with Industrial Automation

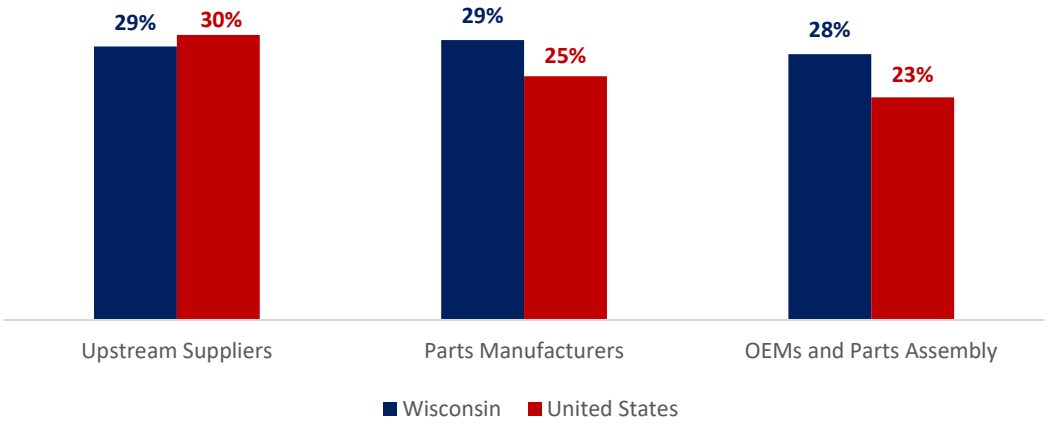
Table 1: Largest Occupations in Wisconsin's Automotive Supply Chain. Sources: SRI analysis of data from Lightcast and Frey & Osborn, 2017.

Occupation	*% of WI Auto Manufacturing Workforce in 2021*	*% of US Auto Manufacturing Workforce in 2021*	*% Growth in WI (2010-2021)*	*% Growth in US (2010-2021)*	*Wisconsin Occupational Location Quotient*	*Susceptibility to Displacement*
Assemblers and Fabricators	12.1%	15.8%	7%	44%	1.7	NA
CNC Tool Operators	6.7%	2.6%	98%	12%	4.7	0.86
Machinists	5.2%	6.0%	(34%)	3%	1.4	0.65
Molding, Coremaking, and Casting Machine Operators	5.1%	2.9%	16%	43%	2.7	0.95
First-Line Supervisors of Production Workers	4.4%	3.9%	14%	18%	2.0	0.02
Welders, Cutters, Solderers, and Brazers	4.1%	3.1%	28%	40%	2.1	0.94
Inspectors, Testers, Sorters, Samplers, and hWeighers	3.6%	3.5%	29%	31%	1.6	0.98
Cutting, Punching, and Press Machine Operators	3.1%	2.6%	24%	25%	2.8	0.78
Industrial Engineers	2.6%	2.3%	89%	47%	2.0	0.02
Mechanical Engineers	2.3%	1.7%	29%	21%	1.8	0.01
Extruding and Drawing Machine Operators	2.1%	1.0%	41%	(9%)	2.8	0.91
Laborers and Freight, Stock, and Material Movers	2.1%	2.5%	15%	49%	1.0	0.85
Industrial Machinery Mechanics	1.8%	2.2%	81%	66%	1.6	0.67

One of the most pressing workforce challenges facing Wisconsin is the aging of its manufacturing workforce. Consistent with the aging of the Baby Boom generation, almost 1 in 3 of the state's manufacturing workers are aged 55 and over, and manufacturers will be challenged to find qualified replacement workers as older workers retire or reduce their work availability in the coming years.[12] While this problem affects manufacturers throughout the United States, it is especially relevant in Wisconsin because older workers comprise a notably greater share of its automotive manufacturing workforce compared to the United States as a whole (see *Figure 17*).

Workers in Wisconsin's Automotive Supply Chain Are Aging

Figure 17: Share of Workforce over 55 Years Old by Supply Chain Segment in Wisconsin and the United States. Source: SRI analysis of Lightcast data.



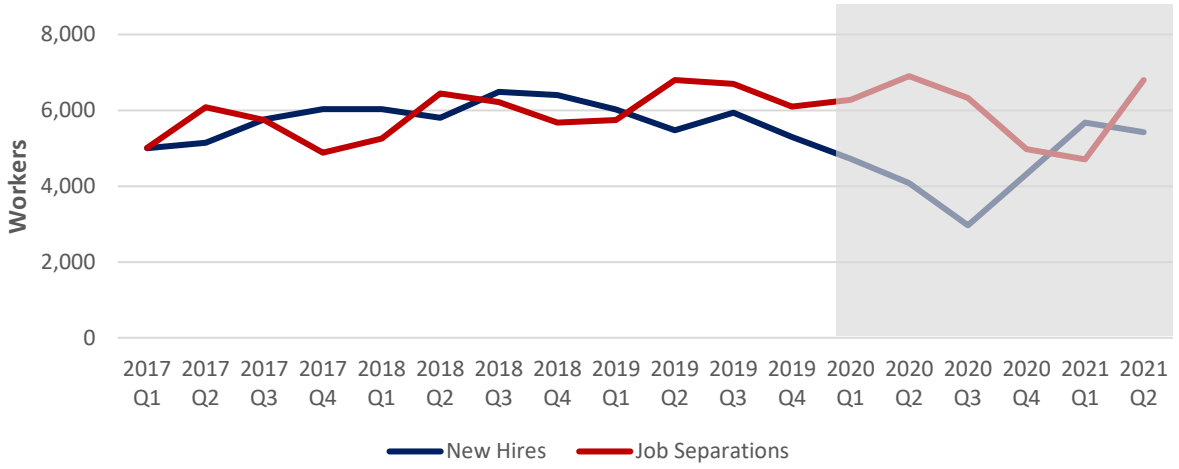
This challenge further underscores the need for greater automation among manufacturers, particularly smaller firms with less resources. Furthermore, Wisconsin needs to train younger workers on skills required for modern manufacturing, such as the ability to work with software and automated systems. In effect, the aging and pending retirement of many workers in Wisconsin's manufacturing industry can be viewed as both an opportunity and a threat. If the state can successfully train enough younger workers on up-to-date technologies while supporting manufacturers in automation, it can potentially spur a revival in manufacturing productivity and dynamism. If the state is unable to do so, however, many Wisconsin manufacturers may be at risk of being out-competed by their peers due to an increasing inability to access skilled labor and technology-intensive capital.

Indeed, a shortage in skilled labor has been identified in stakeholder interviews and secondary research as a critical challenge for Wisconsin manufacturers, who often frame this challenge as both a shortage of workers and a shortage of skills.[13] The worker shortage is characterized by manufacturers' difficulty in hiring enough workers needed to fill customer orders as well as the increasing number of job vacancies.[14] Several stakeholders interviewed for this report noted that the lack of qualified workers has forced them to curtail production or to prioritize certain products over others, while competition for the same group of skilled technicians has incentivized these workers to move from one employer to another depending on which offers better wages and benefits. As a result, manufacturers not only struggle to hire qualified workers but also face serious challenges in workforce retention.

Possibly as a result of these hiring challenges, Wisconsin's automotive manufacturers began to scale back hiring in the second half of 2019 (see *Figure 18*). This hiring decline continued as the COVID-19 pandemic began in the first half of 2020 before reversing in the second half of that year. However, the sudden pick-up in manufacturers' hiring activity in the second half may be more associated with the surge in demand for goods during lockdowns and less as a result of an increase in the availability of skilled workers.

Hiring by Wisconsin's Automotive Manufacturers Declined Even before COVID-19, Only to Recover as Goods Demand Surged during the Pandemic

Figure 18: New Hires and Job Separations in Wisconsin's Automotive Sector. Source: SRI analysis of U.S. Census Bureau, Quarterly Workforce Indicators. NOTE: Shaded area denotes quarters during the COVID-19 pandemic.



Closely tied to the worker shortage is a shortage in relevant skills. Whereas industries that largely employ low-skill workers can integrate new hires into business operations relatively quickly, manufacturers seek workers with specific technical skills or who can quickly develop these skills on the job. Furthermore, as manufacturing operations become more advanced and automated, the depth and breadth of skills required of workers is only expected to increase. For instance, industry stakeholders interviewed for this report noted that familiarity with software and programming has become an important skill for technicians due to the embedding of Internet of Things (IoT) technology in vehicle components that are traditionally not considered high-tech, such as seating. It is therefore to be expected that a significant gap exists between the skills level of new hires and the level required by employers in advanced manufacturing.

Box 1: Changing nature of skill requirements in advanced manufacturing

> "What engineers were doing three years ago, technicians are now expected to do."
> — *Manufacturing Company Representative (taken from Moor et al. 2021)*

According to a manufacturing workforce survey conducted by MIT, the five generalized skills below are highly valued by advanced manufacturers and therefore are expected to be the most important for middle-skill workers in the sector: [15]

- **Provide Consultation and Advice to Others**. This includes both an understanding of the entire system or process as well as communication skills to explain the details of the problem and potential solution.
- **Repair and Maintain Equipment**. More specifically, this entails building, calibrating, and troubleshooting equipment malfunctions.
- **Prepare Specimens, Tools, or Equipment**. This is a skill that requires the worker to follow operating procedures, adhere to safety guidelines, and exercise attention to detail.
- **Interact with Computers**. For the technician, this skill involves programming computer and production systems to perform a desired task as well as debugging code when technical problems arise.

- **Monitor Processes, Materials, or Surroundings**. This skill requires that the technician can independently perform quality assurance, has an ability to collect and interpret detailed data on potentially complex operations, and exercises a general awareness of safety and situations in the workplace.

These generalized skills highlight the importance of both technical and soft skills to a well-trained advanced manufacturing workforce. For technicians working with sophisticated manufacturing equipment, the survey recommended that training programs emphasize the ability to program, operate, and troubleshoot equipment, collect and interpret data, and communicate that interpretation. Other soft skills, such as managing unfamiliar problems, taking the initiative to learn new skills and technologies, and independently organizing time and tasks, were also noted by employers as features of a successful manufacturing worker. Workers, furthermore, are widely expected to demonstrate various aspects of critical thinking, including perceiving issues or problems, forming and testing hypotheses, making inferences, and communicating outcomes.

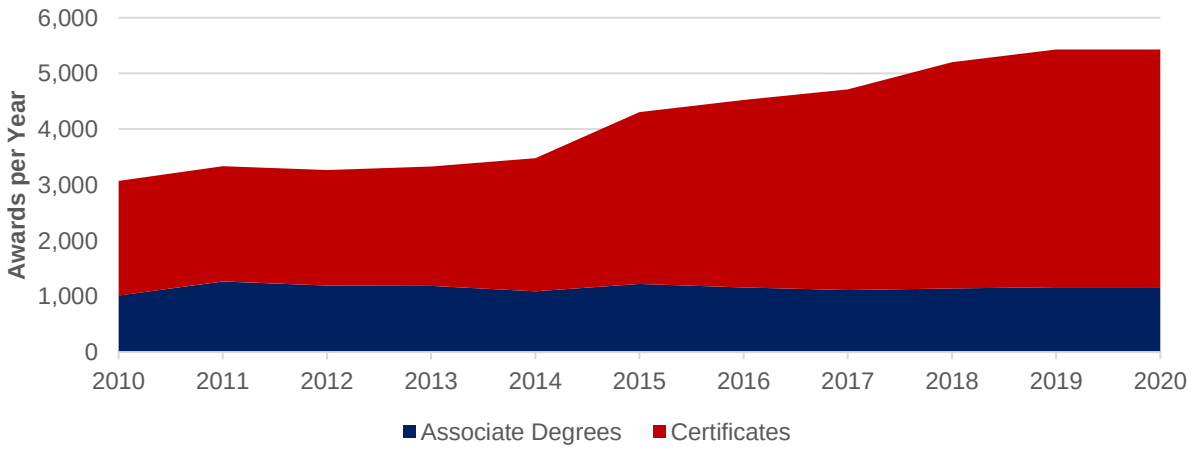
Overall, the skills valued by today's advanced manufacturers reflect a broader shift in the role of human workers toward cognitively demanding jobs that place greater value on critical thinking and communication. At the same time, as manufacturers transition to high levels of automation, they will likely demand greater technical proficiency from their workers. These trends, therefore, highlight a growing need for training programs to partner with industry to keep pace with employers' workforce needs.

Technical Education in Wisconsin

Wisconsin's Technical College System is the backbone of the state's manufacturing workforce development ecosystem. In 2020, its 16 colleges awarded more than 5,300 associate degrees and certificates in engineering technician, mechanical technician, and precision production programs. It is particularly noteworthy that certificates awarded in these three manufacturing-related programs more than doubled, from 2,050 certificates awarded in 2010 to 4,250 certificates awarded in 2020. On the other hand, the number of associate degrees awarded per year has remained stable, growing from 1,000 degrees awarded in 2010 to 1,150 awarded in 2020 (see *Figure 19*).

Wisconsin's Technical College System Drastically Increased Enrollment in Manufacturing-Related Certification Programs since 2010

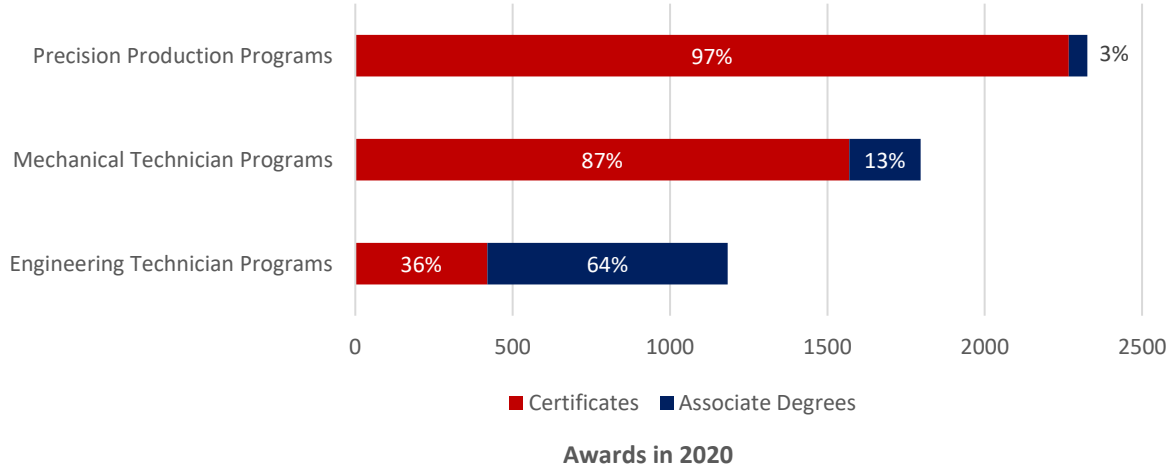
Figure 19: Associate Degree and Certificates Awarded in Engineering Technician, Mechanical Technician, and Precision Production Programs at Wisconsin's Technical Colleges, 2010-2020. Source: SRI analysis of Lightcast data.



As shown in *Figure 20*, the Wisconsin Technical College System considers engineering technician training to be more compatible with associate degree programs and precision production and mechanical technician training to be better suited for certificate programs. This division is likely due to the relatively more advanced training and skill requirements in engineering technician programs, of which the most popular are Electromechanical Technology, Automation Systems Technology, Industrial Welding Technology, and Automated Manufacturing Systems Technology. Among certificate programs—most of which last for one year—Welding is by far the most popular followed by Metal Fabrication and Machine Tool Operation. While students in associate degree programs undergo longer training, graduates of the 2021 class earned a median wage of about $60,000 per year—approximately $13,000 more than graduates of one-year certificate programs.[16]

Most Engineering Technicians Programs—which Provide More Advanced Training—Require Associate Degrees

Figure 20: Associate Degrees and Certificates Awarded in Engineering Technician, Mechanical Technician, and Precision Production Programs at Wisconsin's Technical Colleges, 2010-2020. Source: SRI analysis of Lightcast data.



Given the shortage of skilled workers in Wisconsin's manufacturing sector, the challenge for the state's technical college system is to scale up training in relevant programs. Because most programs associated with automation and advanced manufacturing are offered at the associate degree level—in which higher tuition costs and time to completion may discourage students from enrolling—technical colleges should explore additional mechanisms through which more students can receive advanced manufacturing training without compromising the quality of education. Potential options include offering accelerated associate degree programs or modifying existing certificate programs to train students on the same advanced manufacturing skills as those taught at the associate degree level. Additionally, technical colleges should continue to capitalize on their strength in employer engagement to stay up to date on the latest manufacturing practices and technologies, to continuously update curriculums around both current and anticipated employer needs, and to match student skills and interests with manufacturers' workforce needs.

Innovation and Entrepreneurship Capabilities

- EV-related technologies have not been a focus in Wisconsin's innovation ecosystem. Aside from the Wisconsin Electric Machines and Power Electronics Consortium, the state lacks an organization that is dedicated to EV and power electronics innovation.
- Wisconsin's universities have not been as successful as their peers in translating research and innovation into tangible economic growth. In the EV space, academic labs lack the resources to participate in large-scale collaborative research with industry partners, but stakeholders have recently taken steps to expand this capacity.
- Although Wisconsin has the venture capital and the infrastructure to support startups, it does not have enough individuals with the entrepreneurial experience and networks to build and grow successful ones. Consequently, the state has yet to achieve a critical mass in "hard tech" entrepreneurship.
- Because non-U.S. citizens constitute a significant portion of Wisconsin's EV and power electronics engineers, attraction and retention of international students, researchers, entrepreneurs, and workers is a critical step toward success in EV innovation.

Assessment of EV Innovation Activity in Wisconsin

Wisconsin's innovation ecosystem is predominantly focused on healthcare and information technology. As such, innovation and entrepreneurship in power electronics is still nascent within the state, and an examination of innovation-based metrics indicates that innovation activity in EV-related technologies has been relatively low.

As an example, the state's inventors hold 32 of the more than 1,500 EV-related patents filed to date in the United States, and all EV patents granted are assigned to a few large manufacturers such as Oshkosh, Harley-Davidson, Polaris Industries, and Eaton Corporation. As such, it appears that large firms are responsible for most of the private sector research and development (R&D) in EV-related technologies.

However, while there does not appear to be a significant presence of EV startups in Wisconsin, an analysis of Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants identified eight small- to mid-sized companies that are involved in power electronics R&D (see *Table 2*). Of note are C-Motive (a developer of electrostatic industrial motors), Intraband (a startup based at Madison's University Research Park that is developing sensors using quantum laser technology), Conovate (a university-incubated startup developing an anode material for more efficient batteries), and Universal Real Time Power Conversion (a developer of simulation environments for power conversion R&D).

Wisconsin Is Home to a Small Number of Startups Involved in EV-related Technology Development

Table 2: Wisconsin Firms that Received SBIR and STTR Awards to Develop EV-related Technologies. Source: U.S. Small Business Administration.

SBIR / STTR Recipient	*Technology Focus*	*Location*	*University Affiliation*
C-Motive	Electrostatic motors	Middleton	UW-Madison
Marine Fire Systems	Battery fire protection	Green Bay	
Intraband	Sensors	Madison	UW-Madison
Conovate	Batteries / Materials science	Shorewood	UW-Milwaukee
Universal Real Time Power Conversion	Power converters	New Berlin	
Advanced Engines Development Corp.	Electric hybrid propulsion	Milwaukee	
Oshkosh Nanotechnology	Electrical energy storage	Oshkosh	UW-Oshkosh
Synchrotek	Electric motors	Appleton	

Wisconsin's universities play a central role in the state's innovation ecosystem by serving as hubs for R&D activity and by facilitating the transfer of knowledge, technology, and human capital to the private sector. However, given the quality and potential of the state's university system, Wisconsin can do much more to assist its universities in translating R&D into tangible economic growth. According to the Wisconsin Technology Council's Higher Education Report, the primary impact of the state's universities is in training its workforce, whereas the state lags its Midwestern peers in new company formation.[17] These trends imply that Wisconsin's universities have been less successful in commercializing new technologies and ideas as they have been in basic research. The fragmentation of economic development activities across offices and departments, in addition to decreases in funding allocation from the state, may have contributed to this lack of commercialization success.[18]

Interviewed stakeholders frame the gap between academic research and commercial viability as two separate but related issues. First, collaboration between universities and large manufacturing companies is comparatively low. While the Wisconsin Electric Machines and Power Electronics Consortium's (WEMPEC) industry sponsors program facilitates collaborative research and training between companies and University of Wisconsin (UW)-Madison's engineering faculty and students, WEMPEC's staff of five faculty members and their graduate students lack the scale to conduct the applied research projects of value to large manufacturers.

Nevertheless, there are indications that universities are making efforts to expand academia-industry collaboration in EV development. In 2021, UW-Madison announced a partnership with Canoo, an Arkansas-based EV startup, to launch an EV R&D center at UW-Madison's College of Engineering.[19] The Electrification Challenge Grant, launched by the Wisconsin Alumni Research Foundation (WARF) Accelerator in 2022, is another sign that stakeholders are actively pushing to advance the commercialization potential of the EV innovation activity taking place in Wisconsin.[20]

The second issue related to Wisconsin's lack of EV commercialization success is that universities have yet to develop a critical mass of EV-focused startups and entrepreneurs. While much

entrepreneurship activity in the state has been focused on life sciences and information technology, there are relatively few "hard tech" startups in Wisconsin. Stakeholders familiar with Wisconsin's entrepreneurship ecosystem attribute this absence to a lack of individuals with the entrepreneurship experience and networks needed to build and grow startups. While there is no shortage of incubators and venture capital in Wisconsin—with one stakeholder noting that venture capital firms have difficulties in finding suitable startups in which to make investments—the absence of entrepreneurial networks that enable access to resources and investors has been the primary barrier to the formation of successful startups. In this context, stakeholders identified two common points of failure in a startup's life cycle. First, many entrepreneurs lack the business, legal, and financial expertise needed to form a startup, and they are unable to access resources that can provide this expertise. If entrepreneurs successfully navigate past this stage, many later struggle to obtain funding from local investors—most of whom are focused on the life sciences and information technology sectors. Lacking the professional connections to bigger, out-of-state venture capital firms, many Wisconsin startups have struggled to advance beyond the seed funding stage.

