WORLD RESOURCES INSTITUTE

REPORT

A roadmap for Michigan's electric vehicle future

An assessment of the employment effects and just transition needs

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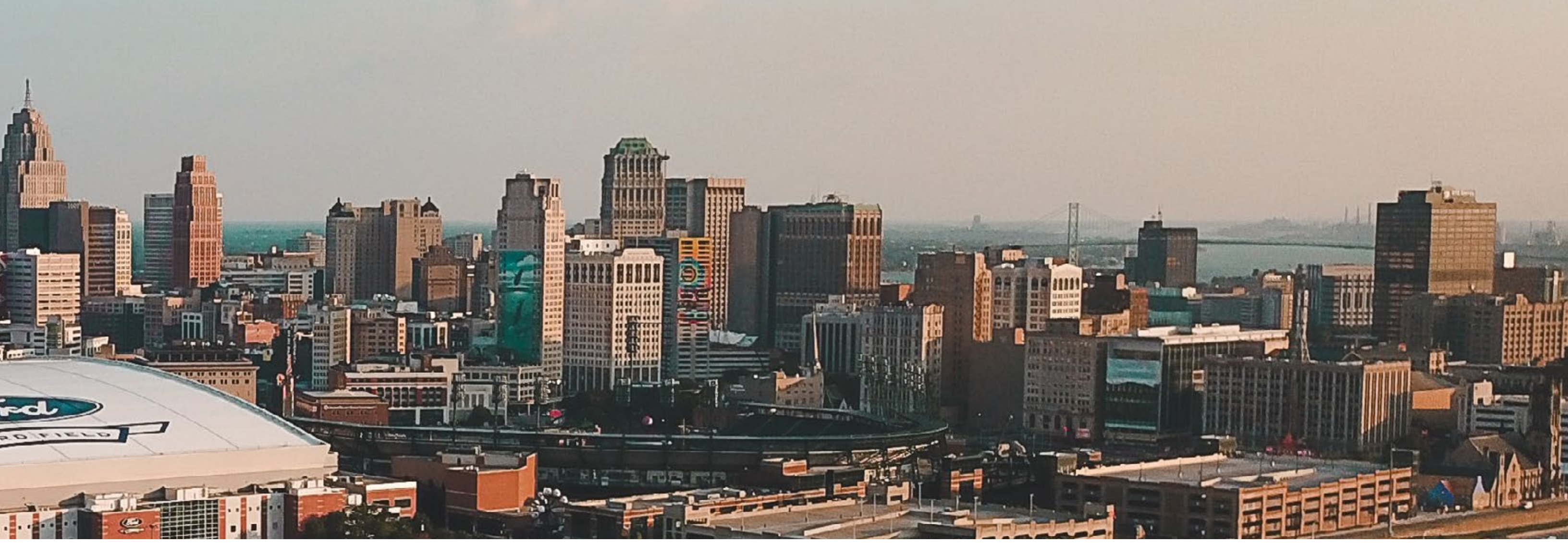

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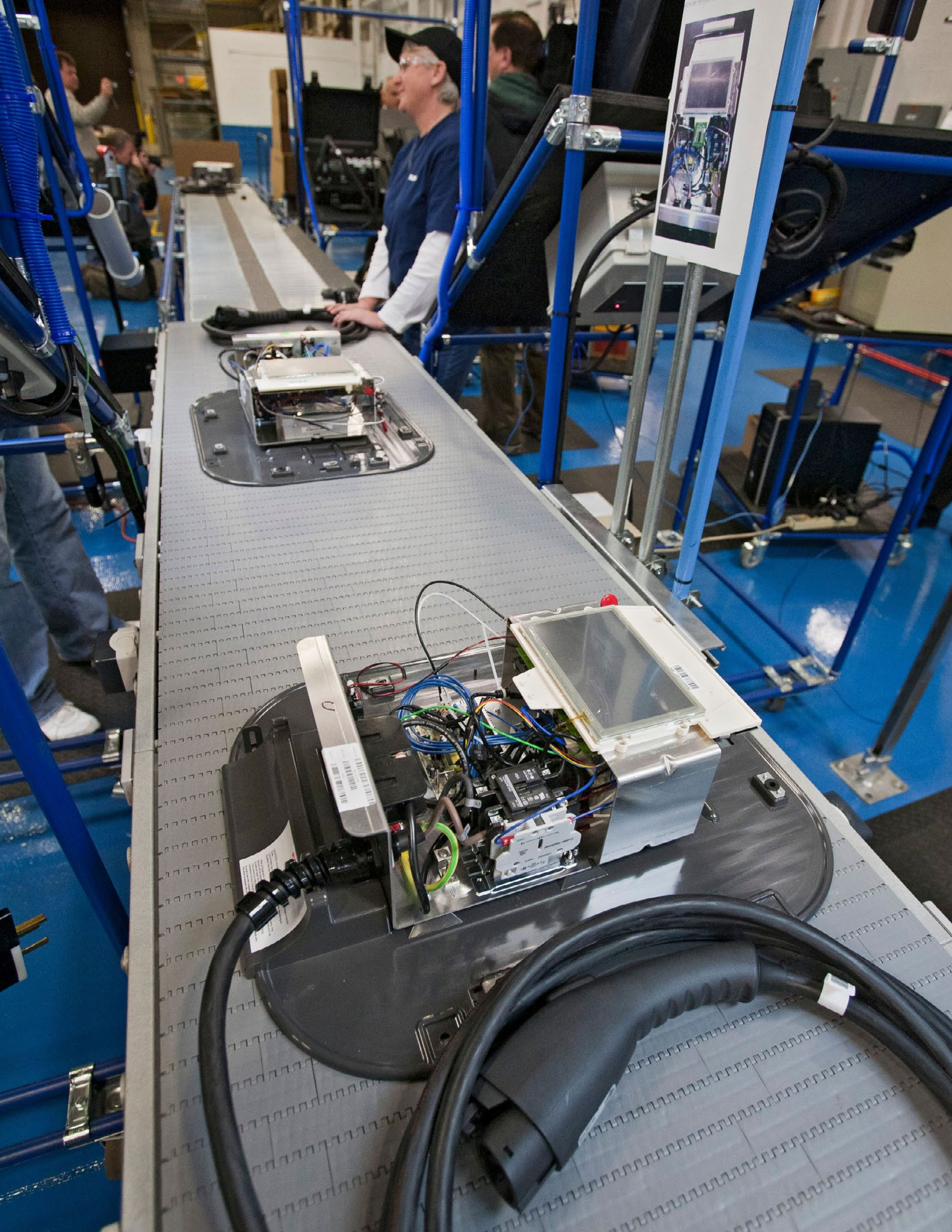


Foreword

Michigan has been synonymous with automotive innovation since the birth of the industry. These combustion engine vehicles have radically transformed American and global society over the last century. At the same time, they have also contributed to dangerous climate-warming emissions. Fossil-fuel powered combustion engine vehicles contribute over 80 percent of transportation emissions in the United States, the largest sector of emissions in the country today. It is clear that business-as-usual cannot continue for much longer as climate impacts make themselves more and more evident for Michiganders, the rest of the nation, and the world.

Electric vehicles (EVs) will play a critical role as more countries decarbonize their economies for a climate-proof future. In order to meet its global climate goals, the world needs to accelerate light-duty EV sales by five times. As home to one-fifth of all auto production in the United States, Michigan can seize the opportunity to lead the next era of automotive transformation and chart a path to an electrified future.

The EV transition is already under way. Sales of new EVs are growing exponentially in the United States. At the same time, recent federal laws have spurred the buildout of charging infrastructure while also promising long-term support for producers and consumers investing in EVs and their supply chains. These measures have invigorated domestic manufacturing and set up the country for growth across industries from battery recycling to semiconductor manufacturing.

At the same time, the benefits of EV growth in the United States will be hollow if states race to attract industry without consideration for impacts on workers and communities. Shifts in automotive production, fueling, and maintenance processes will change where and how people work. Workers and communities will need sustained, timely and targeted support. Investing in education and public infrastructure would allow states to train and retain the talented people they need. States can invest in future industries by investing in workers and creating structures for employers to do the same.

This report assesses the employment impacts, needs, and opportunities that will likely emerge over the course of the EV transition in Michigan. Looking over a decade into the future, it spotlights auto manufacturing but also evaluates the effects of an expanded EV value chain, taking into account the voice of key local stakeholders in building a policy roadmap.

If Michigan seizes the opportunities the transition presents, it stands to gain tens of thousands of high-quality jobs. The state can also realize energy independence, billions of dollars in household savings, and improvements to health and air quality —developments where low-income communities and communities of color stand to benefit the most. Or else, the transition could leave behind longtime autoworkers and communities or even see a broader decline in auto manufacturing jobs.

Michigan has already begun to position itself as a leader in the production and deployment of EVs, establishing a goal to deploy enough charging infrastructure to support 2 million EVs on the roads by 2030. The EV transition has the potential to bring renewed prosperity to the state, occurring in a way that redresses rather than reinforces inequities. As the global just transition movement accelerates, Michigan's automotive industry is in a unique position to show the United States how to navigate this critical juncture in a way that strengthens communities, economies, and the climate.

ANI DASGUPTA
President & CEO
World Resources Institute


Ford
START
STOP

Executive summary

Michigan's economy stands to benefit significantly from the EV transition if it proactively strengthens its position in EV production and deployment. This report aims to equip Michigan policymakers with a strategy to grow the state's EV industry while ensuring that the transition creates quality jobs and does not leave longtime autoworkers and auto manufacturing communities behind.

HIGHLIGHTS

- Michigan can be a leader in the electric vehicle (EV) industry by building on promising state efforts, recent federal laws, and its long-established strengths in automotive research, development, and manufacturing.
- If Michigan adopts the right new policies and increases its market share in EV and battery production during the transition to an all-electric future, the state could add 56,000 jobs in auto manufacturing in 2030 compared with what would occur if the EV transition did not take place. If, however, Michigan fails to seize the opportunities presented by the transition, auto manufacturing jobs could decline.
- Continued, active support for the workforce transition is needed because there will be job gains in some segments of the automotive value chain (e.g., battery manufacturing, EV charging infrastructure) and losses in others (e.g., internal combustion engine manufacturing, auto repair and maintenance).
- Based on extensive stakeholder consultations, this report proposes that Michigan should do the following: continue pursuing innovation-oriented economic development to attract investments and talent in the state's expanding EV industry; equitably accelerate EV deployment; and create quality EV jobs that offer family-sustaining wages, security, and potential for career growth while ensuring that longtime auto workers and communities are not left behind.

CONTEXT

With the right policies, Michigan's economy and environment both stand to benefit tremendously from the EV transition. Building up the EV industry in Michigan can drive economic development and job creation. Adopting more EVs can also allow Michigan drivers to save money on vehicle purchases, maintenance, and gasoline use. At the same time, embracing and properly preparing for the transition to EVs can dramatically reduce the state's greenhouse gas emissions and dependence on fossil fuels, improve public health by lowering air pollution, and support environmental justice outcomes.

The transition to EVs is accelerating in the United States and globally. The future of transportation is electric. In 2022, sales of battery EVs and plug-in hybrid EVs accounted for 6 percent of the US market (Shahan 2023) and 13 percent of the global market (Irle 2023). The transportation sector is the largest source of US greenhouse gas emissions (EPA 2022), making the shift to EVs critically important. The Biden administration has a goal for EVs to comprise 50 percent of new car sales in the country by 2030. This goal is now within reach given the recent passing of the federal Infrastructure Investment and Jobs Act (2021), the CHIPS and Science Act (2022), and the Inflation Reduction Act (2022), which are poised to spur domestic manufacturing and deployment of EVs. In addition, the Environmental Protection Agency has proposed new tailpipe pollution regulations that it expects would cause EV sales to exceed the goal of 50 percent in 2030 and reach two-thirds of light-duty vehicle sales by 2032. Still, even more acceleration is needed at the federal and state levels to reach a 62 percent EV share of light-duty vehicle sales in 2030 and 100 percent share by 2033, which would make the United States consistent with a global target of economy-wide net-zero emissions by 2050 (BNEF 2022a; Slowik et al. 2023).

Building on its historic strengths in the automotive industry, Michigan has begun to position itself as a leader in the production and deployment of EVs. In 2020, the state created an Office of Future Mobility and Electrification to coordinate mobility and electrification activities across the public and private sectors, and last year the government established a goal to deploy enough charging infrastructure to support 2 million EVs on the road by 2030. With the governor's office and the newly elected state legislature signaling their support, Michigan has an opportunity to adopt more ambitious and equitable transportation electrification policies. Automakers, suppliers, and infrastructure providers are pouring billions of dollars in investment into Michigan's economy. However, Michigan is also competing with other states for these investments, and its ability to lead the EV industry is not guaranteed. Implementing the correct policy framework will allow Michigan to maintain its leading role in auto manufacturing.

It is important for Michigan to put in place policies that ensure that longtime autoworkers and communities are not left behind during the transition. The EV transition will bring about changes to auto sector employment patterns, making it critical to ensure that workers and communities benefit from the shift. New industries and job opportunities will be created in EV battery manufacturing, deployment of EV charging infrastructure, and expansion and modernization of the electric grid to power the EVs. These economic opportunities will be amplified because the Inflation Reduction Act has provisions to incentivize domestic EV production. On the other hand, EVs have fewer moving parts than internal combustion engine (ICE) vehicles so less labor will be needed in ICE and ICE vehicle component manufacturing as well as in auto maintenance and repair. In addition, fewer gas stations will be needed. All this will significantly impact the existing automotive workforce and communities where this workforce is concentrated while raising questions around how to create high-quality and inclusive jobs in the growing EV industry.

ABOUT THIS REPORT

This report aims to equip Michigan policymakers with a strategy to grow the state's EV industry while ensuring that the transition creates quality jobs and does not leave behind longtime autoworkers and communities. Our analysis relied on a combination of economic modeling and stakeholder consultations to better understand how the shift to EVs will impact employment. We used the DEEPER (Dynamic Energy Efficiency Policy Evaluation Routine) Modeling System, a macroeconomic input-output model, to estimate the employment effects in Michigan of the transition to light-duty EVs from 2024 to 2040. The economic modeling was complemented with extensive stakeholder engagement to inform both the modeling analysis and the development of a suite of recommendations for Michigan

policymakers. We consulted with stakeholders across the state government, academia, the private sector, labor organizations, nonprofit organizations, and community groups, and also benefited from the expert guidance of a nine-member civil society advisory council.

FINDINGS

This report presents indicative results for an All Electric by 2033 scenario with a High Competitiveness case and a Low Competitiveness case. In the All Electric by 2033 scenario, EVs reach around 62 percent of light-duty vehicle sales by 2030 and 100 percent by 2033. In the High Competitiveness case, Michigan increases its share of domestic auto production and battery manufacturing, while in the Low Competitiveness case those shares decline (Table ES-1). To provide Michigan policymakers with information regarding the magnitude of change that will transpire between now and 2040, all jobs effects are presented in comparison to a No Transition scenario in which EVs do not grow further. Our results include direct jobs in a sector, indirect jobs in the supply chain for that sector, and induced jobs created when direct and indirect workers spend their earnings on goods and services in the wider economy.

TABLE ES-1 | Scenarios and cases

	NO TRANSITION SCENARIO	ALL ELECTRIC BY 2033 SCENARIO, HIGH COMPETITIVENESS CASE	ALL ELECTRIC BY 2033 SCENARIO, LOW COMPETITIVENESS CASE
EV sales	No growth in EVs	EVs reach 62% of light-duty vehicle sales in 2030, 100% by 2033	
Michigan's share of US vehicle production	Remains at 20%	Rises to 25% by 2030 and stays at that level	Falls to 15% by 2030 and stays at that level
Michigan's share of US EV battery production	Remains at 10%	Rises to 15% by 2030 and stays at that level	Falls to 5% by 2030 and stays at that level

Note: See "Approach: Understanding EV Just Transition Needs" and Appendix C for full explanation and sources. EV = electric vehicle.
Source: Authors.

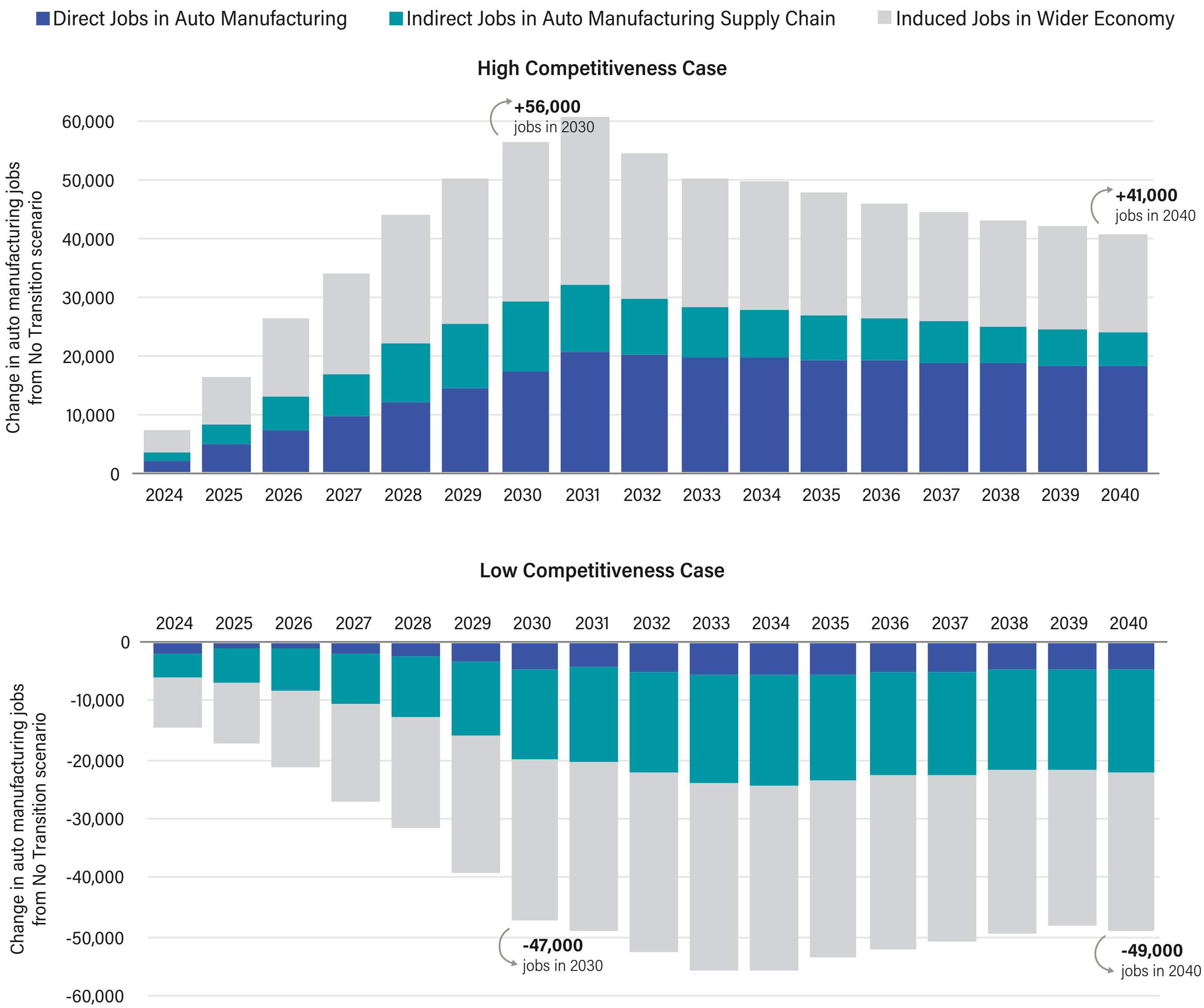
The transition to EVs will lead to net job gains in auto manufacturing if Michigan puts in place policies that enable it to secure a sufficient share of the nation's automotive and battery manufacturing value. In the High Competitiveness case, Michigan would add 17,000 direct jobs in auto manufacturing and around 12,000 indirect jobs in the supply chain in 2030 compared with the No Transition scenario. Battery manufacturing would grow quickly and be responsible for the majority of those additional jobs. In addition, the ripple effect of those workers spending their earnings would create 27,000 induced jobs in the wider economy. The total effect would be 56,000 additional direct, indirect, and induced jobs in 2030, and 41,000 in 2040 (Figure ES-1).[1] On the other hand, in the Low Competitiveness case in which Michigan loses market share, there would be a net negative effect on auto manufacturing employment. Michigan would have 4,000 fewer direct jobs in auto manufacturing and 15,000 fewer indirect jobs in the supply chain in 2030 compared with the No Transition scenario. There would be some increases in battery manufacturing jobs, but they would not be enough to make up for the job losses in the other aspects of auto manufacturing. The direct and indirect job decreases would lead to 28,000 fewer induced jobs in the wider economy. The total effect from all of these would be 47,000 fewer direct, indirect, and induced jobs in 2030, and the effects would stay relatively the same from 2030 to 2040. Achieving the High Competitiveness case rather than the Low Competitiveness case will require Michigan government and companies to successfully take advantage of new opportunities in the emerging EV industry, which will require the consideration of additional policies beyond what Michigan is currently implementing.

Retraining efforts aligned with growing demand for EV production will be critical for ensuring that ICE vehicle manufacturing workers are able to transition to EV manufacturing roles, including in battery manufacturing. With the changes in the production process and the losses in manufacturing, especially in the Low Competitiveness case, some employees will need to be retrained while others may need to transition into work outside the automotive industry. Much of the skills and sectoral transition could be addressed as part of normal rates of retirement, given that 52 percent of all current auto manufacturing workers in Michigan will reach age 65 by 2040 (Census Bureau n.d.).

In addition to production workers to build EVs and manufacture batteries and chargers, Michigan will need to grow its pipeline of high-tech knowledge workers. The software-defined electric vehicle, for instance, will require an influx of electrical and software engineers while the development of new battery technology will need chemical engineers, manufacturing process engineers, and battery lab technicians. These are jobs that will require at least a bachelor's degree, but they also are high-paying and important drivers of economic growth. Michigan will need to consider policies that make it an attractive destination for high-tech talent.

The way that EVs are fueled, operated, and maintained will also have important jobs effects, irrespective of Michigan's level of manufacturing competitiveness (Table ES-2). These jobs effects stay the same in both the High and Low Competitiveness cases, given that they are caused by the number of EVs on the road in Michigan, not the number manufactured in Michigan. The installation and operation

FIGURE ES-1 | Change in auto manufacturing jobs (including battery manufacturing jobs) in All Electric by 2033 scenario



If Michigan puts in place the right policies and increases its share of US auto and battery manufacturing, the electric vehicle (EV) transition would have a net positive effect on Michigan's auto manufacturing employment. It would lead to around 56,000 additional direct, indirect, and induced jobs in 2030, and 41,000 in 2040 compared with a scenario in which the transition to EVs does not occur. On the other hand, if Michigan is left behind in the EV transition and its share of US auto and battery manufacturing decreases, the EV transition would have a net negative effect on employment.

Source: Authors.

of EV charging infrastructure in Michigan in line with an All Electric by 2033 scenario would create around 7,500 additional direct, indirect, and induced jobs in 2040. Electricity purchases to fuel EVs would support direct, indirect, and induced jobs from power generation, transmission, and distribution, equivalent to 12,000 jobs in 2040 above the No Transition scenario. On the other hand, a decline in gasoline use would lead to 46,000 fewer direct, indirect, and induced gas station jobs in 2040 compared with the No Transition scenario if they are not repurposed as EV charging stations. The direct jobs at gas stations are mostly convenience store jobs with below-average wages that current economic trends indicate are particularly likely to become automated regardless of vehicle electrification (Begley et al. 2019; BLS 2022a). The transition can, therefore, offer a chance for these workers to re-skill, upskill, or shift to jobs of equal or greater quality—if Michigan implements appropriate workforce transition policies. Auto maintenance and repair needs would gradually decline as the fleet turns over, leading to 26,000 fewer direct, indirect, and induced maintenance and repair jobs in 2040 compared with the No Transition scenario.

Switching to EVs will allow drivers to save money on vehicle purchases, maintenance, and gasoline, which will improve household finances and have positive employment impacts. In the All Electric by 2033 scenario, Michiganders

TABLE ES-2 | Jobs created from sectors other than auto manufacturing

	CHANGE IN JOBS IN MICHIGAN IN 2040 COMPARED WITH NO TRANSITION SCENARIO			
	Direct jobs	Indirect jobs in supply chain	Induced jobs in wider economy	Total
EV charging infrastructure	4,000	700	2,700	7,500
Electricity purchases	1,500	3,100	7,200	11,800
Gasoline purchases	-24,600	-8,500	-13,100	-46,100
Auto maintenance and repair	-13,200	-2,500	-9,900	-25,700
Auto finance				-6,400
Renewable energy to support transition to EVs				7,600*†
Net savings re-spending				26,900
Inflation Reduction Act tax credit savings				15,000*‡

Notes: Totals may not be equivalent due to rounding; *Back-of-the-envelope calculation rather than full modeling exercise; † Annual average, 2024–40; ‡ Results from 2032, the last year of the tax credits.

Source: Authors.

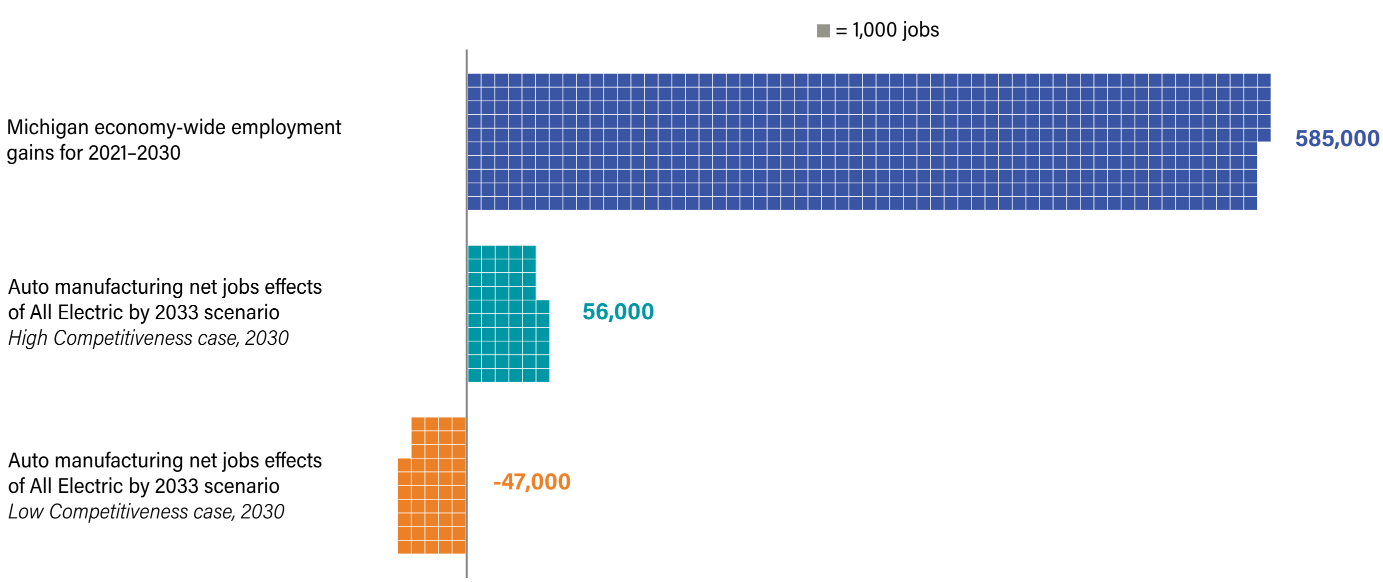
save a cumulative US$39.5 billion on vehicle ownership by 2040. When they re-spend that money in the rest of the economy, it would create around 27,000 jobs in Michigan by 2040. For context, this is enough to fully offset job losses in auto maintenance and repair. The EV and battery tax credits in the Inflation Reduction Act will increase these savings and job creation even further, leading to $8.7 billion in cumulative savings and 15,000 jobs created by 2032, the last year of their effect.

The transition to EVs will also lower health burdens across the state, including in disadvantaged communities. Internal combustion engine vehicles emit sulfur dioxide, nitrogen oxides, volatile organic compounds, and particulate matter. People of color are more likely than average to live in communities with unhealthy air, partially due to traffic patterns. Through a shift to zero-emission transportation, Michigan would avoid approximately 4,700 deaths, 97,400 asthma attacks, and 466,000 lost workdays from 2020 to 2050 (ALA 2022a).

Considering all areas modeled in this report, including auto manufacturing and other sectors related to EVs,[2] the net jobs effect in the All Electric by 2033 scenario's High Competitiveness case is positive. The number of direct, indirect, and induced jobs would be 47,000 higher in 2030 and 10,000 higher in 2040 than the No Transition scenario. On the other hand, in the Low Competitiveness case, there would be 57,000 fewer direct, indirect, and induced jobs in 2030 and 80,000 fewer in 2040 compared with the No Transition scenario.

Michigan's overall economy has the capacity to adapt to the coming changes, but it will require policies to ensure wins for workers and communities. The employment shifts from EVs will be relatively small compared with other employment trends. Outside analysis has estimated that Michigan's entire economy will add 585,000 jobs by 2030 and 880,000 jobs by 2040 (W&PE 2022). This is more than 10 times more than the jobs effects from auto manufacturing in either direction from the High or Low Competitiveness cases (Figure ES-2). However, the effect of the changes will be uneven, with job losses in some segments of the automotive value chain and gains in others. Given the concentration of motor vehicle parts and manufacturing in the Detroit region, it will likely be at the heart of these changes. That means Michigan needs to ensure that the transition maximizes economic and social opportunities for workers and communities while minimizing potential risks.

FIGURE ES-2 | Auto manufacturing jobs effects of the EV transition are small in comparison to Michigan's projected overall employment growth



Note: Our scenarios include direct jobs, indirect jobs in the supply chain, and induced jobs in the wider economy.

Source: Authors. Michigan economy-wide employment gains for 2021–30 from W&PE 2022.

POLICY RECOMMENDATIONS

Michigan should pursue policies to achieve three goals that are critical for ensuring a thriving ecosystem for its auto industry, workers, communities, and economic outlook. Detailed recommendations for Michigan policymakers, including the state legislature, the governor's office, and various departments, are identified in Table ES-3, which also includes information on the key agencies responsible for executing the recommendation and the type of action required.

1. **Pursue innovation-oriented economic development** to improve the state's innovation, manufacturing, and infrastructure ecosystem to be able to attract EV investments and talent in everything from manufacturing to research, design, and development of products and services to meet the needs of an all-electric future.
2. **Accelerate equitable EV and charging infrastructure deployment** to become not only a top producer but also a leading state in EV adoption.
3. **Create quality jobs offering decent wages, security, and opportunities to grow** in the state's expanding EV industry while ensuring that longtime autoworkers and communities are not left behind.

In addition to these recommendations, Michigan should pursue federal funding available through the Infrastructure Investment and Jobs Act, the CHIPS and Science Act, and the Inflation Reduction Act to decarbonize its transportation sector. Michigan can leverage the most out of these opportunities by maximizing its federal funding (e.g., using the National Electric Vehicle Infrastructure Formula Program to strategically deploy EV charging infrastructure) and aligning key state goalposts with the expiration of federal funding provisions.

TABLE ES-3 | Policy recommendations to grow Michigan's EV industry and drive an equitable transition

POLICY RECOMMENDATION	STRATEGIES	AGENT(S)	REQUIRES
Goal 1: Pursue innovation-oriented economic development that enables Michigan to attract EV-related investments and talent (pages 56–62)			
Develop the workforce pipeline for the EV industry.	Track labor market dynamics across the entire automotive value chain and over time to align job demand and labor supply.	LEO; MEDC	Executive action; local coordination and partners
	Support industry-led worker training partnerships.*	LEO; MEDC	Executive action; local coordination and partners
	Support existing apprenticeship and pre-apprenticeship programs and create programs where needed.*	LEO	Executive action; local coordination and partners
	Track outcomes of all workforce and training programs.	LEO	Executive action; local coordination and partners
	Develop curriculum upgrades in postsecondary institutions focusing on occupations that are critical for the transition to EVs.	LEO	Executive action; local coordination and partners
	Introduce middle and high school students to careers in the EV industry.	MDE	Executive action
Bolster Michigan's innovation ecosystem to attract corporate headquarters and R&D facilities.	Provide greater public investments in higher education to strengthen the state's skills base.	State legislature; MDE	Legislative action with public funding
	Invest in programs to attract and retain STEM students.	State legislature; LEO	Legislative action with public funding
	Strengthen business R&D in the state.	State legislature; MEDC	Legislative action with public funding
	Facilitate greater interaction and connections among companies, research universities, national laboratories, and the Department of Energy.	MEDC; LEO	Executive action; local coordination and partners
Protect and bolster Michigan's EV manufacturing competitiveness.	Target economic development incentives to align with Michigan's vision of creating inclusive and equitable economic growth.*	MEDC	Executive action
	Improve Michigan's Project-Ready Sites Program.	MEDC; MPSC	Executive action
	Provide support to automotive parts manufacturers to navigate the EV transition.	MEDC	Executive action
	Investigate and expand new markets in the automotive value chain including in EV battery recycling.	EGLE; MEDC	Executive action; legislative action with public funding
Invest in infrastructure improvements including grid upgrades and low-carbon mobility options.	Increase renewable energy penetration to enable Michigan to meet its planned clean energy target.*	State legislature; EGLE; MPSC	Legislative action; regulatory action
	Invest in grid upgrades to meet the increased demand for electricity from vehicle electrification.*	State legislature; MPSC	Legislative action with public funding; regulatory action
	Invest in low-carbon mobility options to make Michigan a desirable place to live and work.*	State legislature; MDOT	Legislative action with public funding
	Consider adopting "buy clean" policies to ensure that infrastructure investments are the cleanest and most sustainable available.	State legislature; EGLE	Legislative action with public funding; regulatory action

TABLE ES-3 | Policy recommendations to grow Michigan's EV industry and drive an equitable transition (Cont.)