Perhaps one of the most significant aspects of Wisconsin's EV innovation ecosystem is the outsized presence of international talent. Within Wisconsin's advanced engineering workforce, non-U.S. citizens constitute a large portion of researchers, innovators, and entrepreneurs. In effect, skilled immigrants bring a wide range of engineering talent that enhances Wisconsin's technological competitiveness. The state should therefore consider additional policies that both attract international talent to Wisconsin and boost the state's ability to retain this talent over the long-term. For instance, the University of Wisconsin system can consider increasing support for international students seeking employment in the state or simplifying the immigration extension process for students needing additional time to complete their programs. At the state level, there is an opportunity to explore new programs that provide visa assistance to skilled workers as well as sponsorship support to smaller employers that lack the resources to file sponsorships themselves.

Box 2: Implications of H-1B sponsorship on innovation ecosystems.

> "Robust technology ecosystems require freedom of movement of employees between employers. Currently, H-1B visas are not portable from one employer to another; they expire when a foreign national H-1B holder leaves his or her sponsoring employer. H-1B employees can remain in the United States only if they can find a new sponsor within 60 days of separating from their original visa sponsor. Sponsorship is relatively easy for large companies with the resources and legal expertise required for sponsorship filing. Most startups, however, do not have the required resources for filing, a constraint that limits the ability of many skilled employees to bring their expertise to the startups at which a great deal of the most innovative work in [electric vehicle technology] is currently being performed."
> – *Toward a Resilient Quantum Computing Supply Chain* (June 1, 2022. The Quantum Economic Development Consortium)

Regulatory and Policy Environment

- In recent years, Wisconsin's business development toolkit has had mixed success, but opportunities exist to tailor programs toward a greater focus on capital investments in automation and workforce upskilling.
- Wisconsin's strategic location in proximity to existing and future EV assembly plants presents a major opportunity for the state to strengthen regional supply chain connections.
- Funding constraints to Wisconsin's universities and technical college system pose a serious threat to the state's competitiveness in the automotive and EV sectors.
- Aspects of Wisconsin's legislative environment are perceived by some to be counterproductive to the state's EV adoption efforts.
- Given existing barriers to consumer EV adoption, Wisconsin is better positioned to accelerate adoption in commercial EV applications such as electric trucking.

Challenges and Opportunities in Wisconsin's Policy Environment

The ability for Wisconsin to develop a competitive EV ecosystem is predicated upon the presence of tangible and intangible assets. Many manufacturers require strong geographic connectivity to local, regional, national, and international markets, while smaller businesses that are in the early formation and growth stages often require greater institutional assets, such as access to business networks and knowledge capital. The realization of conditions on which an industry cluster can successfully develop depends on a stable and receptive policy environment that makes it easy for manufacturers to do business. At the same time, this policy environment should offer effective incentives that, combined with active dialogue between state officials and industry stakeholders, aligns business interests with the state's policy objectives. The following section provides a brief assessment of the policy environment in Wisconsin as it relates to EV innovation, commercialization, and adoption.

Business Development Toolkit

The effectiveness of Wisconsin's business development programs in achieving its economic development objectives has been mixed. Though programs such as the Business Development Tax Credits (BTC) use job creation as the primary evaluation metric for success, the shortage of skilled labor in Wisconsin makes it difficult for award recipients to fulfill their job creation obligations. Because program awards are made conditional to the fulfillment of these obligations, businesses defaulting on their job creation obligations trigger a claw back provision which partially or fully nullifies the award. Stakeholders interviewed for this assessment reported that a significant percentage of BTC awardees have defaulted on their obligations.

There is broad agreement among stakeholders that Wisconsin can tailor its business development programs to be more targeted toward specific outcomes. For example, Wisconsin can potentially design tax credits that incentivize investments in EV-related manufacturing technologies. More broadly, the state can place a greater emphasis within its BTC program toward capital investments related to automation and productivity enhancements as well as to on-the-job worker training. To ensure that incentives are not misused, the state can also consider partnering with the Wisconsin Center for Manufacturing & Productivity (WCMP) to design awards that are informed by WCMP's assessment of applicants' technical and workforce needs.

Box 3: Programs to incentivize automation investment in other states.[21, 22]

North Dakota's Automation Tax Credit program provides a proven model for incentivizing automation. Designed specifically to subsidize the purchase of automation machinery and equipment in response to labor shortages, the program provides a tax credit to cover up to 20% of equipment leased or purchased with the intent of automating manual processes. Tax credit recipients are required to show that the equipment purchased improves job quality by at least 5% or increases productivity by at least 5%.

Similarly, Texas's Capital Access Program (CAP) sustains a partnership between the State of Texas and selected non-profit lenders to offer small- and medium-sized business loans for the purchase or rental of machinery and equipment. These loans, though underwritten by the lenders, are supported by Texas's contributions to a loan loss reserve account. In effect, by undertaking a portion of the financial risk in capital investment projects, Texas provides crucial strategic assistance to firms that face high barriers to accessing conventional capital.

Beyond incentive programs, one of government's most important roles in business development is to inform, educate, advise, and connect industry stakeholders, especially those that lack the resources to conduct market analysis or long-term strategic planning. Here, the expertise of organizations such as WCMP is an undervalued asset that can be leveraged to help small- and medium- sized businesses identify opportunities to participate in the EV supply chain or to assist these suppliers in becoming familiar with automotive manufacturing best practices.

Box 4: National Manufacturing Extension Partnership Supply Chain Database Act of 2021.[23]

In December 2021, Senator Robert Menendez (D-NJ) introduced the National Manufacturing Extension Partnership (MEP) Supply Chain Database Act of 2021, which would leverage the MEP network to establish a national database to increase government and industry insights into U.S. manufacturing supply chains. This national database, furthermore, is intended as an aggregation of state-level databases that would be created by each state's MEP. The increased supply chain visibility provided by the database would inform manufacturers' strategic decision-making and provide policymakers with improved insights on whether manufacturers should retool in certain areas to meet demand for critical components. As of August 2022, the bill has yet to be passed by the Senate and the House of Representatives.

Opportunities in Neighboring States

The state of Wisconsin is strategically located in a region with a long history of automotive manufacturing. Because the Midwest is where the automotive industry is heavily concentrated, the region is poised to benefit from the transition toward EV manufacturing. Wisconsin's automotive suppliers are uniquely situated to supply materials and components to emerging EV hubs, such as in neighboring Illinois where automakers Rivian and Stellantis are both opening new production facilities.[24] In particular, stakeholders emphasized that Wisconsin's proximity to key automotive clusters positions the state's manufacturers to develop long-term relationships, especially with OEMs in Michigan and Illinois. Moreover, industry stakeholders have noted that EV OEMs are looking for upstream suppliers that have experience with the automotive industry, an important qualification that distinguishes Wisconsin's upstream suppliers from their peers. To emphasize this advantage, some stakeholders suggested that the state increase its engagement efforts with national automotive leaders to better inform them about the capabilities offered by Wisconsin suppliers.

Higher Education

Higher education institutions are the cornerstone of a robust workforce development ecosystem. In Wisconsin's manufacturing sector, the Technical College System sustains a large talent pipeline of middle-skill workers while the state's universities supply the engineers, innovators, and entrepreneurs who are responsible for EV innovation. Yet, budget constraints for the state's higher education system may have contributed to Wisconsin's relative lack of success in commercializing the research taking place in its universities. Stakeholders in universities have noted a shortage of faculty and graduate students in engineering departments, which may limit their capacity to conduct large-scale applied research projects alongside industry partners. In technical colleges, stakeholders mentioned that a shortage in experienced instructors may threaten the ability of the colleges to provide the level of training that employers expect new hires to possess.

EV Adoption and Infrastructure

Although Wisconsin possesses a strong network of green technology non-profits and advocacy groups that actively promote EV within the state, stakeholders have noted that consumer sentiment toward EV does not appear to be as receptive as in states such as California. At the government level, several pieces of proposed or actual legislation have been perceived by some stakeholders as being counterproductive to EV adoption, with one such proposal prohibiting charging station operators from selling solar-powered electricity. Additionally, Wisconsin's prohibition of direct sales from automotive manufacturers limits the ability of EV OEMs, such as Tesla, to sell vehicles in the state. For owners of electric vehicles, Wisconsin also charges an alternative fuels tax and a $100 annual registration fee.[25,26] While some states have chosen to repeal a registration fee for EVs as an incentive, others have used this fee to support electric charging infrastructure. Nevertheless, these taxes and fees may discourage some consumers from owning or using electric vehicles. Finally, stakeholders expressed that state officials have not provided sufficient information to energy providers about the state's electric grid, thereby hindering energy providers' ability to anticipate and plan for future energy delivery.

Given these challenges, stakeholders have suggested that Wisconsin is better positioned for EV adoption by commercial users. A significant amount of ground shipping moves through Wisconsin, especially on I-94 between Chicago and Minneapolis, and planning is underway to electrify this section as part of the Michigan to Montana I-94 Clean Fuel Corridor and in alignment with the *Wisconsin Electric Vehicle Infrastructure Plan*.[27] These factors, combined with Wisconsin's strategic position on freight corridors that extend throughout the Midwest, offer a significant opportunity for the electrification of commercial trucking. For Wisconsin, this opportunity can position the state both as a viable destination for electric trucks and their freight but, more importantly, as a supplier of parts and equipment for the manufacturing and maintenance of electric trucks. Furthermore, the truck building capabilities of Oshkosh—one of Wisconsin's largest OEMs—and the parts manufacturing capabilities of upstream suppliers makes the state particularly well-positioned for commercial electric trucking. Nevertheless, Wisconsin's winter climate may pose challenges to electric trucking operations, and its lower urban density may mean that trucks have fewer opportunities to find a charging station. Thus, efforts to develop an industry cluster around electric commercial trucking will likely only be viable once adequate EV infrastructure has been built.

Conclusion

Wisconsin's automotive and EV ecosystem has the potential to become a major driver of the state's economic development in the coming decades. Its strategic location within the Midwest's automotive supply chain, the competitiveness of its upstream industries, the strength of its technical colleges, and promising developments in EV innovation positions Wisconsin to use the EV transition to pivot toward advanced manufacturing. Doing so, however, requires that Wisconsin address several challenging issues. Wisconsin should:

1. Support automotive manufacturers in achieving greater automation to increase productivity and decrease their vulnerability to future labor market shocks.
2. Support its technical colleges in scaling up advanced manufacturing training to address the ongoing worker and skills shortage.
3. Increase funding to its academic and research institutions, with a focus on industry-academia collaboration, entrepreneurship support, and the attraction and retention of international talent.
4. Consider modifying its policy toolkit to support manufacturers in making investments in automation, to improve firms' access to regional, national, and international markets, to develop interoperability standards, and to encourage commercial EV adoption.

It is critical that the state demonstrate a strong business and economic development case for these actions. All stakeholders and interest groups in Wisconsin desire job creation and economic growth in their communities, but many will also seek evidence that investing in a strong EV cluster will generate substantial economic returns to residents and businesses. To this end, Wisconsin should build stakeholder support around mutual areas of interest. As an illustrative example, one potential area for collaboration is Wisconsin's sand mining industry, which is important to stakeholders in the petroleum industry but also offers a variety of uses in power electronics and energy storage.

Regarding the vulnerability of Wisconsin's automotive supply chain to the EV transition, this assessment finds that most firms in the supply chain are relatively less exposed to the decline of ICE-based technologies. Most upstream suppliers identified in this assessment make components for both ICE and EV products as well as a variety of other industries, and their outsized presence in Wisconsin indicates that the long-term decline of ICE vehicles will not pose a serious threat to a large share of the automotive supply chain. On the other hand, parts manufacturers and OEMs whose businesses depend on ICE-based propulsion systems face the greatest exposure. Many of these firms, however, are actively implementing plans to diversify into EV-compatible product lines or to shift their business models to the automotive aftermarket—a market that is expected to continue for several more decades due to the long lifespan of modern automobiles. For highly exposed firms that have not taken action, Wisconsin should assist and advise on the development of strategic EV transition plans and use its policy toolkit to lower the costs of implementing these plans. This advisory and educational role also applies to Wisconsin's relationship with upstream suppliers, many of whom lack information about strategic opportunities in the EV supply chain and the certifications required to participate in it.

Finally, the geographic distribution of manufacturers within Wisconsin has important equity implications as the state pursues its EV transition strategy. Non-metropolitan counties are home to a greater share of high-vulnerability firms, and their economies and jobs base depends more on ICE-related manufacturing than more urbanized counties. As such, the vulnerability of Wisconsin's non-metropolitan areas to changes in the manufacturing sector—and its wide-ranging implications for economic and community well-being—will need to be seriously considered.

Mapping Wisconsin's Electric Vehicle Manufacturing Ecosystem

Wisconsin's Diverse Assets

Successful clusters arise from a confluence of stakeholder activity in industry, workforce development, innovation and entrepreneurship development, and policymaking, all of which play unique and vital roles that sustain the economic health of the cluster. For Wisconsin to develop a thriving and dynamic EV manufacturing cluster, the state will need to mobilize its immense base of assets and to coordinate their activities and investments in a way that produces sustainable growth conditions for the industry. This section of the report takes stock of the assets that can be leveraged to support the state's EV manufacturing goals and highlights potential gaps in the ecosystem. As *Figure 21* demonstrates, a well-functioning ecosystem requires more than the availability of assets. The *activities* of these assets and the relationships among them define each asset's role in the ecosystem and the institutional capacity of the ecosystem to support the cluster. The assets examined in this section span many different categories, but they can generally be categorized within six areas: Industry, Workforce, Innovation & Entrepreneurship, Government and Nonprofits, EV Adopters, and Community (see *Figure 21*).

Industry. Wisconsin's automotive manufacturers form the cornerstone of its EV manufacturing ecosystem, and their successes and failures can be reflective of broader strengths or challenges prevalent in the ecosystem. Conversely, the needs of industry often shape the activities of supporting stakeholders. Its willingness to convey these needs to the rest of the ecosystem—and supporting stakeholders' responsiveness to these needs—are critical elements of the cluster development process.

Workforce. The availability and quality of Wisconsin's manufacturing workforce is a key determinant to the sector's ability to stay competitive in the 21st century. As automation in manufacturing raises the skills threshold for workers, the burden of reskilling and upskilling the workforce will increasingly fall on Wisconsin's technical colleges and universities. These institutions' ability to scale up training programs—and their responsiveness and adaptability to changing workforce needs—will play a vital role in Wisconsin's future workforce competitiveness.

Innovation & Entrepreneurship. Wisconsin's innovation and entrepreneurship ecosystem comprises academic R&D labs, technology-driven startups, and a support network of investors and business development resources that help transition innovations developed in the lab to the marketplace. To this end, it is critical to create strong partnerships between the EV innovators and the industry stakeholders with a vested interest in the new technologies being developed in the state.

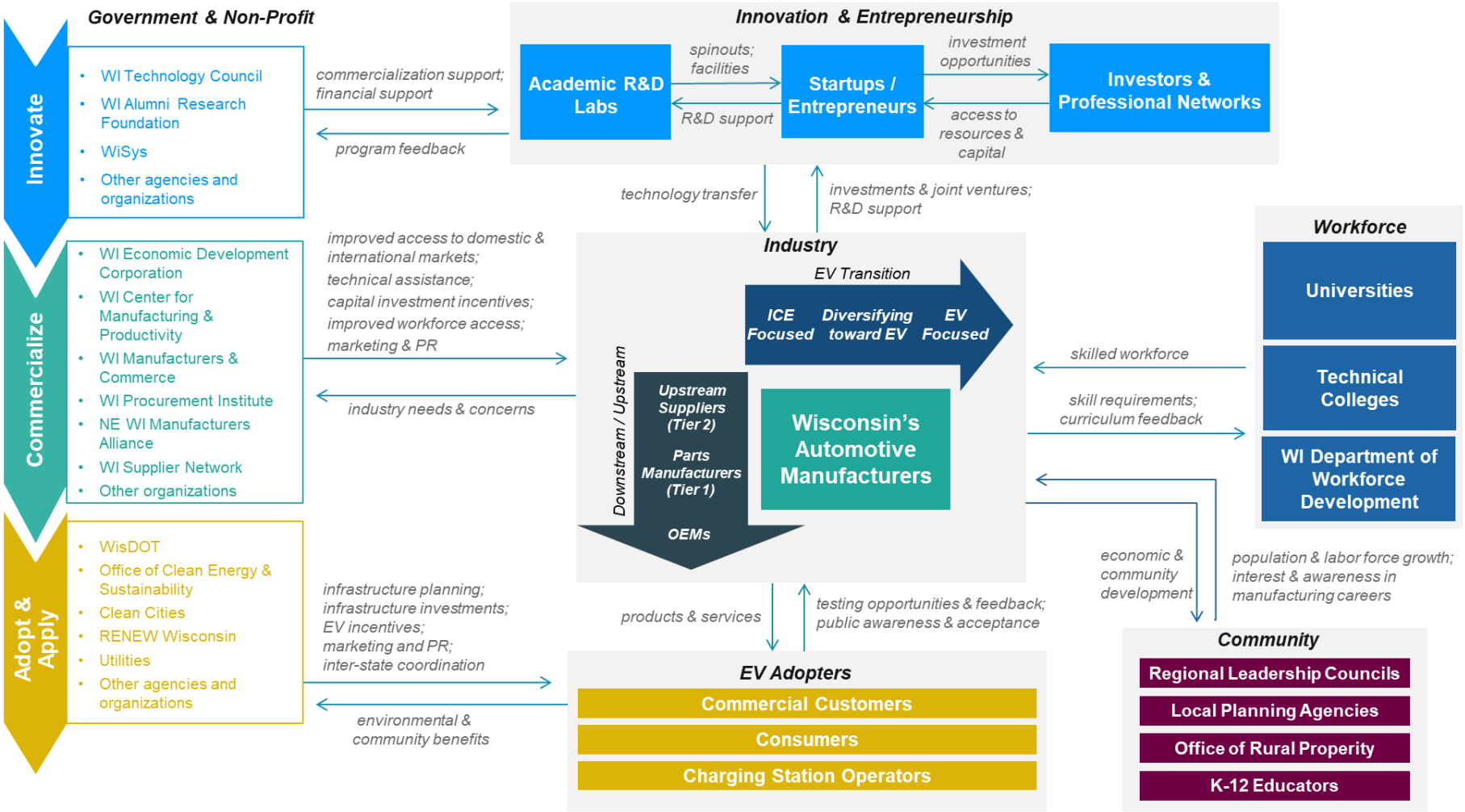
EV Adopters. A strong culture of EV adoption and use in Wisconsin would significantly strengthen cluster development efforts. The presence of local markets that are closely integrated with the activities of an EV manufacturing cluster would provide valuable user feedback and testing opportunities for companies to further refine their technologies.

Government & Nonprofits. Government agencies and nonprofits provide the strategic direction, coordination resources, and convening power that hold together the ecosystem's diverse stakeholders. If used to their full potential, government and non-profit assets can serve as a catalyst whose support speeds up the innovation-commercialization-adoption process that is central to a successful cluster.

Community. Wisconsin's ability to transition to electric vehicles, both from a manufacturing and adoption standpoint, will depend in part on broader demographic and cultural trends, including population growth and interest in new careers emerging from the cluster.

A Successful Industry Cluster is Supported by an Ecosystem of Engaged Stakeholders

Figure 21: A Well-functioning EV Manufacturing Ecosystem in Wisconsin. Source: Stakeholder interviews conducted by SRI International



Industry Assets

- The majority of Wisconsin's larger industry stakeholders is actively adapting to the EV transition.
- For firms that have not made strategic decisions on how to manage the EV transition, opportunities exist for them to leverage technical and planning assistance from both governmental assets (e.g., Wisconsin Center for Manufacturing & Productivity) and Wisconsin-based companies that help clients implement automation and production enhancements.
- The success of Wisconsin's manufacturing sector in general, and its transition to the EV supply chain in particular, will depend to a large extent on building strong relationships with technical and business development assistance resources, such as the Wisconsin Center for Manufacturing & Productivity and various automation consultants throughout the state.

The activities of Wisconsin's automotive manufacturers will play a pivotal role in its industrial transition to electrically powered technologies. A select group of larger industry stakeholders is pursuing independent strategies to adapt to a world increasingly dominated by EV technologies. Such strategies include the diversification of product portfolios toward EV-compatible components or a greater focus on the ICE aftermarket, the secondary market for individual parts that is expected to persist for several more decades. From a policy perspective, coordinating, diffusing, and accelerating these adaptation efforts to take advantage of synergistic supply chain opportunities is an activity that is well suited to WEDC and its partner agencies. However, some upstream suppliers and parts manufacturers have not made strategic decisions on how they will manage the EV transition, and opportunities exist for Wisconsin agencies and organizations to provide these firms with the planning assistance and technical resources that better equip them to adapt.

Crucially, the ability and commitment of industry stakeholders to collaborate with supporting ecosystem stakeholders—from economic development agencies to education institutions—will play a vital role in these industry assets' future dynamism and resilience. While strengthening these ecosystem relationships will require some firms to devote valuable time and resources, they should be viewed as strategic investments in these firms' long-term success. In a well-functioning ecosystem, as shown in *Figure **21***, industry stakeholders would take on an active role in helping educators develop and update curriculums, in collaborating with and investing in promising innovations, in coordinating with government agencies and nonprofits on resolving industry challenges, and in community and consumer engagement as Wisconsinites transition to electrically powered technologies.

ICE-Focused

ICE-focused manufacturers are at highest risk of business disruption due to the EV transition. While many of these businesses are upstream suppliers that serve multiple industries, their exposure to the declining ICE markets nevertheless poses a threat to future business operations. Some ICE-focused suppliers, furthermore, specialize in manufacturing niche ICE components, thus making diversification toward EV difficult. These suppliers can consider partnerships with the Wisconsin Center for Manufacturing & Productivity to develop a plan to ensure that these firms and their workers have a secure future.

Table 3: Select Industry Stakeholders Focused on ICE Component Manufacturing

Supply Chain Segment	*Firm*	*Ecosystem Role*
Upstream Supplier	Waupaca Foundry	Manufactures iron casting components for a variety of industries, including automotive
Upstream Supplier	Milwaukee Forge	Manufactures forging components for a variety of industries, including automotive
Upstream Supplier	Northeast Wisconsin Industries	Produces machined components for a variety of industries, including automotive
Upstream Supplier	Pro Fab Machine	Manufactures parts for pulling trucks and tractors.
Upstream Supplier	Robinson Co.	Manufacturers metals products for a variety of industries, including automotive
Parts Manufacturer	Velvac	Manufacturers parts for commercial trucks, buses, RVs, and emergency service vehicles.
Parts Manufacturer	Butler Gear	Manufacturers gear and transmission products for the automotive industry

Diversifying toward EV

Most of Wisconsin's larger industry stakeholders is actively adapting to the EV transition. With more resources available to undertake strategic planning and capital investments due to their larger size, most of these firms are in the process of building out their own EV-related manufacturing capabilities. Parts manufacturers and OEMs constitute almost all of those industry assets that are diversifying toward EV. The growing EV capabilities of these firms are a promising sign of Wisconsin's EV manufacturing potential, indicating that future growth can be sustained or expanded with support from other critical assets in the ecosystem.

Table 4: Select Industry Stakeholders Diversifying Toward EV

Supply Chain Segment	*Firm*	*Ecosystem Role*
Parts Manufacturer	Modine Manufacturing	Created EV Business Unit in 2021[28]
Parts Manufacturer	Husco	Actively developing battery and EV technologies[29]
Parts Manufacturer	Kohler Co.	Acquired Curtis Instruments to drive electrification plans[30]
Parts Manufacturer	Nemak	Actively expanding into EV parts manufacturing[31]
OEM	Harley Davidson	Growing its LiveWire e-motorcycle business[32]
OEM	Oshkosh	Rolling out EV solutions across its product lines
OEM	REV Group	Rolling out EV solutions across its product lines
OEM	Ariens Co.	Worked closely with two industrial battery companies to develop an electrification strategy, which resulted in the development of an all-electric commercial lawn mower[33]
OEM	Mercury Marine	Recently demonstrated its electrification efforts through the rollout of the Avator electric outboard engine[34]

EV-Focused

EV-focused firms drive a large amount of private sector innovation in EV technologies and are central to the development of any state or regional EV cluster. In Wisconsin, there is a sizable presence of established manufacturers that specialize in power electronics technologies with applications for a wide variety of industries. Developing connections between these firms and ICE-dependent manufacturers seeking to implement their electrification plans—so that knowledge and expertise can be shared in the form of closer supply chain relationships—is an opportunity upon which Wisconsin's economic developers and stakeholders throughout the ecosystem should capitalize.

Table 5: Select Industry Stakeholders Focused on Production of Power Electronics or Automation-related Equipment

Supply Chain Segment	*Firm*	*Ecosystem Role*
Parts Manufacturer	Rockwell Automation	Provides automation technologies and customized solutions to manufacturers, some of which overlap with the technologies needed to transition to the EV supply chain.
Parts Manufacturer	Schneider Electric	Develops and manufactures power electronics technologies, including EV charging stations
Parts Manufacturer	C-Motive	Developing electrostatic motors as a novel form of EV propulsion
Parts Manufacturer	Odyne Systems	Manufacturers electric and hybrid systems for heavy-duty and medium-duty trucks
Parts Manufacturer	Generac	Manufacturer of electric power equipment for a variety of industries.
Parts Manufacturer	Eaton Corporation	Recently launched its e-mobility business division, which produces parts for both EVs and EV charging stations.
Distributor	Warner Electric	Leading distributor of power electronics components for a wide variety of industries

Workforce Assets

- The key challenge for Wisconsin's workforce institutions is to respond and adapt to employers' needs in the face of industrial and technological change.

- Responsiveness entails both scaling up the number of workers trained (quantity) and updating curriculums as skill requirements change (quality).

The primary workforce assets in Wisconsin's automotive manufacturing ecosystem are the state's technical colleges and universities. Wisconsin's technical college system, comprising 16 colleges throughout the state, sustains an impressive talent pipeline of skilled technicians to employers. For higher-skill occupations, such as engineers and software developers, industry stakeholders typically turn to graduates of the University of Wisconsin system and other 4-year institutions in the state. Lastly, the Wisconsin Department of Workforce Development provides job seekers and employers with valuable services that are beyond the purview of higher education institutions.

These workforce assets must be responsive to employers' needs in the face of industrial and technological change. This not only entails scaling up the skilled labor supply in response to shifts in worker demand but also updating curriculums as skills valued by manufacturers change. If the workforce ecosystem can dynamically adjust the quantity and quality of manufacturing workers in response to employers' short-term and long-term needs, it would greatly enhance Wisconsin's manufacturing competitiveness in domestic and international markets.

4-Year Universities

Wisconsin's 4-year universities create and sustain a direct talent pipeline to the state's employers. This relationship allows for companies to disclose their workforce needs while allowing the university system to develop programs to fill in the workforce gaps. While the relationship between universities and employers is strong, keeping Wisconsin's university graduates in the state has been a challenge. According to the University of Wisconsin System President Ray Cross, about 85% of graduates stay in Wisconsin.[35] To further increase retention, the UW System is expanding efforts to match students with long-term career opportunities within Wisconsin, as demonstrated by a partnership with the Wisconsin Economic Development Corporation to support the talent needs of the state's businesses.[36] Going forward, Wisconsin's universities should continue to connect employers' talent needs with students' career aspirations and to prepare students for high-skill jobs with manufacturers through technical education and career advising.

Table 6: Select Workforce Assets Associated with Wisconsin 4-year Universities

Workforce Asset	*Ecosystem Role*
University of Wisconsin Prison Education Initiative	Provides workforce ready curriculum to incarcerated individuals.
Wisconsin Electric Machines & Power Electronics Consortium	Trains EV researchers and innovators and matches them with potential employers
UW-Madison Office of Business Engagement	Connects industry with research, talent, and solutions at UW-Madison
UW-Madison Career Services	Each school or college at UW-Madison has a career services officed dedicated helping students secure employment
UW-Milwaukee College of Engineering & Applied Science	Trains a significant share of Wisconsin's engineers and EV innovators in Wisconsin
Marquette University Opus College of Engineering	Trains a significant share of Wisconsin's engineers and EV innovators in Wisconsin

Technical Colleges and 2-Year Institutions

The Wisconsin Technical College System provides degrees, certificates, and diplomas through programs tailored to the needs of Wisconsin employers.[37] Unlike universities, technical colleges do not struggle with graduate retention, as 9 in 10 technical college graduates still live and work in Wisconsin according to a 5-year graduate follow-up survey.[38] Moreover, the technical college system maintains strong relations with both Wisconsin employers and communities, has proven itself to be adaptable and responsive to employers' changing skills needs, and produces skilled technicians who generally perform well on the manufacturing floor. Employers interviewed for this report noted that graduates from the Technical College System consistently meet or exceed their expectations.

Technical colleges play a crucial role in providing career opportunities for Wisconsin's underserved residents. For many disadvantaged students, the technical education provided by these colleges places them on a pathway toward greater socioeconomic mobility (approximately 1 in 4 enrollees in the 2019-2020 academic year are people of color[39]). As noted in its *2021 System-Wide Equity Report*, the Technical College System is dedicated to removing barriers faced by populations with historically more limited access to higher education—not only people of color, but also women, veterans, single parents, individuals with disabilities, and LGBTQ residents.[40] As Wisconsin prepares its manufacturing workforce for the future, technical colleges will continue to serve as a means through which all Wisconsinites can share in the sector's growth and prosperity.

However, stakeholders also noted several challenges facing the Technical College System. There are concerns that, while technical colleges' original mission is to train students on the skilled trades, some colleges have placed a greater focus on non-technical education offerings. This broadening into general education, according to some, may have an adverse impact on technical colleges' trade and vocational programs. Another concern is a "higher education overbuild" within Wisconsin, by which too many campuses and institutions serving a relatively small population leads to a duplication and inefficient use of resources. Yet, the most pressing challenge for technical colleges is to scale up programs that train more workers in the skills and occupations being sought by employers. Though the performance of technical college graduates has received positive employer feedback, there is simply not enough of them to address the shortage of skilled manufacturing workers in the state.

Figure 22: Wisconsin's 16 Technical Colleges. Source: Wisconsin Technical College System.

Department of Workforce Development

The Wisconsin Department of Workforce Development provides supplemental job services, training, and employment assistance to Wisconsinites looking for work, and it works with employers on finding the necessary workers to fill current job openings.[41] In this role, the department provides critical workforce services, such as short-term employment assistance, which fall outside the purview of typical higher education institutions. Additionally, the department is more effective in bringing employment resources to underserved and target populations through a statewide job center network.

In particular, the department operates the Employment and Training Divisions, whose constituent bureaus specialize in skills development, apprenticeship standards, worker-employer matching, and veterans' services. Furthermore, the Vocational Rehabilitation Division focuses on assisting people with disabilities to find and maintain employment.

Table 7: Select Workforce Assets Associated with the Wisconsin Department of Workforce Development

Workforce Asset	*Ecosystem Role*
Department of Workforce Development	Provides resources for those looking to enter or re-enter the workforce.
DWD- Work-Share Program	Allows for workers to remain employed during times of reduced business activity
DWD- Apprenticeship Programs	Provides on-the-job training and related instruction
DWD- Training Services for Laid Off Workers	Provides employment services for those who have lost their jobs
DWD- Trade Adjustment Assistance Program	Provides resources for those who want to learn a new trade
DWD- Worker Training Grant	Support for short-term and medium-term employer led training.

Innovation & Entrepreneurship Assets

- Wisconsin's innovation and entrepreneurship ecosystem includes a diverse group of institutions that supports all facets of the lab-to-marketplace transition.

- This ecosystem is unique in that university-affiliated institutions, such as the Wisconsin Alumni Research Foundation, play a substantial role in generating and commercializing innovation, often in partnership with the private sector.

Wisconsin's innovation and entrepreneurship assets span a range of academic labs, incubators, and unique organizations whose purpose is to promote the state's innovation competitiveness. While some assets are dedicated to generating new ideas and technologies in EV-related fields, others focus on translating these innovations into economic development. Overall, these assets can be divided into four categories: research centers, commercialization-focused organizations, entrepreneurship-focused organizations, and investors.

Table 8: Select Innovation and Entrepreneurship Assets in Wisconsin

Research Centers	*Commercialization Support Organizations*	*Entrepreneurship Development Organizations*	*Investors*
• Wisconsin Electric Machines & Power Electronics Consortium • UW-Milwaukee College of Engineering & Applied Science • Marquette Opus College of Engineering	• Wisconsin Alumni Research Foundation (WARF) • WiSys • Marquette Office of Economic Engagement • UW-Madison Discovery-to-Product • Wisconsin Technology Council	• UW-Madison Institute for Business & Entrepreneurship • WERCBench Labs Accelerator Program • gener8tor • Ward4 • StartingBlock Madison • Madworks Accelerator	• N29 Capital Partners • M7 Venture Capital Fund • Mason Wells • Golden Angels Investors • WARF Ventures

Research Centers

As places where new ideas and technologies are developed, research centers drive the basic R&D activities that begin the innovation-commercialization-adoption process. These centers include EV-focused academic labs, such as the Wisconsin Electric Machines and Power Electronics Consortium at UW-Madison's College of Engineering, as well as the engineering departments of other institutions with a focus on power electronics. While these research centers are beginning to benefit from increased investments in EV research and in industry partnerships (as evidenced by the partnership between UW-Madison and the EV startup Canoo to develop a new research center) additional investments in applied research capabilities are needed for Wisconsin's research assets to undertake more collaborative projects with industry partners.

Commercialization Support Organizations

The purpose of commercialization support organizations is to help translate the innovation activity performed at the research centers to the marketplace, typically through technology transfer and commercialization support services. In Wisconsin, these organizations are comprised of technology transfer offices at various universities throughout the state. The largest of these organizations are the Wisconsin Alumni Research Foundation (WARF), the designated technology transfer entity for UW-Madison, and WiSys, a similar organization that serves the rest of the University of Wisconsin

System. Additionally, the Office of Economic Engagement at Marquette University integrates the institution's technology transfer, industry engagement, and community engagement activities to maximize the real-world impact of research activities. These organizations are staffed with commercialization experts who work closely with inventors, researchers, and students to move innovations to the marketplace for financial returns and socioeconomic impact. In addition, WARF manages a substantial investment portfolio that funds an annual grant of tens of millions of dollars for UW-Madison's researchers. WARF also operates a successful accelerator program that recently launched an Electrification Challenge Grant to support innovation in power electronics.

Entrepreneurship Development Organizations

Entrepreneurship development organizations support entrepreneurs in launching and growing startups. These organizations usually take the form of startup incubators and accelerators, many of which provide entrepreneurs with collaborative workspaces as well as business development services and programming. Though their activities and customers often overlap with commercialization support organizations, which focus on the technology transfer of innovations originating from academia, entrepreneurship development organizations emphasize the practical aspects of starting and growing a profitable enterprise, such as business financing, customer acquisition, and strategy formulation.

Wisconsin offers a wealth of entrepreneurship support resources in the form of various startup incubators, such as UW-Madison's Discovery to Product program, gBeta (a nationally ranked startup accelerator), and Ward4 (an incubator and coworking space for Milwaukee area startups and investors). The Institute for Business and Entrepreneurship, part of the University of Wisconsin System, offers additional services through the Small Business Development Center, the Center for Technology Commercialization, the Center for Business Intelligence, and the Business Dynamics Research Consortium. Beyond the business and technical assistance these resources provide, entrepreneurs and small business owners gain access to valuable professional networks that are often the primary means through which startups secure financing and discover growth opportunities. However, stakeholders expressed that these professional networks are still underdeveloped compared to those in more established technology hubs, such as California and Massachusetts.

Investors

Key to an innovation ecosystem is the availability of risk capital to support research, development, commercialization, and the scaling of new technologies and ideas. Risk capital can take many forms, including venture capital, private equity investments, angel funding, and small business loans.

Wisconsin has historically faced challenges in accessing risk capital to support startup formation and commercialization efforts, but recent years has seen the state's entrepreneurs attract more and larger investments. According to the Wisconsin Technology Council, 2021 was by far a record year for venture capital and angel investments. Furthermore, while Wisconsin's investors tend to be smaller compared with those in venture capital hubs such as Silicon Valley or Boston, risk capital capacity is supplemented by the investment arms of commercialization support organizations. As a case in point, investors in the Wisconsin-based EV startup C-Motive include N29 Capital Partners, a Wisconsin-based venture capital firm, as well as the Wisconsin Alumni Research Foundation and the Center for Technology Commercialization.[42]

Public & Non-Profit Assets

- Wisconsin boasts a capable selection of governmental and non-profit assets whose efforts in support of EV manufacturing and adoption are essential to the success of industry development.

- While various policies and programs exist in the state to incentivize and facilitate electrification and automation—typically in the form of tax exemptions and refunds, utility rebates, and grants—specific policies to encourage manufacturing toward EV equipment production do not currently exist.

The development and sustainment of a dynamic manufacturing ecosystem depends on the support of government agencies and non-profit organizations. These assets often serve as a convening power that mobilizes stakeholders around strategic initiatives that strengthen the ecosystem. Through their roles as organizers and subject matter experts, government and non-profit institutions inform, educate, advise, and connect disparate groups of stakeholders, thereby building the critical ecosystem linkages as illustrated in *Figure **21***. Wisconsin's public and non-profit assets conduct activities in a wide range of areas but can be framed as supporting either innovation industry and supply chain development or EV adoption and infrastructure efforts. Additionally, state policies and programs that support EV development assets is a third asset category with important implications for stakeholders throughout the ecosystem.

Table 9: Select Public and Non-profit Assets in Wisconsin

Industry and Supply Chain Development	*EV Adoption and Infrastructure Development*	*Public Policies and Programs*
• Wisconsin Economic Development Corporation • Wisconsin Center for Manufacturing & Productivity • Wisconsin Manufacturers and Commerce • Wisconsin Procurement Institute • Wisconsin Supplier Network	• Wisconsin Department of Transportation • Wisconsin Clean Cities • RENEW Wisconsin • Godfrey and Kahn • Office of Clean Energy & Sustainability • Utility Companies in Wisconsin	• Wisconsin Automation Implementation Grant • Alternative Fuel Tax Refund for Taxis • Alternative Fuel Tax Exemption • WI NEVI Planning • Work Opportunity Tax Credit (WOTC) • Vehicle Battery and Engine Research Tax Credits • Heavy-Duty Transit Bus Grants • EV and EV Charging Station Grant Program • WI Renewable Energy and Energy Storage Programs • Clean Diesel Grant Program • Utility Company Rebates

Industry and Supply Chain Development

Wisconsin's manufacturers have access to technical and business development assistance from a host of public and non-profit institutions. These institutions specialize in different aspects of business assistance, from supplier identification and acquisition to manufacturing best practices. For manufacturers that lack the time and resources to conduct long-range strategic planning, these institutions are an asset to identify opportunities to participate in emerging supply chains and to improve productivity and competitiveness through process innovation.

The primary asset for this role is the Wisconsin Center for Manufacturing & Productivity (WCMP). WCMP oversees the activities of the Wisconsin Manufacturing Extension Partnership, which covers customers in Wisconsin's southeastern half, and the Manufacturing Outreach Center at UW-Stout, which covers the state's northwestern half. Both institutions provide various forms of technical, business, and workforce assessments for specific manufacturers to help each manufacturer identify opportunities and pathways to achieve their strategic goals.

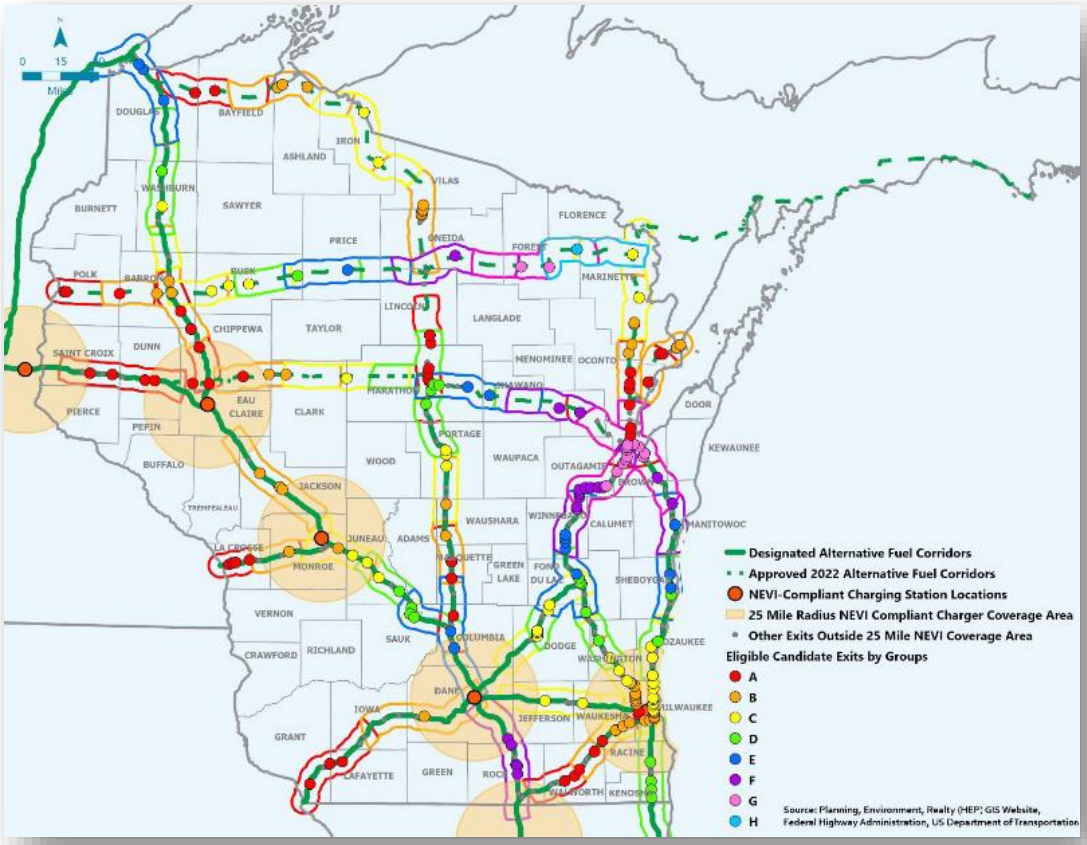
Complementing WCMP's technical assistance work are the business development programs overseen by the Wisconsin Economic Development Corporation (WEDC). The funding support offered by WEDC to steer industry development toward specific outcomes can be packaged with WCMP's technical guidance to maximize the efficacy of the state's economic development efforts. For example, applicants to WEDC's Diverse Business Development Program, which provides financial support for minority, women, disabled, LGBTQ, and veteran-owned businesses, can also benefit from the technical and management consulting services provided by WCMP.