POLICY RECOMMENDATION	STRATEGIES	AGENT(S)	REQUIRES
Goal 2: Accelerate equitable EV and charging infrastructure deployment (pages 62–67)			
Accelerate the widespread and equitable adoption of EVs through supportive policies.	Consider California's motor vehicle emissions standards.	State legislature; EGLE	Legislative action with no public funding
	Adopt a clean fuels standard.*	State legislature; EGLE	Legislative action with no public funding
	Provide financial incentives to purchase new and used EVs and target those that benefit low- and middle-income consumers.*	State legislature; EGLE; Department of the Treasury	Legislative action with public funding
	Accelerate public fleet electrification.*	DTMB; MPSC	Legislative action with public funding
	Address barriers to EV sales by reforming annual EV fees.	EGLE; MDOT	Legislative action set by statute with administration's help with design
	Create educational materials to promote EV adoption, especially in low-income communities.	EGLE	Executive action
Deploy a robust and equitable network of charging infrastructure throughout the state.	Encourage and approve utility electrification programs that continue to incentivize electric vehicle supply equipment (EVSE) purchase, installation, and maintenance and operation.*	MPSC	Regulatory action
	Standardize EVSE permitting.	State legislature; LARA	Legislative action with no public funding
	Adopt EV-ready building and electrical codes for all new buildings.	State legislature; LARA	Legislative action with no public funding; regulatory action
	Prioritize the deployment of EV charging infrastructure in disadvantaged and rural communities.	MPSC; ORD; planning organizations	Executive action; legislative action with public funding
Develop public utility policies that support faster deployment of EVs and improved reliability of electricity services.	Adopt policies to enable faster EV charger interconnection by utilities.	State legislature; MPSC	Legislative action with no public funding
	Adopt policies to ensure reliability and affordability of at-home charging.*	State legislature; MPSC	Legislative action with no public funding; regulatory action
Goal 3: Create quality jobs while ensuring that the EV transition does not leave longtime autoworkers and communities behind (pages 67–71)			
Create robust transition opportunities for longtime auto workers.	Create a transition support fund for workers impacted by the EV transition.	State legislature; LEO; Department of the Treasury	Legislative action with public funding; local coordination and partners
	Establish a "rapid response team" to address job displacement and mass layoff situations.	LEO; planning organizations**	Executive action
	Work with employers to create plans to provide fair early retirement packages for ICE vehicle workers.	LEO	Local coordination and partners

TABLE ES-3 | Policy recommendations to grow Michigan's EV industry and drive an equitable transition (Cont.)

POLICY RECOMMENDATION	STRATEGIES	AGENT(S)	REQUIRES
Ensure that jobs in the EV industry offer family-sustaining wages, security, and potential for growth.	Strengthen prevailing wage requirements and provide guidance on determining comparable jobs and wages in the EV industry.	State legislature; LEO	Legislative action with no public funding
	Ensure workers have the right to unionize, which has been found to be a strong determinant of job quality.	State legislature; LEO	Legislative action with no public funding
	Create clear, time-bound pathways for temporary workers to transition to comparable permanent, full-time roles and disincentivize the use of temporary worker contracts.	LEO	Executive action
Protect communities impacted or at risk of being impacted by the closure of legacy auto facilities.	Provide transition support for communities impacted by the closure of auto facilities related to ICE vehicle production.*	State legislature; LEO; planning organizations	Legislative action with public funding; local coordination and partners
	Support community-based efforts to reimagine how former automotive manufacturing sites should be repurposed.	LEO; ORD; planning organizations	Executive action; local coordination and partners
Ensure communities benefit from new EV investments by adopting supportive policies such as community benefits agreements (CBAs).	Consider adopting a statewide CBA framework as an integral component of the economic development toolkit.	State legislature; LEO; MEDC	Legislative action with no public funding; local coordination and partners
Utilize robust environmental justice screening tools to ensure that EV-related investments do not add to the cumulative pollution burden of Michigan communities.	Clarify how state agencies will use MiEJScreen in their decision-making.*	EGLE	Executive action
	Require a review of the existing pollution burden before approving permits.	EGLE	Regulatory action

Notes: Strategies marked with an asterisk (*) have been included in the Michigan Healthy Climate Plan and/or recommended by the Michigan Council on Future Mobility and Electrification; ** Planning organizations refer to a broad group of entities including local and regional economic development organizations and community-based organizations connecting people to employment opportunities.

Abbreviations: R&D = research and development; STEM = science, technology, engineering, and mathematics; DTMB = Department of Technology, Management & Budget; EGLE = Michigan Department of Environment, Great Lakes, and Energy; LARA = Michigan Department of Licensing and Regulatory Affairs; LEO = Michigan Department of Labor and Economic Opportunity; MEDC = Michigan Economic Development Corporation; MDE = Michigan Department of Education; MDOT = Michigan Department of Transportation; MPSC = Michigan Public Service Commission; ORD = Michigan Office of Rural Development.

Source: Authors.


BLUFF

Introduction

Michigan has begun to position itself as a leader in the production and deployment of electric vehicles, building on its long-established strengths in automotive research, development, and manufacturing, promising state initiatives, and recent federal laws like the Inflation Reduction Act. Further action from the state can enable Michigan to lead the way and show how the transition to EVs can be done in an equitable manner while supporting high-quality jobs and economic development.

The future of cars is increasingly electric. Passenger electric vehicle (EV) sales have increased threefold globally and fourfold in the United States over the last five years (BNEF 2022c). In 2022, sales of battery EVs and plug-in hybrid EVs accounted for 13 percent of the global market (Irle 2023), and 6 percent of the US market (Shahan 2023). Growth in sales has been particularly impressive in the last three years, even as the global pandemic disrupted supply chains and slowed down sales of conventional cars. The upward trajectory of EVs is likely to continue in the coming decades.

The shift to EVs is aided by multiple factors: rising concerns about the economic burden of climate change, volatile oil prices, an influx of private sector investments increasing the variety of EVs consumers can choose from, technological advances leading to improvements in battery range and a rapid decline in battery costs, the growing prevalence of EV charging stations, and an increasing number of government regulations and incentives. Investments and incentives included in the Infrastructure Investment and Jobs Act of 2021 (IIJA), the CHIPS and Science Act of 2022 (CHIPS Act), and the Inflation Reduction Act of 2022 (IRA) are expected to further propel EV adoption in the United States, as will tighter vehicle emissions standards proposed by the Environmental Protection Agency (EPA) this year.

Michigan stands to benefit tremendously from the EV transition. With the right policies in place, EVs can dramatically reduce the state's greenhouse gas emissions[3] and dependence on fossil fuels, improve public health by lowering air pollution, support environmental justice outcomes, and drive economic development and job creation.

Michigan's historic leadership in the automotive industry gives it a significant advantage in manufacturing and deploying EVs. Michigan is home to 26 automotive original equipment manufacturers and 96 of the top 100 automotive suppliers, and accounts for 18 percent of US vehicle production (CFME 2021). Established auto companies like Ford and General Motors (GM), newer EV companies like Rivian, EV manufacturing suppliers, and infrastructure providers are pouring billions of dollars in investment in Michigan. The state is also aggressively leveraging its historic strength in automotive research, development, and design to position itself as a leader in EV innovation. Michigan's public and private sectors are working together to increase the state's share of EV manufacturing and the associated supplier base as well as the uptake of EVs among Michigan consumers.

With the governor's office and the newly elected state legislature signaling their support, Michigan has an opportunity to adopt more ambitious and equitable transportation electrification policies.

For all the benefits and opportunities that Michigan can seize from developing and deploying EVs, the transition from internal combustion engine (ICE) vehicles to EVs is not without its challenges. The transition will be accompanied by changes in technology, production processes, and consumption patterns, which will make some parts of the automotive value chain obsolete while transforming others and introducing entirely new industry segments (Agrawal et al. 2022). All this will significantly impact the existing automotive workforce while raising questions around how to create high-quality and inclusive jobs in the growing EV industry. Furthermore, the shift from ICE vehicles to EV manufacturing could result in the closure of some legacy auto facilities that support the production of ICE vehicles, leading local communities to face losses in local tax revenues and cuts to public services (Cha et al. 2021b; Wang et al. 2022).

Against this backdrop, our analysis focused on answering two questions:

- What are the new opportunities for quality job creation and economic growth for Michigan arising from the EV transition?
- How can Michigan mitigate workforce- and community-level challenges to ensure an equitable EV transition that leaves no one behind?

Our analysis relied on a combination of economic modeling and stakeholder consultations to answer the above questions. The section "Approach: Understanding EV just transition needs" provides a brief overview of our methodology, and more granular details are included in Appendix C. The economic modeling sought to better understand how the EV transition will affect employment—job creation and job losses—in Michigan's automotive value chain. World Resources Institute (WRI) contracted with John A. "Skip" Laitner of Economic and Human Dimensions Research Associates to model the employment impacts using the DEEPER (Dynamic Energy Efficiency Policy Evaluation Routine) Modeling System (ACEEE 2011). "Results: The employment effects of an all-electric future for Michigan" presents modeling results on how the EV transition will impact employment in key segments of the automotive value chain.

WRI created a nine-member civil society advisory council comprising Michigan-based environmental and environmental justice organizations and labor unions to inform the modeling analysis and help WRI develop policy recommendations for Michigan. In addition, WRI solicited input from dozens of stakeholders including representatives from Michigan state agencies, the private sector, academia, and community organizations on modeling assumptions, results, and policy recommendations. "Recommendations for Michigan policymakers: Seizing opportunities, addressing challenges" presents a tripartite framework of policy recommendations to drive an equitable EV transition in Michigan:

- Innovation-oriented economic development policies that enable the state to attract both EV-related investments and talent
- Equitable EV and charging infrastructure deployment policies to position Michigan as a leading EV adopter
- Policies to create quality jobs and ensure that longtime autoworkers and communities are not left behind

We begin this report ("Context: Assessing Michigan's current efforts to lead the EV transition") by providing background information on what Michigan is already doing to move to an electrified transportation future and highlighting key areas where the state will need to do more.

Chevrolet Volt
Charging Station
chevy.com/volt
ChargePoint
ChargePoint Network
571
WINDSOR


CHAPTER 1

Context: Assessing Michigan's current efforts to lead the EV transition

In this chapter, we first describe the initiatives and actions that Michigan has taken to position itself as a national leader in the production and adoption of EVs. Next we describe the challenges that the state will need to address to grow its EV industry and create high quality jobs while enabling an equitable transition.

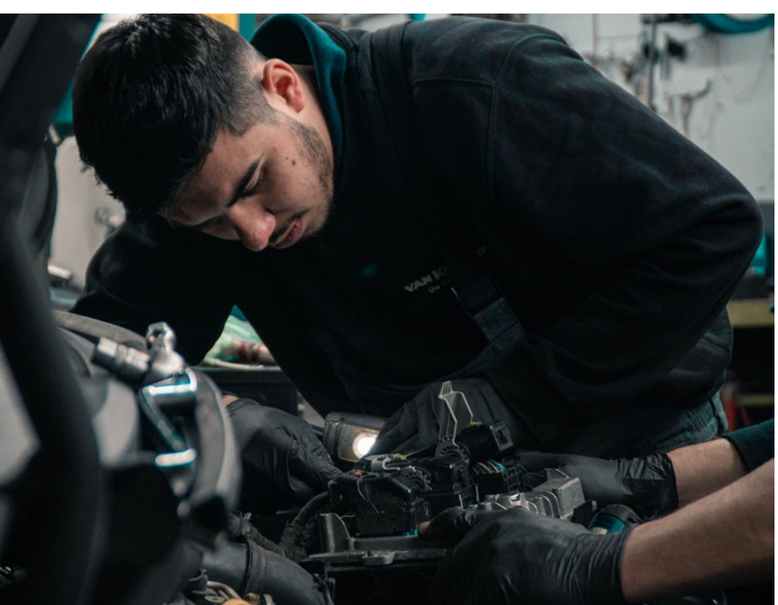
THE EVOLVING EV POLICY LANDSCAPE IN MICHIGAN

Policymakers in Michigan have already taken several significant steps to ensure that the state emerges as a global and national leader in the production and deployment of EVs.

In 2020, Governor Gretchen Whitmer created the Office of Future Mobility and Electrification (OFME) and the position of chief mobility officer, entrusted with the responsibility of working across the state government, the private sector, academia, and other entities to boost the state's mobility ecosystem.[4] OFME is housed within the Department of Labor and Economic Opportunity (LEO) and works in partnership with the Michigan Department of Transportation (MDOT); Department of Environment, Great Lakes, and Energy (EGLE); and the Michigan Economic Development Corporation (MEDC) to align initiatives across departments that focus on economic development, workforce and talent, transportation, the environment, and infrastructure growth.

In addition, Michigan established a Council on Future Mobility and Electrification (CFME) to serve in an advisory capacity to OFME, the governor, and the legislature and provide annual recommendations on how Michigan can continue to be a leader in mobility and electrification (CFME 2021).

The Michigan Future Mobility Plan, developed by OFME and CFME and released in September 2022, provides a three-part strategy to grow the mobility workforce, provide more accessible transportation infrastructure, and develop innovative mobility policies (MEDC 2022c).



Michigan also unveiled a Healthy Climate Plan in April 2022 which lays out the state's vision to achieve economy-wide carbon neutrality by 2050. The plan identifies transportation electrification as an essential decarbonization strategy to reach state goals, with the objective of installing 100,000 EV chargers and infrastructure to support two million EVs by 2030. Michigan will target EVs to account for at least 50 percent of light-duty vehicle (LDV) sales, 30 percent of medium- and heavy-duty vehicle sales, and 100 percent of public transit vehicles and school buses by 2030 in pursuit of that goal (EGLE 2022).

The Michigan governor's proposed fiscal year 2024 budget to the state legislature includes several significant investments in the EV ecosystem, including $150 million in matching grants to school districts to switch to electric buses; $65 million to expand EV charging infrastructure access; $45 million for the Michigan Clean Fleet Initiative to support local governments and businesses in transitioning their vehicle fleets to EVs and clean fuels; $48 million for sales tax incentives for the purchase of new, used, or leased EVs; $15 million for the creation of a critical mineral recycling research hub; $35 million to help small manufacturers address their workforce needs; and $25 million to upgrade equipment in vocational education and career and technical education training centers (OOTG 2023). If these investments are approved by the state legislature, they will further help Michigan in growing its EV industry and accelerating EV adoption.

While a detailed listing of initiatives across Michigan departments is included in Appendix A, Table A-1, we highlight a few here. The availability of a skilled workforce is critical for the EV transition to be successful. Michigan has launched mobility-focused workforce initiatives such as the Electric Vehicle Jobs Academy and the Mobility Talent Action Team to identify EV-related occupational skills needs and to align education and training programs with the most critical workforce needs of the private sector. In addition, the state's "Sixty by 30" educational goal—for 60 percent of adults to have a postsecondary degree or credential by 2030—is geared toward addressing the state's long-standing skills gap. In 2021, Michigan created the Strategic Outreach and Attraction Reserve Fund (SOAR Fund) with a $1.1 billion appropriation to enable it to compete with other states for corporate investments, including those in new EV and battery plants.[5] Beyond EV manufacturing, Michigan is also spearheading initiatives to get more EVs on the road, including the Charge Up Michigan Program to build direct-current fast-charging stations and the Lake Michigan EV Circuit to build a network of charging stations around Lake Michigan.

The private sector is responding by making new investments in Michigan.

The "big three" automakers—Ford, Chrysler Stellantis, and GM—are going all in on EVs, having announced a joint goal for EVs to meet 40–50 percent of their total vehicle sales by 2030 (Lambert 2021). Already, Ford's facility in Dearborn is producing the F-150 Lightning pickup, Stellantis' plant in Detroit is producing the Jeep Grand Cherokee 4xe, GM's plant in Lake Orion is producing the Chevrolet Bolt and will shift to producing other electric vehicles in the coming years, and GM's Factory ZERO in Detroit/Hamtramck will produce the GMC Hummer EV pickup and sport utility vehicle (SUV), the Chevrolet Silverado EV, and the electric shuttle Cruise Origin.

Michigan is also receiving its share of investment in battery research and development (R&D) and manufacturing. In 2021, Ford established a Global Battery Center of Excellence in southeast Michigan while GM announced the building of the Wallace Battery Cell Innovation Center in Warren, Michigan, to accelerate the development and commercialization of longer-range and more affordable batteries. In the first 10 months of 2022, Michigan attracted $8.5 billion of investment in battery manufacturing, including investments by GM, Chinese battery maker Gotion, Michigan-based EV battery startup Our Next Energy, and South Korean LG Energy Solution (Gardner 2022a). Michigan, along with Georgia, Kentucky, and Tennessee, is expected to see the largest growth in battery manufacturing capacity by 2030 based on plans currently in place (Gohlke et al. 2022).

Michigan has also been successful in attracting investments in microchip research and manufacturing, which are crucial components in EVs and whose importance to the growth of the EV industry was recently highlighted by the global chip shortage, which crimped auto production and sent vehicle prices soaring. Michigan is among the top states in semiconductor manufacturing along with Arizona, California, New York, Ohio, and Texas. Companies already operating in this space in Michigan include SK Siltron; Calumet Electronics; Hemlock Semiconductor; and KLA Corp., which opened its second US headquarters in Ann Arbor, Michigan, in 2021 (Gardner 2022b).

Federal legislation passed in 2021 and 2022, including the IIJA, IRA, and CHIPS Act, are further poised to accelerate the EV transition in Michigan and nationally.

See Appendix B, Table B-1, for a longer discussion of the impacts of these laws. The IRA, in particular, provides significant incentives for consumer adoption of EVs and promotes domestic manufacturing of EVs and battery supply chains. The IIJA includes significant funding for building a national network of EV charging stations, identified as a key impediment to the wider adoption of EVs, while the CHIPS Act is expected to boost semiconductor research, design, and development. Leveraging the funding and programs contained in these three federal laws could further enable Michigan to strengthen its economic competitiveness, grow its economy, and create good-paying jobs.

CHALLENGES FACING MICHIGAN

Despite the advantageous position that Michigan holds in growing its EV industry and ecosystem, the state cannot afford to become complacent. Michigan's existing assets and policies are not going to be sufficient to either support the growth and investment the state desires or produce just and equitable outcomes for workers, communities, and EV consumers. Michigan will need to contend with external challenges and address several internal weaknesses.

The external challenges relate to competition among US states to attract corporate investments. While states have been competing for decades, the scale of competition for landing EV assembly, battery manufacturing, semiconductor factories, and other mega projects has intensified in the last few years. Figure 1 shows EV-related private sector investments across the country, which have the potential to create thousands of jobs.

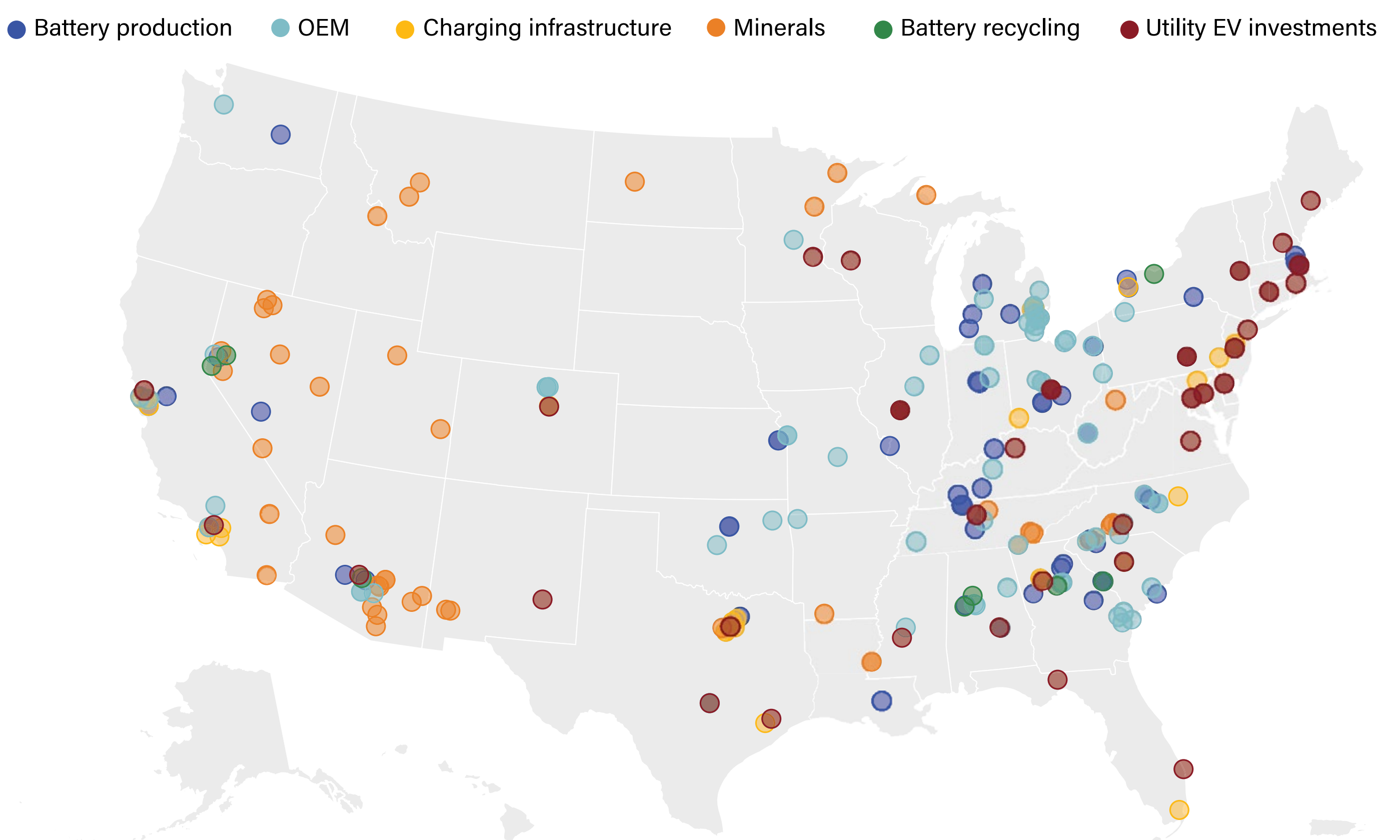
One way that states have been trying to attract companies is through economic development incentives and subsidies.[6] Between the start of 2021 and October 2022, at least $50 billion of investment to build EV assembly and battery facilities have been announced across 10 states that have given out at least $10.8 billion in subsidies (Coppola 2022b). States have defended their use of incentives to stay competitive against other states. However, concerns have been raised in academia and policy circles that these incentives are wasteful, encourage a race-to-the-bottom effect, and are not needed since most companies would make a similar location decision even without the incentive (Slattery and Zidar 2020; Bartik 2018).[7] When incentives are provided, they should be carefully targeted and designed to maximize benefits and reduce costs for states' economies (Bartik 2015).[8]

Irrespective of the merits or demerits of these incentives, Michigan is competing for EV-related investments with several other states, including Georgia, Illinois, Kentucky, Ohio, and Tennessee. Michigan is already well-positioned to grow its EV industry due to its history as a center of automobile R&D and manufacturing, and its ongoing efforts to tackle various challenges related to manufacturing, EV adoption, charging infrastructure deployment, and workforce and skills development (see Appendix A). The more Michigan can strengthen the building blocks of its EV ecosystem (i.e., innovation, workforce and talent, infrastructure, and institutions), the better placed it is likely to be.

The goal of this report is not to justify the benefits of the EV transition for Michigan at the expense of other states or to present state industrial policy as a war among states. If approached in the right way, the EV transition can be a race to the top rather than a race to the bottom, and in the context of a fast-growing EV industry, all states can benefit.

Beyond the external challenges, Michigan will also need to address three key internal challenges:

FIGURE 1 | EV-related investments across US states



Notes: Data are current as of January 24, 2023. OEM = original equipment manufacturer.

Source: Data provided by the Zero Emission Transportation Association to the authors.

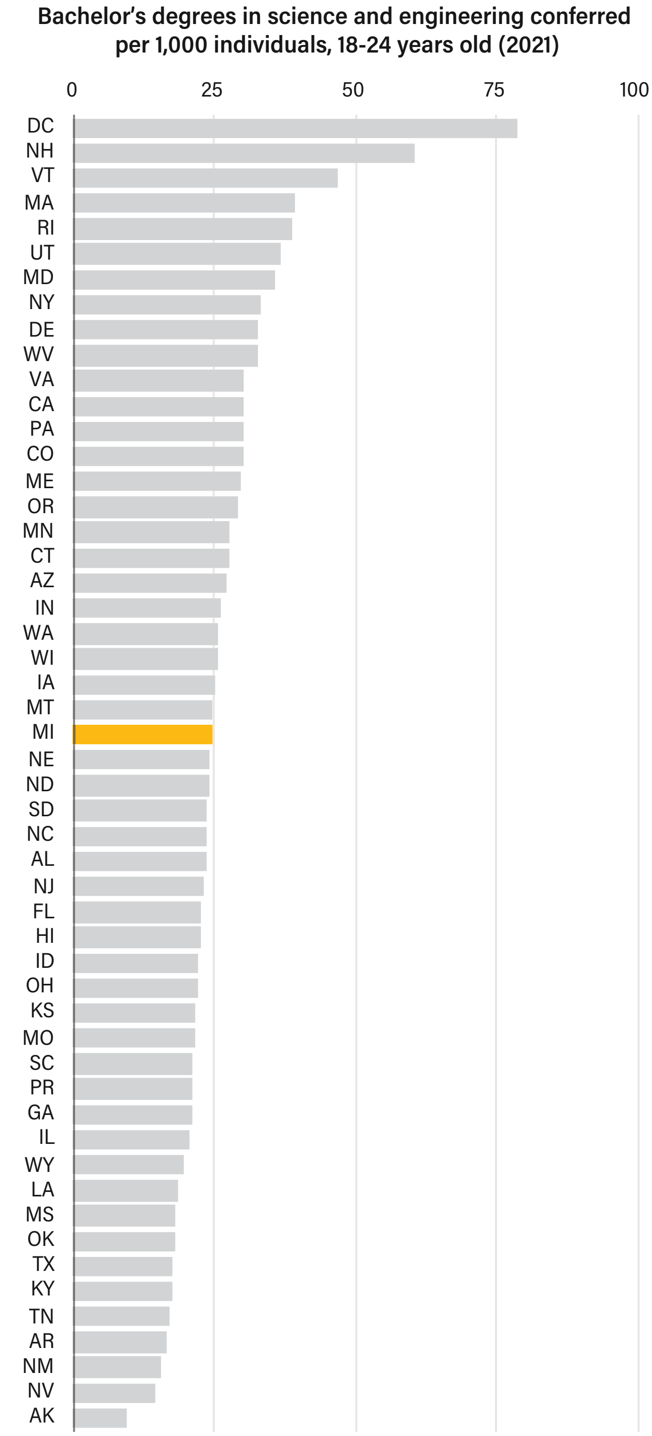
1. **Ensuring the state is attractive for new and expanding companies, including by scaling up the availability of trained technical workers to meet the needs of the growing EV industry**

Site selection by companies involves myriad factors including site and infrastructure availability, utility costs, regulatory environment, access to materials and suppliers, proximity to auto-related innovation and knowledge clusters, and, importantly, the availability of a skilled workforce.

The production of EVs is significantly different from that of ICE vehicles, and EVs will expand the automotive industry's focus from mostly hardware to also include software. GM, for instance, is planning to position itself as a technology platform company instead of defining itself as just an automaker as it makes the transition to EVs and connected vehicles (Glazer 2022; Klayman and Lienert 2021). This transition will force GM and other automakers to attract and retain highly technical engineers, designers, and other professionals who research, design, develop, and commercialize new technologies to meet the needs of an increasingly connected and electrified transportation future. As a result, there will be growing demand in EV and battery manufacturing for research scientists, software developers, engineers and engineering technicians, industrial designers, and other technical talent, many of these positions requiring at least a bachelor's degree.[9] Not only will Michigan's educational institutions, including its four-year institutions and community colleges, need to educate and train this highly technical workforce, but the state will also need to market itself as an attractive location where talent wants to move.

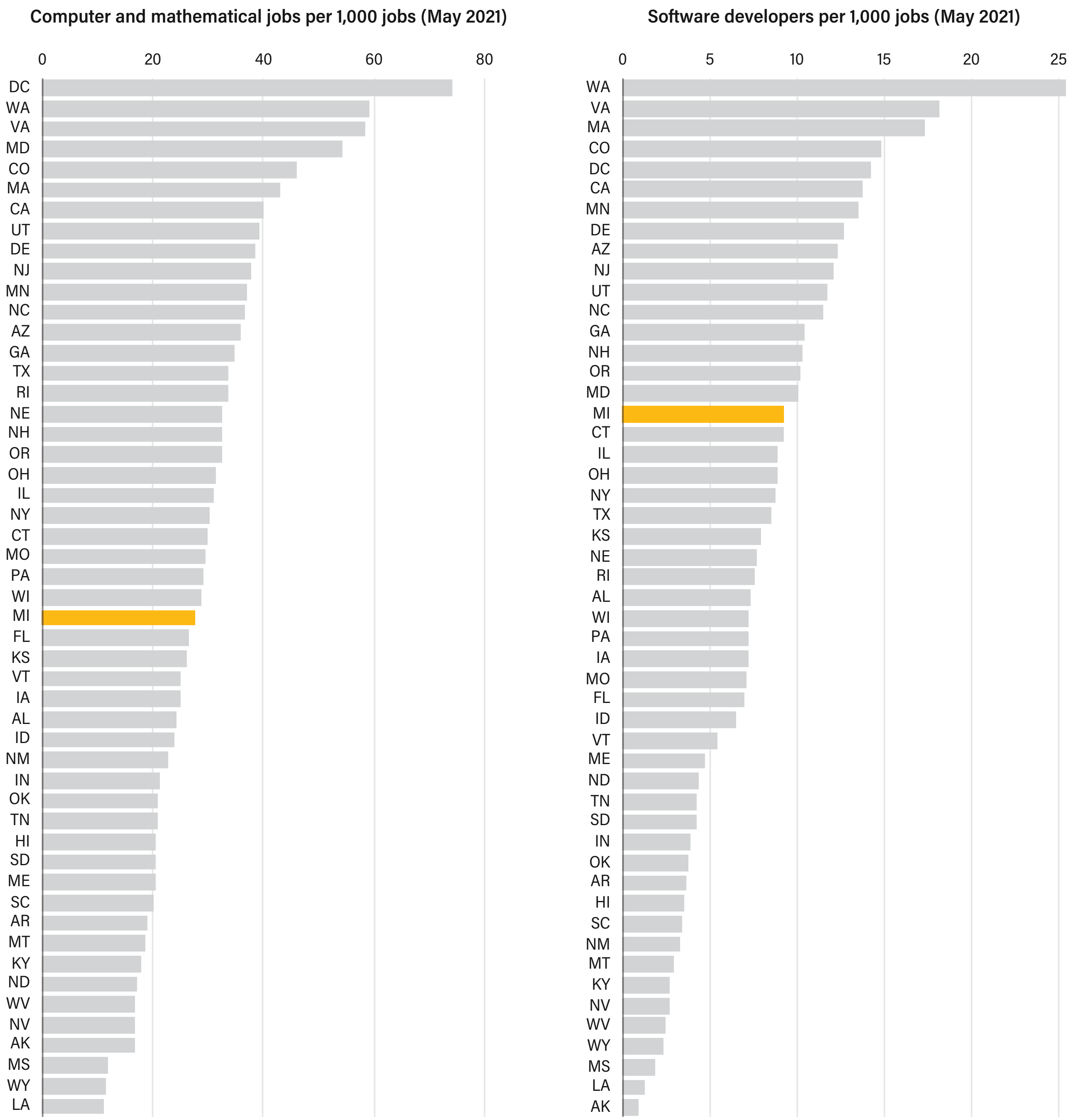
On both fronts, Michigan needs to do more. Despite being home to highly ranked colleges, Michigan is producing far fewer bachelor's degree graduates in science and engineering per thousand inhabitants compared with other states (Figure 2). Furthermore, even though Michigan is the leading state in engineering occupations, it lags other states in attracting software and computer professionals critical to the EV industry (Figure 3). Michigan also needs to evaluate which EV-related jobs do not require a college degree and put in place training and career development opportunities for non-college-educated job seekers. Currently, Michigan's automakers and parts manufacturers are struggling to hire and retain workers, with some analysis finding that there are now more vacant positions than qualified applicants (Keys and Paxson 2022).

FIGURE 2 | Degrees in science and engineering by state



Source: NSF n.d.

FIGURE 3 | Availability of technical talent for the growing EV industry, by state



Source: BLS 2021a.

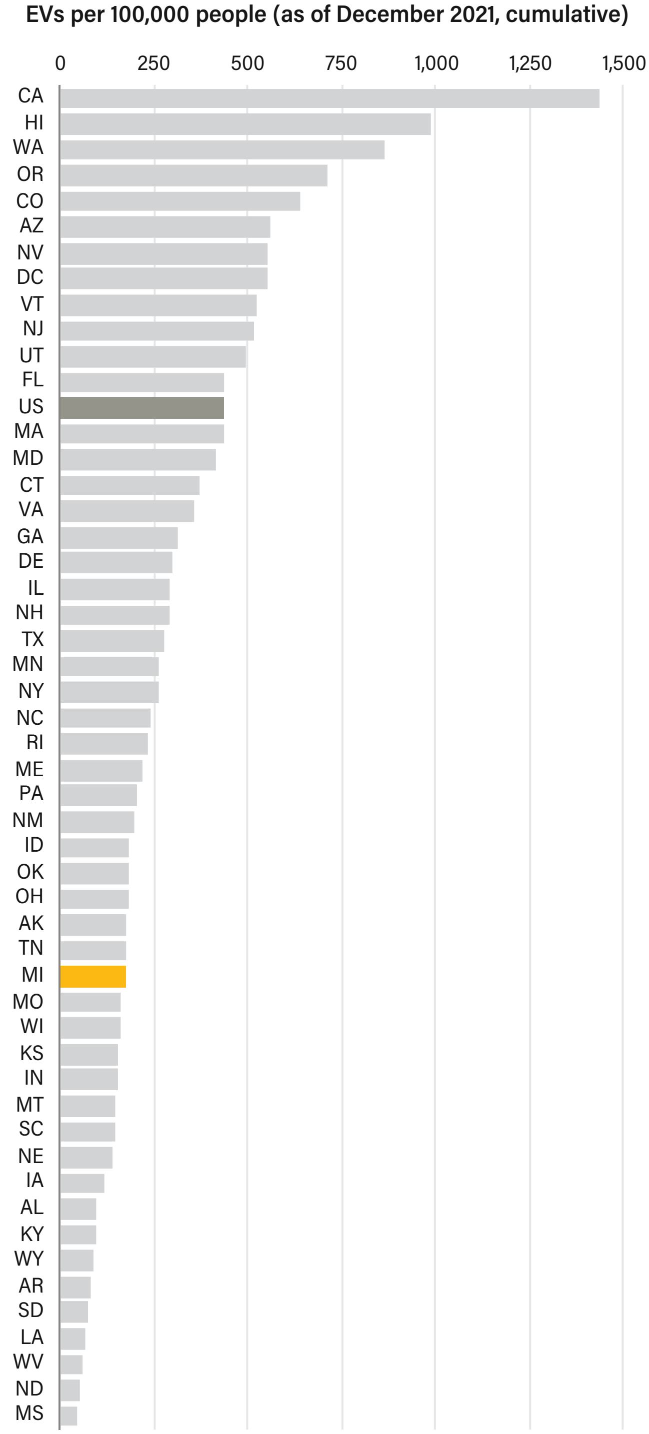
According to findings presented to the Michigan Economic Development Corporation by the Boston Consulting Group, other site selection challenges facing Michigan are the lack of big, ready sites for new automotive companies to locate EV assembly and battery manufacturing facilities, and high utility costs for power-intensive battery manufacturing facilities.[10]

2. **Accelerating the pace of EV adoption and building the required infrastructure**

Michigan's EV adoption currently lags that of other states (Figure 4), which can be largely explained by the absence of robust transportation electrification policies to boost EV deployment (Howard et al. 2021). In 2021, Michigan ranked 29th among 30 states assessed in terms of policies to scale up deployment of EVs and progress in building the necessary charging infrastructure (Howard et al. 2021). Michigan has relatively high electricity prices at 17.90 cents per kilowatt-hour (¢/kWh) for residential customers compared with a national average of 15.95 ¢/kWh (EIA 2022c). This makes it more expensive for consumers to use EVs and can potentially delay the transition. However, it is worth noting here that California, Hawaii, and states in New England all have higher residential electricity rates and higher EV adoption per capita than Michigan, indicating that policies and average incomes interact with relative prices of energy to influence EV adoption.

In addition to the emissions reduction and health benefits of switching to EVs, higher rates of EV adoption can bring economic benefits as consumers save money from the EV's reduced cost of ownership and thus can spend more on local goods and services, among other things. Despite the higher upfront price of an EV, new research finds that financing and owning an EV is cheaper on a monthly basis compared with financing and owning an equivalent ICE car (Orvis 2022).[11] The upfront prices of EVs are expected to soon become cheaper than ICE vehicles as well (ANL 2022). Still, current EV buyers are typically high-income and highly educated homeowners (Hardman et al. 2021). As Michigan works toward accelerating EV adoption, equitable access to auto financing and EV charging infrastructure will be critical for ensuring low-income households, including those in disadvantaged communities, benefit from transportation electrification.

FIGURE 4 | EV registration by state



Sources: Doll 2022; Census Bureau 2021.

Greater adoption of EVs will also trigger needed infrastructure deployment, which can create new careers in charging infrastructure manufacturing, installation, and maintenance and provide thousands of good jobs for trade workers, including electricians. Moreover, growth in EV adoption will impact Michigan's power sector by increasing annual electricity demand. It will be necessary to increase overall generation capacity, which can be achieved cost-effectively by adding renewables into the grid, as well as invest in grid modernization to accommodate varying types of charging, times of day when charging is used, and geographic distribution of the charging load (Gagnon 2022). All these investments can significantly boost job creation in the power sector.

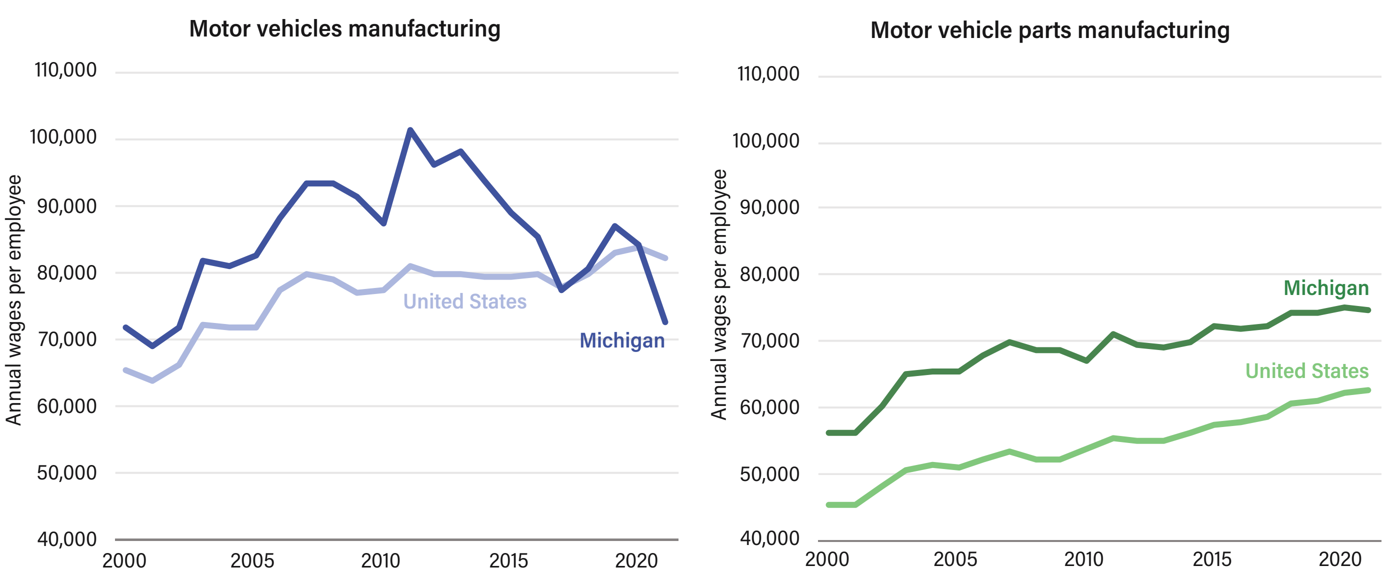
Finally, as Michigan vies with southern states such as Alabama, Georgia, Kentucky, and Tennessee to attract EV-related investments, it can differentiate itself from those states by leaning in on EV adoption. None of these other states are adopting robust policies to spur EV adoption; rather, they are responding to the demand created in other states.

3. **Navigating the EV transition in a way that creates quality jobs and produces equitable outcomes for its longtime autoworkers and communities**

Working in the auto industry was once a ticket into the middle class, and the sector has a particularly high representation of Black workers and those without four-year college degrees. However, US auto workers have witnessed an erosion in wages and working conditions in recent decades. Adjusted for inflation, average hourly wages for production and non-supervisory workers in motor vehicles and parts manufacturing decreased by 17 percent between 1990 and 2018, compared with an 18 percent increase over the same period in the total private sector (BLS 2020). Annual wages for Michigan's auto manufacturing workers have declined in recent years and were significantly below the national average in 2021 (Figure 5). Workers in Michigan's auto parts manufacturing, however, earn much more than the national average.

Higher levels of unionization have been found to lead to better wages and working conditions for workers (Banerjee et al. 2021). However, auto companies have resisted unionization for decades and several have located their manufacturing plants in the southern United States, where every state is a right-to-work state, making it harder for workers to form

FIGURE 5 | Wages in Michigan's auto sector



Source: BLS 2021b.

unions and collectively bargain for better pay and working conditions (Ferris 2021; Nassar 2022). Michigan was also a right-to-work state up until April 2023, with union membership falling from 16.6 percent in 2012 when Michigan adopted right-to-work to 14 percent in 2022 (BLS 2023). Many jobs created in the past decade have been non-union and temporary jobs, with lower wages and benefits and fewer job protections (NELP 2022; Walter et al. 2020; Burton et al. 2022; Wayland 2022). The transition to EVs has made battery manufacturing a critical part of the automotive manufacturing process, but wages in the sector can lag those in traditional automotive assembly by almost a third (Coppola 2022a).

The United Auto Workers' unionization of a GM battery plant in Ohio signals a potential shift. However, concerns remain that the downward trajectory in job quality in the auto industry will continue unless there is a just transition from ICE vehicles to EVs that also prevents disproportionately impacting historically disadvantaged communities and people most likely to be harmed by the transition, including Black workers and those with less education.

Overall, the shift to a clean energy economy, including electric vehicles, is also occurring against the backdrop of long-standing environmental and economic inequities that have disproportionately harmed certain communities, including Black, Indigenous, and other people of color, as well as low-income individuals. Michigan will need to ensure that inequities built into the current system are not carried over into the future and communities hosting EV-related facilities benefit positively from the economic, social, environmental, and health impacts of those projects while communities facing closure of legacy auto facilities are provided adequate support to navigate the transition.

The policy recommendations outlined in "Recommendations for Michigan policymakers: Seizing opportunities, addressing challenges" are geared toward addressing the above key challenges.


CHAPTER 2

Approach: Understanding EV just transition needs

In this section, we first explain conceptually how the transition from ICE vehicles to EVs is expected to impact employment. We next present results from existing literature on the employment impacts of the EV transition in other contexts. Finally, we describe our quantitative methods for estimating the employment impacts of the EV transition in Michigan and our qualitative methods for developing recommendations for state policymakers.

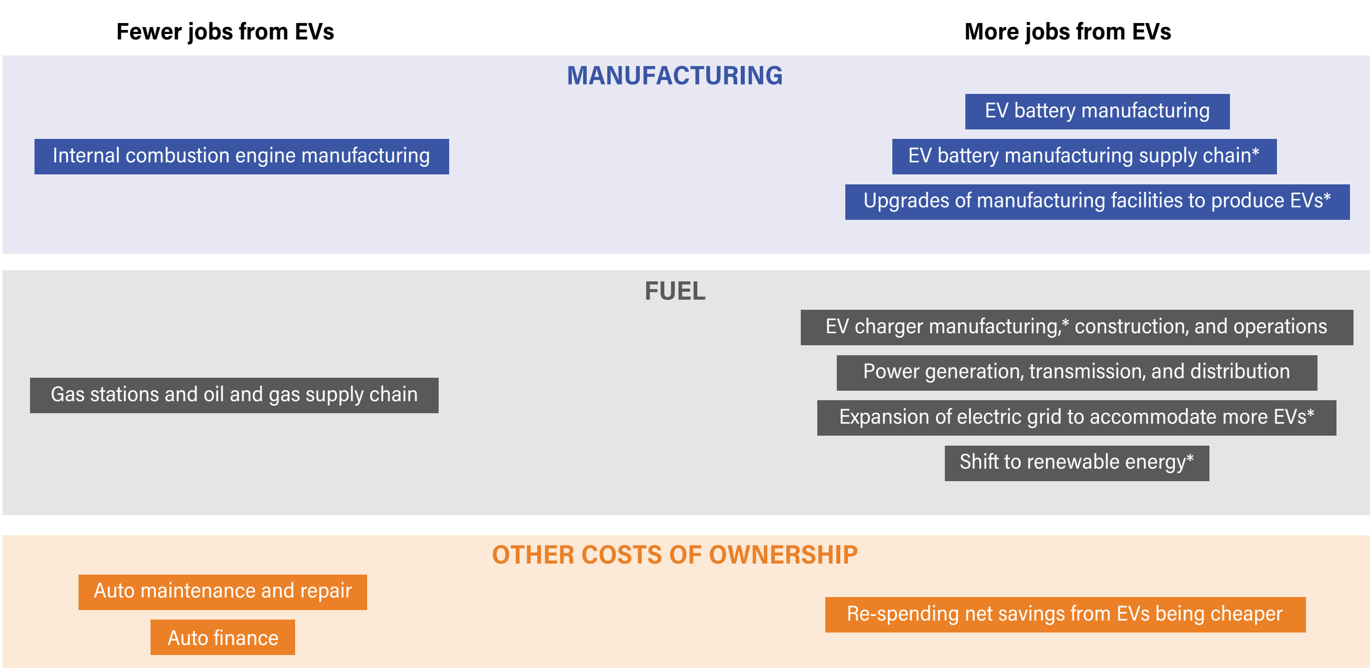
CONCEPTUAL UNDERSTANDING OF WHERE AND HOW JOBS WILL BE IMPACTED

An important consideration for the transition to EVs is where jobs may be created, where jobs may be eliminated, and what will be the likely net jobs impact across the entire automotive value chain. Figure 6 explains various dynamics affecting the automotive value chain as part of the shift to EVs, highlighting which areas could be job creators and which could experience job losses.

EV powertrains are mechanically simpler and have fewer moving parts than ICE vehicles, which is expected to reduce the amount of labor needed for vehicle assembly and parts production (UAW 2019).[12] Ford and Volkswagen have both estimated that EV manufacturing will require 30 percent less labor per unit than ICE vehicle manufacturing, raising concerns that auto manufacturing jobs associated with the internal combustion engine will be lost (Hackett 2017; Fraunhofer IAO 2020).

At the same time, there will be new job opportunities in other parts of auto manufacturing such as battery manufacturing. The battery value chain, which includes everything from sourcing the raw materials to producing battery cells, assembling them into packs, installing them in EVs, and recycling them, can be a great catalyst for jobs. To produce EVs and batteries, new facilities will need to be built or upgrades will need to be made to existing facilities, which will create construction jobs as well. The United States currently lags its global competitors, including China and the European Union, on battery production (Figure 7), though

FIGURE 6 | Expected changes in jobs due to the EV transition



Notes: * = Not included in our modeling. EV = electric vehicle.

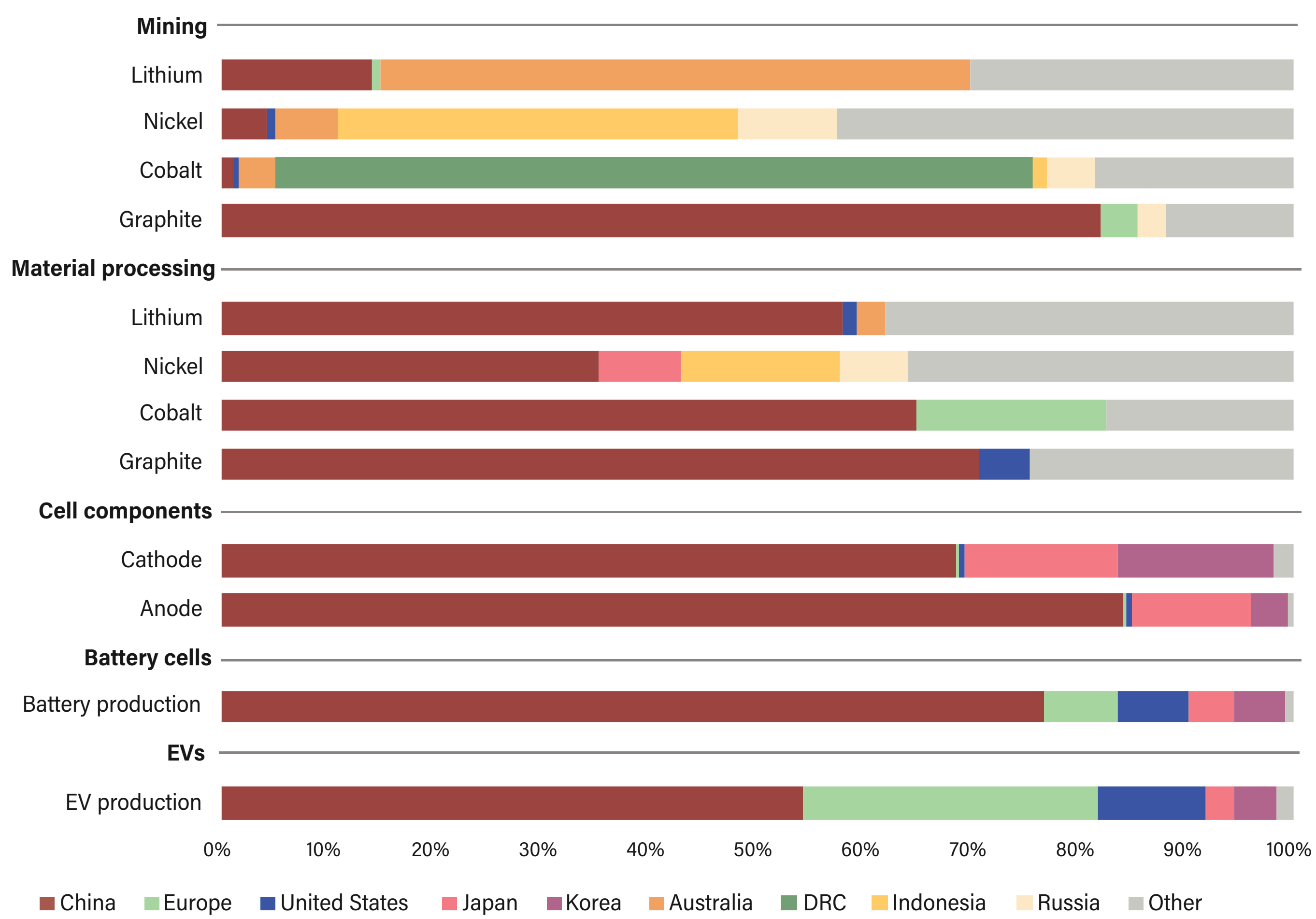
Source: Authors.

incentives for nearly every stage of battery production in the IRA are expected to boost US manufacturing of EV batteries in the coming years (see Appendix B). It is also important to note that manufacturing for all types of vehicles, whether electric or gasoline-powered, will likely see fewer jobs per vehicle in the future due to economy-wide trends in automation and increased labor productivity.

Even for the automotive jobs that do not shift to new sectors, the skills needed by workers may change. For example, EVs are expected to create increased demand for workers with skills and training in software as opposed to hardware.

The way vehicles are fueled will also change employment patterns. As EV adoption rates grow, new EV charging infrastructure will need to be manufactured, installed, and maintained, which will create jobs, including for electricians and other construction workers. The rise in electricity demand from EVs will increase jobs in power generation, transmission, and distribution. The electric grid as a whole will need to expand significantly to accommodate increased EVs on the road, creating jobs in construction and power infrastructure. If this is accompanied by a shift to renewable energy, it would create additional jobs in that sector (Jaeger et al. 2021). On the other hand, given that EVs no

FIGURE 7 | Geographic distribution of EV battery supply chain



Notes: Mining is based on production data. Material processing is based on refining production capacity data. Cell component production is based on cathode and anode material production capacity data. Battery cell production is based on battery cell production capacity data. EV production is based on EV production data. Although Indonesia produces around 40 percent of total nickel, little of this is currently used in the EV battery supply chain. The largest Class 1 battery-grade nickel producers are Russia, Canada, and Australia. EV = electric vehicle; DRC = Democratic Republic of the Congo.

Source: IEA 2022.

longer require gasoline and much of the EV charging will take place in homes rather than in public, there will be a shift in employment away from gas stations and the oil and gas sector.

There will also be broader effects on other economic activities. EVs are expected to require less maintenance and repair than ICE vehicles (ANL 2022). This is a strong positive for consumer savings and convenience but will lead to job losses diffused across the state. Maintenance and repair needs depend on the number of cars on the road, not the number of sales, so any effects from the transition to EVs will take longer to appear. Finally, given that EVs are expected to be cheaper to own and operate than ICE vehicles in the near future (ANL 2022), consumers will save money. When they re-spend those savings, it boosts jobs throughout the entire economy.

No matter the exact change in the number of net jobs, the transition will be uneven. Since jobs in the emerging EV sector will not necessarily be in the same locations as current ICE vehicle jobs, and do not always require the same skillset, a managed transition, one that prioritizes addressing the challenges as well as seizing the opportunities posed by the transition, will determine the extent to which Michigan continues to lead the nation in the auto industry.

EXISTING LITERATURE ON THE JOBS IMPACTS FROM THE EV TRANSITION

A few studies have begun exploring the extent of jobs impacts from the EV transition, yet there is still a lot of uncertainty about the topic. A national analysis from the Economic Policy Institute, which focused narrowly on employment impacts on auto assembly and auto parts, found that nearly 75,000 jobs could be lost by 2030 in a scenario where battery electric vehicles (BEVs) constitute 50 percent of US auto sales (Barrett and Bivens 2021). The analysis further modeled that this effect could be reversed with the adoption of policies incentivizing the domestic manufacturing of batteries and drivetrains powering EVs, as well as increasing the market share of US-made vehicles. Instead of losing jobs, the auto industry could then gain an additional 150,000 jobs by 2030.[13] This analysis highlights the importance of policies to manage the economic impacts of the EV transition, including both the number and quality of jobs.

A second study from the Goldman School of Public Policy at the University of California, Berkeley, has taken a more expansive look at employment impacts arising from the EV transition, including other parts of the economy, such as the electricity sector (Baldwin et al. 2021). It examined a national scenario in which EVs reach 100 percent of new LDV sales by 2030 and 100 percent of new medium- and heavy-duty vehicle sales by 2035, while the grid reaches 90 percent clean electricity by 2035 as substantial EV charging infrastructure is deployed. The study used the Energy Policy Simulator, which includes an embedded input-output model, to estimate jobs effects. It found that there would be 483,000 direct job losses in the US auto sector compared with a Current Policy scenario (based on 2020 policies),[14] but they would be more than made up for by 790,000 direct job gains in the electricity and fuel sectors. When including direct, indirect, and induced jobs across the economy, the net effect would be a gain of 2 million jobs nationally by 2035 compared with the current policy scenario. The employment gains are mostly in induced job creation (1.4 million), including from $1 trillion in consumer savings from EV ownership.

Boston Consulting Group has noted that, despite the elimination of engine manufacturing associated with ICE vehicles, total labor hours required for EV and ICE vehicle manufacturing are close to identical when jobs impacts associated with battery manufacturing are considered (Küper et al. 2020).

The jobs impacts from the EV transition tend to vary depending on the modeling assumptions of each study and which segments of the automotive value chain are included in the analysis. However, a key message that emerges from all studies is that the adoption of the right policy tools can lead to net positive job outcomes across the entire automotive value chain. There will likely be localized job losses in some segments of the automotive industry (for instance, manufacturing of internal combustion engines) and within specific regions of the country due to a geographic mismatch between where jobs are lost and where they are created. All this will require careful consideration of just transition policies to address the impacts on workers arising from the EV transition as well as policies to spur job creation in the growing EV industry.

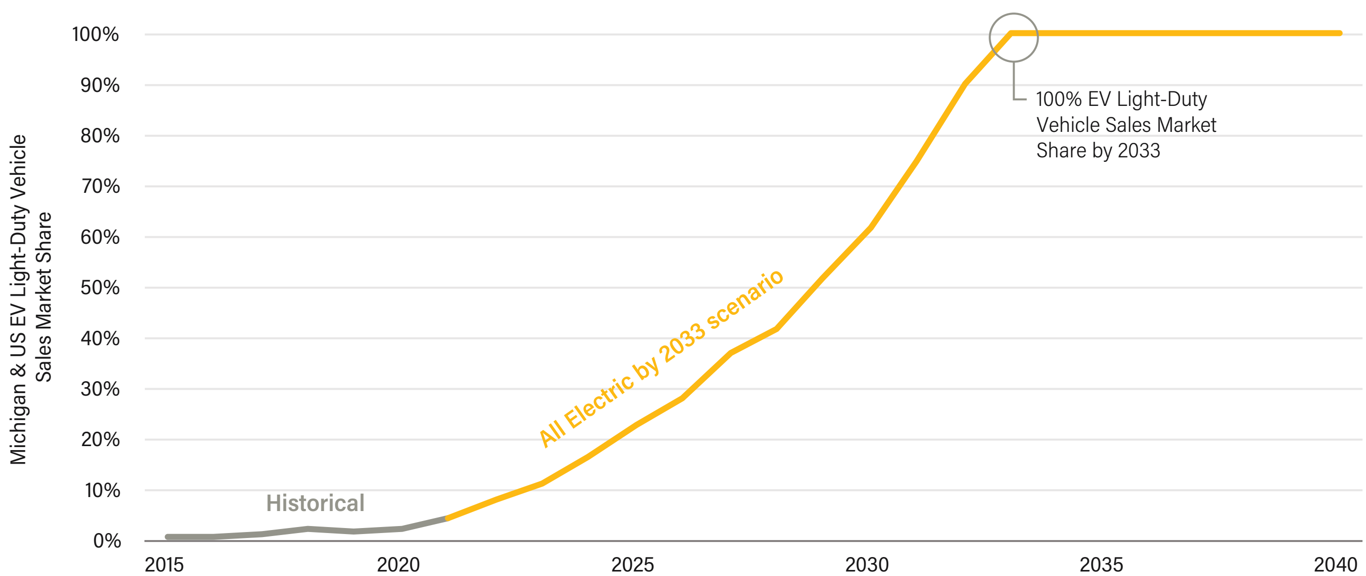
QUANTITATIVE METHODS: MODELING SCENARIOS AND ASSUMPTIONS

We examined the employment effects in Michigan of the transition to EVs for LDVs (cars, SUVs, and light-duty trucks) from 2024 to 2040 using the DEEPER Modeling System, a macroeconomic input-output model estimating employment impacts. The analysis focused on battery electric vehicles, which are expected to be the dominant type of EV (BNEF 2022a). (Throughout our results, the term "electric vehicle" refers to battery electric vehicles.) Due to modeling limitations, we examined the effects of only vehicles purchased in Michigan or manufactured in Michigan and sold in the United States, not international exports. In 2021, Michigan produced vehicles and parts worth about $40 billion, and in 2020 it exported $16 billion of the same (BEA 2023). Though this is a significant portion of the state's production, the fact that it exports mostly to Canada—which has set a goal to electrify all passenger vehicle sales by 2035—implies that Michigan's opportunities in EV manufacturing may be greater than those described below. We provide an overview of our modeling methodology in this section, and the full details are in Appendix C.

Our main analysis focused on an All Electric by 2033 scenario in which EVs reach 62 percent of LDV sales by 2030 and 100 percent of LDV sales by 2033 (Figure 8). This reflects a US EV adoption rate consistent with net-zero emissions by 2050 and is consistent with the MI Healthy Climate Plan's goal of building out charging infrastructure to support 2 million EVs on the road by 2030.[15] For this analysis, we focused on the effects of the EV transition separate from other auto sector trends that will affect both EVs and ICE vehicles—for example, labor productivity gains due to increasing automation and digitalization. For that reason, we created a No Transition reference scenario assuming EV sales and production do not grow beyond what they were in 2019. The employment impacts for our All Electric by 2033 scenario are presented in comparison to this No Transition scenario, thereby isolating the effects of the EV transition. While the No Transition scenario is not realistic given that the EV revolution is already under way nationally and in Michigan, using a counterfactual scenario makes it possible to understand the full scope of the transition needed compared with the old way of producing and using vehicles.[16]

In addition to considering the growth in EV sales, our analysis assessed what the effect on employment would be if Michigan increases or decreases its competitiveness in domestic auto production and EV battery manufacturing (Table 1). The High Competitiveness case assumes that Michigan manufacturers increase their share of US vehicle and battery production from what it is today. Achieving increases in market share will require Michigan's government and companies to successfully take advantage of new opportunities in the emerging EV industry, which will require the consideration of additional policies beyond what Michigan is currently implementing. To measure what is at stake for the state, we also included a Low Competitiveness case in which Michigan loses ground to other states in its share of domestic vehicle production and EV battery manufacturing.

FIGURE 8 | All Electric by 2033 scenario with electric vehicle uptake consistent with economy-wide net-zero emissions by 2050



Note: EV = electric vehicle.

Source: Authors, based on BNEF 2022a and own calculations.

TABLE 1 | High versus Low Competitiveness in vehicle production and EV battery manufacturing

	NO TRANSITION SCENARIO	ALL ELECTRIC BY 2033 SCENARIO, HIGH COMPETITIVENESS CASE	ALL ELECTRIC BY 2033 SCENARIO, LOW COMPETITIVENESS CASE
EV sales	No growth in EVs after 2019	EVs reach 62% of light-duty vehicle sales in 2030, 100% by 2033	
Michigan's share of US vehicle production	Remains at 20%	Rises to 25% by 2030 and stays at that level through 2040	Falls to 15% in 2030 and stays at that level through 2040
Michigan's share of US EV battery production	Remains at 10%	Rises to 15% by 2030 and stays at that level through 2040	Falls to 5% by 2030 and stays at that level through 2040

Note: See Appendix C for full explanation and sources.

Source: Authors.

For each EV adoption scenario and competitiveness case, we developed realistic assumptions around the amount of expenditure needed for relevant sectors of Michigan's economy. These sectors include auto and battery manufacturing, EV charging infrastructure construction and operations, and sectors associated with the total cost of ownership (TCO) during an EV's lifetime, including finance, electricity and fuel purchases, insurance and fees, and maintenance and repair. Using DEEPER, we translated the shifts in spending for each scenario and sensitivity into employment impacts on Michigan's economy. Within DEEPER, the investments were assigned to various sectors, including automotive manufacturing, electric utility services, construction of power and communication structures, government, retail gasoline, finance, and auto repair and maintenance. Each sector has a job multiplier, which is the number of direct, indirect, and induced jobs created per million dollars spent in the sector (Box 1). Due to data limitations, the job multipliers used to model a particular type of investment do not always match the sectors of the auto industry that we modeled. We chose sectors that formed the closest approximation (Figure 9). The job multipliers we used are based on the 2019 economy, with the assumption that they will gradually go down over time as labor productivity goes up, in line with historic trends for each sector. However, some of these industries, especially the new ones like battery manufacturing, could potentially change in faster or different ways than we expect.

We estimated future vehicle costs using Argonne National Laboratory's (ANL's) benefit analysis (BEAN) tool, with EV range assumed at 300 miles from 2024 to 2030, rising to 400 miles by 2040.[17] These estimates show EVs quickly falling in price and undercutting ICE vehicle prices within a few years, a trajectory that seems to be in line with recent developments and announcements from automakers (Ewing 2023). We used electricity and fuel cost projections from the US Energy Information Administration (EIA) and made adjustments to reflect that Michigan's electricity prices are higher than those in the rest of the country and that its gasoline prices are lower.

Finally, our modeling assumes that the IRA's EV tax credits successfully onshore production of vehicles and batteries. The consumer EV tax credits are contingent on certain types of production being done domestically and the EV battery production tax credits also provide a strong cost incentive for

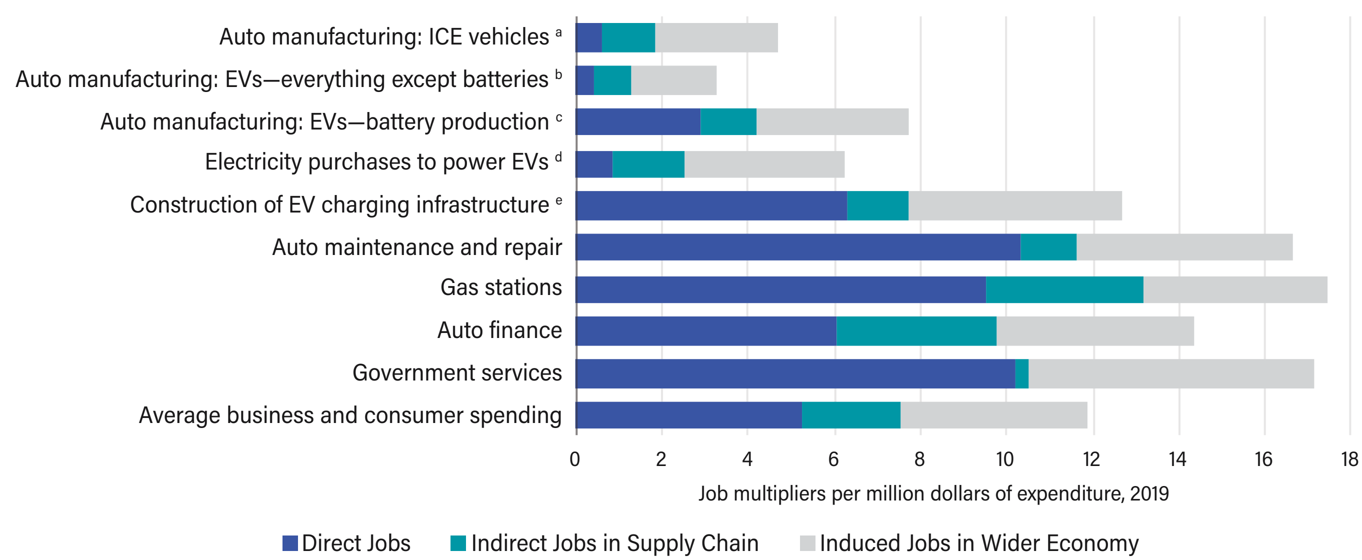
BOX 1 | Key terms for interpreting employment results

Direct jobs: Jobs at companies within a given sector—for example, a vehicle assembler at Ford.