EV Adoption and Infrastructure Development

Wisconsin benefits from a host of organizations that actively advocate and lobby for policies that accelerate the state's transition to EV. These organizations are widely viewed as thought leaders in EV policy and planning, and some of them are part of national networks that offer expertise, insights, and case studies through their work with other states. Wisconsin Clean Cities, for example, brings to Wisconsin the expertise and thought leadership of the Clean Cities Coalition Network. Additionally, the access to EV stakeholders outside Wisconsin and the ability to collaborate and partner with them on inter-state projects are valuable capabilities of institutions such as Wisconsin Clean Cities. Beyond advocacy and policy, these same organizations also work closely with government entities such as the Office of Clean Energy and Sustainability to lead EV education and outreach efforts in Wisconsin communities.

The Wisconsin Department of Transportation's recent EV infrastructure planning efforts, which culminated in the *Wisconsin Electric Vehicle Charging Infrastructure Plan*, represent a significant step forward in the state's transition to EV technologies. The plan—funded by the National Electric Vehicle Infrastructure Program (NEVI) as part of the Bipartisan Infrastructure Law—examines the suitability of EV adoption in Wisconsin, presents a roadmap toward the deployment of statewide EV infrastructure, and discusses the workforce and equity implications of this deployment for Wisconsin communities.[43] Going forward, this plan is expected to serve as a guiding document around which future EV deployment efforts will be framed.

Figure 23: *Proposed Full NEVI-compliant EV Charging Station Build-out Coverage Map. Source: Wisconsin Department of Transportation.*



Public Policies and Programs

For Wisconsin's economy and community to make the electrification transition, a robust policy environment must be in place to support electrification efforts. More specifically, strong policies and programs geared toward supporting and incentivizing electrification is necessary for an increase in adoption. Currently, Wisconsin's policy apparatus regarding electric vehicle adoption offers financial incentives through three pathways: tax exemptions and refunds, utility company rebates, and grants.

For tax incentives to aid in the EV transition, Wisconsin must supplement existing tax incentives that are geared toward alternative fuel sources and electrification research with tax credits that incentivize investments and developments in EV-related manufacturing technologies. Additionally, Wisconsin's Department of Transportation applies a surcharge to hybrid electric vehicles and electric vehicles to be paid annually, which dampens state consumption of EVs.[44]

The utility company rebates provide companies with incentives to adopt clean energy practices. Wisconsin electric companies have begun to provide incentives for companies to develop charging stations. Utility rebates provide Wisconsin a platform to increase incentives for businesses to develop the infrastructure needed to support EV expansion.

Grants provide companies with incentives to adopt and implement electrification and automation practices. Wisconsin offers various grant programs for stakeholders to electrify certain operations. However, capacity is limited, and the grants only encompass a narrow range of electrification processes.

Wisconsin Automation Implementation Grant Program

To incentivize manufacturing automation, WEDC and WCMP have partnered to operate the Wisconsin Automation Implementation Grant program to lower the risk of automation technology implementation by providing technical expertise while offsetting a portion of the cost.[45]

The 2-step process enables manufacturers to select the most appropriate technology, plan effective implementation, and receive financial support for acquiring the technology. Manufacturers first complete an automation assessment with the Wisconsin Manufacturing Extension Partnership or the UW-Stout Manufacturing Outreach Center, resulting in an automation implementation roadmap with specific equipment recommended through the assessment. This roadmap also includes a sequenced technology acquisition and implementation plan tailored to the specific manufacturing operation in question.[46]

Upon completion of the roadmap, the manufacturer is eligible for financial support to acquire the specified equipment. Equipment purchased or leased during the grant period is eligible for reimbursement of up to 20% of total equipment cost (capped at $35,000 for purchased equipment) or up to 10% of total equipment lease expense (capped at $15,000 for leased equipment), contingent upon availability of WEDC funds. To ensure accountability, the program also requires the grant recipient to provide return on investment and labor redeployment metrics as part of the post-project reporting process.[47]

Community Assets

- Wisconsin's demographic challenges, combined with a negative perception of manufacturing careers among young Wisconsinites, pose long-term threats to Wisconsin's manufacturing sector.

- Addressing these broader challenges requires the mobilization of community assets, many of which operate at the local level, to create the human capital that is vital to manufacturers' success.

Wisconsin's ability to transition to electric vehicles, both from a manufacturing and adoption standpoint, will depend in part on broader community and cultural trends that pose far-reaching implications for its manufacturing sector as a whole. First, a major contributor to the shortage in skilled workers is the state's slow population growth, declining labor force participation, and lack of success in attracting large numbers of young workers. To address these demographic challenges, Wisconsin must better utilize state, regional, and local assets to attract more working-age residents. Efforts to accomplish this goal should, furthermore, be informed by research conducted by the Applied Population Lab (APL) at UW-Madison, which has performed detailed analysis into Wisconsin's demographic challenges. In the study *Gaining and Maintaining Young People in Wisconsin Communities*, APL researchers found that only 15% of Wisconsin communities are gaining or maintaining young adults and that the state's most urban area—Milwaukee County—loses more young adults than many rural areas. The study also identified five community qualities that are important for attracting young adults:

1. Perceived quality of schools
2. Perceived appropriate affordability of housing—young adults at different life stages may define affordability differently
3. Availability and perceived quality of outdoor amenities
4. A small-town sense of community and civic engagement
5. Proximity to cities that offer employment, entertainment, and shopping

Second, addressing the negative perception of manufacturing careers held by many young Wisconsinites is a task that is well suited to Wisconsin's community-focused institutions. Local school districts, governments, and planning agencies, in conjunction with regional leadership councils and state agencies such as the Department of Workforce Development, should raise awareness among students about career opportunities in skilled technical occupations. Specifically, the perception of manufacturing careers as repetitive and menial must be dispelled by demonstrating to future workers that 21st century manufacturing jobs are innovative, intellectually challenging, and technology intensive with frequent interactions with robots, AI, and other emerging technologies. Selling this new paradigm requires the buy-in of institutions throughout Wisconsin's communities.

Table 10: Select Community-related Assets in Wisconsin

• UW-Madison Applied Population Lab • Regional Leadership Councils	• Local School Districts • Travel Wisconsin • Local Planning Agencies	• Office of Outdoor Recreation • Office of Rural Prosperity	• WI Technical Colleges • WEDC

Wisconsin's Strategic Position

SWOT Analysis

To advance Wisconsin's strategic position in electrification, SRI conducted an analysis of strengths, weaknesses, opportunities, and threats (SWOT). The SWOT analysis draws upon findings from the Economic and Supply Chain Assessment and the Asset Map to inform Wisconsin's path forward. In the SWOT analysis, (1) strengths refer to characteristics of Wisconsin's economy that impart a competitive advantage, (2) weaknesses refer to characteristics of Wisconsin's economy that put the state at a competitive disadvantage, (3) opportunities refer to elements in the external environment that Wisconsin could leverage to further its objectives, and (4) threats refer to elements in the external environment that could hinder Wisconsin's efforts to achieve its objectives.

Figure 24: Summary of Wisconsin EV / Electrification SWOT Analysis

STRENGTHS

- **Strategic location** near Midwestern automotive manufacturing hubs and transportation networks supports growth.
- **Manufacturing legacy** imparts strong institutional knowledge.
- **Private sector makes active effort** to transition to EV supply chains.
- **Robust network of technical colleges** sustains a strong talent pipeline.
- **Reputable and strong university system** has dedicated technology transfer offices.
- **Strong network of non-profits and advocacy groups** focus on accelerating EV adoption.
- **Low labor and land costs** appeal to prospective businesses.

WEAKNESSES

- **Low manufacturing productivity** decreases competitiveness in national and global markets.
- **Shortage of skilled workers**, due in part to an aging workforce and slow labor force growth**,** is widely cited as a key challenge by manufacturers.
- **Laws and regulations on energy distribution** are inadequate for statewide EV transition.
- **Rural economies** are more vulnerable to business disruption due to the EV transition and to broader changes in the manufacturing sector.

OPPORTUNITIES

Geopolitical Trends

- **Significant federal support** exists for domestic EV manufacturing and infrastructure development.
- Global OEMs accelerate **shift toward EV supply chains.**
- **Government and commercial transition to EV fleets** is increasingly being used to jumpstart and accelerate EV adoption.
- Need for **interoperability standards** can mobilize EV equipment manufacturers to pursue a shared industry vision.

Technological Trends

- New developments for the **reuse of EV batteries** have wide-ranging applications for industries.
- **Smart grid initiatives** focus on sustainability and climate-friendly solutions.
- Long-term paradigm shift **from vehicle ownership to mobility-as-a-service** will open opportunities for new electrically powered modes of transportation.

THREATS

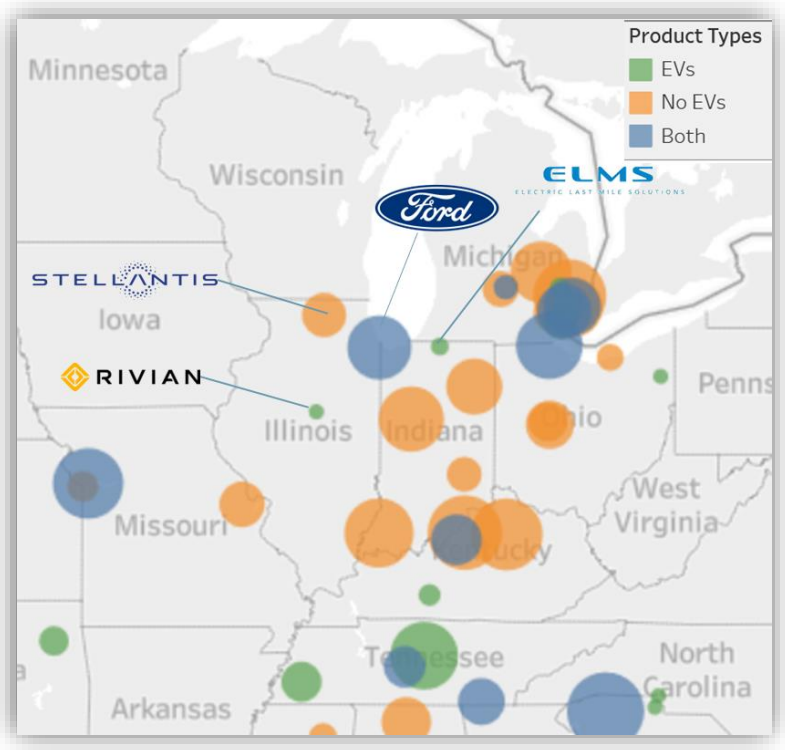
- Reliance on foreign sources for critical minerals and batteries increases vulnerability to **supply chain disruption.**
- **Strategic inaction and failure to invest in the future** threaten the long-term competitiveness of both manufacturers and regions.
- Manufacturers are increasingly exposed to **cybersecurity risks.**
- EV adoption is contingent on the **availability of reliable EV infrastructure and shifting consumer perceptions.**

Strengths

Strategic location near Midwestern automotive manufacturing hubs and transportation networks supports growth.

Wisconsin's strategic location in the automotive supply chain is attributed to its proximity to nearby automotive manufacturing clusters and its position as a key node along midwestern transportation networks. While Wisconsin's manufacturers benefit from being within a day's drive to automotive plants in Michigan, Ohio, and Indiana, it is the state's adjacency to OEM plants in northern Illinois that offers significant potential for additional manufacturing growth. Ford's Chicago plant, which manufacturers the Ford Explorer, has in the past decade ramped up its EV assembly activities to produce the Explorer's EV hybrid configurations.[48] Similarly, according to the Chicago Tribune, there is a high probability that Stellantis will transform its Belvidere, Illinois plant into the automaker's first EV factory, where it will assemble the EV versions of the Dodge Charger and Challenger.[49] Combined with Rivian's EV assembly presence in Bloomington, Illinois, these developments underscore the potential of Wisconsin's EV-oriented manufacturers to strengthen regional supply chain connections.

Figure 25: Locations of Vehicle Assembly Plants near Wisconsin. Source: Third Way. NOTE: Size of bubbles indicate the number of workers employed at the plant.[50]



In terms of EV adoption and infrastructure, Wisconsin's strategic location is highlighted in a white paper published by the Wisconsin Technology Council: *Rust Belt No More: Traveling the "I-Q Corridor."*[51] The I-Q Corridor, the region around the interstate highway system that binds Chicago, Wisconsin, and Minneapolis-St. Paul, is a prime location for EV infrastructure development due to the heavy commercial and consumer traffic that flows through the region. Its potential is also

highlighted by the Wisconsin Department of Transportation's *Wisconsin Electric Vehicle Charging Infrastructure Plan*, which envisions an extensive EV charging station network along the corridor.[52]

Manufacturing legacy imparts strong institutional knowledge.

Wisconsin's manufacturing legacy is one of its greatest assets. This legacy means that stakeholders throughout the state's manufacturing ecosystem—from technical college instructors to plant managers to workers on the factory floor—possess the institutional knowledge accumulated over a century of intensive manufacturing activity. Over time, this institutional knowledge has enabled Wisconsin's manufacturers to pivot and innovate in the face of technological change, with one example being the success of multiple Wisconsin companies in building out EV product lines. Thus, the established social infrastructure and knowledge capital abundant in Wisconsin's manufacturing sector serve as a foundation for the state to continue to modernize its manufacturing ecosystem.

Private sector makes active effort to transition to EV supply chains.

A key finding of this report is that well-resourced manufacturers in Wisconsin are actively and independently transitioning to EV supply chains. Having recognized the business need to diversify into EV product lines in the face of the global trend toward electrification, established manufacturers with long-standing business models focused on the internal combustion engine (ICE) have begun to develop and manufacture electrically-powered versions of their products. The growing EV capabilities of these manufacturers are a promising sign of Wisconsin's EV manufacturing potential, indicating that future growth can be sustained or expanded with support from other critical assets in the ecosystem.

Robust network of technical colleges sustains a strong talent pipeline.

The Wisconsin Technical College System, comprised of 16 technical colleges throughout the state, is a vital contributor to Wisconsin's manufacturing competitiveness by supplying employers with a robust pipeline of skilled technical workers. Technical colleges further distinguish themselves by their adaptability and responsiveness to the needs of employers within the regions they serve. Through contract training programs tailored to specific employers, apprenticeship programs, and frequent curriculum updates in response to changing skills needs, the Wisconsin Technical College System has made employer engagement a cornerstone of its success strategy. Additionally, the colleges' emphasis on underserved populations has made a substantial impact on providing opportunities to students who otherwise would not have access to pathways toward higher-wage careers.

The performance of graduates of the technical colleges has generally been well-received by employers, thereby confirming the quality of technical training taking place in these colleges. However, the challenge for the colleges going forward is to boost enrollment and scale up programs in relevant fields in a way that can substantively address the manufacturing worker shortage in Wisconsin.

Reputable and strong university system has dedicated technology transfer offices.

Research universities often serve as centers of innovation activity, as operators of the institutional infrastructure that enable new technologies to be commercialized in the marketplace, and as enablers for collaboration between academia and industry. This is especially the case in Wisconsin, where institutions such as the Wisconsin Alumni Research Foundation (WARF) are pioneers in developing novel technology transfer models that have since been adopted by research institutions throughout the United States. As such, the engineering colleges and schools of Wisconsin's universities play a significant role in driving EV innovation while supplying a pipeline of EV-focused innovators and engineers to a private sector that is increasingly focused on electrically powered technologies. Recent efforts by Wisconsin's universities to strengthen R&D collaboration with industry partners, as demonstrated by UW-Madison's partnership with the EV startup Canoo to open

an electric vehicle research center, further highlight Wisconsin universities' potential to drive EV innovation.[53]

Strong network of non-profits and advocacy groups focus on accelerating EV adoption.

Although progress in EV adoption and infrastructure development is at an earlier stage compared to states such as California, there is a strong network of non-profits and advocacy groups within Wisconsin that have been proactive in accelerating EV adoption. Over time, these groups have become thought leaders on EV adoption opportunities and challenges within Wisconsin as well as broader trends in the EV space. They have also used their expertise to lobby for greater public and private sector support for EV development, to educate consumers and businesses about EV, and to craft compelling arguments for the need to mobilize stakeholders to advance the state's electrification. Furthermore, because some of these groups are branches of national networks (e.g., Wisconsin Clean Cities), they can draw upon national EV initiatives and best practices from other regions to further inform Wisconsin's own electrification strategy.

Low labor and land costs appeal to prospective businesses.

The cost of capital in Wisconsin is relatively low, and its business-friendly environment makes the state attractive to prospective manufacturers and EV firms. The state has a relatively large number of underutilized or vacant sites that can be repurposed to support new manufacturing operations.[54] Some of these sites house manufacturing facilities and infrastructure for operations that have shut down, and their close-to-shovel-ready status can potentially save prospective manufacturers significant site development costs. More importantly, they can help EV startups accelerate the time between site acquisition and full production, as was the case in Rivian's repurposing of an old Mitsubishi factory in Bloomington-Normal, Illinois into its first EV assembly plant within a short span of time.[55]

Wisconsin's comparatively low cost of labor and the availability of a skilled workforce further enhance the state's appeal to outside manufacturers. For Rivian, Bloomington-Normal's skilled automotive workforce—once displaced after the Mitsubishi plant closed in 2015—was one of the deciding factors for the EV startup's decision to locate operations in the region.[56] Though most of Wisconsin's automotive manufacturing workforce does not face the prospect of displacement in the immediate future, its presence and size poses a similar appeal to EV manufacturers seeking easy access to skilled and experienced workers.

Weaknesses

Low manufacturing productivity decreases competitiveness in national and global markets.

Wisconsin's low manufacturing productivity and the labor-intensive nature of its manufacturing sector is perhaps the sector's greatest weakness. The overreliance on labor over automated machinery as an input to production makes the manufacturing sector more vulnerable to worker shortages. In the long run, lower productivity can potentially hinder Wisconsin manufacturers' ability to compete in an advanced manufacturing economy and has implications for the state's socioeconomic health. For example, continued low productivity growth will likely suppress wage growth for Wisconsin's manufacturing workers. Consequently, there is a serious need for investments in automation and for other forms of process innovation that raise the productivity of Wisconsin's manufacturers.

Shortage of skilled workers, due in part to an aging workforce and slow labor force growth, is widely cited as a key challenge by manufacturers.

A shortage of skilled workers has become a chronic issue for Wisconsin's manufacturers, some of which have had to adjust or curtail production due to understaffing. The causes of this worker shortage are manifold. However, key contributors include an aging manufacturing workforce nearing retirement, a negative perception of manufacturing careers among younger Wisconsinites, and slow population and labor force growth. In 2022, with the statewide unemployment rate nearing record lows, stakeholders have reported that there are far more jobs than there are qualified workers to fill them.

Additionally, worker retention has been cited by employers as a growing challenge and can be considered a result of the worker shortage. With manufacturers competing for a relatively small group of skilled workers, there is a strong incentive for in-demand workers to move from one employer to another in search of better wages and benefits. Increasing the use of technology and automation can potentially alleviate the worker shortage while also creating new and higher-quality jobs. In the meantime, however, increasing the supply of skilled labor by scaling up technical training should be considered a priority over the short-to-medium term. These training initiatives should, furthermore, align with the state's long-term strategy toward manufacturing automation so that future workers and managers are prepared to work with the most up-to-date technologies and processes.

Laws and regulations on EV infrastructure and use are inadequate for statewide transition.

Successful EV adoption within a region requires the necessary physical and energy distribution infrastructure for EVs to operate. Building this infrastructure, in turn, depends on a clear and robust framework of laws and regulations governing the utilization and operation of this infrastructure.

In Wisconsin, this regulatory framework is still being determined through legislative processes, and a key area of contention is determining who will control and benefit most from the operation of a statewide EV infrastructure.[57] A proposed framework that would only permit EV charging stations to obtain electricity from utility providers (thereby disallowing on-site solar-powered charging stations) and prevent governments from building for-pay charging stations was struck down in the State Senate in March 2022.[58] As of September 2022, a clear regulatory framework has yet to be agreed upon, and the absence of such a framework poses a significant barrier to EV adoption efforts.

Rural economies are more vulnerable to business disruption due to the EV transition and to broader changes in the manufacturing sector.

In Wisconsin, rural economies are more dependent on manufacturing than urban areas, and they are home to a greater share of ICE manufacturers that are more likely to be adversely impacted by the EV transition. Moreover, stakeholders noted that rural manufacturers are generally more risk-averse to new or disruptive technologies, and many prefer a more incremental approach to dealing with broader changes in the sector. As such, the vulnerability of Wisconsin's rural areas to changes in the manufacturing sector has important implications for rural economies and communities, and these implications will need to be seriously considered to ensure that Wisconsin's rural communities are not left behind as Wisconsin pursues efforts to reinvigorate its manufacturing sector.

Opportunities

Geopolitical Trends

Significant federal support exists for domestic EV manufacturing, infrastructure development, and adoption.

Policy support for EV includes both supply-side and demand-side incentives. Supply side incentives aid manufacturers, suppliers, and infrastructure development contractors wanting to enter the EV market, increase their market share, or conduct research and development in the EV space.

Federal supply side incentives such as the Advanced Technology Vehicle Manufacturing (ATVM) loans and Advanced Manufacturing Tax Credits (AMTC) have existed for more than a decade. More recently, however, the Biden Administration has radically expanded the scale and scope of these incentives through the passage of the Bipartisan Infrastructure Law. In addition to investing $25 billion toward EV manufacturing, infrastructure development, and adoption efforts, the administration released an EV Charging Action Plan to work with state and local governments to build a national charging network. This includes $5 billion in formula funding for states to build EV infrastructure and an additional $2.5 billion for communities and corridors through a competitive grant program to support innovative approaches and ensure that charging station deployment supports economic, equity, and environmental objectives.[59]

Crucially, the Inflation Reduction Act revives a federal tax credit for EV charging stations, whereby residents and businesses who install charging stations can receive a tax credit worth up to 30% of the equipment purchase and installation cost. The Alternative Fuel Infrastructure Tax Credit, which expired in 2021, was renewed by the Inflation Reduction Act and is expected to increase nationwide demand for EV charging equipment.[60]

Another policy objective at the federal level is to increase domestic manufacturing of EV batteries and to advance domestic sourcing and recycling of critical minerals associated with battery production. To this end, the Biden Administration has:[61]

- Released the National Blueprint for Lithium Batteries, which codifies the findings of a battery supply chain review to urgently develop a domestic lithium battery supply chain
- Established new guidance for the ATVM program to support the domestic battery supply chain through investments in key areas of development and fill gaps in advanced battery manufacturing and innovation
- Earmarked $3 billion in competitive grants for battery minerals and refined materials aimed at accelerating the development of the domestic battery supply chain
- Earmarked $3 billion for competitive grants for building, retooling, or expanding battery manufacturing facilities and to establish battery recycling facilities across the United States
- Offered millions of dollars in funding to support state and local governments in the collection, reuse, and recycling of spent batteries

For Wisconsin, the prioritization of federal policy to support state and local electrification efforts is a considerable opportunity that can be explored further, and the Wisconsin Department of Transportation has spearheaded efforts to do so through the development of the *Wisconsin Electric Vehicle Infrastructure Plan*. Given the substantial levels of financial support being offered by federal agencies, stakeholders throughout Wisconsin can continue to coordinate efforts toward competitive grant and loan applications that fund electrification initiatives within the state. Additionally, opportunities exist for stakeholders to take full advantage of the expanding organizational and technical resources being created at the federal level to assist state agencies and businesses in furthering Wisconsin's electrification strategy.

Global OEMs accelerate shift toward EV supply chains.

Though the shift toward EV supply chains on the part of global automotive makers threatens the survival of ICE-dependent suppliers, it also presents a significant opportunity for manufacturers of EVs and EV charging equipment. As global OEMs reconfigure their supply chains toward EV components, their search for new suppliers will inevitably include consideration for Wisconsin's EV parts manufacturers. As such, raising the visibility of Wisconsin's manufacturing capabilities and proactively engaging with OEMs as they transition their supplier networks are critical for the state's manufacturers to secure an important position in the EV supply chain. To this end, there is a substantial opportunity for Wisconsin's economic developers to market the state's supplier capabilities and manufacturing strengths to OEMs that are in the midst of transitioning their supply chains toward EV components.

Government and commercial transition to EV fleets is increasingly being used to jumpstart and accelerate EV adoption.

In recent years, governments and commercial fleet operators have increasingly used their procurement resources to both support domestic EV demand and to accelerate EV adoption through pilot projects and public demonstrations. The City of New York has invested heavily in electric vehicles and boasts the largest percentage of electrification of any U.S. municipal fleet. In the San Francisco Bay Area, the Plug-In Bay Area initiative engaged 113 local governments and numerous businesses to encourage EV infrastructure demonstration projects, EV fleet orders, and other EV purchase incentives for consumers.[62] Where a lack of consumer demand limits a region's ability to develop EV infrastructure, government and commercial procurement has become a popular tool to jumpstart adoption efforts.

In Wisconsin, opportunities exist for local governments to align their procurement needs with EV adoption goals. The cities of Milwaukee, Madison, and Racine are members of the Climate Mayors Electric Vehicle Purchasing Collaborative, which works to leverage the buying power of more than 30 local governments and agencies to support EV transitions for public fleets.[63] The supplier relationships and best practices gained by these memberships can also be used to encourage commercial fleets to transition to EV. Furthermore, Oshkosh's manufacturing presence in Wisconsin should grant local governments and private fleet operators easier access to the manufacturer's electrically powered public and emergency service vehicles.

Need for interoperability standards can mobilize EV equipment manufacturers to pursue a shared industry vision.

Interoperability refers to the compatibility of key system components—vehicles, charging stations, charging networks, and the grid—and the software systems that support them, allowing all components to work seamlessly and effectively.[64] As a growing number of manufacturers develop various components for EV and EV charging equipment, the burden of setting standards to ensure interoperability between different types of EV hardware will fall on governments. Prior to development of a mature EV manufacturing ecosystem in Wisconsin, there is a real need for the state to facilitate the development of interoperability standards which guide manufacturers' setting of equipment specifications. Doing so will help manufacturers avoid costly retooling by reducing the possibility of components developed by different companies being incompatible. Additionally, the process of setting standards necessitates participation from industry and technical experts throughout Wisconsin and can serve as an opportune exercise to mobilize stakeholders toward a shared industry vision. Lastly, the successful rollout of statewide EV standards would demonstrate Wisconsin's commitment to establishing industry leadership to stakeholders both inside and outside the state.

Technological Trends

New developments for the reuse of EV batteries have wide-ranging applications for industries.

Developing new methods to recycle and reuse spent EV batteries has been a priority for both industry stakeholders and policymakers over the past decade. While only a few minerals within batteries can be recycled efficiently with current technology, companies and researchers have developed novel methods to convert used EV batteries into industrial and home energy storage units. One common application is to bundle together spent batteries—each of which still retain 60%-80% of usable charge—to serve as energy storage devices for solar panels, wind turbines, manufacturing plants, and other industrial applications. Such reuse is now commonplace in Japan and the United Kingdom, where new solar and wind farms are routinely connected to bundles of spent EV batteries.[65,66]

Likewise, the reuse of EV batteries in Wisconsin will hold significant economic potential for both utility and industrial applications. As the state begins planning to reconfigure its energy grid to meet future EV demand, the possibility of integrating spent batteries for grid-scale renewable energy storage should not be discounted. For industrial plant operators and rural consumers, old EV batteries can serve as an alternative source of local or backup energy storage. The opportunities afforded by the reuse of EV batteries therefore illustrate the concept of a circular economy that furthers Wisconsin's conservation and sustainability objectives.

Smart grid initiatives focus on sustainability and climate-friendly solutions.

Smart grids incorporate a suite of advanced software and hardware capabilities to dynamically adjust energy supply based on real-time changes in energy demand.[67] The development of smart grids is widely considered to go hand-in-hand with widespread EV deployment, as the smart grid allows utilities to manage vehicle charging and facilitate billing during on- and off-peak hours.[68] Utilities can also employ sophisticated software and big data to turn vehicle chargers on or off to shape system load. To further improve the dynamism and adaptability of the grid, utilities can employ a vehicle-to-grid (V2G) approach in which idle vehicles feed their electricity back into the grid to supplement electricity supply during peak demand hours.[69]

The integration of mass EV deployment into a smart grid model is both an opportunity and a challenge for Wisconsin. The overhaul and modernization of the state's electricity grid will require utilities to make substantial investments in new hardware and software capabilities, and some of the benefits from these investments will only be realized once EVs have become widespread. Yet, the potential gains in energy efficiency, cost savings, and grid security from Wisconsin's transition to a smart grid approach are considerable, and the integration of EVs into a smart grid is widely considered necessary to fully realize the sustainability potential of mass EV adoption.

Long-term paradigm shift from vehicle ownership to mobility-as-a-service will open opportunities for new electrically powered modes of transportation.

The attitudes and perceptions of U.S. consumers toward the car have undergone enormous change over the past century. Although car ownership has steadily increased during this period, some automotive industry analysts now acknowledge that the world has passed peak car ownership, the point after which car use will begin to decline.[70] Several factors have been attributed to this trend. The movement of people to cities means that cars are no longer regarded as essential, and the availability of alternative modes of transport, from ride hailing and car rental to e-bikes and public transit, makes car ownership less appealing to many urban residents. Consequently, some transportation experts observe a long-term paradigm shift in personal transportation from car-centric to a diverse mixture of transport systems knitted together by smartphone technology—an approach known as mobility-as-a-service (MaaS).[71] In effect, the predominant form of future personal transport may rely on a combination of public transit, e-bikes and e-scooters, and ride hailing that is accessed and paid for via a single digital platform.

The implications of this paradigm shift for Wisconsin's manufacturers are two-fold. First, relatively new modes of electrically powered transportation such as e-bikes and e-scooters may take on a

greater importance in everyday transport and open new market opportunities for manufacturers with established capabilities in power electronics manufacturing. It may therefore be beneficial for automotive manufacturers and suppliers to consider diversifying into other modes of electrically powered transportation. Second, successful MaaS models will likely depend on strong software capabilities as well as an ability to collect and analyze big data. The outsized importance of software in everyday transport further underscores the importance of software training as a necessary component in the education of next-generation workers.

Threats

Reliance on foreign sources for critical minerals and batteries increases vulnerability to supply chain disruption.

Uncertainty over the availability and accessibility of critical materials used in EV production, much of which are sourced from international markets, poses a serious threat to EV manufacturing both in Wisconsin and throughout the United States. These materials include rare earth minerals as well as components used in EV batteries. While the federal government is investing heavily in developing a robust domestic battery supply chain, such an effort will take years to substantially reduce reliance on foreign suppliers.

Because the ability of OEMs to produce electric vehicles depends on battery availability, disruptions in the battery supply chain will also affect the entire EV supply chain as non-battery EV suppliers cannot sell components to customers that are unable to assemble complete vehicles. As such, firms throughout Wisconsin's EV supply chain would do well to pursue a customer diversification strategy that can potentially extend to other industries. For Wisconsin's OEMs, contingency planning for battery supply disruption—including determining which production lines would take priority when batteries do arrive—can alleviate the business impact should disruptions occur.

Strategic inaction and failure to invest in the future threaten the long-term competitiveness of both manufacturers and regions.

While many manufacturers throughout Wisconsin and the United States are taking active steps to adapt to the EV transition and to broader changes in the manufacturing sector, others have adhered to the status quo.[72] This strategic inaction, often demonstrated by a failure to consider a firm's long-term position or to make investments for the future, may eventually threaten a manufacturer's future competitiveness and viability. However, these firms also stand to gain the most from the financial, business development, and technical assistance offered by agencies such as the Wisconsin Economic Development Corporation and the Wisconsin Center for Manufacturing Productivity.

At a broader level, competition between regions and countries to become global hubs for advanced manufacturing and clean technology is expected to intensify over the coming decade. Many regions are making significant investments in the development of key target industries, in the modernization of their workforce apparatus, and in strengthening their innovation ecosystems. Regions that continue to rely on legacy practices without consideration for the future may see their economic competitiveness being gradually eroded. Amidst increasing competition at both the firm level and between regional economies, an urgent need exists for Wisconsin to shore up its strengths in manufacturing through continued modernization efforts to secure a leading economic position in both domestic and international markets.

Manufacturers are increasingly exposed to cybersecurity risks.

According to an analysis by the Wisconsin Center for Manufacturing Productivity, approximately one in six Wisconsin manufacturers recognize that they have been the victim of cyberattacks.[73] This statistic is not uncommon, as cyberattacks on U.S. businesses have been increasing in frequency, severity, and sophistication. However, the cybersecurity capabilities of many manufacturers across the United States are widely regarded as inadequate or nonexistent, and the risk of production stoppage and data theft is too great for stakeholders in Wisconsin's manufacturing sector to ignore.

To strengthen manufacturers' ability to keep operations secure in an environment increasingly dependent on software and digital connectedness, Wisconsin can increase cybersecurity education and outreach efforts by its network of institutional cybersecurity partners. These partners, such as the Wisconsin Security Research Consortium, UW-Oshkosh's Cybersecurity Center of Excellence, and UW-Stout's Cybersecurity Research and Outreach Center, can further increase collaboration with the Wisconsin Center for Manufacturing Productivity to deliver actionable cybersecurity training to the state's manufacturers.

EV adoption is contingent on the availability of reliable EV infrastructure and shifting consumer perceptions.

The development of a reliable and accessible EV charging infrastructure is a prerequisite for widespread EV adoption. Conversely, potential delays or failures in EV infrastructure development threaten a region's ability to achieve mass EV deployment. EV infrastructure availability also plays a key role in alleviating consumer concerns about EV, which are commonly dominated by "range anxiety"—a fear of running out of power without the ability to recharge an EV's batteries—as well as concerns about reliability, maintenance, safety, and financial cost.[74] As such, infrastructure availability is widely considered a key driver to stimulating consumer demand for EVs.

As mentioned in the Weaknesses section, the development of EV infrastructure depends in turn on a clear regulatory framework that governs how this infrastructure is developed and operated. While the federal government has made ample funding and organizational support available for state and local governments to pursue EV infrastructure projects, the lack of a clear vision for how Wisconsin communities, businesses, utilities, and governments should engage with and operate EV infrastructure is a major roadblock on the state's path toward mass EV adoption.

Wisconsin's Path Forward

Recommendations Overview

As Wisconsin undertakes efforts to develop a globally competitive EV cluster in the coming years, it must also build a more productive, dynamic, and inclusive manufacturing sector. As the state's primary economic development organization, the Wisconsin Economic Development Corporation (WEDC) will work alongside key stakeholders to play a leading role in reshaping Wisconsin manufacturing to capitalize on opportunities as they emerge to build the capacity necessary to drive future growth and prosperity.

The recommendations contained in this strategic plan are rooted in the findings of extensive stakeholder engagement, in collaboration with WEDC, and data analysis. These findings show that Wisconsin's manufacturing sector, despite existing challenges, has immense potential to develop a globally competitive cluster in EV and EV-related equipment manufacturing. Much of this potential stems from the state's vast and varied base of assets and stakeholders, but realizing this potential requires collaboration across institutional boundaries to implement a coordinated and collective approach to industry development. To this end, the vision statement below provides a unifying idea that captures the ambitions of Wisconsin's stakeholders:

> **Vision Statement**: Wisconsin will have a dynamic and inclusive manufacturing ecosystem that engages local talent, cultivates innovation, and supports statewide electrification efforts.

The following six strategies and their associated action items will achieve this vision through concrete steps to be taken by stakeholders in Wisconsin's manufacturing and economic development ecosystem. They describe the specific activities to be performed and designate lead and supporting organizations responsible for conducting these activities. Each action has an approximate time frame for implementation, as well as a rough indication of the estimated costs to execute the action. Estimated costs and timelines are determined based on three interval scales:

Estimated Costs	Estimated Timelines
Less than $100,000	0–2 years (short-term actions)
$100,000 to $500,000	3–5 years (medium-term actions)
Greater than $500,000	6–20 years (long-term actions)

In the context of this report, timelines refer to the time needed to implement an action item, such as establishing a program or partnership, and assume that activities sustaining its implementation will continue beyond the prescribed timeframe. Timelines for actions are classified as short, medium, and long. Actions with a short timeline could be implemented within two years. Those in the medium category could plausibly be conducted in three to five years. Actions with long timelines may require six or more years to carry out but could exhibit meaningful progress in a shorter period with prompt implementation.

Estimated costs for actions are classified on a three-value scale. An action with lower estimated costs may be accomplished with less than $100,000. Activities in the moderate category are likely to need more investment, generally in the range of $100,000 to $500,000. Higher estimated costs indicate that the activity requires a large level of investment, likely in excess of $500,000. It is worth noting that these cost estimates pertain largely to the initial investment required to implement an action item and do not include ongoing and indefinite costs, such as the salaries of new staff.

Strategy 1: Enhance Productivity through Automation and Upskilling

Action Item 1.1: Refocus incentive programs to encourage and support productivity-enhancing capital investments by existing manufacturers.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Wisconsin Center for Manufacturing & Productivity
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Greater than $500,000

The business development programs administered by WEDC have historically been structured to encourage firms to pursue activities that advance Wisconsin's economic development objectives. These activities include job creation, capital investment, training, and the location or retention of business operations within the state. Job creation has been a key objective of flagship programs such as the Business Development Tax Credit (BTC), and programs often include provisions that tie job creation as a precondition for firms being awarded the incentive. In other words, if firms fail to achieve the agreed-upon job creation targets, financial awards are retroactively withdrawn by WEDC.

While centering incentive programs on job creation is an economic development best practice, a more tailored approach is needed to address broader labor market challenges, as well as the predominant challenge currently present in Wisconsin's manufacturing ecosystem—namely the need to increase productivity through automation and process efficiency. Given the state's tight labor market in 2022 and manufacturers' difficulties in worker hiring, the job creation provisions of some incentive programs are likely to create jobs that are left unfilled and that could be transitioned to automation. Indeed, stakeholders have estimated that a notable percentage of BTC awardees were unable to meet their job creation obligations, which consequently triggered a claw back provision that partially or fully nullifies the award.

Wisconsin's manufacturers would be well served with a business development toolkit that emphasizes capital investments in automation and the training of existing workers. Furthermore, refocusing WEDC's incentive programs toward these areas would create substantial synergies with the work of organizations such as the Wisconsin Center for Manufacturing & Productivity (WCMP). As discussed in more detail in Action Item 1.2, there is a significant opportunity for Wisconsin to integrate and align WEDC's financial resources with organizations with substantial technical expertise and relationship management capabilities to create a powerful incentive for manufacturers to enhance productivity.

To this end, WEDC should consider redesigning manufacturing-related incentive programs with a greater focus on metrics more relevant to meeting current challenges. These metrics may include output per employee, dollars invested in automation equipment, number of workers who received training, and job quality metrics such as wage growth. Though job creation is still an important objective from an economic development viewpoint, it should be complemented with other activities that are equally as important for Wisconsin's manufacturing future. Therefore, a need and an opportunity exist for WEDC to update its business development programs to focus on enhancing competitiveness, productivity, and job quality in lieu of a predominant focus on job creation.

CASE STUDY

Automation Equipment Incentives in North Dakota and Texas

North Dakota's Automation Tax Credit program provides a proven model for incentivizing automation. Designed specifically to subsidize the purchase of automation machinery and equipment in response to labor shortages, the program provides a tax credit to cover up to 20% of equipment leased or purchased with the intent of automating manual processes. Tax credit recipients are required to show that the equipment purchased improves job quality by at least 5% or increases productivity by at least 5%.

In a similar vein, Texas' Capital Access Program (CAP) sustains a partnership between the State of Texas and selected non-profit lenders to offer small- and medium-sized business loans for the purchase or rental of machinery and equipment. These loans, though underwritten by the lenders, are supported by Texas' contributions to a loan loss reserve account. In effect, by undertaking a portion of the financial risk in capital investment projects, Texas provides crucial strategic assistance to firms that face high barriers to accessing conventional capital.

Action Item 1.2: Strengthen cooperative efforts between the Wisconsin Economic Development Corporation and organizations with technical assistance capabilities, such as the Wisconsin Center for Manufacturing & Productivity, to develop and administer joint programs supporting manufacturers.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Wisconsin Center for Manufacturing & Productivity
- **Est. Timeline:** 0–2 years
- **Est. Cost**: $100,000-$500,000

The work of the Wisconsin Center for Manufacturing & Productivity is critical to ensuring that Wisconsin's manufacturers remain competitive in an age in which competitiveness increasingly depends on technology and good practices. The two institutions with which it collaborates—the Wisconsin Manufacturing Extension Partnership (WMEP) and the Manufacturing Outreach Center at UW-Stout (MOC)—have identified process inefficiencies and the need for automation as major barriers to productivity growth. As such, they have launched statewide programs such as the Transformational Productivity Initiative to assess and assist small- and mid-sized manufacturers in addressing productivity challenges. Many of these challenges, while common, have their roots in problems that are unique to each firm. Therefore, working with a manufacturer to understand its characteristics, culture, and challenges is central to helping it boost productivity. This engagement process has, moreover, helped WMEP and MOC develop working relationships with manufacturers throughout the state—relationships that play a key role in encouraging manufacturers to implement productivity-enhancing measures.

Given their importance in Wisconsin's manufacturing ecosystem, WEDC should strengthen and formalize cooperative efforts with WCMP and other organizations that provide technical assistance to manufacturers. WEDC and WCMP have developed closer ties in recent years, and continued collaboration in industry development activities would allow WEDC to leverage WCMP's experience and relationships while offering greater financial support to WCMP. As part of WEDC's extended network of economic development partners, organizations such as WCMP may also benefit from increased access to the tools and insights of a diverse range of institutions throughout Wisconsin. Thus, formalizing the collaboration between WEDC and organizations that provide technical assistance to manufacturers would make it easier to integrate and align efforts through programs that are jointly developed or administered.

A blueprint for such formalized collaboration already exists in the form of the Wisconsin Automation Implementation Grant.[75] This program, designed to integrate WCMP's technical expertise with WEDC's financial resources, gives manufacturers the opportunity to identify productivity challenges and a powerful financial incentive to acquire the equipment necessary to overcome these challenges. Going forward, WEDC and WCMP should consider scaling up the grant program to a larger pool of awardees and to design similar programs with WCMP or with other organizations that provide technical assistance to manufacturers.

Action Item 1.3: Launch a manufacturing accelerator program for small and/or rural manufacturers in partnership with organizations such as the Wisconsin Small Business Development Center, the Wisconsin Center for Manufacturing & Productivity, and other stakeholders.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Wisconsin Small Business Development Center; Wisconsin Center for Manufacturing & Productivity
- **Est. Timeline:** 0–2 years
- **Est. Cost**: $100,000-$500,000

Wisconsin's rural economies are more dependent on manufacturing than urban areas, and they are home to a higher concentration of internal combustion engine (ICE) manufacturers that are likely to be adversely impacted by the EV transition. Rural manufacturers, furthermore, are more likely to be smaller and family-owned enterprises that can benefit from strategic planning resources as well as productivity-enhancing technical assistance.

The needs of small businesses have been well served by organizations such as the Wisconsin Small Business Development Center (SBDC), a statewide network that supports small business owners through no-cost confidential consulting and business education. Funded by the U.S. Small Business Administration, the network consists of 14 locations throughout Wisconsin, each staffed with consultants who provide business management, growth, and startup guidance to companies with fewer than 500 employees. However, the services provided by SBDC, such as business planning and financial projections, should be complemented with WCMP's technical assistance if Wisconsin is to meaningfully address challenges faced by its small and rural manufacturers.