Indirect jobs: Jobs that provide inputs into the sector—for example, a position at a firm where Ford purchases tires.

Induced jobs: Jobs supported due to the spending of earnings from direct and indirect workers—for example, a manager at a restaurant the Ford employee goes to.

FIGURE 9 | Michigan's job multipliers for key sectors



Notes: ICE = internal combustion engine; EV = electric vehicle; a. Our job multipliers for ICE vehicle auto manufacturing are based on the light-duty auto manufacturing industry as of 2019, which likely includes a negligible number of EVs; b. The job multipliers for EV auto manufacturing including everything except batteries were adjusted downward by 30 percent from those for ICE vehicle auto manufacturing because EVs have fewer parts; c. EV battery production was modeled using multipliers for the production of battery storage; d. Electricity purchases to power EVs were modeled using job multipliers for power generation, transmission, and distribution; e. Construction of EV charging infrastructure was modeled using job multipliers for the construction of power and communication structures.

Source: Authors.

battery production to be located in the United States. The EV value chain is complex and changing quickly, and the exact ways in which the domestic content provisions of the IRA will be administered and enforced are yet to be determined, but we wanted to incorporate them to their fullest extent to gauge the impact.

Key assumptions affecting the modeling are listed below, and full details and sources can be found in Appendix C:

Key domestic content assumptions

- One hundred percent of final EV assembly takes place in North America by 2028, with a 68 percent share by the United States. Meanwhile, the share of ICE vehicle sales assembled domestically remains at 52 percent.
- One hundred percent of EV battery production takes place in North America by 2029, with an 85 percent share by the United States.
- These domestic content requirements continue to be met after 2032 even after the IRA expires.

Key auto manufacturing assumptions

- EVs require 30 percent less labor to assemble per unit than ICE vehicles, not accounting for labor requirements for battery production.
- The temporary increase in EV battery costs due to supply chain constraints in the early 2020s is resolved and costs continue to decline following the historical pattern, which is an approximate 18 percent decrease for every doubling of batteries produced.
- EV retail prices become about 5 percent less expensive than those for ICE vehicles for compact and midsize cars in 2025. They become less expensive for all LDV segments in 2030 and beyond.

Key total cost of ownership assumptions

- Average annual vehicle miles traveled start at 14,000 and decline over the lifetime of the vehicle at a rate of about 3 percent per year.
- The average vehicle lifetime is 12 years for both EVs and ICE vehicles.
- EVs require about 41 percent less maintenance and repair costs than ICE vehicles.
- Consumers re-spend 100 percent of the savings that they realize from buying and owning an EV.

Key EV charging infrastructure assumptions

- Installation and maintenance costs of the public and at-home charging equipment are commensurate with what is needed to meet each scenario's rate of EV penetration.
- The average lifetime of non-home charging equipment is 10 years.

Due to modeling and time limitations, our analysis did not include several economic activities that would impact the number of jobs, including vehicle/battery recycling; the battery materials supply chain; upgrades of manufacturing facilities to allow them to produce EVs; manufacturing of charging and fueling equipment; shifts in earnings associated with the prevailing wage requirements of the IRA; the spending changes associated with the IRA's consumer EV tax credits; or the cleaning, upgrade, and expansion of the electric grid.[18] For some of these, we conducted a back-of-the-envelope analysis to determine the potential magnitude of the changes. Most of the elements left out of the model point toward more jobs in Michigan, so the net jobs effect of the EV transition will likely be more positive than what is presented in our results.

Our modeling also did not assess the employment and just transition effects on other US states. Modeling a High Competitiveness case where Michigan increases its share of automotive manufacturing, including battery manufacturing, implies a "zero-sum" framework in which other states lose market share in these sectors. However, battery manufacturing in North America is nascent and on track to grow tenfold by 2030 due to IRA provisions, according to some estimates (Picon 2022). Vehicle assembly requirements are also expected to re-shore jobs in auto manufacturing (Ma 2022). Even if Michigan expands its share of these markets, other states are likely to experience simultaneous growth in these sectors. Given this context, our modeling does not speak to whether the net employment effects of the transition on other states are positive or negative. It does imply that other auto-producing states, like Michigan, will undergo economic realignments that will require worker retraining, transition support, and investments in communities impacted

by the closure of legacy auto facilities to foster new industries. It is challenging to model the full impact of a shift to EVs given that the industry is evolving rapidly.

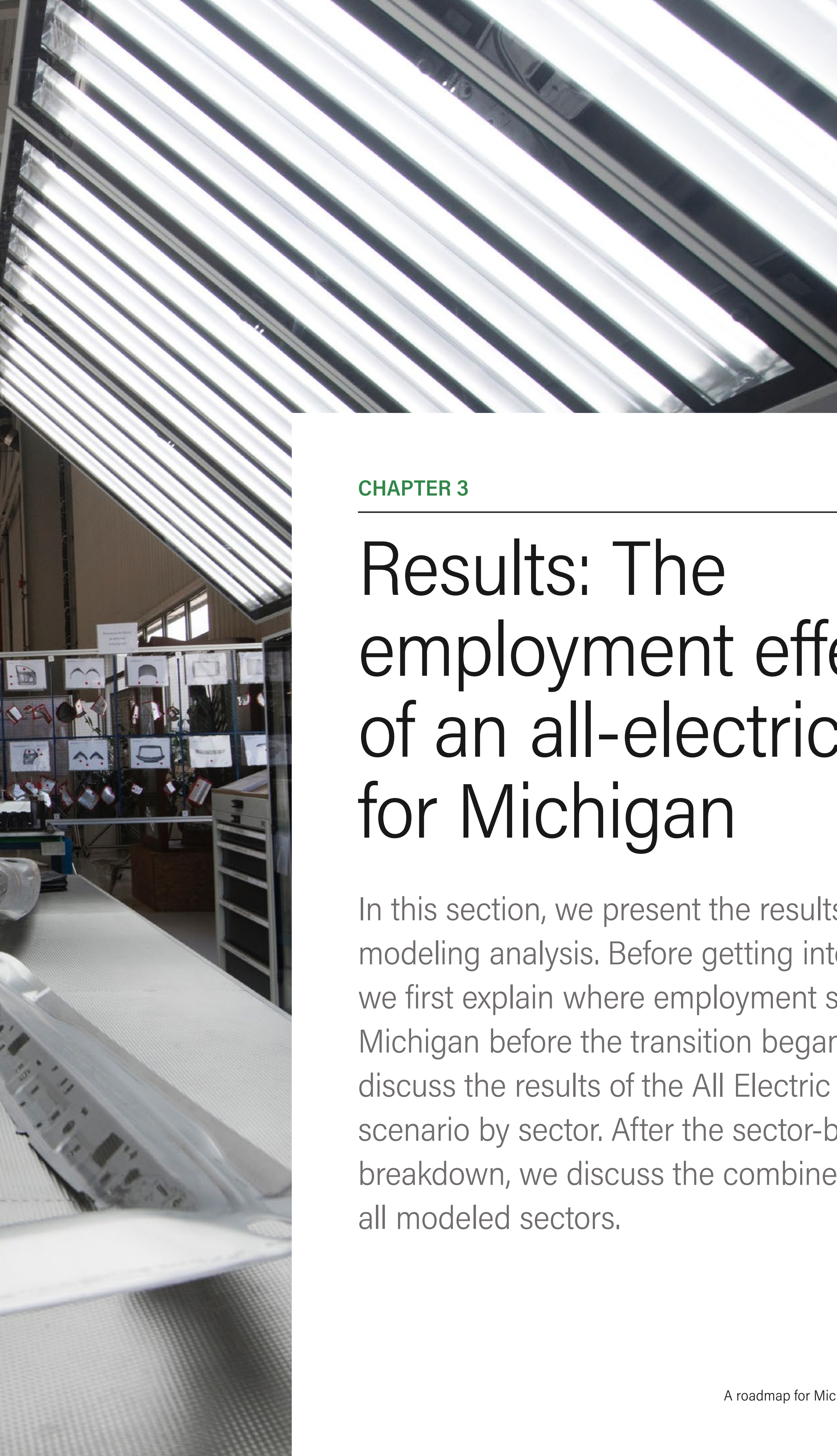
Our analysis is not a forecast. Instead, our results are intended to provide useful indicative insights into what the employment impacts of the transition could be under certain conditions. They can inform both businesses and policymakers about smart programs and policies that will likely strengthen the state's economic well-being and future employment opportunities as well as reduce the economic burden of greenhouse gas emissions and air pollution.

QUALITATIVE METHODS: STAKEHOLDER CONSULTATIONS

To complement our quantitative modeling, we engaged with stakeholders in over 40 organizations across state government, academia, the private sector, labor organizations, nonprofit organizations, and community groups. These conversations were conducted both one-on-one and in group settings, with follow up over email. Participants provided Michigan-specific context for our research, gave feedback on the modeling assumptions and results, and informed our policy recommendations.

To support our focus on an equitable transition, we established a civil society advisory council consisting of representatives from labor organizations and Michigan-based environmental justice and environmental organizations (see "Acknowledgments"). The group convened to review modeling results, provide feedback on proposed policy recommendations, and identify areas where follow-up consultations or additional local expertise was needed.

We also carried out a literature review to understand the context of Michigan's auto sector and the transition to EVs, as well as to review economic modeling and policy recommendations from state- and national-level studies. The policy recommendations in this report are therefore the result of a review of best practices backed by academic literature, a survey of Michigan's ongoing initiatives in this area, and targeted consultations with stakeholders impacted by and involved in the ongoing transformation of the automotive sector.



CHAPTER 3

Results: The employment effects of an all-electric future for Michigan

In this section, we present the results of our modeling analysis. Before getting into the results, we first explain where employment stood in Michigan before the transition began. Then, we discuss the results of the All Electric by 2033 scenario by sector. After the sector-by-sector breakdown, we discuss the combined results for all modeled sectors.

We did additional analysis beyond our modeling, so we then provide employment insights on sectors not included in the model. Finally, we provide overall takeaways from the results. Appendix D, Tables D-1–D-10, presents full employment results for the All Electric by 2033 scenario, as well as a Current Policy scenario, which we briefly discuss in Box 3.

OVERVIEW OF MICHIGAN'S CURRENT AUTO-RELATED JOBS

Michigan is home to a variety of jobs in the auto industry and related economic sectors. Figure 10 breaks down employment by category in 2019. Note that this report's modeling analysis focuses only on employment for light-duty vehicles, while the data in Figure 10 include light-, medium-, and heavy-duty vehicles. However, the figure gives an indicative sense of the level of employment and the types of professions in various sectors.

Motor vehicle and parts manufacturing was by far the largest employer, comprising around 174,000 jobs in 2019. Of these, around 37,000 jobs were in vehicle assembly; 9,000 were in body and trailer manufacturing; and 129,000 were in parts manufacturing, including transmissions, engines, steering, brakes, and electrical components (IMPLAN 2021). Parts manufacturing is reflected in indirect jobs effects in this report's modeling analysis.

After manufacturing, motor vehicle repair and maintenance was the second-highest category, with around 64,000 jobs. Motor vehicle and parts dealers (around 30,000 jobs), motor vehicle and parts wholesalers (around 23,000), and gas stations (around 22,000) were also significant employers. There are no data on the number of jobs in EV battery manufacturing in 2019, though we know there was a limited amount of employment in storage battery manufacturing. Data are unavailable on the number of workers in vehicle research and development, but for context Michigan has around 80,000 workers in all scientific research and development services, not just vehicles (IMPLAN 2021).

RESULTS BY SEGMENT OF THE AUTOMOTIVE VALUE CHAIN FOR THE ALL ELECTRIC BY 2033 SCENARIO

In this section, we go sector by sector to present the employment results of our modeling analysis of the All Electric by 2033 scenario, focused on light-duty EVs. We first cover the auto manufacturing results, which depend on whether Michigan achieves the High or Low Competitiveness case. Then, we discuss the segments of the automotive value chain that depend on the number of EVs on the road in Michigan—for example, EV charging infrastructure and auto maintenance and repair—and which, therefore, do not change depending on the level of manufacturing competitiveness.

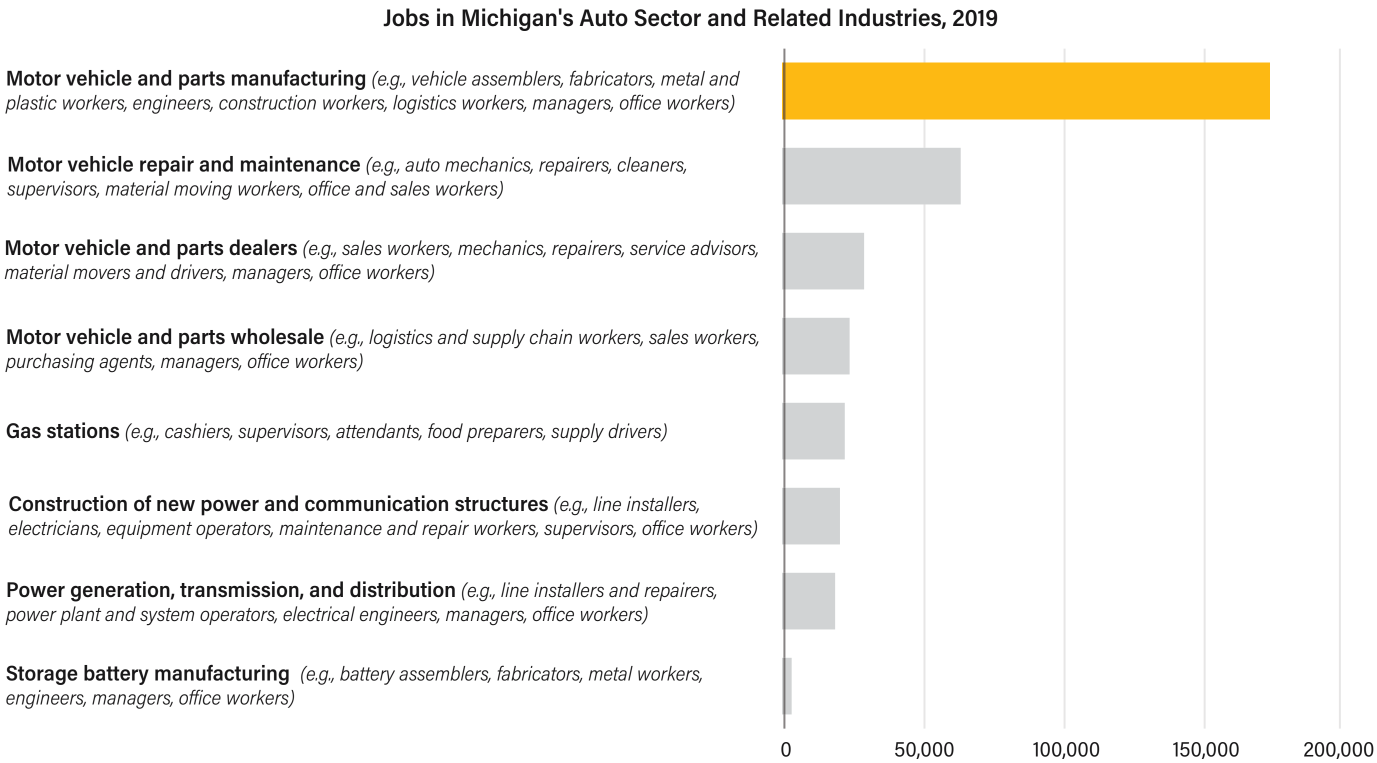
All results are presented in comparison to a reference No Transition scenario in which a transition to EVs does not occur and Michigan's share of battery and automotive manufacturing remains at present day levels. The results include direct, indirect, and induced jobs. Direct jobs are positions employed within a specified sector, indirect jobs are those associated with the supply chain of that sector, and induced jobs are created when direct and indirect workers spend their earnings in the wider economy.

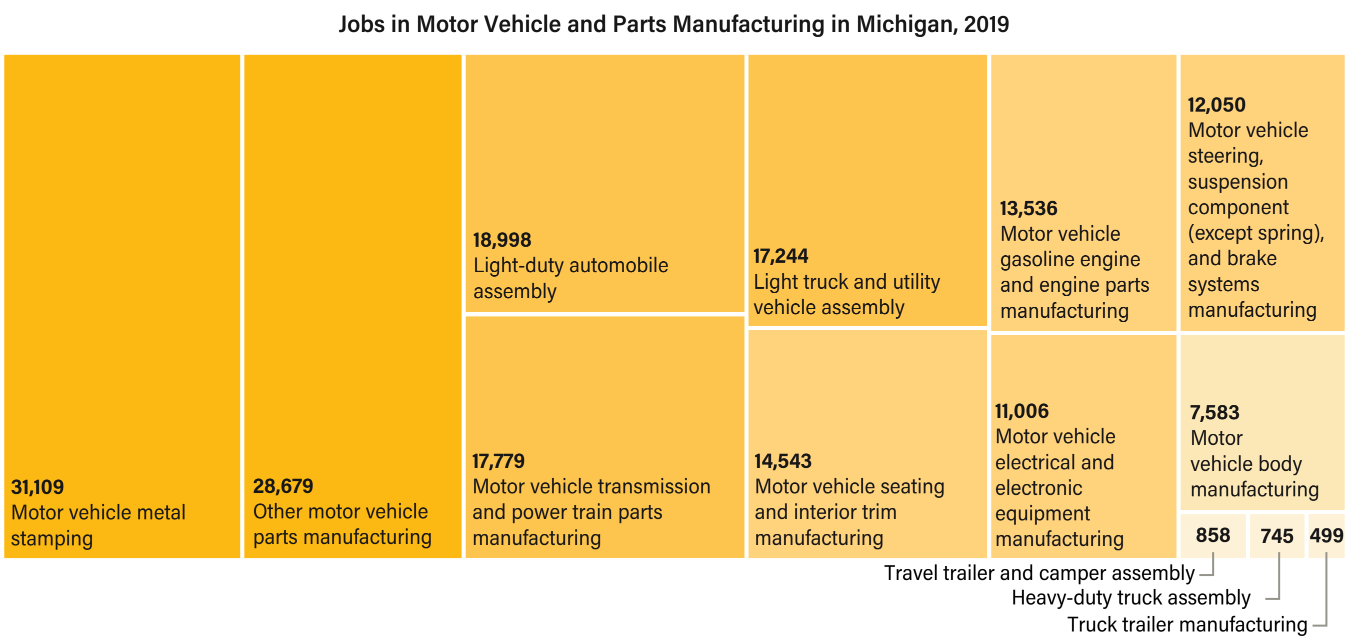
Automotive manufacturing

The EV transition will lead to net job gains for Michigan's auto manufacturing if the state enacts the right policies and is able to secure a sufficient share of the nation's automotive and battery manufacturing value chain, as in the High Competitiveness case. However, if Michigan loses market share, as in the Low Competitiveness case, it could lose auto manufacturing jobs.

We first present results for auto manufacturing as a whole. Then, because of the salience of EV battery manufacturing in policy considerations, we present the auto manufacturing results in two parts—one that covers EV battery manufacturing, and one that covers all other aspects of auto manufacturing.[19]

FIGURE 10 | Pre-transition employment breakdown in Michigan

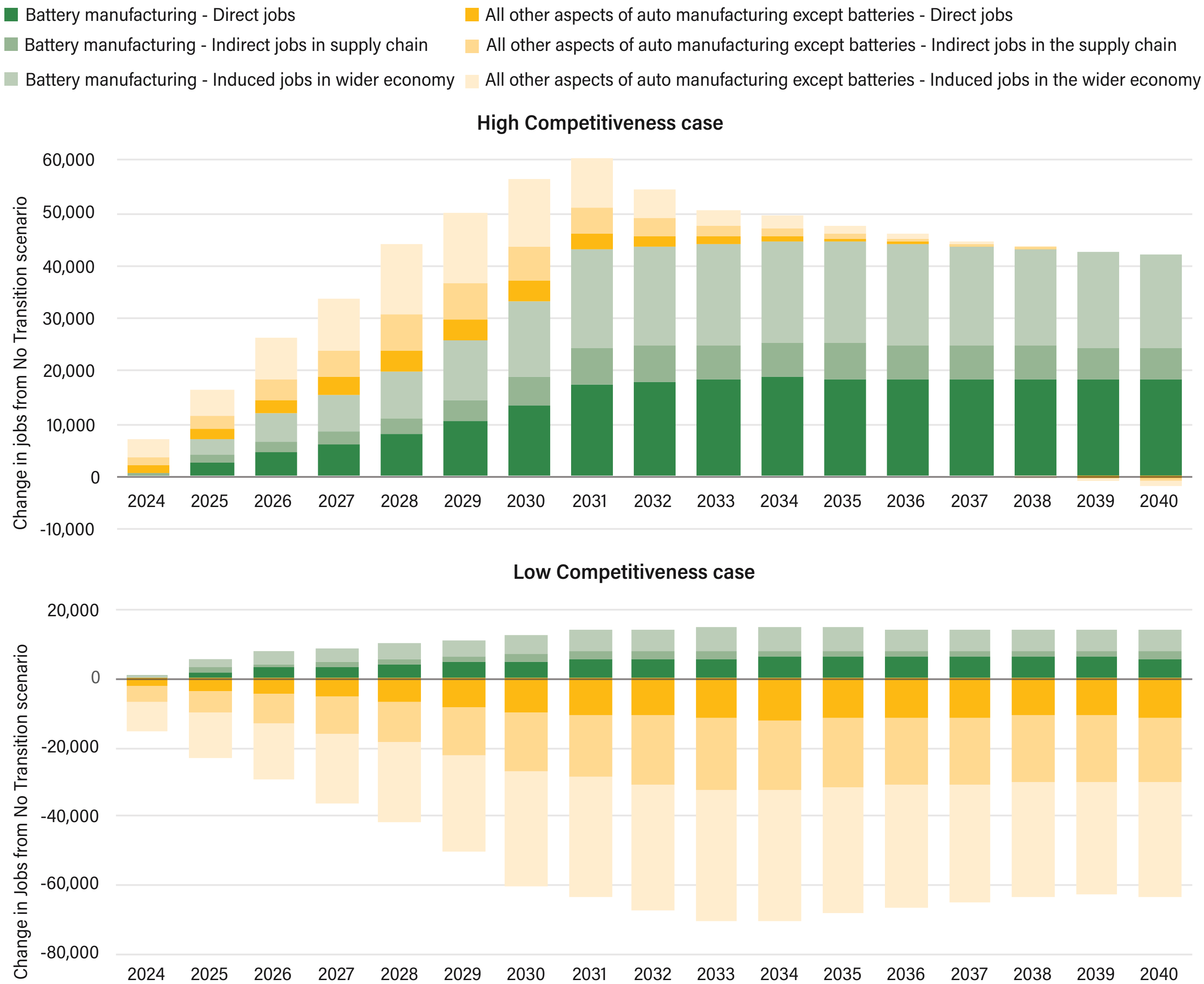




Note: "Motor vehicles" encompass light-, medium-, and heavy-duty vehicles.

Source: IMPLAN 2021 for employment levels; BLS 2023 for examples of specific professions.

FIGURE 11 | Auto manufacturing jobs in the All Electric by 2033 scenario



Source: Authors.

High Competitiveness case

In the High Competitiveness case, Michigan increases its share of US auto manufacturing from 20 percent today to 25 percent by 2030 and increases its share of US battery manufacturing from 10 percent today to 15 percent by 2030.

In the High Competitiveness case, the EV transition would have a net positive effect on Michigan's auto manufacturing employment. Michigan would have 17,000 more direct jobs in auto manufacturing and 12,000 more indirect jobs in the supply chain in 2030 compared with the No Transition scenario. In addition, the ripple effect of these workers spending their earnings would create 27,000 induced jobs in the wider economy. In total, the effect would be 56,000 additional jobs in 2030 compared with the No Transition scenario, which would decline to 41,000 additional jobs in 2040.[20]

Within these results, there are different dynamics for battery manufacturing and the rest of auto manufacturing. In the High Competitiveness case, the total annual value of Michigan's battery production grows fiftyfold from $130 million to $6.7 billion from 2024 to 2040 and the total annual value of the rest of Michigan's auto manufacturing grows by 27 percent in the same period. Battery manufacturing jobs grow steadily until 2033, when 100 percent EV sales are reached, and then remain at a similar level going forward. The rest of auto manufacturing except batteries grows compared with the No Transition scenario from 2024 to 2029, spurred by the fact that a higher proportion of EV assembly will likely be done in the United States compared with that of ICE vehicles due to the North America content requirements of the IRA. Then, around 2030, these jobs begin to decline, as the costs and labor needs of EV production go down, given that EVs are easier to assemble, and thus overall spending in the sector decreases.[21] This is more than offset by the battery production job gains, so the overall effect is still positive in 2040 but lower than it was in 2030.

The year-by-year results are presented in Figure 11. In 2030, battery production in Michigan would be responsible for 14,000 direct jobs, 5,000 indirect jobs in the supply chain, and 15,000 induced jobs in the wider economy compared with a No Transition scenario. Together, the total effect would be 34,000 additional direct, indirect, and induced jobs in 2030 and 42,000 in 2040. The rest of auto manufacturing other than battery manufacturing would support 4,000 additional direct jobs, 7,000 indirect jobs in the supply chain, and 12,000 induced jobs in the wider economy in 2030 compared with the No Transition scenario. The total effect in 2030 would be 23,000 additional jobs. Later on, in 2040, the number falls to 2,000 jobs below the No Transition scenario, for the reasons described above.

Note that our modeling assumes battery manufacturing experiences average labor productivity gains over the time period, but given it is an early-stage industry, it could be that battery manufacturing becomes automated faster than other industries as battery prices come down, which would reduce the job creation impact. In addition, very little of the battery supply chain is currently in Michigan and our model assumes that it stays roughly the same; however, if more of the battery supply chain moves to Michigan it would increase the number of indirect jobs.

Low Competitiveness case

Under the Low Competitiveness case, Michigan decreases its share of US auto manufacturing from 20 percent today to 15 percent by 2030 and decreases its share of US battery manufacturing from 10 percent today to 5 percent.

In the Low Competitiveness case, the EV transition would have a net negative effect on Michigan's auto manufacturing employment. Michigan would have 4,000 fewer direct jobs in auto manufacturing and 15,000 fewer indirect jobs in the supply chain in 2030 compared with the No Transition scenario. This would lead to 28,000 fewer induced jobs in the wider economy. The total effect from all of these would be 47,000 fewer direct, indirect, and induced jobs in 2030, and 49,000 fewer jobs in 2040.

The reason that there are net job decreases in the Low Competitiveness case is because while there would be some increases in battery manufacturing jobs, they would be smaller than in the High Competitiveness case, and would be outweighed by the declines in the rest of auto manufacturing. The annual value of Michigan's vehicle production would shrink by 11 percent from 2024 to 2040, while the value of its battery production would grow thirteenfold from $167 million to $2.24 billion. In 2030, employment in battery manufacturing would increase by 5,000 direct jobs, 2,000 indirect jobs in the supply chain, and 6,000 induced jobs in the wider economy, compared with the No Transition sce-

nario. That amounts to 13,000 additional jobs. For all other aspects of auto manufacturing except batteries, in 2030 there would be 10,000 fewer direct jobs, 17,000 fewer indirect jobs in the supply chain, and 33,000 fewer induced jobs in the wider economy. This amounts to a total of 60,000 fewer jobs in 2030 compared with the No Transition scenario, and the effect would stay roughly the same through 2040.

Battery manufacturing and other auto manufacturing should always be considered together when planning for the EV transition. While some components of vehicles will remain the same, EVs will have new elements and production processes. Whether ICE vehicle manufacturing and parts workers are able to transition to EV manufacturing roles including battery manufacturing is contingent on retraining efforts that must align training timelines with growing demand for EV production. In the Low Competitiveness case, where there are net job losses, some employees would need to transition to a role outside the automotive industry in the rest of Michigan's growing economy. Even in the High Competitiveness case, where there are net job gains in auto manufacturing, as skillsets and production processes are not the same, the transition will require retraining and potentially relocating to other sectors and early retirement in some cases. Many of the jobs effects in manufacturing occur quite quickly, but much of the skills and sectoral transition could be addressed as part of normal patterns of retirement, as auto manufacturing workers in Michigan are older than the national average (Box 2). For Michigan to be successful in increasing its share of auto and battery manufacturing, as is assumed in our High Competitiveness case, it will also need to foster the talent pool necessary to create the next generation of electric vehicles.

Our recommendations later in this report on "Innovation-oriented economic development policies" and "Quality job creation and just transition policies" outline the policy responses needed to grow the state's EV-related industry and the required workforce, create quality jobs, and ensure that the transition does not leave its longtime autoworkers and communities behind. In particular, it will be critical to ensure quality job creation that offers family-sustaining wages, security, and potential for growth in the growing battery manufacturing sector. For example, at present, one GM joint venture plant in Ohio offers battery workers a maximum of $22 an hour compared with the $32 hourly wage of a unionized traditional vehicle assembly worker (Coppola 2022a).

EV charging infrastructure

To support the EV transition, Michigan will have to build out large amounts of public EV charging infrastructure and support at-home charging. Our analysis found that a cumulative $9 billion in public and private investment will be needed for construction and operation of public charging from 2024 to 2040, which is on average $510 million per year. In 2040, we found that around 7,500 jobs would be created due to the installation and operation of EV charging stations to power the EVs that would be on Michigan's roads. This includes 4,000 direct jobs, 700 indirect jobs in the supply chain, and 3,000 induced jobs in the wider economy. Over time, more of the jobs effects will shift from EV charging infrastructure installation to operations including maintenance and repair. We did not assess the jobs effects from the manufacturing of EV charging equipment, which could be a job creator too depending on whether it takes place in Michigan.

Multiple types of workers will be needed for the planning, construction and installation, and operations and maintenance phases of EV charging infrastructure. Many of these jobs will be an extension of existing employment sectors but will require additional training and certifications (Carr et al. 2021). For instance, charger installations will require electrical workers who are trained to handle and safely install high-powered electrical equipment. It will be important that building charging infrastructure for EVs creates good jobs. Our "Recommendations for Michigan policymakers" identifies ways to achieve that aim.

Gasoline stations

Gas stations will experience lower demand as EV owners switch from using gasoline to electricity to fuel their vehicles, affecting employment. Our simulations show approximately 20,000 gas station–supported jobs would be lost by 2030 and 46,000 by 2040, compared with the No Transition scenario. In 2040, this includes 25,000 direct jobs at gas stations, 8,500 indirect jobs in the supply chain, and 13,000 induced jobs effects in the wider economy. The effect on indirect jobs in the supply chain is relatively low considering that Michigan is not home to a substantial amount of oil and gas extraction or refining.

BOX 2 | Demographics in auto manufacturing

Auto manufacturing workers in Michigan are older than the national average for other industries. This has important implications when considering the effect of our scenarios on auto manufacturing jobs and skills requirements.

Of light-, medium-, and heavy-duty vehicle manufacturing workers in Michigan, 25 percent were 55 and older in 2019. These workers would be more than 65 years old, a typical retirement age, in 2030. Fifty-two percent of vehicle manufacturing workers in Michigan were 45 and older in 2019 and thus would be more than 65 years old in 2040.[a] There were about 175,000 jobs in light-, medium-, and heavy-duty motor vehicle and parts manufacturing in Michigan in 2019.[b] Applying these ratios reveals that approximately 43,000 Michigan auto manufacturing workers will reach retirement age by 2030 and 91,000 by 2040.

These numbers cannot be directly compared to the results of our All Electric by 2033 scenario analysis given the mechanics of our modeling and our focus on light-duty vehicles in particular, but they provide useful insight. In our Low Competitiveness case, where there are auto manufacturing job losses, it is likely that attrition by retirement when employees reach 65 would be able to account for a large portion of the changes. In the High Competitiveness case, where there are auto manufacturing job gains, the patterns of retirement are still relevant as the industry shifts to new skillsets.

It is important to note that not everyone wants to retire at age 65, and that patterns of job gains and job losses will not always follow the same timeframes as retirement trends. Michigan government and automakers should explore designing early retirement packages to ensure that turnover in the auto industry is as smooth as possible. See "Innovation-oriented economic development policies" below for full recommendations.

Notes and sources: a. Census Bureau n.d. We used age data from the US Census Bureau, which are not exactly the same as the data from IMPLAN that we used for our DEEPER modeling, but the numbers are close enough that using them for this back-of-the-envelope analysis is valid. We used Census Bureau data from 2019 even though more recent data exist to ensure that the Census Bureau data are more comparable with the 2019 IMPLAN data we had available for modeling; b. IMPLAN 2021.

Our modeling also does not account for the consideration that some gas stations could be repurposed as EV charging stations so that some workers may remain employed at vehicle refueling stations that shift to selling electricity.[22] Accordingly, the model estimates that practically all of Michigan's direct gas station jobs would be lost by 2040. Given that the majority of EV charging will take place at home, there will certainly be less demand for public fueling facilities. But that doesn't mean that there won't be some possibility of gas stations transforming themselves. For instance, as companies shift to zero-emission fleets, gas stations could be in a position to take advantage of business opportunities presented by EV charging for large business fleets, providing both on-the-go and at-depot charging (Bau et al. 2021).

Jobs in Michigan's gas stations have relatively low wages, about 40 percent of the national average wage for all economic sectors (BLS 2021c). Current economic trends also indicate that gas station jobs are particularly likely to become automated, with the US Bureau of Labor Statistics projecting that automation will especially impact cashiers, such as those employed at gas stations (Begley et al. 2019; BLS 2022a). Therefore, the job losses in gasoline stations should be interpreted within the broader context of ongoing automation. The transition away from gasoline could also be an opportunity for workers to reskill, upskill, or shift to jobs of equal or greater quality—if Michigan implements appropriate workforce transition policies.