The establishment of a manufacturing accelerator program with the aim of removing barriers to growth for small manufacturers can serve as a platform to harness the combined resources of SBDC, WCMP, and other stakeholders. Such an accelerator, though requiring a substantial investment, can help small manufacturers jumpstart or revitalize process innovation on the factory floor. Additionally, an accelerator would serve as a platform to connect manufacturers to other resources, such as the U.S. Department of Agriculture's Rural Business Investment Program, and a conduit to innovators who are developing new production technologies both inside and outside Wisconsin. Initiatives launched by other states, such as the California Manufacturers Accelerator Program and Michigan's Industry 4.0 Accelerator, offer potential models for how Wisconsin can structure its own manufacturing accelerator.

CASE STUDY

Catalyzing Growth for Small- and Mid-Sized Manufacturers: California Manufacturers Accelerator Program and Michigan's Industry 4.0 Accelerator

The problem of accelerating growth among small manufacturers in an environment of technological change has been a long-standing concern for states and regions. To address this challenge, California and Michigan have created accelerator programs that assist small manufacturers in different ways. California launched the California Manufacturers Accelerator (CMA) program as a key service of its Manufacturing Extension Partnership. Participating manufacturers work with a Growth Coach—a subject matter expert with substantial technical and business development experience—to overcome strategic barriers and refine operational processes. The overarching goal of the accelerator is to improve productivity and profitability through a curriculum that teaches best manufacturing practices that are customized to the needs of each manufacturer. Additionally, the CMA program offers incentives and funding to offset the costs of capital projects or workforce training recommended by the Growth Coach.

In Michigan, economic developers took a different approach to small manufacturer assistance. Launched in 2021 by the Michigan Economic Development Corporation in partnership with several entrepreneurship development organizations, Industry 4.0 Accelerator supports Michigan's manufacturers in adopting novel production technologies developed by Michigan startups. This accelerator model, focused on connecting manufacturers to startups developing Industry 4.0 technologies, is the first of its kind in North America. Although the accelerator's activities and programs are targeted toward startups, the Michigan Economic Development Corporation is actively working to help small- and mid-sized manufacturers understand and implement technology from the accelerator's startups.

Action Item 1.4: Establish technology demonstration centers that enable manufacturers to learn about, experiment with, and pilot new technologies and practices.

- **Lead:** Wisconsin Center for Manufacturing & Productivity
- **Support:** Wisconsin Economic Development Corporation
- **Est. Timeline:** 3–5 years
- **Est. Cost**: Greater than $500,000

Technology demonstration centers have been established and used by many states to help manufacturers accelerate their transition to new technologies and practices. These centers, equipped with multiple new technologies that integrate software with hardware, serve as physical venues in which manufacturers explore how to apply new technologies and practices to their own day-to-day operations. The opportunity for managers and workers to physically engage with new technologies is one advantage provided by demonstration centers that is difficult to replicate by on-site consulting.

Leveraging existing assets and institutions, each technology demonstration center can serve as the go-to place to learn about one or more technologies and can be designed with the manufacturing needs of its surrounding region in mind. In northwestern Wisconsin, where fewer manufacturers operate, there is a need to establish a central venue at an institution with existing manufacturing capabilities, such as UW-Stout. As such, greater public investment will likely be necessary to procure space and install the necessary equipment. In the southeast, where some of Wisconsin's larger manufacturers may already be engaged in new technologies, there is an opportunity to designate innovative firms as "lighthouses" through which manufacturers in the rest of the state can observe a specific technology in action. Such firms would be viewed as experts and role models in

the application of a manufacturing technology, and their practices can further inform WCMP's own technical assistance activities. Moreover, the involvement of pioneering companies in technology demonstration is an excellent example of how Wisconsin's private sector assets can be mobilized to enhance productivity throughout the state, as will be discussed in Action Item 1.5.

Action Item 1.5: Mobilize Wisconsin's industrial automation and power electronics providers to boost productivity for under-resourced manufacturers and to accelerate their transition to EV supply chains.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Industry stakeholders
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

The sizable presence of industrial automation, process control, and power electronics companies in Wisconsin presents an opportunity to strengthen connections between these companies and manufacturers facing automation challenges. Firms such as Rockwell Automation and Johnson Controls offer a full suite of manufacturing automation consulting services as well as a range of automation equipment and software. Some of these companies also provide workforce training to manufacturers that use their equipment and services. Wisconsin's private sector, therefore, is well equipped to assist manufacturers that are struggling with productivity challenges and to help vulnerable ICE parts producers transition to the EV supply chain.

To capitalize on this opportunity, WEDC should consider developing formal or informal partnerships with established industrial automation or power electronics providers to bring their products and services to under-resourced manufacturers. Potential features of such partnerships may include financial assistance from WEDC for manufacturers to implement providers' technologies as well as increased technical collaboration between providers and WCMP's consultants to identify how the needs of manufacturers can best be served. Greater integration of strong private sector assets into Wisconsin's effort to boost manufacturing competitiveness can greatly enhance the capabilities and effectiveness of ongoing initiatives undertaken by WEDC and WCMP. Forging partnerships with these assets should thus be seriously considered by key stakeholders in the state's manufacturing ecosystem.

Action Item 1.6: Deepen engagement with rural counties whose economies are highly dependent on manufacturing.

- **Lead:** Wisconsin Economic Development Corporation; Office of Rural Prosperity
- **Support:** Regional Economic Development Agencies
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Less than $100,000

For some rural Wisconsin counties, a disproportional part of economic well-being is attached to a small number of manufacturers. While not all rural manufacturers produce automotive-related products, this study found that rural areas are more economically dependent on manufacturers, some of which are at risk of being displaced by the EV disruption. Such areas are therefore more vulnerable to the EV transition as well as to broader changes in the manufacturing sector. Whereas the economic diversity of urban areas generally enables them to be more resilient to manufacturing

shocks and trends, and even benefit from them, the greater reliance of some rural communities on manufacturing employment exposes them to the negative impacts of these same transitions.

Beyond the economic impact, there are important family and community implications of rural dependence on manufacturing. A 2017 study links declining employment prospects of male workers in manufacturing to an increase in drug overdoses, out-of-wedlock childbearing, and childhood poverty.[76] Thus, in many ways, a loss of manufacturing jobs in rural communities that rely heavily on them may have far-reaching consequences.[77]

Recognizing the vulnerability of some rural communities to changes in the manufacturing sector, organizations such as the Wisconsin Center for Manufacturing & Productivity should place a particular focus on identifying and engaging with rural manufacturers whose future success is closely linked to the socioeconomic well-being of surrounding communities. Cultivating relationships with these manufacturers would ensure that WCMP's technical expertise and WEDC's financial resources are available to help rural manufacturers adapt to a rapidly evolving industry via better access to technology, best practices, supply chains, and capital. It would also enable state agencies to develop a better understanding of the needs of Wisconsin's rural manufacturers while providing a means for continued engagement with communities in which these manufacturers operate. Targeting assistance efforts toward rural manufacturers, therefore, may generate an outsized return on investment in terms of economic and community benefits.

Strategy 2: Scale Up the Middle-Skill Workforce Pipeline

Action Item 2.1: Establish and maintain relationships with technical colleges that (1) boost enrollment in programs that are in high demand by manufacturers and (2) direct talent to fill high demand positions.

- **Lead:** Wisconsin Department of Workforce Development
- **Support:** Wisconsin Technical College System, Wisconsin Economic Development Corporation
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Greater than $500,000

The shortage of skilled manufacturing workers in Wisconsin has, at times, limited the competitiveness and growth potential of its automotive manufacturers. Traditionally, the responsibility for training middle-skill workers—workers in STEM fields who do not have a 4-year degree—has been, almost entirely, shouldered by the Wisconsin Technical College System. Technical colleges' flexibility of programs, employer engagement focus, and customized contract training have been immensely effective in supplying the manufacturing sector with skilled workers. For workers, technical colleges are attractive in that they offer a flexible pathway toward career development and serve a more diverse population than 4-year universities. However, the predominant challenge facing technical colleges is the ability to scale up relevant training programs, due to low enrollment and difficulty finding experienced instructors.

To scale up relevant training programs, the Department of Workforce Development (DWD) should bring its resources to bear in helping technical colleges create and expand apprenticeship programs that serve the manufacturing sector, which increasingly requires workers to be trained in automation, software, and problem-solving. With financial backing from WEDC, whose Workforce Innovation Grant program has funded a variety of place-based workforce initiatives, technical colleges should consider a formal partnership with DWD to expand apprenticeship programs with established employers while encouraging greater participation from small businesses. Additionally, as existing apprenticeship programs are scaled up and new ones are created, it is critical that both technical colleges and employers continue to track trainee outcomes to gauge performance and make adjustments as needed—a task that will benefit from DWD resources.

CASE STUDY

California: State Apprenticeship Expansion, Equity, and Innovation Grant

California offers state registered apprenticeship training through the workforce development system in the state. The state has a collaborative effort between the Department of Industrial Relations (DIR), the Division of Apprenticeship Standards (DAS), and industry stakeholders to develop apprenticeships programs that align with employers' requirements and needs. The DAS promotes and develops employment-based apprenticeship training programs, improves apprenticeship working conditions, and advances profitability for apprentices. In order to provide the aforementioned objective, DAS provides consultative services to apprenticeship program sponsors, employers, employee organizations, and education providers. The DAS provides a tailored structure to help support and aid in the growth of apprenticeship programs in the state of California.

In 2021, California was awarded the State Apprenticeship Expansion, Equity, and Innovation Grant by the U.S. Department of Labor to create pathways aligned with the Californian workforce ecosystem. In May of 2022 DAS selected six awardees to receive apprenticeship expansion assistance with a performance period from July 2022 through July 2025. Through this grant, California apprenticeship programs have been able to expand the manufacturing, information technology (IT) and cyber security, energy and climate, and advanced manufacturing occupations.

California's apprenticeship programs expand access to industry opportunities as new work and occupations arise. These programs and grants are geared toward advancing California's workforce, as well as providing opportunities for women, youth, communities of color, and veterans.

Action Item 2.2: Develop and launch a basic mechanical aptitude program to evaluate the skill level of job seekers, based on skills and needs identified by the industry.

- **Lead:** Wisconsin Department of Workforce Development
- **Support:** Wisconsin Economic Development Corporation
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Less than $100,000

While skilled technical workers are a critical asset to any manufacturing ecosystem, most firms also employ a sizable pool of less-skilled workers who do not possess formal training in a manufacturing occupation. A major stakeholder concern regarding less-skilled workers is that many new hires lack the basic qualifications or knowledge to perform hands-on, technical, and mechanical job functions. This lack of field knowledge has led to high employee turnover and unfilled positions for many manufacturers.

To ensure that candidates are qualified for manufacturing jobs and that employers are hiring workers with the basic skills needed to perform job functions, the Wisconsin Department of Workforce Development (DWD) should develop a program that evaluates applicants' mechanical aptitude on top of its existing suite of employer services. Currently, DWD provides job seekers with the opportunity to explore apprenticeships, training, job entry services, and opportunities for youth applicants. Although, resources exist for job seekers to be matched with jobs deemed suitable for their skill set, these resources are not able to capture the true aptitude of job seekers on skills needed to be successful in the industry.

To this end, WEDC should partner with the DWD to develop an aptitude program that captures the skills of job seekers and better match them with jobs suitable to their skill level. The basic aptitude assessment will be developed according to the needs of Wisconsin's manufacturers and will test for skills that are deemed necessary by employers, such as basic technical and mechanical knowledge and application. An aptitude assessment will require an extensive partnership with stakeholders. The success of the assessment relies on stakeholders providing information on the skills needed to perform a job successfully, as well as identifying skill gaps in the industry. The assessment should remain relevant, and a tracking program should be developed to determine the success of the aptitude test in job placement. This aptitude assessment will serve two functions. First, it will provide job seekers the opportunity to gauge their skills and allow them to find a job that is more suitable to their current skill level. Second, because new hires would already be equipped with basic skills, companies will be able to dedicate resources to more specialized, on-the-job training.

WEDC and DWD should expand the Worker Connection Program to include the aptitude test in pairing job seekers with employers.[78] The Worker Connection Program is a free navigation service that works with jobseekers to identify interest, values, and conditions of work. In addition to working with jobseekers, the program partners with stakeholders to support their workforce needs. The program is currently not offered statewide and is only active in Milwaukee County (WDA 2) and the Bay area (WDA 5). To enroll in the Worker Connection Program, job seekers must email or call the representatives. To optimize processes and garner more participation, this process should be automated to increase ease of access to the program.

Action Item 2.3: Remove barriers to labor force participation and increase job access for individuals who are not currently in the workforce.

- **Lead:** Wisconsin Department of Workforce Development
- **Support:** Wisconsin Economic Development Corporation, Office of Rural Prosperity, Local and Regional Partners
- **Est. Timeline:** 3–5 years
- **Est. Cost**: More than $500,000

The shortage of manufacturing workers in Wisconsin can be viewed as both a shortage in skills and a shortage in people. While the skills shortage can primarily be addressed through workforce training and upskilling (see previous action items), one pathway to broadening the number of people available to fill manufacturing jobs is increasing labor force participation. The aim of this approach is to increase job access for individuals who, for one reason or another, face barriers to labor force participation. Such individuals include people with childcare or elderly care responsibilities, people who lack stable housing and the means to travel to work, people without the resources and information to enter the labor market, those who have been recently incarcerated, and others who would otherwise be working if not for one or more barriers to workforce participation. Removing these barriers so that more Wisconsinites can enter and stay in the workforce should be a statewide priority that complements traditional training and upskilling initiatives.

Existing initiatives such as the Workforce Innovation Grant Program and the Worker Connection Program can serve as platforms that can be expanded to incorporate job access and workforce participation goals. As a collaborative effort between WEDC and DWD, the Workforce Innovation Grant Program funds regional organizations' efforts to implement plans that help solve local workforce challenges caused by the COVID-19 pandemic. While much of the program's initial funding has already been allocated, the state should consider continuing the program with a greater focus on removing barriers to labor force participation. Examples of activities that can be further emphasized and funded include subsidizing access to transit, broadband, and childcare services as well as providing career counseling and coaching.

The Worker Connection Program, centered on "career navigators" who assist potential workers with establishing the foundation to secure and retain a job, is another platform whose scope should expand. While the Worker Connection Program offers support for transportation, childcare, mental health, and financial literacy, the program only serves 11 counties, which comprise the Bay Area and Milwaukee Workforce Development Areas. This geographic limitation prevents residents from other parts of the state from utilizing these services. With increased public funding and support, DWD should consider expanding the program to provide statewide coverage and potentially partnering with the Office of Rural Prosperity to address rural job access challenges.

Additionally, there are opportunities to leverage resources from the Workforce Innovation Grant Program to tailor career navigation services to the job access needs of specific regions or populations. Wisconsin nonprofits, such as Mission Wisconsin and the La Crosse Chamber of Commerce, are already providing models for these more tailored approaches, and the state should consider increased support for these organizations that can help them scale up ongoing efforts.

CASE STUDY

Tailored Approaches to Job Access: Mission Wisconsin and the First Friend Newcomer Connection Program

Several Wisconsin organizations have launched initiatives to boost job access for specific regions or populations. One such organization is Mission Wisconsin, which is dedicated to connecting service members transitioning out of the military, veterans, and their spouses/life partners with Wisconsin employers. Through direct engagement with service members on the one hand and employers on the other, Mission Wisconsin serves as a job access intermediary that champions service members' career goals. The organization also partners with other veteran organizations as well as state agencies, including the Wisconsin Economic Development Corporation, to assist service members in building successful careers after the military.[79]

In La Crosse, WI, the local chamber of commerce launched the First Friend Newcomer Connection Program to help job candidates and new hires connect with local employers and the community. The program revolves around a concierge who makes connections on behalf of job seekers and new hires in areas such as housing, schools, and childcare. As the community ambassador, the concierge's engagement with job candidates helps sell the community to relocating individuals, thereby supplementing local employers' recruiting and retention efforts. The concierge charges a fee to conduct tours and provide other engagement services on behalf of employers, and these activities have been effective in securing the relocation of many prospective residents. The program has therefore become a powerful asset in the La Crosse region's economic development toolkit.[80]

Action Item 2.4: Improve perception of manufacturing occupations by launching a Made in Wisconsin marketing campaign.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** N/A
- **Est. Timeline:** 0-2 years
- **Est. Cost**: $100,000-$500,000

Historically, manufacturing careers were perceived as laborious and repetitive, but this view is not an accurate perception of the type and breadth of manufacturing jobs. Today, manufacturing jobs have grown to include robotics, cybersecurity, supply chain analytics, automation, and other fields that demand intensive problem-solving skills and offer a variety of intellectually stimulating work. It is therefore critical to convey to potential workers the full range of opportunities offered by manufacturing careers.

To better showcase the diversity of careers in Wisconsin's manufacturing sector, WEDC should launch a Made in Wisconsin campaign to increase public awareness on technology-intensive manufacturing jobs and attract workers to Wisconsin manufacturers. By focusing on awareness and attraction, a Made in Wisconsin campaign will target two key areas of the workforce: (1) young Wisconsinites with potential to pursue fulfilling manufacturing careers and (2) manufacturing workers

outside Wisconsin who are considering moving to an area with manufacturing job opportunities. The campaign's showcasing of technology-intensive manufacturing jobs can increase workers' exposure to the breadth of manufacturing jobs available in the state and better publicize manufacturers' efforts to integrate autonomous processes. As such, the marketing campaign can provide a renewed perspective of Wisconsin's manufacturing sector as one that provides opportunities to engage with emerging technologies, utilize advanced skills, and solve challenging problems. To maximize the impact of this marketing effort, WEDC should partner with government officials and high-ranking executives to raise public awareness about career opportunities in advanced manufacturing.

Action Item 2.5: Incentivize manufacturers implementing automation and other productivity-enhancing measures to invest in workforce upskilling.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Wisconsin Center for Manufacturing & Productivity
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Greater than $500,000

As manufacturers integrate automation into their operations and streamline processes to increase productivity, their workers will likely require some degree of retraining and upskilling. However, partially due to the older age of many manufacturing workers, a significant share of the workforce lacks the skills necessary to work with the latest technologies and manufacturing processes. The ongoing worker shortage, furthermore, has led to some employees performing multiple job functions. Thus, the need for manufacturers to retrain their workers will grow as they implement productivity-enhancing measures. In effect, future workers and managers should be prepared to work with the most up-to-date technologies and processes.

To prepare Wisconsin workers for automation and advanced manufacturing, WEDC should jointly administer and develop a program with WCMP that provides financial incentives for manufacturers to retrain their workers as they implement productivity-enhancing measures. Given the recommendations in Action Items 1.1 and 1.2, the most logical way to implement this program is to add a workforce upskilling component to the Wisconsin Automation Grant Program. Under this structure, WCMP can potentially work with instructors from the Wisconsin Technical College System to recommend an upskilling regimen oriented toward the equipment and technology purchased by the awardee. Part of the cost can subsequently be reimbursed by WEDC in a similar manner to equipment purchases under the Automation Grant Program. Moreover, as WEDC administers the program, it should ensure that this workforce incentive is only awarded to manufacturers that have passed the "but-for" test (i.e., those who otherwise would not have independently invested in the recommended upskilling but for the incentive).

Strategy 3: Improve Manufacturers' Access to Regional, National, and Global Markets

Action Item 3.1: Assist manufacturers in obtaining automotive industry certifications.

- **Lead:** Wisconsin Center for Manufacturing & Productivity
- **Support:** UW-Madison College of Engineering Interdisciplinary Professional Programs, Wisconsin Economic Development Corporation
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

The automotive industry uses a variety of standards and certifications to ensure the quality of products and materials manufactured throughout the supply chain. As such, manufacturers and suppliers seeking to participate in the automotive supply chain are often required to obtain certifications that demonstrate their familiarity with the industry's supply chain practices. For instance, stakeholders interviewed for this report noted that OEMs seeking information about Wisconsin's automotive suppliers looked for suppliers' ability to comply with the Production Part Approval Process (PPAP). Other important certifications include IATF 16949, ASPICE (focused on the performance of software systems), IEC (focused on the quality and standardization of electrical systems), and the ISO family of standards. Yet many Wisconsin suppliers, especially in the upstream segment, lack the certifications needed to fully participate in the automotive supply chain.

To remove this barrier to Wisconsin manufacturers' ability to access automotive markets, the state should establish a program to assist manufacturers in obtaining automotive industry certifications. WCMP already offers manufacturers assistance and training for some standards and certifications, but this assistance can be expanded to include EV-focused standards, such as those developed by the International Electrotechnical Commission. Additionally, the state should consider working with the Interdisciplinary Professional Programs (Interpro) at UW-Madison's College of Engineering to develop certification courses for relevant suppliers. Because Interpro's curricula specialize in vehicle powertrains, transportation infrastructure, and manufacturing best practices for plant managers and engineers, its resources can serve as a valuable asset in preparing and certifying manufacturers for automotive and EV supply chains.

Action Item 3.2: Develop interoperability standards for EV components and EV charging equipment manufacturing.

- **Lead:** Wisconsin Department of Transportation
- **Support:** Argonne National Lab EV-Smart Grid Interoperability Center, Industry Stakeholders, Utility Companies, Community Stakeholders, and Wisconsin Economic Development Corporation
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

As Wisconsin develops an industry cluster centered on EV equipment manufacturing, there will be a growing need to ensure interoperability between different types of EV hardware and software systems. A lack of interoperability standards may result in components developed by different manufacturers to become incompatible, thereby requiring costly retooling and redevelopment. The burden of convening the industry and technical experts to develop these standards often falls on government stakeholders assisted by subject matter experts such as the Argonne National Lab EV-Smart Grid Interoperability Center. The process of developing statewide interoperability standards, however, will serve as an opportune exercise to mobilize stakeholders around a shared industry vision, and their successful rollout would also serve as a signal of Wisconsin's commitment to establishing leadership in EV equipment manufacturing.

To this end, the Wisconsin Department of Transportation (WisDOT) should work with subject matter experts such as the EV-Smart Grid Interoperability Center, Wisconsin Clean Cities, RENEW Wisconsin, and others to convene an EV interoperability working group. This working group will develop non-binding standards that will guide manufacturers and suppliers in developing compatible EV equipment. Successful implementation of these standards will allow Wisconsin businesses and organizations to seamlessly deploy EV equipment from multiple suppliers, thereby eliminating unnecessary costs and enabling faster EV adoption.

CASE STUDY

MassRobotics Interoperability Working Group: Developing Interoperability Standards in the Robotics Industry

In recent years, Massachusetts has made an intentional effort to strengthen its robotics industry. A key asset in Massachusetts' robotics ecosystem is MassRobotics, an independent non-profit robotics innovation center dedicated to developing the robotics industry in the state. Recently, warehouses and factories have begun using robotics equipment from multiple vendors, but the lack of protocols and interfaces for different types of robots to communicate with each other has created major problems for users of industrial robots. Fleets of robots from multiple vendors had no standard way to coordinate activities or share information, and this incompatibility between different systems discouraged some factories from adopting robotic technologies.[81]

To address this challenge, MassRobotics convened a robot interoperability working group in 2020, comprised of robot vendors, engineers, and end-users to address compatibility challenges and simplify the adoption and use of industrial robots. This collaborative effort resulted in the publication of the MassRobotics Interoperability Standard, a consortium-built open-source standard to ensure that robots from multiple suppliers can work together seamlessly to support safe and efficient operations in factories, warehouses, and distribution centers. Shortly after the release, FedEx successfully trialed the interoperability standards with robots from various suppliers, marking a major step toward standardization in the robotics industry. Going forward, users of industrial robots are encouraged to purchase from suppliers with the MassRobotics Interoperability Standard compliance badge when making procurement decisions.[82]

Action Item 3.3: Partner with the Wisconsin Supplier Diversity Program to facilitate supplier relationships with Minority-Owned, Service-Disabled-Veteran-Owned, and Woman-Owned businesses in the private sector.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** Wisconsin Department of Administration
- **Est. Timeline:** 0–2 years
- **Est. Cost**: Less than $100,000

A key objective of WEDC is to support Wisconsin's minority-, woman-, LGBT-, and veteran-owned businesses, as demonstrated by its Diverse Business Development (DBD) program. Programs such as the DBD seek to ensure that economic development is equitable, by which businesses from communities that have traditionally faced socioeconomic barriers have the same opportunities to grow and expand. Similarly, as Wisconsin develops an EV equipment manufacturing cluster, it is important to ensure that manufacturers and suppliers from minority and underserved communities have opportunities to participate in the EV supply chain. Wisconsin's focus on supplier diversity stems from the creation of the Wisconsin Supplier Diversity Program in 1983, when the Legislature passed a law that set a 5% participation goal for state agencies to procure goods and services from certified Minority Business Enterprises. Over time, women-owned businesses and disabled-veteran-owned businesses have also been incorporated into the program.

The institutional expertise and relationships developed by the Wisconsin Supplier Diversity Program are a significant asset that WEDC can use to facilitate supplier relationships with businesses owned by people from disadvantaged backgrounds. Although the purview of the Supplier Diversity Program is limited to public sector procurement, its relationships with suppliers and its databases on supplier networks can also be used to advance other economic and industrial development goals. As such, WEDC should consider partnering with the Supplier Diversity Program to identify and engage with minority-, woman-, and disabled-veteran-owned suppliers with potential to participate in the EV supply chain. Leveraging its existing relationships with the state's OEMs and larger manufacturers, WEDC is well positioned to facilitate the supplier connections that can integrate these suppliers into Wisconsin's EV manufacturing cluster.

Action Item 3.4: Strengthen supply chain relationships with nearby EV OEM plants through the establishment of an automotive industry liaison.

- **Lead:** Wisconsin Economic Development Corporation
- **Support:** N/A
- **Est. Timeline:** 0–2 years
- **Est. Cost**: $100,000-$500,000

Wisconsin's proximity to Midwestern automotive manufacturing hubs presents a significant opportunity for the state to strengthen supply chain relationships with nearby EV OEM plants. As discussed earlier in this report, the proximity of many Wisconsin manufacturers to Ford's Chicago EV assembly plant, Stellantis' Belvidere plant, and Rivian's Bloomington-Normal facility underscores the potential of Wisconsin's EV-oriented manufacturers to strengthen regional supply chain connections.

Given Wisconsin's strategic location, WEDC should strengthen dialogue with established and emerging EV OEMs to identify opportunities to further integrate Wisconsin manufacturers into

regional supply chains. To achieve this goal, WEDC should consider designating a staff member or team as the formal liaison to global automotive companies. This liaison would possess in-depth knowledge into Wisconsin's supplier capabilities and serve as a "one-stop-shop" for information about the state's automotive supplier network. As such, the liaison would enhance WEDC's institutional capacity to engage with both global OEMs and in-state suppliers, thereby enabling supplier relationships that strengthen Wisconsin's role in the Midwestern EV supply chain.

Strategy 4: Build Connections between Innovators and Industry

Action Item 4.1: Launch a manufacturing innovation consortium of university researchers to work on use-inspired projects alongside industry partners.

- **Lead:** Wisconsin Alumni Research Foundation
- **Support:** Wisconsin Economic Development Corporation, Wisconsin Technology Council
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

Given the size of Wisconsin's manufacturing sector and the importance of its universities in spurring innovation, there is a significant opportunity to harness the collective impact of the state's world-renowned researchers and engineers to address challenges faced by industry. To better align manufacturing technology R&D in academia with industry priorities, Wisconsin should launch a manufacturing innovation consortium comprising the state's leading academics in industrial engineering and electrification technologies. In close partnership with industry, this network of manufacturing and engineering researchers could intensify work on use-inspired R&D projects that can be adapted by manufacturers.

The Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC) provides an existing model on which a manufacturing innovation consortium can build. Its sponsorship model provides industry partners access to faculty research and technology transfer opportunities in exchange for an annual membership fee, though industry partners do not directly dictate the specific research projects conducted at WEMPEC. In contrast, another potential model centers on client-sponsored R&D, in which industry partners pay a consortium of innovators a fee to undertake specific research projects. Under this client-sponsored R&D model, the financial incentives better align academic research to the needs of industry. Organizations such as the Massachusetts Life Sciences Center have seen success using this model to strengthen industry-academia collaboration.

Whatever the structure of the manufacturing innovation consortium, Wisconsin will first need to gather support from both universities and industry for the consortium as a way accelerate manufacturing innovation. This stakeholder mobilization effort will likely require the leadership of the Wisconsin Technology Council, the Wisconsin Alumni Research Foundation, and other innovation assets as well as some degree of initial investment. If implemented successfully, however, the manufacturing innovation consortium can play a central role in reinvigorating Wisconsin's manufacturing sector by channeling Wisconsin's formidable academic research capabilities toward addressing technological challenges faced by manufacturers.

CASE STUDY

Massachusetts Life Sciences Center: Facilitating Industry and Academic Collaboration through the Neuroscience Consortium

The Massachusetts Life Science Center's (MLSC) Neuroscience Consortium is reflective of the goals and organization of the proposed consortium of robotics-researchers. The Neuroscience Consortium's focus is to facilitate dialogue and collaboration between industry and academia. Consortium membership is composed of both Massachusetts-based researchers and industry partners.

Organizationally, the Neuroscience Consortium relies on the commitment of member biotech companies, such as AbbVie, Biogen, Celgene, and Novartis, to identify research needs and design novel projects with a translational focus. These projects are then shared with researchers who apply for research funding provided by the biotech companies. In the consortium's first call for proposals in 2012, industry members Abbott, Biogen Idec, EMD Serono, Janssen Research & Development, Merck, Pfizer, and Sunovion Pharmaceuticals all contributed $250,000.[83]

Given significant legal and other barriers involved in collaborations in the biotech industry, MLSC has been touted for bringing together academic and industry stakeholders, enabling collaboration and project-funding that would otherwise not exist. Since 2013, the consortium has raised almost $10 million in industry commitments for pre-clinical neuroscience research projects of 30 principal investigators in the state.

Action Item 4.2: Establish a "hard tech" entrepreneurial mentorship network that connects experienced entrepreneurs and investors to promising power electronics, mechanical engineering, and advanced manufacturing startups seeking to commercialize new technologies.

- **Lead:** Wisconsin Technology Council
- **Support:** Wisconsin Electric Machines and Power Electronics Consortium, Wisconsin Alumni Research Foundation, Wisconsin Economic Development Corporation
- **Est. Timeline:** 6–20 years
- **Est. Cost**: Greater than $500,000

Compared with the amount of entrepreneurship activity in Wisconsin that is focused on life sciences and information technology, there are relatively few entrepreneurs developing startups in power electronics and advanced manufacturing technologies. Stakeholders have attributed this absence to a lack of EV innovators with entrepreneurship experience and networks needed to build and grow startups. Without access to more experienced entrepreneurs and the professional networks that guide founders through a startup's early stages, many entrepreneurs are unable to overcome business, legal, and financial barriers despite possessing promising ideas and technologies.

To cultivate an entrepreneurial ecosystem focused on "hard tech"—technology based on tangible hardware—Wisconsin should establish an entrepreneurial mentorship network that connects experienced entrepreneurs and investors to promising startups developing new power electronics, mechanical engineering, and advanced manufacturing technologies. While similar programs exist throughout Wisconsin, a mentorship network dedicated to the hard tech space will address the commercialization challenges unique to technology development in EV and advanced manufacturing. Such a network can moreover serve as a commercialization resource for academics to better gauge the market viability of new technologies developed in the lab.

As the case study on the HAX Accelerator below demonstrates, an entrepreneurial network would greatly benefit from the involvement of venture capitalists well versed in the hard tech space. These venture capitalists can potentially offer access to suppliers, facilities, manufacturers, and local experts who otherwise would be out of reach for founders on their own. Though the scope and scale of the HAX Accelerator greatly exceeds that of the proposed mentorship network at its outset, the HAX Accelerator is nevertheless a useful case study on the importance of entrepreneurial communities and knowledge networks in developing successful startups.

CASE STUDY

HAX Accelerator: An Established Model for Helping Hardware Startups Achieve Market Viability

HAX is a hard tech accelerator providing funding and resources to startups developing hardware, robotics, and connected devices. The accelerator program is run by the venture capital firm SOSV and has offices in San Francisco, Shenzhen, and Tokyo. In 2021, HAX announced that it will build a new state-of-the-art facility in Newark, NJ to house its new U.S. headquarters.[84]

The accelerator program consists of 180 days that is divided into 3 phases. The first phase entails rapid product development for startups with submitted initial prototypes and market strategies. Each startup receives a $250,000 seed investment and collaborates with HAX's in-house team of engineers, designers, and entrepreneurs. Much of the work conducted in this phase involves iterating through low-fidelity prototypes and testing to better understand customers, markets, and technology roadmaps. HAX grants teams access to its proprietary network of local experts, investors, manufacturers, and supply chains. As startups reach critical milestones in the second phase, HAX support shifts to fundraising strategy development, investor introductions, and continued investment into follow-on rounds from Pre-Seed to Pre-IPO. The third phase involves onward support and continued participation in the HAX community as the startup matures.

According to HAX, the most valuable part of the program is engagement with a globally diverse community of startup founders whose experience and expertise are shared with the program's entrepreneurs. Over time, this community has grown to include a curated group of mentors, experts, and partners, giving early-stage startups the global reach and resources of far larger organizations. To date, over 250 startups have completed the program.

Action Item 4.3: Support international students, workers, and entrepreneurs in contributing to Wisconsin's EV ecosystem.

- **Lead:** University of Wisconsin System; Independent Colleges and Universities
- **Support:** Wisconsin Higher Educational Aids Board; Wisconsin Department of Human Services
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

One of the most significant aspects of Wisconsin's EV innovation ecosystem is the outsized presence of international talent. Within Wisconsin's advanced engineering workforce, non-U.S. citizens constitute a large portion of researchers, innovators, and entrepreneurs. Skilled immigrants' wide range of engineering talent enhances Wisconsin's technological competitiveness.

The state should therefore consider additional policies that both attract international talent to Wisconsin and boost the state's ability to retain this talent over the long term. For instance, the University of Wisconsin system can increase support for international students seeking employment in the state or simplifying the immigration extension process for students needing additional time to complete their programs. At the state level, there is an opportunity to explore new programs that provide visa assistance to skilled workers as well as sponsorship support to smaller employers that lack the resources to file sponsorships themselves.

Strategy 5: Align EV Policymaking with Economic Development Interests

Action Item 5.1: Identify and pursue changes to electric system infrastructure to align with EV adoption increases.

- **Lead:** Wisconsin Public Service Commission
- **Support:** Wisconsin Economic Development Corporation
- **Est. Timeline:** 0-2 years
- **Est. Cost**: Less than $100,000

Widespread adoption of electric vehicles would likely result in significant increases in electricity use and place increased demands on the state's existing electric utility infrastructure. To understand and address this issue, the Public Service Commission of Wisconsin conducted a study with the goal of developing policies and regulations related to EV and EV infrastructure use.[85] The Commission concluded that utility companies should propose and implement EV pilot programs to generate data that better determine the regulation and use of EV infrastructure. According to the case management system,[86] there have been five applications from four different utilities since 2019 for pilot programs. The companies that submitted applications are Wisconsin Public Service Commission, Wisconsin Electric Power Company, Northern States Power Company, and Madison Gas and Electric Company. The Commission has also supported studies to begin assessing the impacts of increased EV adoption on electric system reliability and awarded funding to support ongoing utility planning for increased EV adoption.

Informed by results from the 2020 investigation and findings from utility pilot programs, WEDC and the Wisconsin Public Service Commission should continue to study the impacts of increased EV adoption on the electric system and identify opportunities to proactively prepare for widespread EV use. Efforts can focus on a variety of considerations, including enhanced data collection on EV adoption and grid impacts, continued collaboration with utilities and stakeholders to assess technological developments and customer service considerations, interagency partnerships that integrate utility and electric system considerations with state policy development related to other aspects of EV development, and the exploration of federal funding and support opportunities available through the Bipartisan Infrastructure Law and the Inflation Reduction Act.

CASE STUDY
Madison Gas and Electric's EV Initiatives

In 2019, Madison Gas and Electric Company (MGE) announced a goal of net-zero carbon electricity by 2050. After the announcement of this goal, MGE began to increase its use of renewable energy and intensified its electrification efforts by building out EV infrastructure that is supported by renewable energy sources such as wind energy. MGE also launched the Charge@Home initiative, a program that provides EV owners with a home charger and simplifies EV charging for consumers.

MGE has developed a comprehensive charging station site that leverages two partnerships: Tesla and ChargePoint. The site off of East Washington Avenue includes eight Tesla superchargers and eight ChargePoint fast chargers. The inclusion of both Tesla and ChargePoint overcame an issue with charging infrastructure, which was to allow more than one type of car to charge at the station with the infrastructure

being able to support the charge of larger batteries. In addition to the increase of EV infrastructure, the charging stations are powered by 100% renewable wind energy.

Providing EV infrastructure can be costly, and MGE has leveraged partnerships with EV charger manufacturers to provide the materials and charging stations. MGE has also partnered with the city of Madison to develop an EV charging pilot program to determine the use and reliability of public charging stations in parking ramps. MGE's collaborative efforts with private businesses have resulted in the development of EV infrastructure in Madison, Wisconsin.

Action Item 5.2 Coordinate EV infrastructure and manufacturing development with other Midwestern states

- **Lead:** Wisconsin Department of Transportation
- **Support:** Wisconsin Clean Cities, Office of Sustainability and Clean Energy, Wisconsin Economic Development Corporation
- **Est. Timeline:** 0-2 years
- **Est. Cost**: Less than $100,000

Wisconsin's strategic location and its integration into the Midwestern economy places it in an ideal position to coordinate EV infrastructure deployment with nearby states. The state's membership in the Regional Electric Vehicle Midwest Coalition—a partnership between Wisconsin, Illinois, Indiana, Michigan, and Minnesota to accelerate electrification, collaborate on EV charging station routes, evaluate workforce development, and educate consumers—provides an existing framework for Wisconsin to integrate its infrastructure deployment into a broader regional network. Wisconsin is also a member of the Lake Michigan Electric Vehicle Circuit Tour, a multistate collaboration project between Wisconsin, Illinois, Indiana, and Michigan to deploy EV infrastructure along the scenic Lake Michigan coastline. However, as of 2022, no major actions appear to have been taken by member states to implement the initiatives' regional infrastructure goals. This presents an opportunity for WisDOT to spearhead regional efforts on EV infrastructure deployment, with support from Wisconsin Clean Cities and the Office of Sustainability and Clean Energy. Such actions may also help Wisconsin take a leadership role in facilitating inter-state planning efforts.

To further strengthen Wisconsin's connectivity to regional and national supply chains, WisDOT should consider membership in the Automotive Communities Partnership—a community of stakeholders in the automotive industry that collaborate on industry-wide initiatives. Membership in the partnership will allow access to proprietary research, facilities, and other resources useful to a region's automotive companies. However, the key benefit for members is access to collaborative opportunities with other states, including Indiana, Illinois, Michigan, Missouri, North Carolina, and Ohio.

Strategy 6: Prepare for the Future of Mobility and Sustainability

Action Item 6.1: Explore opportunities to leverage Wisconsin's sand mining industry for novel applications in sustainability and mobility.

- **Lead:** Office of Clean Energy and Sustainability
- **Support:** Wisconsin Alumni Research Foundation; Wisconsin Economic Development Corporation
- **Est. Timeline:** 0–2 years
- **Est. Cost**: $100,000-$500,000

The development of new technologies often leads to novel applications of certain raw materials, thereby increasing the demand and value of these materials. Recently, new technologies in sustainable energy storage and EV manufacturing processes have raised the potential of Wisconsin's sand mining industry as a key player in global sustainability efforts. Traditionally serving the petroleum industry, demand for industrial sand mining in Wisconsin has grown with the advent of hydraulic fracturing in the United States. In recent years, however, sand is increasingly being used to rapidly make EV prototypes, as an input in the process to make alloys used in EV components, and to make structural castings in which EV components are molded.[87] Additionally, technologies using sand as an energy storage mechanism are currently being developed, with Finland building the world's first commercial sand-based thermal energy storage system in 2022.[88]

Given sand's potential as an input in the sustainable technologies of the future, Wisconsin should commission a study to measure the future economic potential of its sand mining industry and to develop a strategy to align future sand mining activities with the state's sustainability initiatives. Because almost all of Wisconsin's sand mines are located in the state's western half—predominantly in rural areas within the general vicinity of Eau Claire—realizing sand mining's sustainability potential also poses significant implications for the economic development of many rural communities.

CASE STUDY

Polar Night Energy: Finland's Sand-Based Thermal Energy Storage System

In July 2022, the first commercial sand-based thermal energy storage system in the world began operations in Finland. The system, developed by the Finnish clean energy startup Polar Night Energy, centers around a 13 x 23 feet steel silo containing hundreds of tons of sand that can be heated to a temperature of 900–1,100 degrees Fahrenheit. Heat generated by renewable electricity is stored in the sand for future use by a nearby community, and the technology's cost-effectiveness and ease of construction allows it to be easily scaled up or adopted by other users.

The sand-based energy storage system has a particularly strong use case in Finland, whose long and cold winters and its disconnection from Russian gas supplies during the 2022 Russo-Ukraine War has raised demand for novel energy storage technologies. The system can discharge a maximum of 100 kilowatts of heat power and has a total energy capacity of 8 megawatts, equating to up to 80 hours' storage duration. Going forward, Finnish authorities plan to scale the system by a factor of one thousand to 8 gigawatts.[89]

Action Item 6.2: Conduct long-range planning on the integration of emerging clean technologies and trends into Wisconsin's economy and communities.

- **Lead:** Office of Clean Energy and Sustainability
- **Support:** Wisconsin Clean Cities, Wisconsin Economic Development Corporation
- **Est. Timeline:** 3–5 years
- **Est. Cost**: $100,000-$500,000

Over the medium-to-long term, new developments in clean technologies and shifting paradigms in how people view mobility and sustainability will continue to both disrupt the status quo and create opportunities for forward-thinking regions to gain a first-mover advantage in emerging industries. Opportunities will arise to apply existing technologies and industry in new ways, such as the utilization of sand and used EV batteries for energy storage, provided that barriers such as smart grid implementation and EV infrastructure deployment can be overcome.

To anticipate and capitalize on these long-term opportunities, key stakeholders in Wisconsin should conduct a long-range planning exercise that assesses Wisconsin's positioning in a changing technological and socioeconomic landscape. In its planning efforts, Wisconsin should leverage the subject matter expertise of national organizations such as the Clean Cities Coalition, examine actions undertaken by other states and regions to position themselves for emerging clean technologies, and identify sustainability pioneers within the state whose practices can be adopted by others.

One such pioneer is Madison Gas and Electric Company, which leads the state's utilities in both clean energy commitments (net-zero carbon electricity by 2050) and renewables infrastructure deployment. As various communities in Wisconsin undergo the electrification transition in the coming years, many will look to the practices set forth by these pioneer institutions as a blueprint for their own electrification efforts.