Electricity

There will be job gains from electricity generation, transmission, and distribution as more spending is directed toward electricity to power EVs. In Michigan, electricity-supported jobs will be 4,200 higher in 2030 compared with the No Transition scenario, and 12,000 higher in 2040 compared with the No Transition scenario. Of these jobs effects in

2040, 1,500 are additional direct jobs, 3,000 are indirect jobs in the supply chain, and 7,000 are induced jobs in the wider economy. Our modeling does not consider the jobs effects of the decarbonization and expansion of the electric grid to meet increased demand, which could create additional jobs as well as increase the climate benefits of EVs.

In addition, the cheaper costs of fueling EVs compared with ICE vehicles allow households to accrue savings, which is a benefit in itself and creates jobs when those savings are spent in other parts of the economy (discussed below).

Maintenance and repair

EVs are expected to require less maintenance and repair than ICE vehicles, which will significantly impact the automotive repair and maintenance workforce. Lower labor needs for auto maintenance and repair will also affect auto dealers, given that roughly a third of car owners go to dealerships for maintenance and repair (Finlay 2021). In 2030, our modeling shows there would be around 11,000 fewer jobs supported by auto maintenance and repair in Michigan and, by 2040, 26,000 fewer jobs compared with the No Transition scenario. Of these effects in 2040, approximately 13,000 are direct maintenance and repair jobs, 2,500 are indirect jobs in the supply chain, and 10,000 are induced jobs in the rest of the economy. Maintenance and repair job losses would be diffused throughout the state. Like with job losses in gas stations, maintenance and repair job losses would not be unique to Michigan, given that all states transitioning to EVs will experience these types of job losses.

Net savings re-spending

EVs are going to be cheaper to own and operate than ICE vehicles over their lifetimes (ANL 2022). There will be an increase in jobs when consumers save money on EVs and re-spend that money to support jobs in the rest of the economy. These savings total $39.5 billion for Michiganders from 2020 to 2024, or about $2.3 billion a year. By 2030, our model shows this effect could lead to 8,500 jobs, and by 2040 around 27,000 jobs across Michigan.

While the estimates here are based on average consumer spending, wealthier groups that are early adopters of EVs tend to save more and lower-income groups tend to spend a higher share of their incomes (Fisher et al. 2019). This means policies to ensure equitable EV deployment could improve Michigan's job gains by helping early savings accrue to lower-income groups. Moreover, if consumers direct spending to investments in education or other long-term economic growth opportunities, it could significantly increase employment gains associated with the transition.

COMBINED RESULTS FOR THE ALL ELECTRIC BY 2033 SCENARIO

To understand the scale of the various sectoral transformations, in Figure 12 we combine the jobs effects from all sectors modeled and discussed above. Due to modeling and time limitations, we were not able to include the jobs effects of a shift to renewable energy to support EVs or the jobs effects of the IRA's EV tax credit savings. These are covered in the following section.

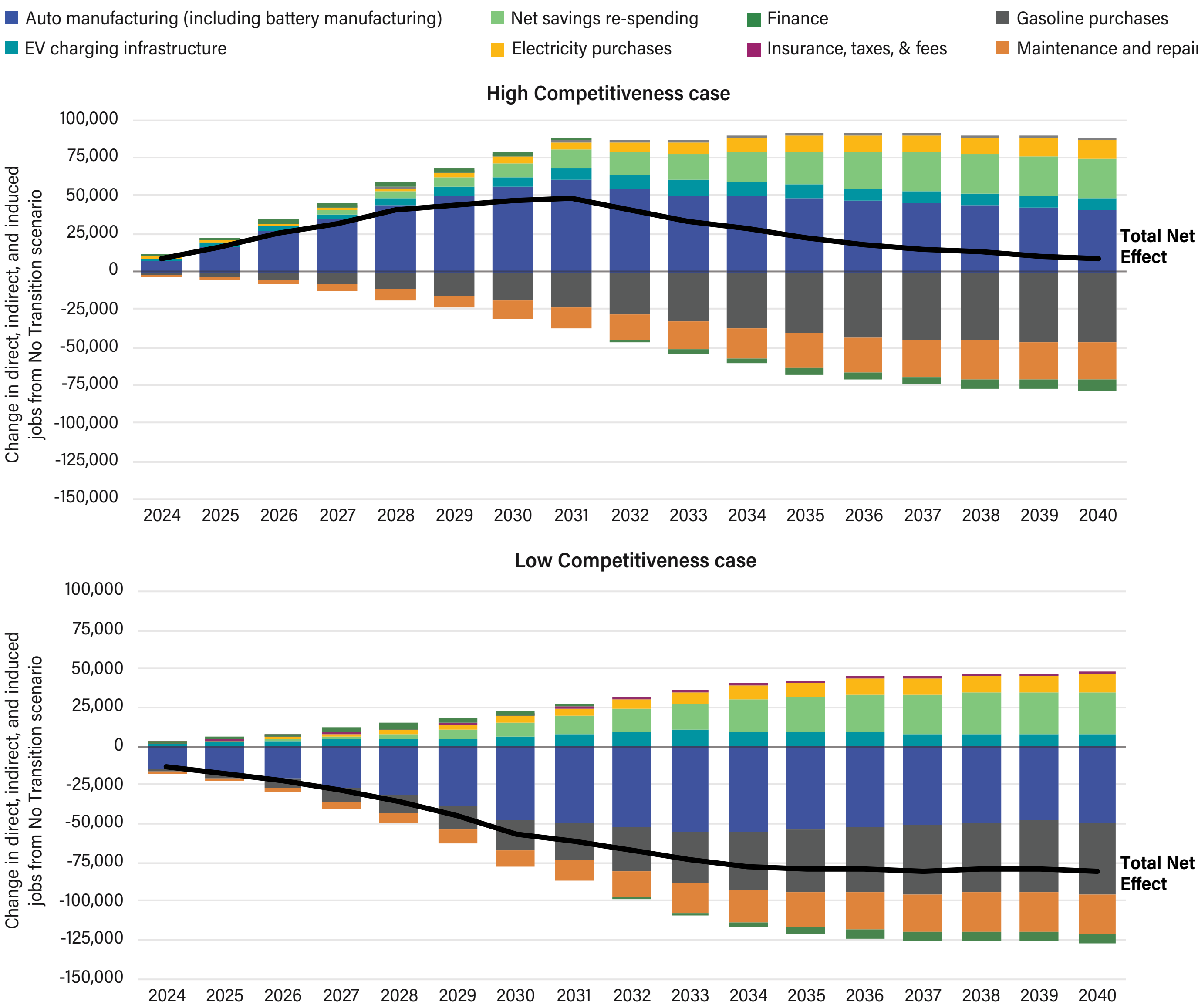
Under the High Competitiveness case, for these modeled sectors Michigan would see a net increase in jobs compared with a No Transition scenario. In 2030, Michigan would have an additional 47,000 direct, indirect, and induced jobs compared with the No Transition scenario (Figure 12). By 2040, the effect would be lower, but it would still be a net gain of around 9,000 jobs compared with the No Transition scenario. On average, there would be 27,000 additional jobs per year supported over the 2024–40 timeframe.

Under the Low Competitiveness case, direct, indirect, and induced jobs in 2030 for these modeled sectors would be 56,000 fewer than what would occur under the No Transition scenario (Figure 12). By 2040, employment would be about 80,000 fewer than in the No Transition scenario. On average, there would be around 57,000 fewer jobs per year supported over the 2024–40 timeframe.

The difference between the two cases is driven entirely by auto manufacturing, which has a net gain in the High Competitiveness case and a net loss in the Low Competitiveness case. Beyond manufacturing, many other sectors of Michigan's economy are impacted. On the positive side, the transition yields employment gains from re-spending of household savings from the cheaper total cost of EV ownership, the installation and operation of EV charging equipment, and electricity purchases to fuel EVs. Employment losses occur due to the phase out of gasoline, the reduced need for maintenance and repair work, and cheaper EVs requiring less financing than more expensive ICE vehicles. Importantly, paying less for fuel, needing less automotive repair work, and paying lower purchase prices for vehicles also reflect improvements in household quality of life, captured here by the re-spending of household savings.

The High and Low Competitiveness cases depict a range of outcomes that Michigan could realize under an All Electric by 2033 scenario. This range is from around 47,000 more net jobs supported on average in 2030 compared with the No Transition scenario (in the High Competitiveness case) to around 56,000 fewer net jobs supported on average per year compared with the No Transition scenario (in the Low Competitiveness case). Whether Michigan ends up on the high end or low end of this spectrum depends on whether Michigan acts now to put in place the right policies to be a leader in EV manufacturing going forward. In addition, Michigan will need to implement the right policies to support its broader economy.

FIGURE 12 | Combined jobs impacts of the All Electric by 2033 scenario in Michigan



Note: EV = electric vehicle.

Source: Authors.

BOX 3 | The speed of the EV transition will influence the magnitude of the shifts in jobs

In this section, we present the impacts of an ambitious All Electric by 2033 scenario. We also analyzed a Current Policy scenario based on national trends, in which EVs make up a little over 50 percent of light-duty vehicle sales in 2030 and around 90 percent in 2040, which is not as ambitious as the All Electric by 2033 scenario but still represents a substantial change from today. The assumptions and results of the Current Policy scenario can be found in Appendices C and D. The jobs effects of the EV transition follow the same overall pattern in both the All Electric by 2033 scenario and the Current Policy scenario. However, in the All Electric by 2033 scenario the jobs transition would happen faster than in the Current Policy scenario. Thus, in the All Electric by 2033 scenario there is a need for more and faster policies to help legacy auto workers and communities adjust. Pursuing more ambitious action to reach net-zero emissions is necessary to limit climate change, which will otherwise harm the health and well-being of all people in Michigan. The air pollution reduction from zero-emission transportation alone would result in $51 billion in health benefits from 2020 to 2050.[a] In the long run, the magnitude of the job shifts in auto manufacturing in Michigan will pale in comparison to the economic damages from the growing impacts of unchecked climate change.[b]

Notes and sources: a. ALA 2022a.; b. Reidmiller et al. 2018.

INSIGHTS ON ASPECTS NOT INCLUDED IN THE MODEL

Renewable energy

While we didn't include renewable energy in our modeling analysis due to time and modeling constraints, renewables are a big potential job creator for Michigan. A US analysis has found that investing $1 million in solar energy supports 2.7 times as many jobs as investing the same amount in fossil fuels (Garrett-Peltier 2017). Therefore, we conducted a back-of-the-envelope calculation to illustrate the potential impact of the clean energy transition for Michigan. We took projected growth in electricity demand across sectors from the reference, or business-as-usual, scenario of the EIA's Annual Energy Outlook, and electrification of passenger vehicle sales in line with our All Electric by 2033 scenario. We analyzed the effect of Michigan's shifting its current capacity mix of about 25 percent renewable energy to 80 percent renewable energy by 2040. In this setting, the transition to electric vehicles would support over one-fifth, or about 7,600 jobs a year, of the employment created due to the renewable energy shift. This includes only construction jobs, though more jobs would be created in planning, designing, financing, operating, and maintaining renewable energy infrastructure. It does not include the economic impacts of the ways used to pay for the infrastructure.

Health and climate benefits

The transition from gasoline- and diesel-powered vehicles to EVs will reduce greenhouse gas emissions and other dangerous pollutants like sulfur dioxide, nitrogen oxides, particulate matter, and volatile organic compounds, which will improve the health of Michiganders (Carey 2023). In 2021, Michigan's air quality was ranked 33rd lowest in the nation as measured by exposure to small particulate matter (UHF 2022). Our modeling did not estimate the value of health and climate benefits attributable to a transition to EVs and a cleaner grid, but other research highlights these important benefits. Recent analysis by the American Lung Association estimated that from 2020 to 2050 Michigan would realize approximately $51.4 billion in public health benefits, 4,700 avoided deaths, 97,400 avoided asthma attacks, and 466,000 avoided lost workdays through a shift to zero-emission transportation (ALA 2022a). Nationwide, a person of color is 61 percent more likely than a white person to live in a community impacted by unhealthy air, in part due to traffic patterns (ALA 2022b). This indicates the potential for significant improvements in health equity through

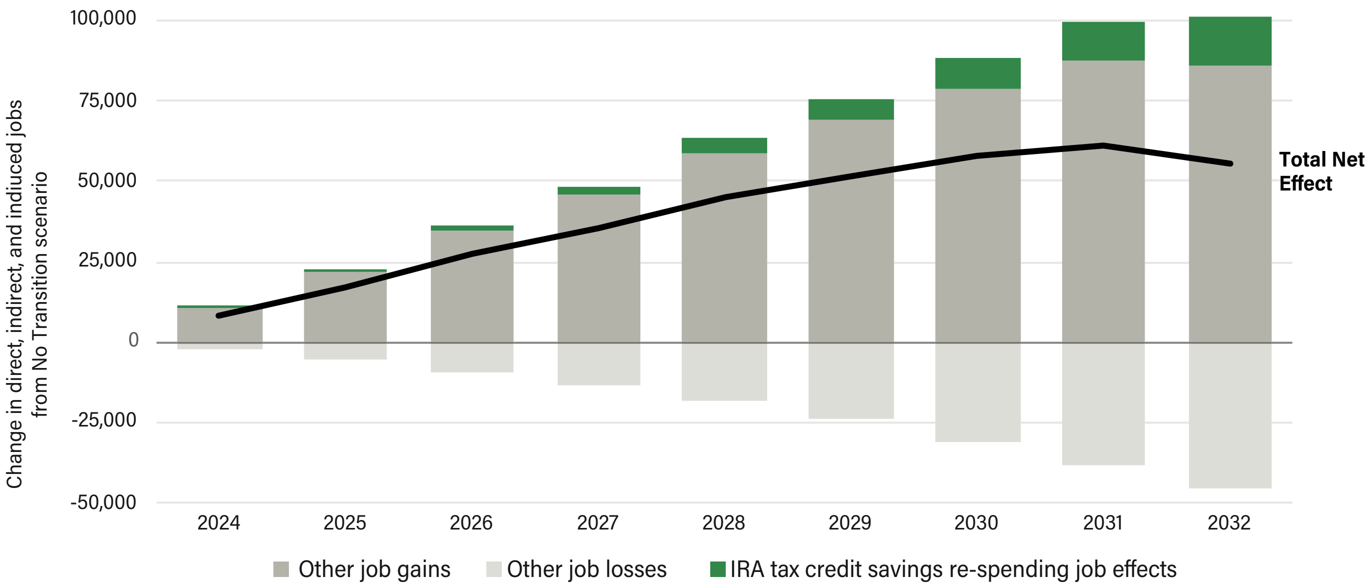
vehicle electrification. Given the scale of these benefits, it is important for policymakers to account for these gains when considering policies to support vehicle electrification.

Another analysis found that if the Michigan Healthy Climate Plan is fully implemented, it could enable the state to reduce greenhouse gas emissions by more than 50 percent by 2030 (5LE et al. 2022). While the plan includes several strategies to help Michigan meet its climate goals, the analysis found that setting an EV sales goal of 50 percent for LDVs and 30 percent for heavy-duty EVs is one of the most significant drivers of emissions reduction in the plan along with implementing a clean electricity standard, phasing out coal-fired plants by 2030, and building efficiency and electrification.

Benefits of IRA tax credit savings

We incorporated the IRA's EV tax credits into our main modeling scenarios in terms of how they affect domestic content in auto manufacturing and the number of EVs sold, but due to modeling constraints we analyzed the consumer savings separately in a back-of-the-envelope analysis. Under the All Electric by 2033 scenario, we found that Michigan consumers stand to save at least $8.7 billion from 2024 to 2032 due to the EV and battery production tax credits in the IRA, and as much as $18 billion depending on how many vehicles qualify for the credits. The re-spending of the minimum level of savings would support an estimated 15,000 jobs in 2032, in addition to the jobs effects due to savings from the lower price and ownership costs of EVs reflected in our main modeling. Combined with the employment impacts of the High-Competitiveness All Electric by 2033 scenario, this amounts to a net gain of 55,700 jobs in 2032 compared with a No-Transition scenario (Figure 13). This estimate does not include savings from the EV tax credit for used cars, savings from 2022 to 2023, or the employment generated by the share of consumer savings spent outside Michigan. These calculations rely on an analysis by Energy Innovation (Baldwin and Orvis 2022) that estimated the expected value of the tax credits per vehicle sold, given that many vehicles would not qualify for the full $7,500 credit, and that only a portion of the battery production tax credit would be passed on to consumers. For the full methodology, see Appendix C.

FIGURE 13 | Effect of IRA tax credit savings on jobs impacts of the All Electric by 2033 scenario—High Competitiveness case



Note: IRA = Inflation Reduction Act.

Source: Authors.

OVERALL TAKEAWAYS FROM THE RESULTS

If Michigan implements the right policies and increases its share of domestic auto production to 25 percent and its share of domestic battery manufacturing to 15 percent, an ambitious EV transition consistent with net-zero emissions would have a net positive effect on Michigan's employment in auto manufacturing and EV-related sectors—equivalent to 47,000 more direct, indirect, and induced jobs than a No Transition scenario in 2030. On the other hand, if Michigan's share of auto and battery production decreases, the state stands to lose jobs in the automotive supply chain.

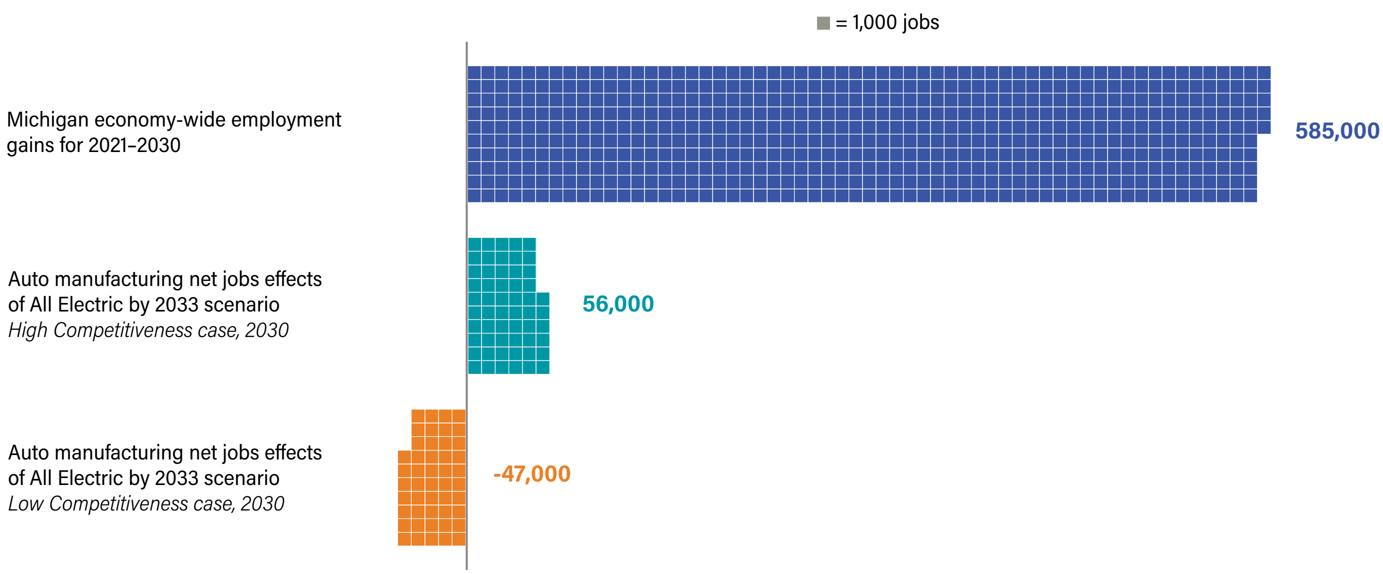
There are big job opportunities in the transition to EVs, including in battery manufacturing, EV charging infrastructure, net savings from EVs being cheaper, and modernizing and adding renewable energy resources to the electric grid. These job gains can counterbalance losses in ICE manufacturing, auto maintenance and repair, and gas stations. This means that Michigan needs to consider forward-looking policies that will make it an attractive destination for companies in the EV industry. This is a race to the top, not a race to the bottom, so Michigan should also ensure that the jobs created are high quality.

However, the effects are going to be uneven, with job losses in some segments of the automotive value chain and gains in others. Michigan needs to ensure that the transition does not leave its longtime autoworkers and communities behind. Our modeling does not have a geographic component to it, but it is important to note that Michigan's motor vehicle and parts manufacturing is heavily concentrated in and around the Detroit region, covering Macomb, Wayne, and Oakland Counties. This geographic concentration could increase the impact on the workers and communities if there are losses in jobs, tax revenue, or support for public services (Raimi et al. 2022). The Detroit region is beginning to attract EV and battery investments, but the exact impact remains to be seen, and further research is needed on this topic.

It's important to consider Michigan's broader economy to see whether it has the capacity to adapt. An analysis from Woods & Poole Economics based on broad economic trends in Michigan's economy forecasts that the state will add approximately 585,000 more jobs by 2030 and 880,000 more jobs by 2040 (W&PE 2022). That overall job growth is much larger than the auto manufacturing net jobs effects of the EV transition in either the High Competitiveness (56,000 more jobs in 2030 versus the No Transition scenario) or the Low Competitiveness case (47,000 fewer jobs in 2030 versus the No Transition scenario) (Figure 14). If the transition is handled right and Michigan enacts the right policies, there is a real opportunity for the workers in the auto sector to shift to other parts of Michigan's economy.

As Michigan advances its economy, attracting and retaining talent, investing in energy productivity, and increasing domestic content, it can thrive as a state in the coming years.

FIGURE 14 | Auto manufacturing jobs effects of the EV transition are small compared with Michigan's projected overall employment growth



Note: Our scenario jobs effects include direct jobs, indirect jobs in the supply chain, and induced effects in the wider economy.

Source: Authors. Michigan economy-wide employment gains for 2021–30 from W&PE 2022.

CHAPTER 4

Recommendations for Michigan policymakers: Seizing opportunities, addressing challenges

In this chapter, we present a tripartite framework of policy recommendations that can help Michigan to grow its EV industry, create high quality jobs, and accelerate EV adoption, while ensuring that the transition does not leave longtime autoworkers and communities behind.

It is critical for Michigan to seize opportunities for quality job creation and economic growth while addressing challenges facing longtime autoworkers and communities from the EV transition through the adoption of forward-looking policies. For this reason, we propose a tripartite framework of policy goals, with equity at the core of all policy considerations (Figure 15). The three categories center around how Michigan can attract robust EV-related investments and talent, deploy the necessary infrastructure to support widespread EV adoption, and create quality jobs while supporting workers and communities during the transition to ensure an equitable outcome.

For each policy goal, we present a suite of recommendations, including some that are already under consideration by Michigan policymakers. These goals and recommendations are not ordered by any priority; rather, we believe that Michigan will need to focus on all three policy categories simultaneously. Additionally, Appendix F provides examples from other states of promising policies and programs to grow the EV industry and achieve the transition in a just manner, which may prove helpful for Michigan.

In addition to the recommendations highlighted in this section, Michigan should pursue federal funding available through the IIJA, CHIPS Act, and IRA to decarbonize its transportation sector. Michigan can leverage the most out of these opportunities by aligning key state goalposts with the expiration of federal funding provisions—for example, by bringing forward its fleet electrification target from 2035 to 2032 to take advantage of the IRA's EV tax credits. See Appendix B for programs and funding listed under each piece of legislation that Michigan can qualify for. In addition, Michigan's Office of Future Mobility and Electrification should be entrusted with the responsibility of assisting in-state original equipment manufacturers and other businesses in the EV ecosystem to navigate the IIJA, CHIPS Act, and IRA so that they can take advantage of funding opportunities and support in-state economic development. OFME should become a go-to resource for information on federal tax credits, grants, and loans.

As described in "Approach: Understanding EV just transition needs," the policy recommendations in this report are the result of a review of best practices backed by academic literature, a survey of Michigan's ongoing initiatives in this area, and targeted consultations with stakeholders impacted by and involved in the ongoing transformation of the automotive sector.

INNOVATION-ORIENTED ECONOMIC DEVELOPMENT POLICIES

Develop the workforce pipeline for the EV industry

The varied educational and training needs of the EV workforce will require Michigan to adopt distinct strategies to assess, prepare, and train workers across the EV value chain; this includes targeting high-wage and high-skilled jobs in research, design, and development as well as blue-collar and

FIGURE 15 | Policy goals to grow Michigan's EV industry and drive a just and equitable EV transition

1	2	3
Innovation-oriented economic development policies	**Equitable EV and charging infrastructure deployment policies**	**Quality job creation and just transition policies**
What policies should Michigan consider to attract EV-related investments and talent?	What policies should Michigan consider to advance equitable EV adoption?	What policies should Michigan consider to support high-quality jobs in the EV industry and ensure that longtime autoworkers and communities aren't left behind?

Source: Authors.

technical workers (Agrawal et al. 2022). The most effective workforce development strategies are those that collaborate with the private sector; pay attention to job quality; build broad skills for an occupation rather than a specific technology; and continually monitor program outcomes such as job placement rates, wages, benefits, worker productivity, and ongoing commitment by employers (Zabin 2020).

Key recommendations:

- **Track labor market dynamics across the entire automotive value chain and over time to align job demand and labor supply.** Michigan will need to consider which types of occupations are needed, whether existing occupations can extend into the EV industry or new skills will be needed, how many jobs will be required, how those jobs will be distributed across the automotive value chain, and how labor supply and demand can be matched, among other considerations.
- **Support industry-led worker training partnerships.** Industry-led training partnerships bring business leaders from an industry—best positioned to understand workforce needs—together with local workforce and economic development organizations, labor organizations, educational institutions, and community organizations to address workforce needs. The EV Jobs Academy and Mobility Talent Action Team are two examples where Michigan is currently doing this. Michigan can further ensure that such initiatives cover workforce needs across the entire automotive value chain, including in charging infrastructure and battery R&D and manufacturing. Targeting such programs to benefit low-income communities, women, and other groups that are underrepresented in the sector is important to making sure that diverse groups of people benefit from these opportunities.
- **Support existing apprenticeship and pre-apprenticeship programs and create new ones where needed.** Apprenticeships are industry-driven programs where individuals obtain paid on-the-job training combined with classroom instruction and a nationally recognized credential, helping employers and relevant labor stakeholders prepare their future workforce (Hauge and Baddour 2020; Zabin 2020; Walter et al. 2020). Pre-apprenticeships are short programs that help individuals enter and succeed in registered apprenticeships.

  Apprenticeships and pre-apprenticeships are crucial for engaging underrepresented populations, allowing them to earn money without having to choose between work and school, and providing them with a pathway to employment in high-quality jobs. Box 4 highlights a promising state example of an apprenticeship program.
- **Track outcomes of all workforce and training programs.** Michigan should systematically track workforce outcomes to evaluate and improve state-funded workforce programs. While tracking can be expensive and time-consuming, it can ensure that public investment in such programs provides the best outcome for both workers and employers. Michigan can consider third-party studies and evaluations that assess workforce outcomes using a broad range of criteria.
- **Develop curriculum upgrades in postsecondary institutions focused on occupations that are critical for the transition to EVs.** Michigan's community and four-year colleges are developing curricula to prepare students for careers in the EV industry, such as the new EV training center at the University of Michigan, Ann Arbor (Nagl 2022). Building on this, Michigan should

develop and maintain a database of existing EV-related educational offerings across its postsecondary institutions and match those to industry needs to identify gaps and further opportunities for curriculum development. Michigan's EV workforce can also benefit from additional academic programs and concentrations in next-generation technologies such as data analytics, machine learning, artificial intelligence, and cybersecurity.

- **Introduce middle and high school students to careers in the EV industry.** Providing middle and high school students with opportunities to understand the fundamentals of the EV industry can help spark students' interest in pursuing a career in science, technology, engineering, and mathematics (STEM). Furthermore, as students become excited about EVs, they can educate their families and friends and help accelerate the widespread adoption of EVs. North Carolina State University offers the Sustainable Transportation Education Program, which helps middle and high school teachers with curriculum and professional development to teach their students about sustainable transportation and EVs.[23]

BOX 4 | Apprenticeships as a strategy to build access to quality jobs

Siemens and Wake Technical Community College (WTCC) have launched a new apprenticeship program to meet employment demand in EV charging manufacturing, engineering, and research and development in Siemens' eMobility manufacturing hub in Wendell, North Carolina. During the four-year program, which starts in the 11th grade, students will attend classes part-time and receive on-the-job training from Siemens while earning a paycheck. Siemens will provide input to WTCC for curriculum development. Upon completion, apprentices will receive an associate's degree from WTCC, a journeyman apprenticeship certificate from the state, and have an opportunity for full-time employment at Siemens. The program is registered with ApprenticeshipNC.

Source: McIntosh 2022.

Bolster Michigan's innovation ecosystem to attract corporate headquarters and R&D facilities

The growing EV industry is likely to see significant innovation and technological advancements including in the development and improvement of different battery technologies, vehicle-to-grid systems, wireless and ultra-fast charging, and even electrified roads. Michigan should bolster its innovation ecosystem so it can attract both corporate headquarters and R&D facilities as well as high-tech talent to support the digital and knowledge-based jobs of the EV and mobility industry. This will be crucial for driving economic growth, creating high-wage jobs, and increasing global competitiveness and productivity while positioning Michigan as the hub of EV-related R&D and manufacturing (Ezell and Andes 2016; Tharpe et al. 2020). Michigan should also avail itself of all opportunities to link these efforts to achieving its goals around diversity, equity, and inclusion.

Key recommendations:

- **Provide greater public investment in higher education to strengthen the state's skills base.** Michigan's support for higher education per full-time-equivalent student is among the lowest in the country (NSF 2022). This has significant ramifications for Michigan businesses looking to hire educated graduates. The education budget for fiscal year 2023 includes a significant increase in higher education funding but is not enough to reverse the last two decades of disinvestment (Affolter-Caine 2022). In addition to attracting talent from outside state borders, Michigan must invest more in higher education and graduate more students for businesses to have the talent they need. Although Michigan has announced an ambitious goal for 60 percent of its adults obtaining a postsecondary degree or an industry-recognized credential by 2030, significant policy innovation and systemic education reform are needed for the state to reach this goal.[24] It will require more investment to provide the needed support to students, including by making college more affordable and providing financial and academic support so that students are able to finish college (Steel 2022). The proposed fiscal year 2024 budget includes several proposals to boost K-12 and higher education in the state, which if passed by the state legislature will further enable Michigan to revamp its

lagging education system (OOTG 2023). This includes a proposal to lower the age for free community college tuition under Michigan Reconnect from 25 to 21 and increase investment in the Michigan Achievement Scholarship, which provides tuition assistance to high school graduates to attend a community college or four-year public university.

- **Invest in programs to attract and retain STEM students.** A recent analysis found that Michigan has nearly 14 percent fewer graduate students living in-state than are produced by its institutions of higher education (Conzelmann et al. 2022). In comparison, several other states including Colorado, California, Georgia, Illinois, Minnesota, and Washington are home to more graduates than they produce themselves. With the expected growth in the EV industry, Michigan should consider putting in place incentives to attract and retain high-tech talent including software engineers and computer scientists. Some options include providing a STEM-graduate tax credit, remote worker incentives, or reverse scholarships—the last of which provides scholarships to students toward the end of their college careers if they agree to work in-state. Connecticut has a Governor's Innovation Fellowship program that provides qualifying graduates with STEM backgrounds with a $5,000 fellowship grant and matches them with tech companies in Connecticut (CTNext 2021).
- **Strengthen business R&D in the state.** Michigan should consider providing business R&D tax credits to incentivize companies to do cutting-edge research in the state, a strategy that has generally been found to be effective in encouraging R&D investment by domestic and foreign firms in the United States (Appelt et al. 2016; Billings et al. 2020; Tyson and Linden 2012).[25] Michigan can also consider limiting the credit to new and emerging businesses, providing small firms with larger credit, or restricting the credit to technologies the state is interested in nurturing (Tyson and Linden 2012; CFME 2021).
- **Facilitate greater interaction and connections among companies, research universities, national laboratories, and the Department of Energy.** Bigger companies in the automotive industry have more access to resources and the ability to stay abreast of available opportunities and emerging technologies. Small and midsize companies and startups may find it difficult to find support for their innovative ideas. Michigan's OFME can communicate and coordinate with industry to help them connect to and access resources from Michigan's research universities, the national laboratories, and DOE.

Protect and bolster Michigan's EV manufacturing competitiveness

As US states vie for leadership in building the EV industry, Michigan should consider strategies that enable it to remain competitive for EV and battery manufacturers, especially as it adapts its decades-long automotive strengths from ICE vehicles to EVs. Electrification may be particularly disruptive for automotive parts manufacturers, which are the backbone of Michigan's auto industry.[26]

Key recommendations:

- **Target economic development incentives to align with Michigan's vision of creating inclusive and equitable economic growth.** Michigan should review its existing economic development incentives and, where appropriate, design them to encourage companies receiving state support to remain in Michigan. Given that talent development is a priority for both Michigan and the EV industry, Michigan can consider incorporating requirements in its incentive programs that companies commit to investing in the state's education and workforce development. Additionally, Michigan can consider attaching other conditions to ensure that public funding produces the best results, such as incorporating prevailing-wage requirements, the use of registered apprenticeships, and community benefits agreements.

- **Improve Michigan's project-ready sites program.** Availability of large sites that are ready for construction—meaning that roads, water, sewer, and electrical infrastructure are all in place—is crucial for Michigan to grow its EV industry. In 2022, Michigan created a Strategic Site Readiness Program (SSRP) to create investment-ready sites. Michigan should use SSRP funding to create an up-to-date inventory of Michigan's sites, categorized by size and listing of available infrastructure, and ensure that SSRP funding prioritizes sites in disinvested areas and addresses environmental justice concerns.