CASE STUDY
Madison Gas and Electric's Sustainability Initiatives

To achieve its goal of net-zero carbon electricity by 2050, Madison Gas and Electric introduced its Energy 2030 framework, which set a carbon reduction goal of 40% (from 2005 levels) by 2030. The utility has since undertaken a major effort to transition away from coal, announcing the retirement of the coal-fired Columbia Energy Center and the transition of the Elm Road Generating Station from coal to natural gas. At the same time, the utility has increased its wind generation capacity 15-fold, from 11 megawatts to 153 megawatts within a 10-year period, through the construction or expansion of five wind farms in Wisconsin and Iowa. Additionally, it has launched various solar projects throughout Wisconsin.

As Madison Gas and Electric shifted its energy supply to renewable sources, it also sought to achieve better grid management through the deployment of advanced metering infrastructure, a new distribution management system, and electric vehicle charging stations. As technologies evolve and enter the market, the utility plans to continue collaborating with its customers through pilot and outreach programs as it formulates next steps for achieving its sustainability goals.

Appendices

Appendix A: Methodology

Vulnerability Assessment

In assessing the vulnerability of Wisconsin's automotive manufacturing to disruption from the EV transition, SRI pulled a comprehensive list of suppliers from two data sources—Marklines (an automotive supplier database) and ThomasNet (a manufacturer database which includes automotive suppliers). For each supplier, SRI researched the products manufactured by the company to identify the category of automotive parts that is associated with the supplier. Because many suppliers manufactured components in more than one category, SRI associated each supplier with every component category. SRI then assigned each supplier a vulnerability score based on whether the supplier manufactures components exclusively used in ICE vehicles and the diversity of their product portfolios. Metal fabricators and suppliers which predominately produced raw materials were generally considered low risk because their products and services are generally applicable to both ICE and EV supply chains. However, suppliers manufacturing fuel system, powertrain, ignition system, and exhaust system parts are considered high risk because these products are predominantly used in the production of ICE vehicles. Suppliers which manufacturer a diversified mix of products that includes ICE components were classified as medium risk.

Classification of Wisconsin's Automotive Supply Chain Segments

SRI's classification of Wisconsin's automotive supply chain into upstream suppliers, parts manufacturers, and OEMs is informed by stakeholder interviews and extensive research on automotive-related industries as defined under the North American Industry Classification System (NAICS). SRI began with NAICS Code 3363 (Motor Vehicle Parts Manufacturing) as the basis for its parts manufacturing definition. Using the Lightcast data analytics platform, SRI conduct an input-output analysis to identify upstream industries from which parts manufacturers made purchases and downstream industries (OEMs) to which parts manufacturers made sales. A detailed definition of each segment is shown in *Appendix B: Table 11*.

Index of Automotive Manufacturing Specialization

SRI's development of a specialization index is motivated by a need to construct a normalized measure of automotive manufacturing competitiveness, at the county level, for all three supply chain segments to enable comparison across different regions in the state. To construct this index, SRI calculated a county's location quotient in each of the three supply chain segments. SRI then ranked each county to determine its percentile for each segment. The percentiles are then added together to form a consolidated specialization index. The county-level location quotients and percentiles are shown in Appendix B: *Table 12*.

Susceptibility to Displacement

A measure developed by Frey & Osborn (2017) to evaluate an occupation's exposure to displacement from automation. This measure is bounded between 0 and 1, with 0 indicating that an occupation's exposure to automation is extremely low, and 1 indicating that an occupation's exposure is extremely high.

Metropolitan and Non-Metropolitan Areas

Metropolitan areas, also known as metropolitan statistical areas, are defined by the Census Bureau as a core area containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration with that core.[90] In Wisconsin, counties which lie within metropolitan areas include Calumet, Kewaunee, Winnebago, Oconto, Lincoln, Outagamie, Fond du Lac, Douglas, Racine, Green, Washington, Columbia, St. Croix, Waukesha, Milwaukee, Marathon, Ozaukee, Rock, Dane, Brown, Chippewa, Sheboygan, Eau Claire, Kenosha, La Crosse, Pierce, and Iowa counties.

Rounding

All references to job and establishment counts are rounded to the nearest 50.

Appendix B: Additional Figures

Figure 26: Location Quotient for Upstream Suppliers in Wisconsin (2022). Source: SRI analysis of Lightcast data.

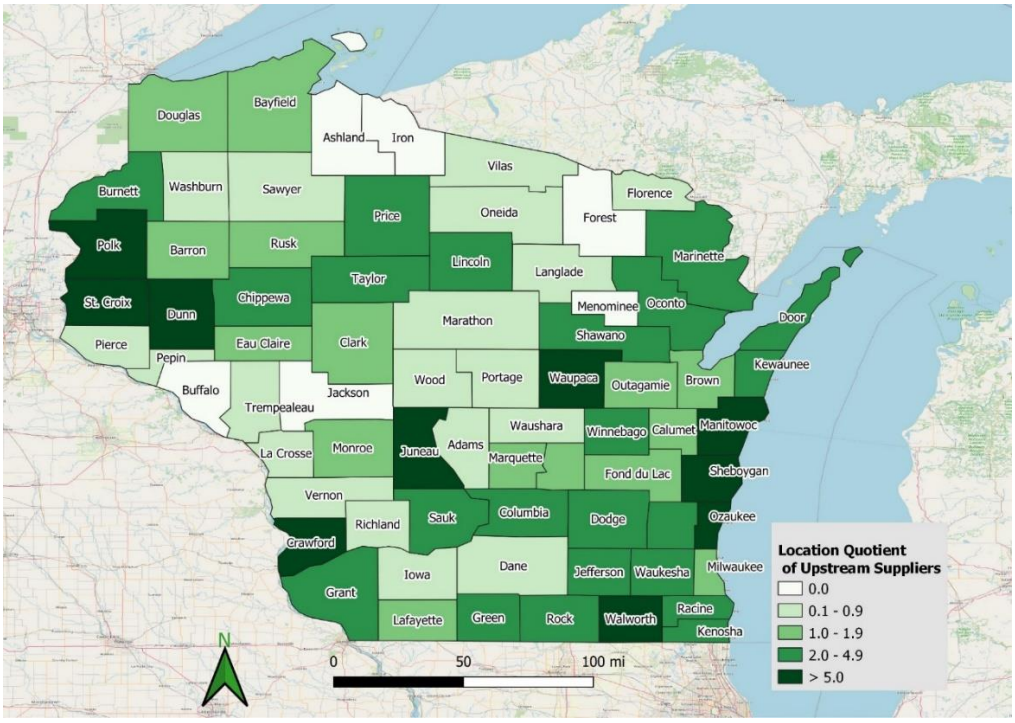


Figure 27: Location Quotient for Parts Manufacturers in Wisconsin (2022). Source: SRI analysis of Lightcast data.

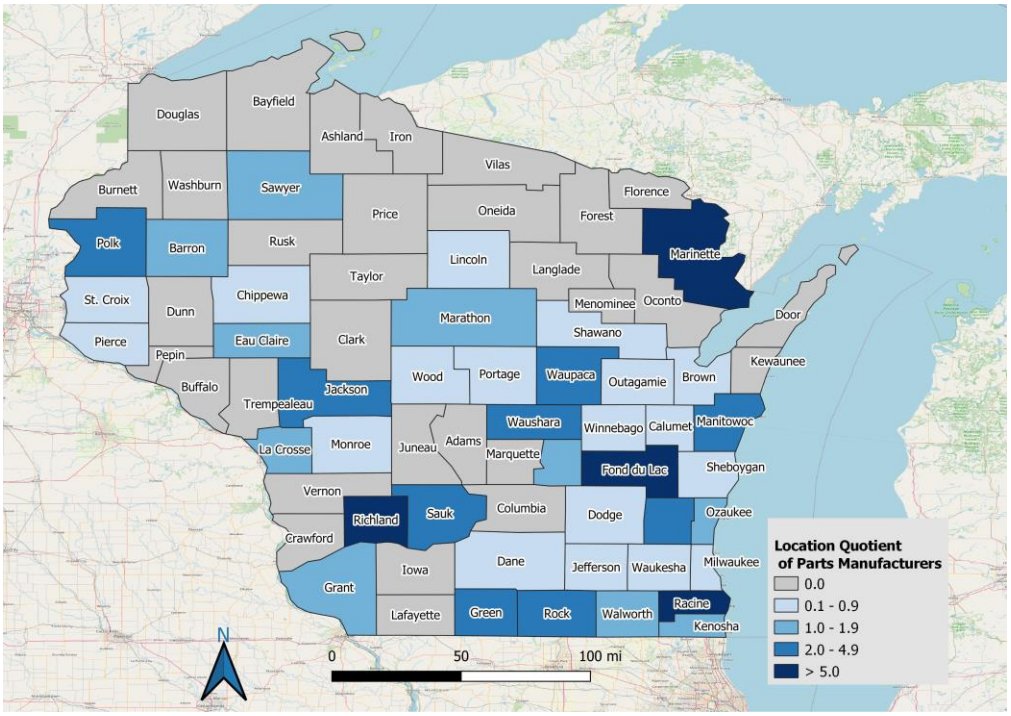


Figure 28: Location Quotient for OEMs in Wisconsin (2022). Source: SRI analysis of Lightcast data.

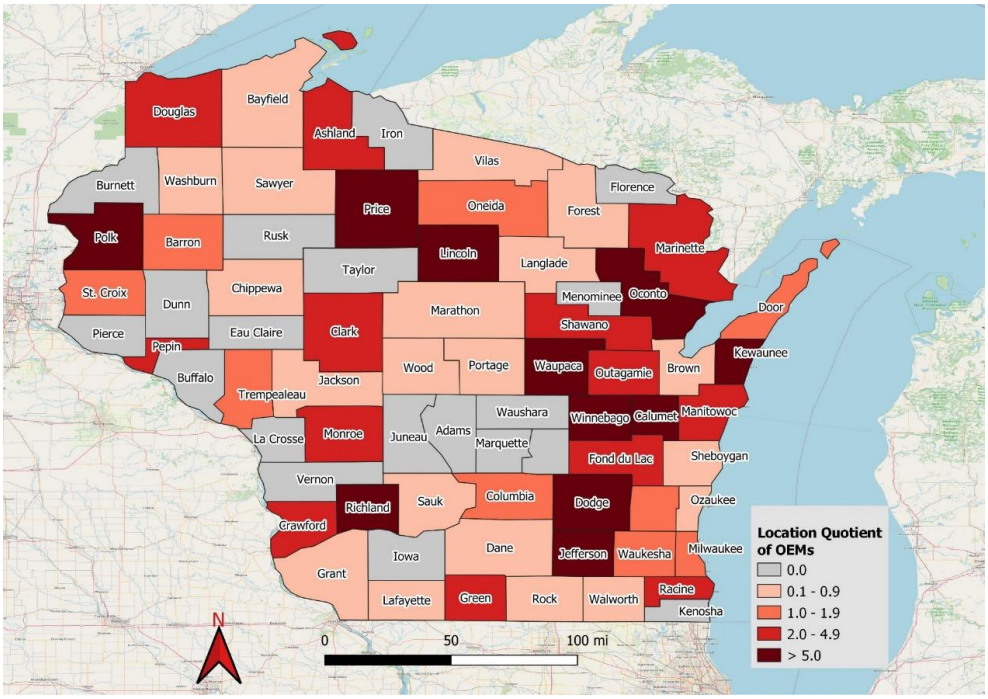


Table 11: Mapping of Wisconsin's Automotive Supply Chain Segments to NAICS Industries. Source: SRI research

Firm Type	*NAICS Code*	*Industry*
Parts Manufacturers	336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing
Parts Manufacturers	336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing
Parts Manufacturers	336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing
Parts Manufacturers	336340	Motor Vehicle Brake System Manufacturing
Parts Manufacturers	336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
Parts Manufacturers	336360	Motor Vehicle Seating and Interior Trim Manufacturing
Parts Manufacturers	336370	Motor Vehicle Metal Stamping
Parts Manufacturers	336211	Motor Vehicle Body Manufacturing
Parts Manufacturers	336390	Other Motor Vehicle Parts Manufacturing
Parts Manufacturers	333618	Other Engine Equipment Manufacturing
Upstream Suppliers	331110	Iron and Steel Mills and Ferroalloy Manufacturing
Upstream Suppliers	332710	Machine Shops
Upstream Suppliers	326199	All Other Plastics Product Manufacturing
Upstream Suppliers	331523	Nonferrous Metal Die-Casting Foundries
Upstream Suppliers	332114	Custom Roll Forming
Upstream Suppliers	334413	Semiconductor and Related Device Manufacturing
Upstream Suppliers	332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing

Firm Type	*NAICS Code*	*Industry*
Upstream Suppliers	332119	Metal Crown, Closure, and Other Metal Stamping (except Automotive)
Upstream Suppliers	332721	Precision Turned Product Manufacturing
Upstream Suppliers	331511	Iron Foundries
Upstream Suppliers	325211	Plastics Material and Resin Manufacturing
Upstream Suppliers	331524	Aluminum Foundries (except Die-Casting)
Upstream Suppliers	331529	Other Nonferrous Metal Foundries (except Die-Casting)
Upstream Suppliers	332111	Iron and Steel Forging
OEMs	333111	Farm Machinery and Equipment Manufacturing
OEMs	333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing
OEMs	333120	Construction Machinery Manufacturing
OEMs	333131	Mining Machinery and Equipment Manufacturing
OEMs	333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing
OEMs	336111	Automobile Manufacturing
OEMs	336112	Light Truck and Utility Vehicle Manufacturing
OEMs	336120	Heavy Duty Truck Manufacturing
OEMs	336510	Railroad Rolling Stock Manufacturing
OEMs	336612	Boat Building
OEMs	336991	Motorcycle, Bicycle, and Parts Manufacturing
OEMs	336999	All Other Transportation Equipment Manufacturing

Table 12: Automotive Manufacturing Specialization Index, Location Quotients, Location Quotient Percentiles, and Metropolitan Status of Wisconsin Counties. Source: SRI analysis of Lightcast data.

		Location Quotients			*Location Quotient Percentiles*				
County	*Specialization Index*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	Economic Development Region	*Metro / Non-metro*
Waupaca	2.82	4.72	17.38	7.00	93%	100%	89%	New North	Non-Metro
Polk	2.71	4.28	5.98	5.48	92%	92%	88%	Momentum West	Non-Metro
Manitowoc	2.60	4.21	6.98	2.63	90%	96%	74%	New North	Non-Metro
Marinette	2.57	7.99	4.46	2.70	99%	82%	76%	Grow North	Non-Metro
Washington	2.40	3.41	4.79	1.92	89%	86%	65%	Milwaukee 7	Metro
Fond du Lac	2.33	16.68	1.92	2.80	100%	56%	78%	New North	Metro
Racine	2.31	5.12	2.90	2.23	96%	65%	69%	Milwaukee 7	Metro
Green	2.28	3.36	3.66	2.15	88%	72%	68%	Prosperity Southwest	Metro
Dodge	2.26	0.59	3.18	12.62	61%	69%	96%	Madison Region	Non-Metro
Richland	2.24	5.97	0.77	21.91	97%	28%	99%	Prosperity Southwest	Non-Metro
Jefferson	2.21	0.49	3.81	8.82	57%	74%	90%	Madison Region	Non-Metro

		Location Quotients			Location Quotient Percentiles				
County	*Specialization Index*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	Economic Development Region	*Metro / Non-metro*
Ozaukee	2.19	1.54	6.58	0.71	76%	93%	50%	Milwaukee 7	Metro
Shawano	2.15	0.67	3.88	2.65	64%	76%	75%	New North	Non-Metro
Calumet	2.13	0.65	1.71	37.28	63%	50%	100%	New North	Metro
St. Croix	2.08	0.34	6.84	1.40	51%	94%	63%	Momentum West	Metro
Winnebago	2.06	0.32	2.43	12.54	50%	61%	94%	New North	Metro
Walworth	2.01	1.02	5.48	0.37	69%	88%	44%	Milwaukee 7	Non-Metro
Sauk	2.00	3.14	4.12	0.12	85%	79%	36%	Madison Region	Non-Metro
Lincoln	1.96	0.06	2.05	9.56	47%	57%	92%	Centergy	Metro
Rock	1.90	3.24	2.76	0.29	86%	63%	42%	Madison Region	Metro
Waukesha	1.88	0.50	3.04	1.29	58%	68%	61%	Milwaukee 7	Metro
Barron	1.88	1.55	1.72	1.07	78%	53%	57%	Momentum West	Non-Metro
Monroe	1.83	0.92	1.40	2.33	68%	44%	71%	7 Rivers Alliance	Non-Metro
Kewaunee	1.82	0.00	4.47	14.84	1%	83%	97%	New North	Metro
Grant	1.78	1.62	2.33	0.24	79%	60%	39%	Prosperity Southwest	Non-Metro
Crawford	1.72	0.00	5.69	3.75	1%	89%	82%	Prosperity Southwest	Non-Metro
Outagamie	1.71	0.12	1.35	3.09	49%	43%	79%	New North	Metro
Sheboygan	1.71	0.03	8.81	0.01	44%	99%	28%	New North	Metro
Milwaukee	1.63	0.88	1.15	1.09	67%	38%	58%	Milwaukee 7	Metro
Oconto	1.61	0.00	2.92	10.77	1%	67%	93%	Grow North	Metro
Price	1.58	0.00	3.50	5.14	1%	71%	86%	Visions Northwest	Non-Metro
Marathon	1.57	1.14	0.83	0.76	74%	32%	51%	Centergy	Metro
Eau Claire	1.56	1.75	1.62	0.01	82%	47%	26%	Momentum West	Metro
Door	1.49	0.00	4.40	1.99	1%	81%	67%	New North	Non-Metro
Chippewa	1.49	0.40	2.80	0.06	54%	64%	31%	Momentum West	Metro
Portage	1.43	0.67	0.77	0.68	65%	29%	49%	Centergy	Non-Metro
Sawyer	1.43	1.68	0.31	0.59	81%	15%	47%	Visions Northwest	Non-Metro
Columbia	1.43	0.00	4.10	1.73	1%	78%	64%	Madison Region	Metro
Jackson	1.38	2.76	0.00	0.89	83%	1%	53%	7 Rivers Alliance	Non-Metro
Kenosha	1.32	1.05	2.22	0.00	72%	58%	1%	Milwaukee 7	Metro
Dane	1.31	0.42	0.95	0.29	56%	35%	40%	Madison Region	Metro
Douglas	1.28	0.00	1.91	2.57	1%	54%	72%	Visions Northwest	Metro
Clark	1.26	0.00	1.30	4.41	1%	40%	85%	Centergy	Non-Metro
Green Lake	1.25	1.40	1.70	0.00	75%	49%	1%	New North	Non-Metro
Wood	1.21	0.35	0.61	0.41	53%	22%	46%	Centergy	Non-Metro

		Location Quotients			Location Quotient Percentiles				
County	*Specialization Index*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	*Parts Manuf.*	*Upstream Suppliers*	*OEMs*	Economic Development Region	*Metro / Non-metro*
Waushara	1.19	4.82	0.62	0.00	94%	24%	1%	New North	Non-Metro
Pepin	1.18	0.00	0.86	3.86	1%	33%	83%	7 Rivers Alliance	Non-Metro
Brown	1.17	0.06	1.03	0.10	46%	36%	35%	New North	Metro
Juneau	1.00	0.00	7.37	0.00	1%	97%	1%	7 Rivers Alliance	Non-Metro
Lafayette	0.96	0.00	1.71	0.36	1%	51%	43%	Prosperity Southwest	Non-Metro
Dunn	0.93	0.00	5.90	0.00	1%	90%	1%	Momentum West	Non-Metro
La Crosse	0.90	1.03	0.41	0.00	71%	18%	1%	7 Rivers Alliance	Metro
Trempealeau	0.88	0.00	0.81	1.01	1%	31%	56%	7 Rivers Alliance	Non-Metro
Taylor	0.88	0.00	4.66	0.00	1%	85%	1%	Visions Northwest	Non-Metro
Oneida	0.86	0.00	0.64	1.19	1%	25%	60%	Grow North	Non-Metro
Ashland	0.83	0.00	0.00	3.50	1%	1%	81%	Visions Northwest	Non-Metro
Bayfield	0.78	0.00	1.17	0.16	1%	39%	38%	Visions Northwest	Non-Metro
Burnett	0.78	0.00	3.85	0.00	1%	75%	1%	Visions Northwest	Non-Metro
Pierce	0.74	0.56	0.04	0.00	60%	13%	1%	Momentum West	Metro
Washburn	0.65	0.00	0.00	0.91	1%	10%	54%	Visions Northwest	Non-Metro
Langlade	0.54	0.00	0.42	0.09	1%	19%	33%	Grow North	Non-Metro
Vilas	0.50	0.00	0.34	0.06	1%	17%	32%	Grow North	Non-Metro
Rusk	0.49	0.00	1.46	0.00	1%	46%	1%	Visions Northwest	Non-Metro
Marquette	0.44	0.00	1.31	0.00	1%	42%	1%	New North	Non-Metro
Forest	0.32	0.00	0.00	0.04	1%	1%	29%	Grow North	Non-Metro
Florence	0.29	0.00	0.72	0.00	1%	26%	1%	Grow North	Non-Metro
Adams	0.24	0.00	0.47	0.00	1%	21%	1%	Centergy	Non-Metro
Vernon	0.17	0.00	0.15	0.00	1%	14%	1%	7 Rivers Alliance	Non-Metro
Iowa	0.14	0.00	0.02	0.00	1%	11%	1%	Prosperity Southwest	Metro
Buffalo	0.04	0.00	0.00	0.00	1%	1%	1%	7 Rivers Alliance	Non-Metro
Iron	0.04	0.00	0.00	0.00	1%	1%	1%	Visions Northwest	Non-Metro
Menominee	0.04	0.00	0.00	0.00	1%	1%	1%	New North	Non-Metro

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