- **Provide support to automotive parts manufacturers to navigate the EV transition.** Large tier 1 suppliers like Bosch and Magna are already manufacturing EV parts and components (Johnson 2022; Field 2022). However, small-to-medium-sized automotive parts manufacturers often do not have large R&D budgets or engineering departments and lack the connection to access external resources. While original equipment manufacturers will play a role in cultivating the capabilities of smaller firms in their supply chains, Michigan can augment private-sector efforts to help smaller manufacturers access cutting-edge research, engineering expertise, equipment, and capital to develop products for EVs. Box 5 highlights one such promising strategy.

- **Investigate and expand new markets in the automotive value chain.** As EVs take off, there will be a growing need to recycle their batteries; invest in semiconductor manufacturing and a clean energy–powered grid; and improve cybersecurity to protect vehicles, charging stations, and the grid. Growing these segments in the automotive value chain could be a significant job creator and enable Michigan to attract more EV-related investments. In particular, battery recycling presents a significant opportunity for Michigan to create well-paying jobs and strengthen the battery supply chain. It has been estimated that battery recycling could support 22–27 percent of the lithium, 40–46 percent of the nickel, and 45–52 percent of the cobalt needed for EVs in the United States by 2050 (Hoffs 2022). Michigan should consider financial incentives and other policies, such as a producer take-back policy, to establish the foundation for strong battery recycling research and development and attract the businesses needed to develop a closed-loop battery electric ecosystem. This would also generate significant environmental benefits, including reducing the environmental impacts of batteries and the reliance on raw minerals extraction.

BOX 5 | Innovation vouchers to promote supply chain innovation in the EV industry

Innovation vouchers are grants provided to small manufacturers to purchase services from research institutions, national laboratories, and universities to promote innovation. They can be used for R&D assistance, technological feasibility assessments, overcoming specific product development hurdles, product prototyping, and field testing. Recent research shows that innovation voucher programs help establish collaboration on innovation and improve small businesses' products and services. A growing number of states, including Indiana and Illinois, have created innovation voucher programs in recent years. Indiana provides up to $50,000 for small businesses to access services from in-state higher education institutions and nonprofit research providers. Illinois offers matching funds in the form of innovation vouchers of up to 75 percent of the cost of research, not to exceed $75,000. As with any policy, the effectiveness of innovation voucher programs will depend on how well they are designed, and states should continue to monitor implementation and success.

Sources: Elevate Ventures 2021; LegiScan n.d.; Kleine et al. 2022; Roelandt and van der Wiel 2020; Tian et al. 2021.

Invest in infrastructure improvements including grid upgrades and low-carbon mobility options

In addition to widespread charging infrastructure deployment, large-scale transportation electrification will require more zero-carbon and distributed energy resources on the grid. As EVs increase the demand on the grid, a substantial investment in modernizing the grid will be needed. Furthermore, stepped-up investment in low-carbon mobility options, especially in affordable and zero-emission public transit or walking and biking solutions, can expand access to jobs, healthcare, education, and retail for everyone and make Michigan a desirable and equitable place for workers.

Key recommendations:

- **Increase renewable energy penetration to enable Michigan to meet its planned clean energy target.** The MI Healthy Climate Plan has a goal of generating 60 percent of the state's electricity from renewables and phasing out coal by 2030 (EGLE 2022). In 2021, renewables accounted for 11 percent and coal accounted for 32 percent of Michigan's net electricity generation (EIA 2022b). Low renewable penetration impacts Michigan's attractiveness to companies against a backdrop of growing interest by businesses to have 100 percent of their energy needs met by renewables.[27] To advance from renewables providing 11 percent of net electricity generation to 60 percent by 2030, Michigan will need ambitious policies such as implementing a clean electricity standard; revisiting existing renewable portfolio standards to increase targets; and reducing siting, permitting, and interconnection barriers to wind and solar project deployment.
- **Invest in grid upgrades to meet the increased demand for electricity from vehicle electrification.** Based on anticipated growth in EVs, Michigan utilities and regulators should assess system capacity and develop a plan to ensure that the grid can meet electricity demand for charging EVs. This can include considering options such as colocating energy storage systems with EV charging infrastructure and using distributed energy resource management systems to support vehicle-to-grid functionality.
- **Invest in low-carbon mobility options to make Michigan a desirable place to live and work.** Low-carbon mobility options reduce congestion, improve air quality, and expand access to transportation for people who do not have cars. While programs and policies to encourage the adoption of personal EVs are important, complementary programs to sustainably fund public transit and walking and cycling solutions are essential for keeping transportation systems accessible. According to the Michigan Healthy Climate Plan, non-white households represent 79 percent of Michigan transit riders—yet a large majority of in-state jobs are not accessible with existing transit services, creating equity and economic mobility challenges. Vulnerable communities, such as seniors, children, and those with disabilities, require access to critical services like healthcare and education but may not have access to vehicles. For example, 60 percent of low-income students rely on school buses compared with 45 percent of higher-income students (Noblet 2021). In addition, the Michigan Healthy Climate Plan acknowledged that ICE vehicle fleet turnover to EVs will not be fast enough to achieve transportation decarbonization goals, meaning that alternate, affordable transportation strategies will need to be funded. Michigan should expand public transit and multimodal networks, electrify public transit fleets, and improve micromobility solutions such as electric (e-) scooters and e-bikes. Investment in public transit offers a five-to-one economic return, can potentially create 49,700 jobs per $1 billion invested (EDRG 2020), and creates 1.4 times as many jobs as investment in road construction (Jaeger et al. 2021). Policies like Colorado's Greenhouse Gas Transportation Planning Standard can enable Michigan to assess the emissions impacts of planned large transportation projects and reduce overall transportation emissions over time, effectively prioritizing state funds toward transit and multimodal solutions that complement EV efforts (CDOT n.d.).

- **Consider adopting "buy clean" policies to ensure that infrastructure investments are the cleanest and most sustainable available.** Buy clean policies help ensure that taxpayer dollars are spent responsibly on materials that are manufactured in a cleaner, more efficient, and environmentally friendly manner. This reduces pollution and negative health impacts and supports the creation of good jobs. California, Colorado, and Oregon have enacted buy clean laws, and other states such as New York, New Jersey, and Washington are considering it. In a similar fashion, Michigan can leverage its significant purchasing power to drive demand for low-carbon material products.

EQUITABLE EV AND CHARGING INFRASTRUCTURE DEPLOYMENT POLICIES

Accelerate the widespread and equitable adoption of EVs through supportive policies

Given that Michigan has been lagging in the national rate of EV adoption (Figure 4), achieving the goal of 50 percent electric LDV sales by 2030 set in the Michigan Healthy Climate Plan or the more ambitious 62 percent sales by 2030 in our All Electric by 2033 scenario will require targeted policy support to encourage EV deployment and help build out the charging infrastructure across the state.

Key recommendations:

- **Consider California's motor vehicle emissions standards.** California has a low-emission vehicle (LEV) standard, which sets increasingly stringent standards for vehicle tailpipe emissions of criteria pollutants and greenhouse gases. California also has a Zero-Emission Vehicle (ZEV) program, which requires automakers to produce an increasing share of zero-emission vehicles. Together, these constitute the state's Advanced Clean Cars Program. Other states can adopt California's Advanced Clean Cars standards, including its LEV and ZEV standards. So far, 14 states have adopted both the LEV and ZEV standards while another 3 are following California's LEV standards. In November 2022, California updated its Advanced Clean Cars regulations to require zero-emission vehicles to reach 100 percent of new vehicle sales by 2035. A few states, including Massachusetts, New York, Oregon, Vermont, and Washington, have either already adopted or started rulemaking to adopt California's latest ZEV target (NCEL 2023). Michigan can consider adopting California's more stringent tailpipe emission and ZEV targets to get to 50 percent or more EV sales by 2030 while ensuring that its program is tailored to the state's specific needs through a stakeholder consultation process that includes the private sector, environmental organizations, and equity groups.
- **Adopt a clean fuel standard.** A clean fuel standard (CFS) is a technology-neutral, performance-based strategy to reduce the carbon intensity of transportation fuels and can be designed to help increase EV adoption (Jordan et al. 2021; Kelly 2020). A CFS policy sets the annual carbon intensity for all transportation fuel providers (including electricity) and can be set to increase in stringency over time. Transportation fuels with less carbon intensity than the standard generate credits while those with higher carbon intensities than allowed must obtain credits, creating a tradable system. A CFS can help fund the EV transition—revenue generated from the sale of credits can be used to finance EV adoption and charging infrastructure deployment, with benefits focused on low- and moderate-income communities—and lower the carbon intensity of the remaining stock of non-ZEV vehicles. California, Oregon, and Washington have a CFS policy. Equity concerns—especially concerns that the market-driven nature of a CFS policy can leave low-income communities in pollution hotspots—should be addressed upfront in the design of a CFS policy, and a broad coalition should be included in the design process, including representation from environmental justice groups, consumer organizations, nongovernmental organizations, utilities, EV charging operators, and automakers.
- **Provide financial incentives to purchase or lease new and used EVs and target them to benefit low- and middle-income consumers.** Financial incentives, including tax credits and rebates, have been found to be effective in encouraging EV sales, especially for low- and middle-income consumers (Bauer et al. 2021;

IEA 2021).[28] Financial incentives can be made more effective by offering them as point-of-sale rebates, setting eligibility tiers based on the vehicle manufacturer's suggested retail price (MSRP), and creating additional incentives for certain income groups (Saha et al. 2021; Clinton and Steinberg 2019). In November 2022, the Michigan Public Service Commission approved DTE Energy's plan to provide up to 1,300 rebates, with each rebate offering up to $1,500, to income-eligible households for purchase of new and used EVs (MPSC 2022). While this is a good start, Michigan needs to provide these kinds of incentives statewide. Governor Whitmer's fiscal year 2024 budget proposes $48 million in sales tax incentives of up to $2,400 for the purchase of new, used, or leased EVs. Box 6 provides examples of two state approaches to providing financial incentives. Proceeds from implementing a CFS can be used to create financial incentives as has been done in California (CPUC n.d.). State financial incentives are especially important given that the federal consumer EV tax credits come with assembly, manufacturing, and other types of requirements which could potentially limit their availability in the initial years (Ewing 2022). Non-monetary incentives, such as high-occupancy vehicle lane access and preferred parking access, can also improve EV adoption.

- **Accelerate public fleet electrification.** Accelerating the electrification of public transportation, school buses, semi-trucks, delivery vehicles, and municipal fleets would spur demand for EVs—directly benefiting the local economy—and pave the way for corporate fleet electrification while offering health, climate, and economic benefits. The IRA offers significant tax incentives for vehicle fleet electrification, including direct pay provisions for non-taxable entities such as state and local governments. Governments, for instance, are eligible for the commercial EV tax credit covering as much as 30 percent of a vehicle's sales price; it has no domestic content requirements and offers up to $40,000 per vehicle over 14,000 pounds and $7,500 per vehicle under 14,000 pounds. Michigan's current light-duty fleet electrification target is set for 2035 with medium- and-heavy-duty vehicle electrification targets set for 2045, but the IRA provisions expire in 2032, so the sooner Michigan acts the more it can take advantage of the savings. Michigan can lead by example by requiring 100 percent of public light-duty vehicle procurements by 2030 and 100 percent of medium- and heavy-duty vehicle procurements to be electric by 2045. Michigan should also require that all school bus procurements be zero-emission when TCO parity is reached, which will be in 2026, according to projections by WRI's Electric School Bus Initiative. Governor Whitmer's proposed budget for fiscal year 2024 includes $150 million in matching grants for school districts to buy electric school buses, which is an important step to ensure that school bus electrification becomes a funded mandate and can prioritize underserved communities (MDOE 2023).
- **Address barriers to EV sales by reforming annual EV fees.** To make up for declining gas tax revenues, many states impose additional fees on EVs separate from motor vehicle registration fees.[29] Michigan's EV fees have been found to cost EV owners up to two-thirds more than what someone driving a similar-sized ICE vehicle would

BOX 6 | Two approaches to providing EV financial incentives

The Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program provides a point-of-sale rebate to those who purchase or lease an EV. The rebate amount is $4,250 for an eligible new EV and those in certain qualified income groups can receive an additional rebate. Colorado offers a tax credit for consumers who purchase or lease an EV. Light-duty EVs purchased before January 1, 2026, are eligible for a $2,000 tax credit while those that are leased are eligible for $1,500. The credits are refundable, meaning the purchaser receives the full value even if they owe less in tax liability. Colorado also allows purchasers to obtain the tax credit value at the time of purchase.

Sources: CDEEP 2022; DEC 2023.

pay annually in fuel taxes and fees (VanSteel and Griffith 2019). While EV owners should pay their fair share of road and highway maintenance, an alternative approach being considered by some states and advocated by policy experts is a road usage or vehicle miles traveled–based fee, which charges all drivers a fee based on miles driven and can be adapted to reward EV drivers for producing zero tailpipe emissions (Plug In America 2020).

- **Create educational materials to promote EV adoption, especially in low-income communities.** Educating consumers through public marketing campaigns about the lower lifetime costs of EVs, the availability of charging, and the federal tax credits available through the IRA can help Michigan increase EV adoption along with the accompanying health and economic benefits for households and the public (Hebbale and Urpelainen 2022). Michigan could consider partnering with an EV-focused organization to create an EV awareness campaign and associated educational materials. When surveyed, communities of color have expressed relatively high interest in EVs but heightened concern about access to charging (Consumer Reports et al. 2022), so the state can emphasize the build-out of public charging infrastructure and accessibility of purchase incentives in messaging to marginalized groups.

Deploy a robust and equitable network of charging infrastructure throughout the state

Increasing access to charging infrastructure is critical to ensuring EV uptake, with studies finding spending on charging infrastructure twice as effective at promoting EV adoption as spending on EV tax credits (Li et al. 2017; Springel 2021). The $110 million in federal National Electric Vehicle Infrastructure (NEVI) program funding allocated to Michigan and utility EV infrastructure programs (such as charger rebates provided by DTE's Charging Forward) lay a strong foundation, but our modeling shows that significant additional public and private sector investment in charging infrastructure is needed to meet the MI Healthy Climate Plan goal of building infrastructure to support 2 million EVs on Michigan roads by 2030.

Key recommendations:

- **Encourage and approve utility electrification programs that continue to incentivize electric vehicle supply equipment (EVSE) purchase, installation, and maintenance and operation.** Investment in public charging infrastructure has largely come from the Charge Up Michigan program, which leverages Volkswagen

settlement money, and from utility programs throughout the state. Michigan's two largest investor-owned utilities also offer rebates for the installation of charging infrastructure for both residential and commercial customers, and for fleets. These have proved to be very successful, but their funding is limited. Additional funds from the federal NEVI program are expected to further supplement the state's contribution to EV infrastructure deployment. But even with all of these funding sources, Michigan can consider providing further financial support for public and private investments to meet expected gaps in charging infrastructure. Other states have created charging infrastructure incentive programs using general funds, revenues from carbon reduction programs, or in the case of Hawaii imposing a fee on gasoline cars to fund the installation of EV charging infrastructure (CFME 2021; Ubay 2021).

- **Standardize EVSE permitting.** Permitting processes for EVSE projects can oftentimes cause uncertainty and delays and result in higher costs. Recommended practices to facilitate their faster installation include standardizing the permit review and inspection process, having an online permit application process, offering expedited processing, providing dedicated staff to review EV infrastructure applications, amending minimum parking requirements to count EV charging sites as spaces, and requiring utilities to develop and publish distribution system load hosting capacity maps so developers can proactively focus development efforts on favorable grid locations (Saha et al. 2022; Hernandez 2022). In addition, Michigan can pass legislation to streamline, standardize, and expedite the permitting process at the local level. California, for instance, passed AB970 in 2021, which imposes strict timelines for local governments to review permit applications for charging stations.[30]
- **Adopt EV-ready building and electrical codes for all new buildings.** Michigan can consider updating the state's building and electrical codes to require that new buildings be built with greater electrical service capacity for a specified percentage of parking spaces.[31] For example, Oregon requires certain types of new construction to have EV charging capacity in at least 20 percent of parking spaces while New Jersey adopted a model statewide municipal EV ordinance that requires the installation of EVSE and make-ready parking spaces in local communities.[32]
- **Prioritize the deployment of EV charging infrastructure in disadvantaged and rural communities.** Increasing access to charging infrastructure in disadvantaged and rural communities is essential to ensuring that all communities experience the benefits of EVs equitably. Targeting investments toward such communities, in addition to educational outreach, can help increase the uptake of EVs statewide while addressing disparities in access. Socioeconomic factors included in environmental justice screening tools can help identify communities where such investments can be prioritized to ensure that they experience the associated health, economic, and social benefits. Box 7 highlights one such example. In addition, the Sustainable Transportation Equity Project, administered by the California Air Resources Board, has been identified as a promising example by various practitioners (Yozwiak et al. 2022). The project aims to advance transportation equity among low-income and disadvantaged communities and provides two types of grants—planning and capacity-building grants, and implementation grants—enabling communities to do their own needs assessments and propose local solutions.[33]

BOX 7 | Promoting equitable access to EV charging stations in California

The state of California and Valley Clean Air Now, a non-profit organization in the San Joaquin Valley, launched a nine-month demonstration project called the Zero-Emissions Vehicle Equity Charging Card in August 2022. The project provides 100 low-income EV owners in the San Joaquin Valley with a $1,000 reloadable, contactless debit card to use at public charging stations. Each card is loaded with an initial $50 and provided an additional $50 per week, with up to $1,000 in benefits. The program is funded by the California Office of Business and Economic Development and is geared toward removing barriers to EV ownership among low-income individuals.

Source: CARB n.d.

Develop public utility policies that support faster deployment of EVs and improved reliability of electricity services

As the pace of EV adoption intensifies, states and their regulatory agencies will have to develop utility policies for EVs that support significant penetration levels in the coming years. State public utility commissions retain jurisdiction over electricity rates, and one strategy, which Michigan has already adopted, is to design EV charging-only rates that incentivize EVs to be charged during off-peak hours.[34] Utilities will also play a key role in charging infrastructure build-out and there is more that Michigan can do in this regard.

Key recommendations:

- **Adopt policies to enable faster EV charger interconnection by utilities.** Efficient interconnection processes—in which EV charging equipment is connected to the grid—are needed to accommodate the required growth in charging stations. Interconnection bottlenecks can delay projects for months (Hernandez 2022; Trabish 2019). Ensuring a streamlined process for connecting EV chargers to the grid can also facilitate vehicle-to-grid integration, allowing energy to flow to and from plugged-in EVs. Michigan can require its utilities to offer EV make-ready programs that reduce the charging infrastructure costs for developers or customers.[35] California's AB 841, for instance, requires utilities to design, construct, and maintain electrical infrastructure on the utility side of the meter at no cost to the customer (Muller and Baumhefner 2021). The Michigan Public Service Commission can also require utilities to publish average interconnection timelines for different stages in the process as well as hosting capacity maps with all relevant load data to help developers identify favorable locations for their projects and plan ahead (Hernandez 2022).
- **Adopt policies to ensure the reliability and affordability of at-home charging.** Michigan currently ranks 46th in the nation on measures of utility reliability and performance, due primarily to the duration of its outages

(CUB 2021). Given that 60 to 80 percent of EV charging is expected to occur at home, Michigan must improve reliability to avoid service disruptions. Michigan utilities have proposed investments in the distribution system in part to improve reliability (CUB 2020). Michigan can follow Illinois's example where in 2011 the legislature stipulated that utilities must meet performance goals for decreasing the frequency and duration of outages or be ineligible to recoup full return on equity for such investments (CUB 2020). Illinois currently ranks fifth in utility reliability and performance. Additionally, Michigan can set penalties that increase in alignment with the duration of outages, make reimbursement to customers for outages automatic, and implement performance-based targets so that underperforming utilities can't pass the cost of penalties on to ratepayers. While early evidence shows that EV uptake reduces rather than increases residential electricity rates (Fitch et al. 2022), this outcome is dependent on the regulatory environment and should be carefully monitored given the performance of Michigan utilities and the fact that in 2020 the state's residential rates were the 12th highest in the nation (Gantert 2022).

QUALITY JOB CREATION AND JUST TRANSITION POLICIES

Create robust transition opportunities for longtime autoworkers

Irrespective of whether Michigan's EV trajectory follows a high or low competitiveness pathway, as discussed in the previous section, the transition will be uneven, including for workers within the auto manufacturing segment. It is critical to ensure that all workers currently employed in ICE vehicle manufacturing can transition to other roles, whether within EV manufacturing or in other sectors and while assisting workers at or near retirement age. Some workers may have skills that allow them to find new jobs quickly, while others may require more extensive training or reskilling or desire to switch fields or careers.

Key recommendations:

- **Create a transition support fund for workers impacted by the EV transition.** A dedicated fund can help workers affected by the EV transition with retraining and education programs, counseling, relocation fees, and short-term wage replacement if workers lose their incomes before finding a new job or before they are eligible for full retirement benefits (Cha et al. 2021a; Saha and Jaeger 2020; Wang et al. 2022). Funding sources can include general appropriations, redirecting existing funding streams, and/or private sector contributions. Appendix F provides examples of states offering transition support to workers. While those are mostly in the context of coal workers and communities, they can be expanded to include all workers impacted by the energy transition, including auto workers.
- **Establish a "rapid response team" to address job displacement and mass layoff situations.** This team could be housed within a newly created office of just transition, which would be entrusted with the responsibility of coordinating Michigan's just transition policies for all fossil fuel sectors, or within an existing office (for example, the Office of Future Mobility and Electrification).[36] Such a team could work with employers

to provide incentives to keep legacy workers employed, respond to layoffs by quickly coordinating resources and providing support to affected workers, and help employees shift to new roles through employer-provided training.[37] In addition, such a team could help troubled employers or businesses look for incentives and other programs they may qualify for to help them shift their work to new or expanding industries, helping them remain open as a successful business. Michigan can also consider requiring that companies provide advance notice (beyond what is required by federal law) of facility closure or mass layoffs. This can enable the state and impacted local governments to work together with the company to proactively provide support for displaced workers.

- **Work with employers to create plans to provide fair early retirement packages for ICE vehicle workers.** One-quarter of Michigan's motor vehicle and motor vehicle parts manufacturing workers were over 55 years of age in 2019 (Census Bureau n.d.). Older workers may find it difficult to train for a new position or switch to a different industry. State offices should work with employers to determine what would be included in a fair compensation package for workers entering early retirement who are not yet eligible for their pensions or full federal retirement benefits. Doing so can help ensure that workers do not slip through the cracks while helping the state understand the size of the workforce that will need to be replaced in the EV transition and assisted as they retire.

Ensure that jobs in the EV industry offer family-sustaining wages, security, and potential for growth

Making sure jobs created through the EV value chain are high quality and safe and provide opportunities for development is critical to ensuring that Michigan's auto industry remains a desirable space for workers (Jaeger et al. 2021). As Michigan provides millions of dollars in grants, loans, tax breaks, and various economic development incentives, it can also adopt policies to ensure that government spending is creating good jobs.

Key recommendations:

- **Strengthen prevailing wage requirements and provide guidance on determining comparable jobs and wages in the EV industry.** Prevailing wages—requiring employers to pay the basic hourly rate of wages and benefits paid to similarly employed workers—are generally limited to workers in the construction industry (BGA 2020; Glass et al. 2022). In March 2023, Michigan restored prevailing wages for state-subsidized construction projects that had been repealed in 2018, which makes EV charging station installation and construction projects eligible for prevailing wages.[38] Michigan can go further and consider extending prevailing wage requirements to manufacturing projects funded with state money, including in battery manufacturing where there are concerns about low wages and poor working conditions, thereby upholding high job standards in the auto industry as it electrifies (Glass et al. 2022; White House 2021).[39] To do this, Michigan will need to develop guidance for determining "comparable workers," which can be done by using jobs in ICE vehicle manufacturing as reference points for EV jobs.[40] Additionally, Michigan will need to invest in appropriate data collection to ensure that prevailing wage calculations reflect market conditions, provide periodic updates of wage determinations, and ensure effective implementation (Glass et al. 2022).

- **Ensure workers have the right to unionize, which has been found to be a strong determinant of job quality.** Unions have been a key factor in creating good jobs in the state's current ICE vehicle industry, highlighting the need to safeguard the right of workers to unionize and ensure that jobs created in the EV industry offer high wages, health benefits, job protection, and workplace safety, and follow prevailing wage requirements (Madland 2022; Lafer 2021).[41] California, New Jersey, New York, and Oregon have long-established policies for enabling workers to form unions without fear of retaliation from their employers, which is reflected in high union membership in those states compared with Michigan (Lafer 2021; BLS 2022b). Ensuring that workers have the right to unionize, especially in relatively new industries such as battery manufacturing, is key for establishing good jobs and setting precedent for other companies and facilities.[42] In March 2023, Michigan repealed its right-to-work law, which had allowed workers in unionized jobs to opt out of membership and paying dues, thus making a significant step toward restoring workers' collective bargaining power. Establishing wage boards by industry or occupation, which bring together representatives from workers, business, and the government to set minimum pay standards, can also be a useful strategy to ensure workers in low-union-density industries are protected (Wall and Madland 2021; Dube 2020).[43]
- **Create clear, time-bound pathways for temporary workers to transition to comparable permanent, full-time roles and disincentivize the use of temporary worker contracts.** Temporary workers often do the same job but earn less and lack protection, workplace safety and training, access to healthcare and benefits, and the stability of full-time workers (Upjohn Institute n.d.). It is estimated that temporary workers make up about 20 percent of the employees in the auto industry and are sometimes in their assignments for over a year (NELP 2022). Helping such workers transition (see Box 8) and designing policies to limit the use of such contracts is critical to ensuring automotive jobs are good jobs. One option is to make public subsidies and support contingent on the status of workers within companies (for instance, designating that public subsidies are available to companies with no more than a certain percentage of temporary workers), while training and workforce development programs should be dependent on the creation of full-time jobs. For competitive grants, agencies should include criteria that consider labor policies, like the IIJA's battery grant applications, which encourage applicants to demonstrate their credentials as a responsible employer, particularly when it comes to ensuring that workers have access to and the opportunity to join a union (DOE 2022b).

BOX 8 | Transitioning temporary workers to permanent, full-time status

Collective bargaining led by the United Auto Workers at several of Ford's plants in Michigan, Ohio, and Missouri has helped thousands of temporary workers transition to full-time status and receive better wages, job security, healthcare, and access to profit-sharing. It has also helped some workers qualify for supplemental unemployment benefits. These allow permanent workers with one year of service to have steady incomes even during layoffs when factory downtime is required, a necessary part of the industry due to disruptions caused by supply shortages, such as of semiconductor chips.

Source: UAW 2019; Ford 2022.

Protect communities impacted or at risk of being impacted by the closure of legacy auto facilities

While the transition to EVs will involve significant retooling of legacy auto facilities, it may also force some facilities to close, even if temporarily.[44] This can create significant disruption to communities and local governments due to losses in jobs and local revenues. Local communities and governments will need support to alleviate those losses immediately following a facility's closure as well as robust reinvestment to promote long-term economic resilience.

Key recommendations:

- **Provide transition support for communities impacted by the closure of auto facilities related to ICE vehicle production.** Michigan should provide funding to assist communities, businesses, and local governments in developing plans to address the economic dislocation associated with the closing of a facility that is a major employer and revenue generator. This can include funding for worker retraining, local capacity building, establishing alternative economic development strategies to attract new employers, and/or providing temporary local revenue replacement for the lost tax base. Transition support to communities should include transportation assistance, through subsidies or credits, which has been identified as an important factor in helping community members look for other economic opportunities. Appendix F provides examples of a few states that are doing this. Over the long term, investing in infrastructure upgrades, including in broadband access, public transit, and schools, can provide a strong economic foundation for local communities' recovery from facility closures.
- **Support community-based efforts to reimagine how former automotive manufacturing sites should be repurposed.** It is important to prevent sites from becoming unusable or unhealthy brownfield sites, should the company shutdown or relocate elsewhere, including requiring comprehensive environmental remediation upon facility shutdown. While some brownfields may be suitable for site development for EV charging facilities (EPA 2021), local communities should have a leading voice in determining what the site will be repurposed for and how investments can be most beneficial.

Ensure communities benefit from new EV investments by adopting supportive policies such as community benefits agreements

A community benefits agreement (CBA) is typically a private legal agreement between a company and community groups, labor unions, or other entities whereby the company agrees to specific commitments to benefit the community (Patterson et al. 2017; Been 2010). Local governments have often participated in the negotiations and sometimes incorporated the CBA into their development agreement with the company. Recently, however, a handful of states and localities have adopted policies to institutionalize CBAs, including New Jersey[45] and the city of Detroit.[46] Well-designed CBAs can be a powerful tool to ensure that new investments in EV assembly, battery manufacturing, and other facilities benefit the communities they are sited in.

Key recommendation:

- **Consider adopting a statewide CBA framework as an integral component of the economic development toolkit.** While there are legitimate concerns about whether CBAs will lower Michigan's competitiveness vis-à-vis other jurisdictions that do not have CBAs, there are several reasons for Michigan to do this. The institutionalization of CBAs at the state or local level can increase predictability in the development process for the private sector, community groups, and local governments. Properly designed, enforceable CBAs can also reduce frictions that delay the process, such as community opposition to EV and other clean energy projects, potentially speeding up the transition while ensuring accountability. As CBAs become increasingly popular, it may benefit Michigan to have a state-sanctioned CBA framework rather than leave it to community groups with fewer resources and less capacity to negotiate with large companies. Part of the process should require that tools and resources be provided to community members so that they can be empowered to meaningfully engage in the process. Appendix E provides an overview of Detroit's Community Benefits Ordinance and identifies key recommendations to make CBAs more effective.

Utilize robust environmental justice screening tools to mitigate the cumulative pollution burden that auto-related investments impose on Michigan communities

Environmental injustices have imposed disproportionate pollution burdens on communities of color and low-income communities for decades. As Michigan seeks to attract EV-related investments, it has to be mindful of the fact that emissions from EV production and battery manufacturing powered by fossil fuels can impact surrounding communities (White-Newsome et al. 2021). While the Biden administration has made achieving environmental justice a top priority, scholars have long argued that actions taken at the state level are the most efficient and effective ways to correct distributive inequities (Zrzavy et al. 2022). A growing number of states, including Michigan, have developed environmental justice screening tools, which typically combine data on socioeconomic factors and environmental hazards and pollutants to identify areas with the greatest health burden from cumulative pollution, though a key gap in the development of these tools is that they do not consider pollution burdens from areas outside of their respective states (Konisky et al. 2021; Ravichandran et al. 2021). Such screening tools can also be used to identify communities that face other barriers, such as a lack of available transportation, which can help policymakers target investments.

Key recommendations:

- **Clarify how state agencies will use MiEJScreen in their decision-making.** While MiEJScreen, Michigan's screening tool, is still in development, Michigan should clarify how state agencies will use MiEJScreen in their decision-making going forward. For example, California requires the state's EPA to allocate a certain share of funds generated through the state's carbon trading program to benefit disadvantaged communities, and the agency uses CalEnviroScreen to comply with that requirement.[47]
- **Require a review of the existing pollution burden before approving permits.** In most cases, the use of screening tools to inform permitting decisions tends to be informal and ad hoc (Konisky et al. 2021). New Jersey's 2020 Environmental Justice Law, however, requires the state's Department of Environmental Protection to review the existing pollution burden on communities before issuing a new permit and to refuse to issue a permit if a new facility will have a disproportionately negative impact on overburdened communities.[48] Following New Jersey's example, Michigan can consider using its screening tool to identify overburdened communities—including those that are impacted by interstate pollution, especially in state border areas and main airsheds—and deny permits to new and expanding facilities if those are found to add to the cumulative burden on these communities.


ELECTRIC


Conclusion

The transition to EVs presents significant economic opportunities for Michigan. However, realizing the full benefits of the transition will depend on the extent to which Michigan adopts policies to both manufacture EVs, batteries, and other components as well as deploy EVs and associated infrastructure—while doing all this in a manner that brings the benefit of the transition to workers, communities, and all its residents.

The development of the EV industry in Michigan should not be viewed as a zero-sum game. In fact, the policy recommendations offered in this report can inform policymakers in other states as well as they look to speed up EV adoption and manufacturing of EVs, chargers, and batteries. The shift to EVs has begun to pick up but we should not underestimate the scale of what is required. It will take a significant effort to build up a supply chain and an ecosystem that can support the goal of 100 percent EV sales by the mid-2030s. In addition to Michigan, other states should be investing in the EV revolution and reaping its benefits.

Our analysis revealed that in a scenario where EVs reach 62 percent of LDV sales by 2030 and 100 percent by 2033, and Michigan raises its share of domestic auto production from the current 20 percent to 25 percent, and its share of domestic battery manufacturing from 10 percent to 15 percent, Michigan stands to add 56,000 direct, indirect, and induced jobs in auto manufacturing in 2030 compared with a No Transition scenario. There will also be employment opportunities in other areas such as EV charging infrastructure, renewable energy, and net savings from EV ownership.

Achieving this outcome will primarily depend on policy choices. It will all come down to whether Michigan is able to strengthen its innovation ecosystem, develop a workforce pipeline, bolster its manufacturing competitiveness, and improve its infrastructure. These are the fundamental building blocks to attracting new investments in EV assembly, battery manufacturing, and related industries as well as talent. In particular, exploring new markets, including battery recycling, and investing in a clean grid and low-carbon mobility options will make Michigan a more attractive place for job creation and talent.

By the same token, many of the economic benefits of the EV transition will depend on whether Michigan invests in the EV charging infrastructure that will be needed and pursues other policies and incentives that will support the growth in EV adoption. This will ensure that Michigan EV drivers realize fuel savings, that new jobs are created for installing charging stations and upgrading the grid, and that Michigan maximizes the potential capture of federal tax incentives and other funding from the IIJA and IRA. These policies will also help attract talent and new companies to the state, as part of a culture of innovation.

Beyond attracting new investments and facilitating EV adoption, Michigan will also need to make sure that it is facilitating a just and equitable EV transition for its workers, communities, and EV consumers. The EV transition is bound to have an uneven impact on workers, even in a scenario where Michigan has a net job advantage from the transition. Given the technical and operational differences in EVs and ICE vehicles, some workers in ICE vehicles and parts manufacturing can be trained to work in the EV industry but it is also possible that some jobs will be eliminated. Furthermore, it will be important to ensure that new jobs in the EV industry are good jobs with decent wages, benefits, and options to unionize. Finally, the deployment of EVs and charging infrastructure will need to take place in an equitable manner such that low-income communities, communities of color, and those most burdened by the impacts of local air pollution benefit from the transition.

Michigan has already made important strides toward an electrified transportation future. The modeling results and policy recommendations presented in this report lay out a roadmap for Michigan to build on its progress thus far and stake out a leadership position in enabling a just and equitable transition to EVs. Michigan leaning in on EV policy could also help drive EV adoption in the Midwest and arguably other parts of the United States, as more states seek to follow Michigan's example and learn from its efforts.

Appendices

APPENDIX A: EV-RELATED PROGRAMS AND EFFORTS IN MICHIGAN

TABLE A-1 | List of Michigan's existing EV-related programs and efforts

PROGRAM	DESCRIPTION	LEAD STATE AGENCY	CATEGORY
Alternative Fuel Development Property Tax Exemption[a]	Offers tax exemptions for industrial properties that are used for high-technology activities, including those related to advancing electric, hybrid electric, and alternative fuel vehicle technologies	Michigan State Tax Commission	Economic development
Charge Up Michigan[b]	Provides funding for qualified direct-current fast-charger EV charging equipment, site preparation, equipment installation, networking fees, and signage	EGLE	EV adoption/charging
Connected and autonomous vehicle corridor by Cavnue[c]	A first-of-its-kind corridor for connected and autonomous vehicles between Ann Arbor and Detroit	MDOT	EV adoption/charging
Council on Climate Solutions[d]	An advisory body, created via Executive Order 2020-182, to advise the governor's office and EGLE on the implementation of climate solutions	Governor, EGLE	Community needs
Critical Industry Program[e]	Provides investments to businesses to create or retain jobs resulting from a technological shift in product or production	MEDC on behalf of Michigan Strategic Fund	Workforce/education, community needs
Cross-Border Mobility Technologies[f]	A partnership with Ontario, Canada, to create a test bed for new technologies to spur innovation and transportation solutions	MDOT and OFME, along with Ontario's government	Economic development
Detroit Smart Parking Lab[g]	A physical parking structure offering a place for real-world testing of parking-related mobility technologies, logistics, and EV charging	OFME	EV adoption/charging
Emerging Technologies Fund[h]	Designed to expand funding opportunities for technology-based companies working on innovative research and development	MEDC	Economic development

TABLE A-1 | List of Michigan's existing EV-related programs and efforts (Cont.)

PROGRAM	DESCRIPTION	LEAD STATE AGENCY	CATEGORY
Fuel Transformation Program[i]	Offers grants for eligible on- and off-road medium- and heavy-duty vehicles and equipment that reduce nitrogen oxide emissions, improve air quality, and increase adoption of zero-emission or alternative-fuel vehicles and equipment	EGLE	EV adoption/charging
Inductive Vehicle Charging Pilot[j]	A pilot program to deploy an electrified roadway system that allows vehicles to charge while driving; Electreon was chosen by the state to build an electric road system in Detroit	MDOT and OFME	EV adoption/charging
Lake Michigan Electric Vehicle Circuit[k]	Collaboration among Illinois, Indiana, Michigan, and Wisconsin to build chargers along more than 1,100 miles around Lake Michigan	Michigan, along with other states	EV adoption/charging
MI Future Mobility Plan[l]	A plan that coordinates efforts across multiple state agencies to address challenges and support the growth of Michigan's mobility and electrification industry	Developed by OFME, CFME, and other Michigan partners	EV adoption/charging, economic development, community needs
Michigan Central Innovation District[m]	A partnership among the city of Detroit, Ford, and Google to identify solutions with community members to attract and retain talent and high-growth companies while supporting the development of neighborhoods	OFME, MEDC, and other state departments	Workforce/education, community needs
Michigan Alliance for Greater Mobility Advancement[n]	Established by the Workforce Development Agency, an employer-led collaborative created to develop skills training programs and build a robust EV talent pipeline	LEO	Workforce/education
Michigan Council on Future Mobility and Electrification[o]	Established within LEO in 2020 to replace the Council on Future Mobility to advise LEO and OFME	LEO	Economic development
Michigan Healthy Climate Plan[p]	A statewide plan that lays out a vision for achieving economy-wide carbon neutrality by 2050	EGLE	Economic development
Michigan Learning and Education Advancement Program[q]	A program that provides education and training programs to help job seekers transition to high-skill, high-wage employment opportunities	LEO	Workforce/education
Michigan Mobility Funding Platform[r]	A program to provide grants to mobility and electrification companies to deploy their technology solutions	MDOT and OFME	Economic development

TABLE A-1 | List of Michigan's existing EV-related programs and efforts (Cont.)

PROGRAM	DESCRIPTION	LEAD STATE AGENCY	CATEGORY
Michigan Reconnect[s]	Provides tuition assistance toward earning an associate's degree or a skills certificate for people over 25	LEO	Workforce/education
Michigan STEM Forward internship program[t]	A program that places STEM students in Michigan's colleges into internships with leading companies	MEDC	Workforce/education
Mobility Talent Action Team[u]	Program focused on delivering professional development programs that engage workers in improving their skills and competencies in line with in-demand roles	MEDC	Workforce/education
Office of Future Mobility and Electrification[v]	Established the OFME to support mobility and EV growth across state government, academia, and private industry	OFME	Economic development
Pure Michigan Talent Connect[w]	An online marketplace connecting Michigan's job seekers and employers	MEDC, Workforce Development Agency, Talent Investment Agency	Workforce/education
Regional Electric Vehicle (REV) Midwest Coalition[x]	Illinois, Indiana, Michigan, Minnesota, and Wisconsin signed the REV Midwest memorandum of understanding to accelerate vehicle electrification in the Midwest	Michigan, along with other states	EV adoption/charging
Regional Talent Innovation Grants[y]	A program providing grants to organizations providing training programs in specific occupations that are in high demand at regional employers	MEDC	Workforce/education
Semiconductor Career and Apprenticeship Network[z]	A program to strengthen the state's semiconductor workforce	MEDC	Workforce/education
Sixty by 30[aa]	A state goal of increasing workforce and education programs, ensuring that 60% of working-age adults have a college degree or skill certificate by 2030	LEO	Workforce/education
Strategic Outreach and Attraction Reserve Fund (SOAR Fund)[ab]	Over $1 billion to support economic development and site development statewide through grants, strategic site improvement, remediation, and redevelopment for future projects	MEDC	Economic development, just transition/community needs
Strategic Site Readiness Program[ac]	Provides financial incentives such as access to grants, loans, and other economic assistance to eligible applicants to create investment-ready sites	MEDC on behalf of Michigan Strategic Fund	Economic development
Transportation and Civil Engineering Program[ad]	Connects high school and middle school students with transportation- and civil engineering–related jobs	MDOT	Workforce/education
Transformational education project[ae]	Invested $130 million to focus on research, development, and educational pathways for the future of mobility and electrification	Governor	Workforce/education

Note: EV = electric vehicle; EGLE = Department of Environment, Great Lakes, and Energy; MDOT = Michigan Department of Transportation; MEDC = Michigan Economic Development Corporation; OFME = Office of Future Mobility and Electrification; CFME = Council on Future Mobility and Electrification; LEO = Department of Labor and Economic Opportunity; STEM = science, technology, engineering, and mathematics.

Sources: a. DOE n.d.e; b. EGLE n.d.b; c. Cavnue n.d.; d. EGLE n.d.a; e. MEDC 2022a; f. OOTG 2021c; g. MEDC 2021; h. MSBDC 2017; i. EGLE n.d.c; j. MEDC 2022b; k. OOTG 2022c; l. OFME 2022; m. Michigan Central 2021; n. MAGMA n.d.; o. OOTG n.d.; p. EGLE 2022; q. LEO n.d.b; r. MEDC n.d.a; s. LEO n.d.a; t. Ann Arbor SPARK n.d.; u. OOTG 2022b; v. MEDC n.d.b; w. LEO n.d.c; x. DOE 2021; y. MEDC n.d.c; z. OOTG 2022a; aa. LEO n.d.d; ab. OOTG 2021b; ac. MEDC 2023; ad. MDOT 2022; ae. OOTG 2022d.

APPENDIX B: PROVISIONS IN THE INFRASTRUCTURE INVESTMENT AND JOBS ACT, INFLATION REDUCTION ACT, AND CHIPS AND SCIENCE ACT FOR ACCELERATING EV DEPLOYMENT

TABLE B-1 | Provisions in US legislation that accelerate EV deployment

PROGRAM NAME	FUNDING AMOUNT	PROGRAM DESCRIPTION
The Infrastructure Investment and Jobs Act contains significant funding for accelerating transportation electrification. It primarily does so by addressing barriers to the widespread adoption of EVs; namely, the need for a rapid build-out of EV charging infrastructure.[a]		
National Electric Vehicle Infrastructure Formula Program	$5 billion between FY2022 and FY2026	The program provides dedicated funding to states to build out a national network of EV charging stations, primarily along interstate highways. Funds can also be used to add charging capacity on any public road or in other publicly accessible community locations once the national network is built out. Funding can be used by states both for the acquisition and installation of EV infrastructure and their operation and maintenance. States were required to submit an EV Infrastructure Deployment Plan to the Joint Office of Energy and Transportation by August 1, 2022.
Charging and Fueling Infrastructure Discretionary Grant Program	$2.5 billion between FY2022 and FY2026	Funding is to be divided equally between corridor charging along designated alternative fuel corridors and community charging in other locations with an emphasis on rural and underserved communities. Funding is directed toward states, local governments, metropolitan planning organizations, and other public sector entities. Guidelines are being developed, and the Federal Highway Administration established the program with applications due by May 30, 2023.
Clean School Bus Program	$5 billion between FY2022 and FY2026	The program provides funding to replace existing school buses with zero-emission and low-emission buses. In most cases, funding will be awarded directly to school districts. The first funding opportunity under this program is the 2022 Clean School Bus Rebates with the EPA offering $500 million for zero-emission and low-emission school buses.
Battery Material Processing Grant Program	$3 billion between FY2022 and FY2026	Administered by the Department of Energy's Office of Fossil Energy and Carbon Management, this program will fund demonstration projects and the construction of facilities for processing battery materials.
Battery Manufacturing and Recycling Grants Program	$3 billion between FY2022 and FY2026	Administered by the Department of Energy's Office of Energy Efficiency and Renewable Energy, this program will fund demonstration projects and the construction of facilities for advanced battery component manufacturing, advanced battery manufacturing, and recycling.

TABLE B-1 | Provisions in US legislation that accelerate EV deployment (Cont.)

PROGRAM NAME	FUNDING AMOUNT	PROGRAM DESCRIPTION
The Inflation Reduction Act takes significant steps to accelerate vehicle electrification by providing incentives to spur greater adoption of EVs and promoting domestic manufacturing of zero-emission vehicles. Key provisions are listed below under two categories—tax credits and domestic manufacturing investments.[b]		
Section 30D tax credit for new EVs	$7.5 billion until December 2032	The provision provides up to $7,500 in consumer tax credit. The credit amount is divided equally such that a vehicle will qualify for a $3,750 tax credit if it meets a "critical materials" requirement and another $3,750 if it meets a "battery component" requirement. The critical materials requirement provides that a specified portion of the materials contained in the battery must be extracted or processed in a country with which the United States has a free trade agreement or that the materials be recycled in North America. This requirement starts at 40% and increases to 80% after 2026. The battery component requires that a specified portion of the components must be manufactured or assembled in North America. This requirement starts at 50% and increases to 100% after 2028. Vehicles in which the critical materials or components of a battery are sourced from a "foreign entity of concern" (e.g., an entity owned or controlled by the government of China or Russia) are not eligible. The final assembly of vehicles should be in North America. Taxpayers are permitted to transfer the credit to the dealer from which the vehicle has been purchased if the dealer has been registered with the Secretary of the Treasury and meets other requirements. This will enable buyers to receive the credit as a rebate at the point of sale. Price caps have been set for qualifying vehicles and modified adjusted gross income limitations placed on eligible taxpayers. (Van/SUV/pickup truck threshold is $80,000, others $55,000; income limitation for joint returns = $300,000, head of household = $225,000, other = $150,000).
Section 25E tax credit for used EVs	$1.4 billion until December 2032	The provision provides up to $4,000 in consumer tax credit. Buyers can qualify for a credit that is the lesser of $4,000 or 30% of the sales price for used EVs weighing less than 14,000 lbs. The sales price of a qualified used EV cannot exceed $25,000, and the vehicle must be at least two years old. There are income caps for eligibility (single = $75,000, head of household = $112,500, joint filing = $150,000).
Section 45W tax credit for commercial EVs	$3.6 billion until December 2032	The tax credit provides up to $7,500 for vehicles with a gross vehicle weight rating (GVWR) of less than 14,000 lbs., and up to $40,000 for vehicles with a GVWR of more than 14,000 lbs. The eligible credit amount per qualified commercial EV is the lesser of 30% of the sales price or the incremental cost of the vehicle. The incremental cost is defined as the difference between the purchase price of the EV and that of a comparable internal combustion engine vehicle. There are no battery or mineral sourcing requirements under Section 45W. Direct pay is available for non-taxable entities.
Section 30C alternative refueling property credit	$1.7 billion until December 2032	The provision provides up to 30% of the cost of a "qualified alternative fuel vehicle refueling" station, subject to a limit of $100,000 per station. The tax credit starts at a 6% baseline, with the full 30% available only if certain prevailing wage and apprenticeship requirements are met. Credits are also restricted to locations in low-income communities and census tracts that are "not an urban area." Residential consumers who purchase residential refueling equipment may receive a tax credit of up to $1,000.
Advanced Manufacturing Production Tax Credit	$30.6 billion until December 2032	The tax credit provides $35/kWh of capacity for battery cells and $10/kWh for makers of battery modules.
Domestic Manufacturing Conversion Grant Program	$2 billion through 2031	Grants are provided to retool existing auto manufacturing facilities to produce clean vehicles, including hybrids, plug-in hybrids, EVs, and hydrogen fuel cell vehicles.
Advanced Technology Vehicle Manufacturing Loan Program	$3 billion	The DOE Loan Programs Office will provide direct loans for re-equipping, expanding, or establishing manufacturing facilities for making low- or no-emission vehicles and their components.

TABLE B-1 | Provisions in US legislation that accelerate EV deployment (Cont.)

PROGRAM NAME	FUNDING AMOUNT	PROGRAM DESCRIPTION
Section 48C Advanced Energy Project Investment Tax Credit	$10 billion—energy storage technology projects starting construction before December 31, 2024, are eligible	Factory owners apply to the IRS for tax credits worth up to 30% of the project value, with the full credit value available to those meeting prevailing wage and apprenticeship standards, and bonuses for projects located in energy communities. Forty percent of the funds are earmarked for projects in these communities.
Clean Heavy-Duty Vehicle Program	$1 billion through 2031	The EPA will offer grants and rebates to eligible participants to replace existing class 6 and 7 heavy-duty vehicles with zero-emission vehicles. From this funding, $400 million is earmarked for communities in nonattainment areas.
The CHIPS Act includes several billion dollars for semiconductor research, development, and manufacturing, including dedicated funding set aside for chips used in automobiles.[c]		
Section 48D Advanced Manufacturing Investment Credit	$24 billion until December 2026	The provision provides a 25% investment tax credit for investments in manufacturing of semiconductors and related equipment. The tax credit is eligible for direct pay option.
CHIPS Fund	$50 billion over five years	Funding is provided over five years to build, expand, or modernize domestic facilities and equipment for semiconductor fabrication, assembly, testing, advanced packaging, or research and development; $2 billion is devoted to legacy chip production in the auto industry and the military.
CHIPS for America Workforce and Education Fund	$200 million over five years	Funding is provided to the National Science Foundation to promote the development of the domestic semiconductor workforce.

Note: FY = fiscal year; EPA = Environmental Protection Agency; SUV = sport utility vehicle; lbs. = pounds; IRS = Internal Revenue Service.

Sources: a. US Congress 2021; b. US Congress 2022b; c. US Congress 2022a.

APPENDIX C: MODELING ASSUMPTIONS AND METHODOLOGY

Approach

Our analysis in this paper modeled the employment impact of the EV transition between 2024 and 2040, focusing on light-duty passenger vehicles. WRI developed the assumptions for this analysis in partnership with John A. "Skip" Laitner of Economic and Human Dimensions Research Associates, who also conducted the economic modeling.

The analysis relies on the DEEPER model, which is a quasi-dynamic linear programming model. DEEPER takes patterns of spending across time and matches them with coefficients based on IMPLAN, an input-output model grounded in data from the US Bureau of Economic Analysis, to determine a final net spending pattern for the Michigan economy and the jobs that translates to. It has been widely used and was the foundational model for the American Council for an Energy-Efficient Economy.

While data on Michigan's present day economic activity are geographically specific, it is important to note that projections of future activity cannot be interpreted as geographically bound. The estimates we present reflect the Michigan employment associated with the vehicle electrification and competitiveness scenarios we define assuming current state-level geographic patterns of corporate spending hold constant. Actual employment could differ if firms change where they locate specific operations, or even where they purchase inputs.

Electric vehicle sales scenarios

For our analysis, we modeled three scenarios of EV update: an All Electric by 2033 scenario, a Current Policy scenario (not presented in the full report), and a No Transition reference scenario (Figure C-1). These scenarios refer to EV LDV sales penetration for both Michigan and the United States as a whole.

In 2021, EVs reached 4.7 percent of vehicle sales in the United States. In our Current Policy scenario, EVs reach around 50 percent of LDV sales in 2030 and around 90 percent of sales in 2040. This was derived from the Economic Transition scenario from BloombergNEF (BNEF), which assumes that US EV sales are primarily driven by technological and economic trends, and that no new policies or regulations are enacted that impact the market. BNEF's latest update of its Economic Transition scenario (BNEF 2022b) accounts for the impacts of the Inflation Reduction Act, but it goes only to 2030. Therefore, we extrapolated past 2030 by using the average growth rate for 2030–40 from a prior version of the analysis (BNEF 2022a), simply adjusting the 2030 starting point upwards based on the new pre-2030 analysis.

In our All Electric by 2033 scenario, EVs reach around 60 percent of LDV sales in 2030 and 100 percent of sales by 2033. This was derived from BNEF's Net Zero scenario, which investigates what it would take to reach net-zero emissions for the road transport sector in the United States (BNEF 2022a). We adjusted BNEF's Net Zero scenario for the years prior to 2027 to ensure that the All Electric by 2033 scenario was not lower than the current policy scenario.

Note that in BNEF's scenarios EVs include battery electric vehicles (BEVs), plug-in hybrid vehicles, and fuel cell electric vehicles. BNEF does not provide a breakdown for the United States, but globally it forecasts that BEVs will dominate, making up 88 percent of these types of sales in 2030 and 97 percent in 2040. In our scenarios, we assumed that all the EV sales will be BEVs. This greatly simplified the modeling needed, and we feel it is appropriate given that automakers are primarily focused on expanding their lines of BEVs and the majority of EV sales are expected to be BEVs in the coming decades. Therefore, when we use the term "electric vehicle" in this publication, we are referring only to BEVs.

Finally, we also modeled a No Transition reference scenario in which no EVs are sold, only ICE vehicles. We measured the employment impacts of the other two scenarios in comparison to this No Transition scenario, thereby isolating the effects of the transition to EVs from other trends. For example, our modeling assumes that labor productivity gains will continue to reduce the number of jobs needed per unit of output across the entire economy, including for both EVs and ICE vehicles. By using a No Transition scenario, we controlled for this effect. An important note is that this No Transition scenario is not a business-as-usual scenario, and it is not something that is remotely realistic. If Michigan continued to buy and produce only ICE vehicles, it would be left behind as the rest of the world pivots to EVs, very likely losing substantial market share. The continued use of ICE vehicles would also contribute to climate damages. The No Transition scenario is simply included to give a sense of the scale of the employment transition that is needed.

Assumptions and sensitivities

For each EV sales scenario, we developed assumptions around the amount of expenditure in the various auto-related sectors of Michigan's economy.

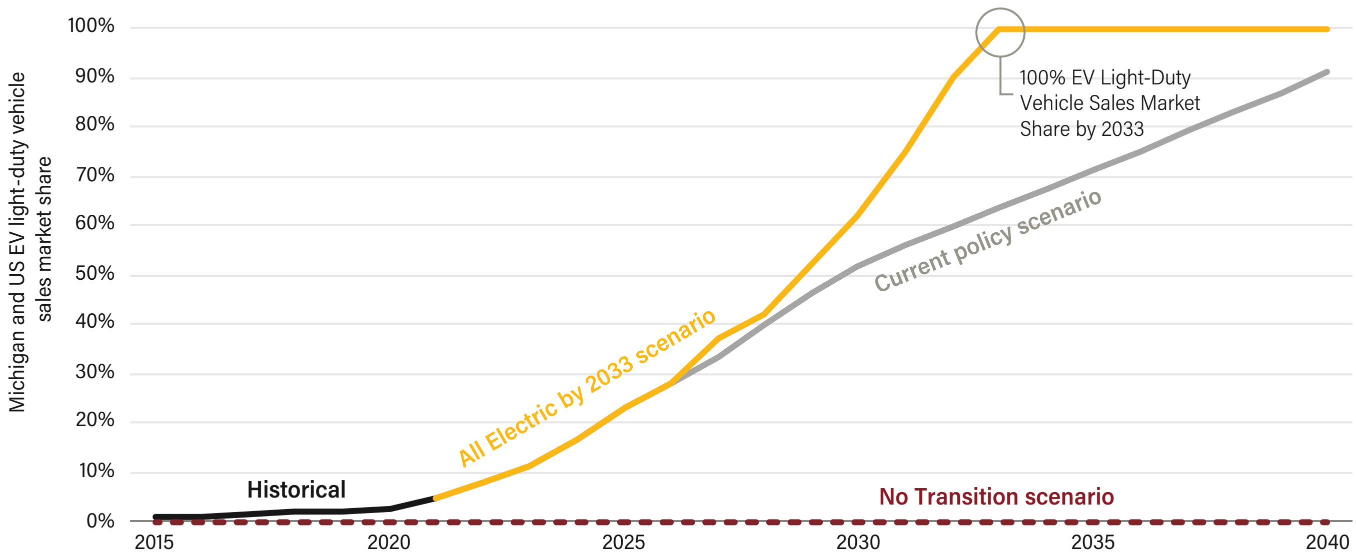
For the following sectors, we divided the expenditures into how much would go into EV-related expenditures versus how much would go to ICE vehicle–related expenditures in each scenario.

- Auto manufacturing: Everything except batteries (expenditures on EV production versus ICE vehicle production)
- Fuel (expenditures on gasoline versus electricity)
- Maintenance and repair (expenditures on EV maintenance and repair versus ICE vehicle maintenance and repair)
- Auto financing (expenditures on EV financing versus ICE vehicle financing)
- Insurance and fees (expenditures on EV insurance and fees versus ICE vehicle insurance and fees)
- Re-spending of savings from vehicle ownership (depends on whether EVs or ICE vehicles are cheaper)

For other sectors, we looked only at expenditures relevant to EVs in each scenario, because there is no ICE vehicle equivalent:

- Battery manufacturing
- EV charging infrastructure

FIGURE C-1 | EV sales modeling scenarios



Note: EV = electric vehicle.

Source: Authors, based on BNEF 2022a, BNEF 2022b, and own calculations.

Auto manufacturing expenditures: Everything except batteries

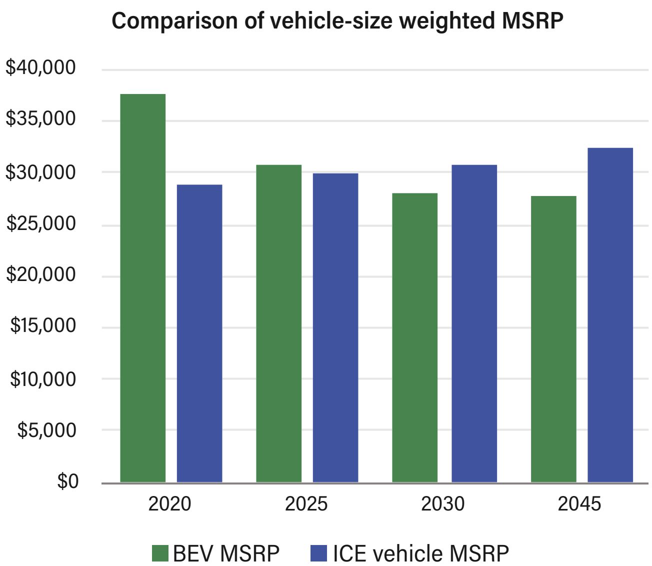
We arrived at our assumptions for auto manufacturing expenditures (except batteries) by multiplying the cost of vehicles for each type of powertrain and segment by the number of vehicles manufactured in Michigan and then making adjustments to compensate for the changed composition of EVs compared with ICE vehicles.

Our definition of the automotive sector includes the full value chain of electric vehicles, with battery manufacturing representing a new and critical part. However, given the salience of battery manufacturing in a changing auto industry and due to modeling constraints, employment in battery manufacturing was estimated separately from automotive manufacturing, and the battery materials supply chain was not included.

Vehicle costs:

We used Argonne National Lab's BEAN tool to form our assumptions about EV and ICE vehicle manufacturing costs (ANL 2022). We used the BEAN tool's vehicle manufacturing price outputs to estimate the cost of EVs and ICE vehicles in 2025, 2030, and 2045 by car segment (compact, midsize, small SUV, midsize SUV, pickup). These prices were based on the BEAN tool's medium technology progress scenario, which assumes a medium level of progress in efficiency for powertrain technologies. Instead of using the BEAN tool's default battery costs for 2025 and 2030, we substituted in EV battery cost projections from BNEF (2022a): $85 per kilowatt-hour in 2025 and $59 per kilowatt-hour in 2030. BNEF's data extends only to 2035 so to arrive at the 2045 input for the BEAN tool we assumed that the ratio between the BNEF battery cost estimates and the BEAN tool battery cost estimates in 2045 is the same as it was in 2035, arriving at an assumption of $34 per kilowatt-hour in 2045. We assumed that EVs have a 300-mile range in 2025 and 2030 and a 400-mile range in 2045. Using these assumptions in the BEAN tool, EVs are less expensive than ICE vehicles for compact and midsize cars in 2025, and they are less expensive for all vehicle segments in 2030 and after. The BEAN tool provides vehicle costs only for 2025, 2030, and 2045, so we interpolated vehicle costs for the years in between. As we did not include sales of used cars in our modeling, the resale values of vehicles were not included. See Figure C-2.

FIGURE C-2 | Vehicle cost assumptions



Note: MSRP = manufacturer's suggested retail price; BEV = battery electric vehicle; ICE = internal combustion engine.

Sources: ANL 2022; BNEF 2022a; authors.

Quantity of vehicles manufactured in Michigan:

The starting point of our calculations was to consider the total number of vehicles projected to be sold in the United States (BNEF 2022a).

For ICE vehicles, we assumed that 52 percent of LDVs sold within the United States will be manufactured in the United States, keeping the share the same as it was for all vehicles in 2017 (Schultz et al. 2019).

For EVs, we assumed that the Inflation Reduction Act's tax incentives successfully onshore more EV manufacturing. For companies to access IRA tax credits, final assembly of EVs has to take place in North America, effective immediately. Final assembly is expected to be in North America for 76 percent of US EV sales in 2022–23 (BNEF 2022b). We assumed that over the next five years that share increases steadily, reaching 100 percent of final assembly taking place in North America in 2028. However, the United States will likely not make up all North American EV manufacturing. For example, of the LDVs purchased in the United States in 2017, 52 percent were US-produced, 14 percent were Mexico-produced, 11 percent were Canada-produced, and 23 percent were produced elsewhere (Schultz et al. 2019). In a situation where final assembly takes place only in North America, we assumed the breakdown would be 68 percent US-produced, 18 percent Mexico-produced, and 14 percent Canada-produced.

The next step was to determine what share of the US vehicle manufacturing market will be taken up by Michigan. Since 2009, Michigan's share of US vehicle production has fluctuated from roughly 17 percent to 24 percent (Dziczek 2022). In the No Transition scenario, we assumed that 20 percent of US vehicle production is manufactured in Michigan throughout the study period. For the Current Policy and All Electric by 2033 scenarios, we adjusted this depending on the case. In our High Competitiveness case we assumed Michigan's share starts at 20 percent and increases to 25 percent in 2030, staying at that level thereafter. This is an optimistic assumption and would require Michigan to seize the opportunity with EVs to gain market share. Therefore, we also included a Low Competitiveness case in which Michigan's share starts at 20 percent of US production and then declines to 15 percent in 2030, staying at that level thereafter.

We focused on domestic sales, not including the value of motor vehicles and parts that Michigan exports, which totaled about $16 billion in 2020 (GlobalEdge and MSU 2020). As those exports go mostly to Canada, which has a 2035 zero-emission target for LDVs, we would expect the inclusion of exports to only accentuate the trends seen in our results for auto manufacturing, though not for sectors based on the number of EVs sold in Michigan.

We weighted Michigan's vehicle manufacturing and purchases to reflect 2020 market shares of vehicle segments, holding those constant through 2040. However, the vehicle segments that we used to calculate costs in the BEAN tool (compact, midsize, small SUV, midsize SUV, pickup) did not align with the vehicle segments used to project sales from BNEF (small, medium, large, SUVs). We needed to match these to calculate total expenditures on vehicle manufacturing, so we translated the BNEF segment sales numbers into percentages and then aligned those to the BEAN categories. We translated sales of small to compact, medium to midsize, large to pickup, and split SUVs evenly into small SUVs and midsize SUVs.

To calculate how many vehicles Michigan will manufacture in each segment, we multiplied the percentage of vehicles sold in each segment by the number of US sales of vehicles manufactured in Michigan. We assumed that the breakdown of segments of vehicles that Michigan manufactures is identical to the national breakdown. For each segment, we distributed the number of vehicles manufactured in Michigan between EVs and ICE vehicles based on our scenarios and previously described assumptions. We assumed that the share of vehicles that are EVs versus ICE vehicles in a given year is the same across each segment.

Labor intensity adjustments

EVs are less complex and have fewer moving parts than ICE vehicles, which is expected to make them easier to assemble. It is difficult to know for certain what the labor comparison will be given that the EV industry is still relatively new, but we wanted to account for this expected change. Ford and Volkswagen have both estimated that EV manufacturing will require 30 percent less labor (Hackett 2017; Fraunhofer IAO 2020), and we validated the estimate in our stakeholder consultations. Therefore, in the modeling we modified our job multipliers for all aspects of auto manufacturing excluding batteries to reflect that EVs require 30 percent less labor to manufacture than ICE vehicles. Other studies use similar assumptions (Barrett and Bivens 2021).

Some studies find that there is no difference between labor for EVs and that for ICE vehicles (Küpper et al. 2020; Cotterman 2022), but these studies take into account that the decrease in labor for vehicle manufacturing is made up for by the increase in labor for battery manufacturing. In our analysis, we considered vehicle and battery manufacturing separately, which is why we applied this assumption of 30 percent less labor than ICE vehicle manufacturing to the EV manufacturing side of our analysis. We are not experts in the auto manufacturing process, but we have validated this assumption with stakeholders throughout Michigan. There is not a consensus given that electric vehicles are an evolving technology, but this is a working assumption. We kept the value constant at 30 percent for simplicity, but it could be that the relative labor intensity of EV production to ICE vehicle production changes over time as the EV industry develops.

Transport, wholesale, and dealership jobs

Our modeling in DEEPER for all aspects of auto manufacturing except for batteries encompassed not only manufacturing but also the transport, wholesale, and retail dealership jobs that go along with manufacturing. Our modeling applied a simple ratio to the changes in manufacturing expenditures to determine the effect on transport, wholesale, and retail dealerships based on their past economic relationship. We did not add any specific assumptions about how the shift to EVs will change these types of jobs beyond changing expenditures in the overall manufacturing sector, though direct sales models embraced first by Tesla and now by Ford could change industry dynamics.

Battery manufacturing expenditures

EV batteries represent a significant portion of the automotive value chain and are not fully accounted for in historical automotive manufacturing data, which primarily reflect the production process of ICE vehicles. To better reflect total vehicle manufacturing costs, the total costs of EV batteries were modeled separately.

We first estimated the total value of all EV batteries sold in the United States in each scenario in a given year. We did this using the same battery cost assumptions per segment and BEAN tool battery cost outputs as described in the previous section, multiplied times the number of EVs sold in the United States in each segment for each scenario. This means that our battery costs reflect EV batteries that vary by vehicle size, go from a 300-mile range in 2025 and 2030 to a 400-mile range in 2045, and consider the changing price per kilowatt-hour from BNEF, as well as updates to vehicle efficiency embedded in the BEAN tool. We did not include battery exports.

The next step was to determine how much of the total value of all EV batteries sold in the United States would be captured domestically, and by Michigan in particular.

First, to determine the number of batteries sold in the United States that are produced domestically, we considered the requirements of the Inflation Reduction Act. The IRA aims to vastly increase the amount of EV batteries produced domestically. The IRA bifurcates the $7,500 consumer tax credit amount so that a vehicle will qualify for a $3,750 tax credit if it meets a "critical materials" requirement and another $3,750 if it meets a "battery component" requirement. The critical materials requirement provides that a specified portion of the materials contained in the battery must be extracted or processed in a country with which the United States has a free trade agreement or that they be recycled in North America. This requirement starts at 40 percent and increases to 80 percent after 2026. The battery component requires that a specified portion of the components must be manufactured or assembled in North America. This requirement starts at 50 percent and increases to 100 percent after 2028. The value chain of EV batteries is complex and changing quickly, and the exact ways in which these domestic content provisions of the IRA will be administered and enforced is yet to be determined, so understanding the full impact is difficult.

To understand what the impact of the IRA's battery component requirement could be, we assumed all vehicles sold in the United States fully meet the IRA's domestic content requirements for batteries to access the tax credits. This is likely possible because there have been enough announcements of planned lithium-ion battery plants in North America to meet expected US EV demand in 2030 (BNEF 2022b), and there will presumably be more announcements in the future. Based on our research, the United States is expected to make up 85 percent of North American battery capacity—the United States has approximately 700 gigawatt-hours (GWh) of battery production announced for 2030 (BMI 2022); Canada has approximately 120 GWh of battery production announced for 2030 (Gisbert and Careaga 2022); there is no announced battery capacity in Mexico yet. Applying this ratio to the IRA requirements, we assumed that 43 percent of EV battery production will be in the United States in 2023, rising to 85 percent in 2029. The IRA provisions are set to expire after 2032, but we assumed that 85 percent of EV batteries will continue to be produced in the United States.

The second step was to determine what proportion of the US EV battery value chain is captured by Michigan. In 2021, Michigan manufactured 9.7 percent of US batteries, according to Benchmark Mineral Intelligence with updates by Our Next Energy (BMI 2022). In our reference scenario, Michigan manufactures 10 percent of US batteries throughout the time period. In the Current Policy and All Electric by 2033 scenarios we adjusted this depending on the case. For the High Competitiveness case, we assumed that Michigan begins by manufacturing 10 percent of US batteries today, but this rises to 15 percent by 2030 and stays at 15 percent thereafter. This is an optimistic assumption, so we also modeled a Low Competitiveness case in which Michigan begins by manufacturing 10 percent of US batteries today, but this falls to 5 percent by 2030 and stays at 5 percent thereafter.

Total cost of ownership (TCO)

While manufacturing expenditures depend on the number of vehicles sold by Michigan plants, TCO expenditures depend on the number of vehicles purchased by Michigan households, firms, and others. We assumed that 2.78 percent of vehicles sold in the United States end up in Michigan based on the average percentage of LDVs in the United States that were registered in Michigan from 2015 to 2020 (DOT 2022).

We calculated the TCO for vehicles using the BEAN tool for each powertrain and each car segment in each year, and then added those numbers to find the total TCO. We used the BEAN tool with certain settings adjustments. We adjusted the default price of gasoline and electricity to account for Michigan having prices different than national average prices. We assumed that vehicles will travel 14,000 miles per year at the start, which gradually declines over the vehicles' lifetimes. We assumed that the MSRP was 40 percent higher than the cost of manufacturing the vehicle based on Bureau of Labor Statistics data. We used the BEAN tool's medium technology scenario, and a 5 percent discount rate.

Using the tool, we found the costs of financing, fuel or electricity, insurance, taxes and fees, maintenance and repair, and net savings, as well as the other costs provided by the tool for each vehicle type on an annual basis. We then multiplied the total cost of ownership by the total number of EVs and ICE vehicles by segment on Michigan roads per year, assuming vehicles have a 12-year lifetime, to get the total expenditures on TCO.

1. Financing

We used the cost of financing per vehicle found in ANL's BEAN tool and employed the previously mentioned settings. We assumed 100 percent of vehicle sales are financed at a 4 percent financing rate over a six-year term.

2. Fuel for ICE vehicles (gasoline)

We used the cost of gasoline per vehicle found in ANL's BEAN tool and employed the previously mentioned settings and the following adjustments.

We projected the price of fuel in Michigan through 2040 by finding the difference between US fuel prices and Michigan fuel prices from 2010 to 2019 using data from the US Energy Information Administration's State Energy Data System (EIA 2022a). We calculated that difference as a percentage and added that to the projected cost of fuel in the United States for 2025–40 from the EIA Annual Energy Outlook 2022's Reference scenario to find Michigan-specific costs for each year. These estimates likely underestimate ICE fuel costs, as the EIA projections do not capture effects from the Russian invasion of Ukraine. We used EIA fuel efficiency projections for LDVs to calculate the amount of fuel needed per vehicle on an annual basis.

3. Fuel for EVs (electricity)

We used the cost of electricity per vehicle found in ANL's BEAN tool and employed the previously mentioned settings and the following adjustments.

We projected the price of electricity in Michigan through 2040 by finding the difference between US electricity prices and Michigan electricity prices from 2010 to 2020 using data from the EIA (EIA 2022a). We calculated that difference as a percentage for both residential and commercial electricity prices and added that to the EIA's projected cost of electricity in the United States for 2025–40 to find Michigan-specific costs. For residential electricity prices, we assumed an additional discount of 25 percent, as we expect utilities to move to time-of-use charging rates to encourage off-peak charging. This discount is based on the difference between the average rate and the off-peak EV rate charged by Pacific Gas and Electric, the largest utility in the state with the highest rate of EV ownership. Note, we didn't include it in our modeling, but the Inflation Reduction Act is likely to make electricity prices cheaper for households (O'Boyle et al. 2022).

We assumed that each EV requires 0.32 kilowatt-hours per mile (kWh/mi) of electricity generation and consumes approximately 0.30 kWh/mi of alternating current energy, assuming 4.9 percent system losses for transmission and distribution, based on a calculation from the Department of Energy (DOE 2019). The 4.9 percent is specific to Michigan, using EIA data from 2020, and mirrors the 4.9 percent used nationally by DOE.

Referencing the International Council on Clean Transportation's estimates that home charging will fall from 78 percent of EV electricity consumption in 2020 to 59 percent by 2030, we assumed that 80 percent of charging will take place at home in 2024, decreasing to 60 percent over time (Bauer et al. 2021). Additionally, to account for decreased battery range during Michigan's cold winters, we assumed a 40 percent drop in battery efficiency and a corresponding increase in electricity needs for three months of the year.

4. Insurance

We used the default cost of insurance per vehicle found in ANL's BEAN tool and employed the previously mentioned settings.

5. Taxes and fees

We used the default cost of taxes and fees per vehicle found in ANL's BEAN tool and adjusted the BEV fee to reflect Michigan's $140 annual EV fee for non-hybrid vehicles.

6. Maintenance and repair

We used the cost of maintenance and repair per vehicle found in ANL's BEAN tool and employed the previously mentioned settings. EVs are expected to require less maintenance and repair than ICE vehicles as they are less complex. On average, the BEAN tool has EVs requiring 41 percent lower maintenance and repair costs than ICE vehicles.

7. Net savings

EVs are going to be cheaper to own and operate than ICE vehicles, so consumers will save money. The BEAN tool does not output these savings, so we calculated them ourselves. For every EV, we used the difference between the projected EV and ICE vehicle model MSRP each year, multiplied that by the number of vehicles sold each year, and added that to the savings total. We did the same for total cost of ownership to reflect the savings on fuel and maintenance and repair that accrue to EV owners. For the modeling, we assumed that 100 percent of those savings are re-spent in the rest of the US economy, but only about 65 percent of that is spent in Michigan—consistent with observed consumer spending patterns.

EV charging infrastructure

Using cost estimates derived in Bauer et al. (2021), we assumed that each EV sold in Michigan will require $1,100 in investment in non-home (public and workplace) charging, and $850 invested in at-home charging. Applying these to the 2.78 percent of US vehicles sold in Michigan each year, we arrived at annual estimates for expenditures on construction of electric vehicle supply equipment in Michigan. Based on the finding of Bauer et al. (2021) that public and workplace chargers can support 13 EVs per charger, and data from Argonne National Lab's EVSE JOBS tool showing that EV charging stations require $55 in operational expenditures per month, we estimated cumulative spending on public EVSE operations throughout the time period, with the assumption that all non-home EV charging stations have a life of 10 years. We assumed replacing non-home EV charging stations costs 10 percent of the original expenditure on the station, consistent with the range provided in Nelder and Rogers (2019).

Key limitations of assumptions

It is challenging to model electric vehicles and battery manufacturing when the industry is so new and still evolving rapidly. Our analysis is intended to provide indicative insights into what the employment impacts of the transition could be, especially to understand the direction of the impacts. The level of uncertainty in our results is high, and the level of precision is low. Especially for results past 2030, there are fewer data points available to form assumptions. Small changes to the assumptions can cause substantial changes in the results. We conducted multiple rounds of modeling to improve our methods. We consider this analysis to be one of the most in-depth modeling exercises of the auto industry and supply chain as it regards the EV transition, but the auto supply chain is incredibly complex and there were numerous data limitations, so we made many simplifying assumptions and educated guesses, as described in the sections above.

There are several types of jobs emerging from the EV transition that we were unable to model due to data or time limitations. These include recycling of EV batteries, upgrades of manufacturing facilities to allow them to produce EVs, and the manufacturing of EV charging equipment. Each of these sectors would increase the number of jobs as a result of the EV transition if the job gains in these sectors were greater than the number of jobs lost in ICE vehicle recycling and manufacturing of gasoline pumps.

Our model does not reflect all expected or potential structural shifts within sectors. In the case of gasoline, the No Transition scenario includes basic assumptions about labor productivity increases based on economic trends but does not account for the fact that many gasoline retail jobs are likely to disappear due to automation regardless of vehicle electrification trends. Our estimates for the automotive sector do not incorporate a shift away from the dominant dealership sales model that is being challenged by the direct sales models of new EV manufacturers.

We attempted to incorporate the EV provisions in the IRA as much as possible but did not capture every element. Our main scenarios did not include the critical minerals requirements of the IRA in our assumptions due to the complexity of modeling them and the fact that the rules were not yet finalized, though these are incorporated into the separate section estimating consumer savings due to the IRA. We did not consider the IRA's battery production tax, the shifts in earnings associated with the prevailing wage requirements of the IRA, or the household savings associated with its EV tax credits. While these types of price changes would impact the results in some ways, they do not impact our scenarios of EV penetration since the scenarios are set exogenously, not based on the cost of the vehicles.

Our analysis of electricity costs is based on the current electricity generation mix. We did not model changes to the energy system such as a shift to renewables or an expansion of the electric grid, given that the focus of our modeling was on the auto industry, not the broader energy system. That is, our modeling for electricity purchases considers the jobs effect of operation of electricity generation, transmission, and distribution, but not new construction.

The DEEPER model

The foundation for the overall economic assessment was the proprietary modeling system known as the Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER). The model, developed by Skip Laitner in early 1992, is a quasi-dynamic input-output model of a given local, state, or national economy. The model is essentially a recipe that shows how different sectors of the economy are expected to buy and sell to each other, and how they might, in turn, be affected by changed investment and spending patterns. Setting up that production recipe is a first step in exploring the future job creation opportunities and other macroeconomic impacts as, in this case, Michigan shifts from the production of internal combustion engine vehicles to the manufacture, purchase, and use of electric vehicles over time.

Although it has been updated here to reflect the economic dynamics specific to Michigan, the formal DEEPER model has a 30-year history of development and application while even earlier versions of the tool were used by entities like the Arizona Energy Office and the Nebraska Energy Office in the mid-1980s. The model was utilized to assess the net employment impacts of proposed automobile fuel economy standards within the United States in 2012 (Busch et al. 2011). It also underpinned the 2012 *Long-Term Energy Efficiency Potential* study (Laitner et al. 2012). It has been employed to evaluate the macroeconomic impacts of a variety of energy efficiency, renewable energy, and climate policies at the regional, state, national, and international levels. As a recent illustration, it was used to show the positive economic and employment benefits in a 2021 assessment of a $16 trillion investment strategy to reduce the nation's energy-related carbon emissions over the next several decades (Rifkin 2021). While this WRI report has been peer-reviewed, the DEEPER model has not been independently evaluated.

The timeframe of the model for evaluating the EV transition in Michigan was 2019 through 2040. The IMPLAN data on Michigan employment that was used as the basis for the

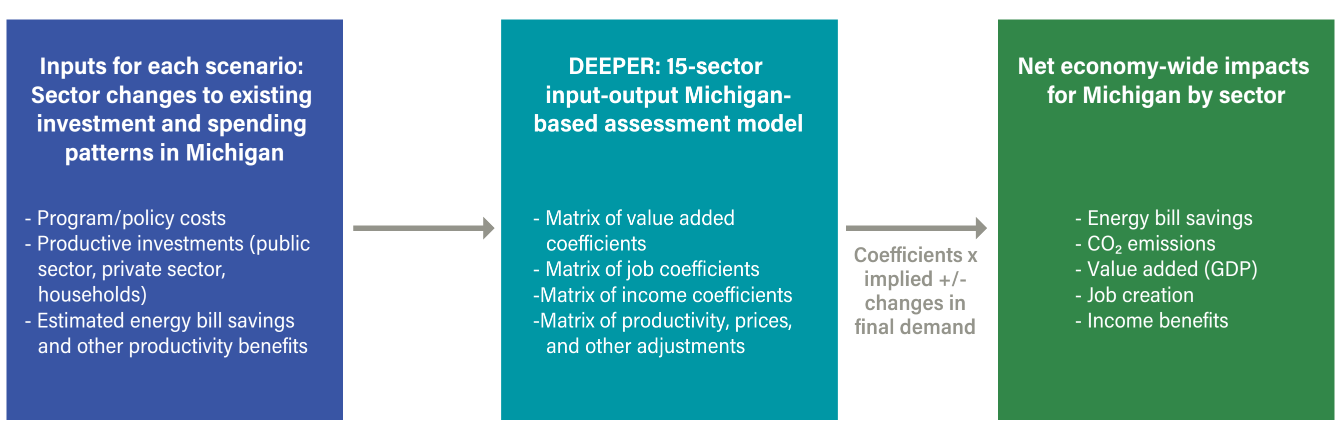
DEEPER modeling was from 2019. The years 2019 through 2023 provided a useful benchmark. The period 2024 through 2040 afforded an assessment of future trends and is what we present in the report. As it was implemented for this analysis, the model mapped in the changed spending and investment patterns that might be undertaken as a result of the EV transition. Results are expressed in "job-years," or employment associated with a spending and investment pattern in a given year. A single job or position created by an employer that lasts for five years is equivalent to five job-years. The structural core of the model relies on a variety of data made available by IMPLAN LLC, Woods & Poole Economics, the Bureau of Labor Statistics, and the Energy Information Administration—with all data used or purchased in 2022. Figure C-3 provides a diagrammatic view of the DEEPER Modeling System as it was reflected within the dynamics of all previous assessments.

Although the DEEPER model is not a detailed general equilibrium model, it does provide sufficient accounting to track investments and expenditures within one sector of the economy and balance them against changes in other sectors. Like any economic assessment tool, however, there are some understandable limitations. While the model reflects anticipated changes in the future costs of energy, vehicle manufacturing, and the production of batteries, it does not fully track how changes in the use and production of vehicles might affect those costs. Moreover, the model does not reflect how changes in the production of electric vehicles and batteries might affect the sales and quantity of other goods and services within Michigan. As in IMPLAN, induced employment effects were not derived directly from the Department of Commerce's business survey evidence, so they are therefore less precise than direct and indirect employment estimates. Nonetheless, the model provides a set of what we call "useful indicative analytics" that can inform both businesses and policymakers about smart programs and policies that will likely strengthen the state's economic well-being and future employment opportunities while significantly reducing the economic burden of greenhouse gas emissions and air pollution.

Renewable energy thought experiment

This thought experiment first estimates the average annual investment necessary to construct and install renewable energy systems from 2024 through 2040, then multiplies that total by the number of jobs likely necessary to achieve that outcome. Using Michigan-specific data from the Energy Information Administration (EIA 2022a) on the Midcontinent Independent System Operator/East Electricity Supply Region and business-as-usual projections out to the year 2040 (EIA 2022b), the state will have an electric power net summer generation capacity of 30,574 megawatts (MW) in 2023, increasing to 39,112 MW by 2040. Renewables represent about 24.5 percent of capacity in 2023, rising to 32.7 percent by 2040. In this thought experiment we imagine renewables—specifically solar photovoltaic energy—representing an 80

FIGURE C-3 | The DEEPER Modeling System



Note: CO_2 = carbon dioxide; GDP = gross domestic product.
Source: Skip Laitner.

percent share by 2040. Adjusting for capacity factors based on the medium technology progress projections from the National Renewable Energy Laboratory's Annual Technology Baseline (NREL 2022)—42 percent for conventional electricity generation units and 23.5 percent for solar photovoltaic—renewables must grow from an estimated 13,402 MW in 2023 to 55,969 MW by 2040, a net increase of 42,567 (Table C1).

However, business-as-usual projections do not include electricity to power electric vehicles. In our All Electric by 2033 scenario, by 2040 Michigan EVs will consume an estimated 22,657,614 megawatt-hours (MWh) of electricity, requiring another 11,016 MW of renewables. A total increase of 53,583 MW of new capacity over the 17-year period 2024 through 2040 suggests an average annual increase of 3,152 MW in new photovoltaic installations, per Table C-1. The Annual Technology Baseline estimates costs of $1,336 per installed kilowatt of photovoltaic systems in 2024, declining to $770/kW by 2040.

We used an average cost of $1,053 per kW installed and the estimated average annual increase of 3,152 MW to arrive at an annual investment of $3,320 million (using 2019 constant dollars), per Table C-2.

Using the DEEPER Modeling System sector for construction for new power and communication structures in Michigan (IMPLAN 2021), adjusted for anticipated improvements in labor productivity (BLS 2022a), we arrived at a working estimate of 19,366 direct construction jobs; 3,865 supply-chain and manufacturing jobs; and 13,785 induced jobs through wages of the direct and indirect jobs that are re-spent in Michigan. In total, the average annual employment required to support this scale of infrastructure upgrade is estimated at 37,015 jobs per year, with the EV share of the total representing about 7,610 of that (Table C2).

TABLE C1 | Illustration of Michigan's potential for renewable energy expansion by 2040

IMPLIED CAPACITY BY CATEGORY OF GENERATION (MW)	2023	2024	2040
(1) BAU total net generation capacity	30,574	31,020	39,112
(2) Capacity-factor adjusted renewables—80% by 2040	13,402	14,351	55,969
(3) Implied year 2040 net increase			42,567
(4) Additional renewables capacity to support EV usage			11,016
(5) Net total renewables increase			53,583
(6) Average annual increase 2024 through 2040			3,152

Note: MW = megawatt; BAU = business as usual.
Source: Authors.

TABLE C-2 | Michigan jobs from renewables transition thought experiment

AVERAGE ANNUAL, 2024 TO 2040	DIRECT	INDIRECT	INDUCED	TOTAL
Average annual investment (2019 US$, millions)				3,320
Job coefficients (per million 2019 $)	5.83	1.16	4.15	11.15
Total electricity transition jobs (actual)	19,366	3,865	13,785	37,015
EV share of electricity transition jobs (actual)	3,981	795	2,834	7,610

Source: Authors.

Benefits of IRA tax credits

Our calculations in the section "Insights on aspects not included in the model" on the minimum value and employment impact of the IRA's EV tax credits relied on the estimated average tax credit value for all vehicles sold in the United States from the "High" scenario in Energy Innovation's *Implementing the Inflation Reduction Act* (Baldwin and Orvis 2022). In this scenario, 100 percent of vehicles satisfy IRA requirements around sourcing of minerals and components from entities of concern and other tax credit requirements by 2032, and 25 percent of the battery production tax credit is passed through to consumers. To develop an average tax credit value, Energy Innovation developed annual weighted average credit estimates for both the share of vehicles that could meet IRA domestic battery assembly requirements and those that could meet critical minerals requirements. It reduced the tax credit value to reflect that only vehicles estimated to be under the IRA's vehicle MSRP cap would qualify. It also limited the credit to whichever was least of the following three options: BEVs assembled in North America, qualifying consumers under the adjusted gross income cap, or estimates of the shares of vehicles that can meet the requirements for not sourcing materials from entities of concern. A 5 percent transferability penalty was applied to further reduce the average tax credit value to reflect transaction costs.

Our analysis used an estimated tax credit value that differs from the value used in Energy Innovation's analysis only in that it removed the estimated value of state EV rebates and incentives given that Michigan does not offer any. We calculated consumer savings due to IRA provisions by multiplying this average tax credit value by the number of vehicles sold to Michiganders in each year. For our estimate of the maximum consumer savings due to the IRA, we used the annual weighted average credit estimates from the High scenario of Energy Innovation and ICCT's January 2023 report *Analyzing the Impact of the Inflation Reduction Act on Electric Vehicle Uptake in the United States* (Slowik et. al 2023).

APPENDIX D: FULL MODELING RESULTS BY SCENARIO

TABLE D-1 | Expenditures by scenario (US$, millions)

SECTOR	SCENARIO	2024	2030	2040
Auto manufacturing: Everything except batteries	All Electric by 2033, High Competitive case	$43,687	$61,883	$55,305
	All Electric by 2033, Low Competitive case	$38,959	$38,939	$34,573
	No Transition	$40,475	$45,568	$40,510
Auto manufacturing: Battery manufacturing	All Electric by 2033, High Competitive case	$130	$4,835	$6,732
	All Electric by 2033, Low Competitive case	$167	$1,861	$2,244
	No Transition	$0	$0	$0
EV charging infrastructure	All Electric by 2033	$146	$607	$865
	No Transition	$0	$0	$0
Gasoline purchases	All Electric by 2033	$252	$1,164	$135
	No Transition	$350	$2,614	$4,312

TABLE D-1 | Expenditures by scenario (US$, millions) (Cont.)

SECTOR	SCENARIO	2024	2030	2040
Electricity purchases	All Electric by 2033	$52	$814	$2,647
	No Transition	$0	$0	$0
Auto maintenance and repair	All Electric by 2033	$480	$3,106	$4,029
	No Transition	$540	$4,018	$6,740
Auto finance	All Electric by 2033	$1,826	$11,641	$10,263
	No Transition	$1,753	$11,467	$10,856
Insurance, taxes, and fees	All Electric by 2033	$264	$3,932	$6,583
	No Transition	$519	$3,868	$6,502
Net savings on total cost of ownership	All Electric by 2033	$24	$1,309	$4,753
	No Transition	$0	$0	$0

Note: Full set of expenditures available upon request.

Source: Authors.

All Electric by 2033 scenario

High Competitive case

TABLE D-2 | Net jobs impact compared with No Transition scenario

ALL ELECTRIC BY 2033 SCENARIO—HIGH COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOB IMPACT	CUMULATIVE IMPACT 2024–40 (JOB-YEARS)
Auto manufacturing: Battery manufacturing	33,505	42,325	32,460	551,816
Auto manufacturing: Everything except batteries	22,765	-1,682	9,538	162,139
EV charging infrastructure	6,499	7,454	6,630	112,711
Net savings re-spending	8,538	26,919	14,019	238,328
EV electricity	4,216	11,756	6,248	106,212
Gasoline	-19,763	-46,144	-26,826	-456,040
Insurance, taxes, and fees	639	706	649	11,033
Maintenance and repair	-11,173	-25,709	-15,061	-256,030
Finance	2,148	-6,411	-1,131	-19,226
Total net effect	**47,374**	**9,214**	**26,526**	**450,943**

Source: Authors.

TABLE D-3 | Absolute jobs impact (from production and use of vehicles post-2024, not vehicles in use before 2024 that are still on the road)

ALL ELECTRIC BY 2033 SCENARIO—HIGH COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOB IMPACT	CUMULATIVE TOTAL IMPACT 2024–40 (JOB-YEARS)
Auto manufacturing: Battery manufacturing	33,505	42,325	32,460	551,816
Auto manufacturing: Everything except batteries	250,520	180,089	222,798	3,787,569
EV charging infrastructure	6,499	7,454	6,630	112,711
Net savings re-spending	8,538	26,919	14,019	238,328
EV electricity	4,216	11,756	6,248	106,212
Gasoline	15,867	1,489	11,696	198,835
Insurance, taxes, and fees	38,907	57,151	42,682	725,601
Maintenance and repair	38,046	38,212	36,356	618,058
Finance	143,232	111,667	114,081	1,939,374
Total effect	**539,330**	**477,062**	**486,970**	**8,278,504**

Source: Authors.

Low Competitive case

TABLE D-4 | Net jobs impact compared with No Transition scenario

ALL ELECTRIC BY 2033 SCENARIO—LOW COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOB IMPACT	CUMULATIVE TOTAL IMPACT (JOB-YEARS)
Auto manufacturing: Battery manufacturing	12,896	14,108	12,034	204,575
Auto manufacturing: Everything except batteries	-60,268	-63,172	-54,026	-918,443
EV charging infrastructure	6,499	7,454	6,630	112,711
Net savings re-spending	8,538	26,919	14,019	238,328
EV electricity	4,216	11,756	6,248	106,212
Gasoline	-19,763	-46,144	-26,826	-456,040
Insurance, taxes, and fees	639	706	649	11,033
Maintenance and repair	-11,173	-25,709	-15,061	-256,030
Finance	2,148	-6,411	-1,131	-19,226
Total net effect	**-56,268**	**-80,493**	**-57,464**	**-976,880**

Source: Authors.

TABLE D-5 | Absolute jobs impact (from production and use of vehicles post-2024, not vehicles in use before 2024 that are still on the road)

ALL ELECTRIC BY 2033 SCENARIO—LOW COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOB IMPACT	CUMULATIVE TOTAL IMPACT (JOB-YEARS)
Auto manufacturing: Battery manufacturing	12,896	14,108	12,034	204,575
Auto manufacturing: Everything except batteries	167,487	118,599	159,235	2,706,987
EV charging infrastructure	6,499	7,454	6,630	112,711
Net savings re-spending	8,538	26,919	14,019	238,328
EV electricity	4,216	11,756	6,248	106,212
Gasoline	15,867	1,489	11,696	198,835
Insurance, taxes, and fees	38,907	57,151	42,682	725,601
Maintenance and repair	38,046	38,212	36,356	618,058
Finance	143,232	111,667	114,081	1,939,374
Total effect	**435,688**	**387,355**	**402,981**	**6,850,681**

Source: Authors.

Range of the High and Low Competitiveness cases in the All Electric by 2030 scenario

The High and Low Competitiveness cases form a range of what outcomes in Michigan could occur under an All Electric by 2033 scenario. This range is from around 27,000 more net jobs supported on average per year compared with a No Transition scenario (in the High Competitiveness case) to around 57,000 fewer net jobs supported on average per year compared with a No Transition scenario (in the Low Competitiveness case). The average of two cases would be around 15,000 fewer jobs supported on average per year compared with a No Transition scenario. Whether Michigan ends up on the upper or lower end of this spectrum depends on whether the state puts in place the right policies to be a leader in auto and battery manufacturing going forward.

Current Policy scenario

In the Current Policy scenario, the United States and Michigan reach around 50 percent of LDV sales in 2030 and around 90 percent of sales in 2040. This is based on national sales expectations. For Michigan's auto manufacturing sector, national sales trends are important because Michigan exports cars to states across the nation. The number of EVs sold in Michigan itself will likely lag these expectations without more policies, but the scenario is consistent with the MI Healthy Climate Plan target of 50 percent EV LDV sales by 2030.

We offer results for the High and Low Competitive cases of the Current Policy scenario in Tables D-6 to D-9. On average, in the High Competitive case the Current Policy scenario sees a net gain of about 34,000 jobs a year over a No Transition scenario. In the Low Competitiveness case it sees an average net loss of 55,000 jobs a year. We also report results for the absolute employment impacts of the Current Policy scenario in both cases, independent of any comparison to the No Transition scenario.

High Competitiveness case

TABLE D-6 | Net jobs impact compared with No Transition scenario

CURRENT POLICY SCENARIO—HIGH COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOBS IMPACT	CUMULATIVE IMPACT 2024–40 (JOB-YEARS)
Auto manufacturing: Battery manufacturing	28,848	39,160	28,290	480,922
Auto manufacturing: Everything except batteries	27,304	1,681	15,261	259,436
EV charging infrastructure	5,210	6,492	5,040	85,676
Net savings re-spending	6,810	21,526	10,849	184,437
EV electricity	3,414	9,322	4,863	82,678
Gasoline	-16,101	-36,371	-20,968	-356,450
Insurance, taxes, and fees	543	531	526	8,947
Maintenance and repair	-9,074	-20,270	-11,753	-199,797
Finance	2,018	-5,742	-712	-12,097
Total net effect	**46,953**	**22,072**	**32,109**	**545,851**

Source: Authors.

TABLE D-7 | Absolute jobs impact (from production and use of vehicles post-2024, not vehicles in use before 2024 that are still on the road)

CURRENT POLICY SCENARIO—HIGH COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOBS IMPACT	CUMULATIVE TOTAL IMPACT 2024–40 (JOB-YEARS)
Auto manufacturing: Battery manufacturing	28,848	39,160	28,290	480,922
Auto manufacturing: Everything except batteries	255,059	183,452	228,522	3,884,866
EV charging infrastructure	5,210	6,492	5,040	85,676
Net savings re-spending	6,810	21,526	10,849	184,437
EV electricity	3,414	9,322	4,863	82,678
Gasoline	19,529	11,262	16,688	283,694
Insurance, taxes, and fees	38,811	56,977	43,560	723,515
Maintenance and repair	40,145	43,652	39,664	674,291
Finance	143,103	111,667	114,500	1,946,503
Total effect	**540,929**	**483,510**	**491,976**	**8,346,582**

Source: Authors.

Low Competitiveness case

TABLE D-8 | Net jobs impact compared with No Transition scenario

CURRENT POLICY SCENARIO—LOW COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOBS IMPACT	CUMULATIVE TOTAL IMPACT (JOB-YEARS)
Auto manufacturing: Battery manufacturing	11,103	13,053	10,588	179,989
Auto manufacturing: Everything except batteries	-58,476	-61,130	-50,642	-860,907
EV charging infrastructure	5,210	6,492	5,040	85,676
Net savings re-spending	6,810	21,526	10,849	184,437
EV electricity	3,414	9,322	4,863	82,678
Gasoline	-16,101	-36,371	-20,968	-356,450
Insurance, taxes, and fees	543	531	526	8,947
Maintenance and repair	-9,074	-20,270	-11,753	-199,797
Finance	2,018	-5,742	-712	-12,097
Total net effect	**-54,554**	**-72,588**	**-52,207**	**-887,523**

Source: Authors.

TABLE D-9 | Absolute jobs impact (from production and use of vehicles post-2024, not vehicles in use before 2024 that are still on the road)

CURRENT POLICY SCENARIO—LOW COMPETITIVENESS CASE	2030	2040	AVERAGE ANNUAL JOBS IMPACT	CUMULATIVE TOTAL IMPACT (JOB-YEARS)
Auto manufacturing: Battery manufacturing	11,103	13,053	10,588	179,989
Auto manufacturing: Everything except batteries	169,279	120,641	162,619	2,764,523
EV charging infrastructure	5,210	6,492	5,040	85,676
Net savings re-spending	6,810	21,526	10,849	184,437
EV electricity	3,414	9,322	4,863	82,678
Gasoline	19,529	11,262	16,688	283,694
Insurance, taxes, and fees	38,811	56,977	43,560	723,515
Maintenance and repair	40,145	43,652	39,664	674,291
Finance	143,103	111,667	114,500	1,946,503
Total effect	**437,404**	**394,592**	**408,371**	**6,925,306**

Source: Authors.

Range of the High and Low Competitiveness cases, Current Policy scenario

The High and Low Competitiveness cases form a range of what outcomes in Michigan could occur under a Current Policy scenario. This range is from around 32,000 more net jobs supported on average per year compared with a No Transition scenario (in the High Competitiveness case) to around 52,000 fewer net jobs supported on average per year compared with a No Transition scenario (in the Low Competitiveness case). The average of these two cases would be around 10,000 fewer jobs supported on average per year compared with a No Transition scenario. Whether Michigan ends up on the upper or lower side of this spectrum depends on whether Michigan puts in place the right policies to be a leader in auto and battery manufacturing going forward.

No Transition scenario

The No Transition scenario in Table D-10 projects the employment impacts of a counterfactual scenario in which only ICE vehicles are sold, and Michigan retains its present-day 20 percent share of the domestic auto manufacturing market. Net impacts of the Current Policy and All Electric by 2033 scenarios are reported in relation to it. It was chosen as a reference scenario to understand the scale of the jobs effects of the EV transition in comparison to what it would have been if the industry had not changed at all.

TABLE D-10 | Absolute jobs impact (from production and use of vehicles post-2024, not vehicles in use before 2024 that are still on the road)

REFERENCE SCENARIO—NO TRANSITION	2030	2040	AVERAGE ANNUAL JOB IMPACT	CUMULATIVE TOTAL IMPACT (JOB-YEARS)
Auto manufacturing: Battery manufacturing	0	0	0	0
Auto manufacturing: Everything except batteries	227,755	181,771	213,261	3,625,430
EV charging infrastructure	0	0	0	0
Net savings re-spending	0	0	0	0
EV electricity	0	0	0	0
Gasoline	35,630	47,633	37,656	640,144
Insurance, taxes, and fees	38,268	56,445	42,033	714,568
Maintenance and repair	49,219	63,921	51,417	874,088
Finance	141,085	117,409	115,212	1,958,600
Total effect	**491,956**	**467,180**	**459,579**	**7,812,830**

Source: Authors.

APPENDIX E: COMMUNITY BENEFITS AGREEMENTS—MAKING ECONOMIC DEVELOPMENT PROJECTS ACCOUNTABLE

What is a community benefits agreement (CBA)?

A CBA is typically a private agreement made between community groups and project developers that spells out all the benefits for the community that a developer has agreed to provide as part of a development project (Berglund 2021; Wolf-Powers 2010).

CBAs are based on the premise that economic development projects should benefit local communities, especially low-income communities and communities of color, and create tangible improvements in their lives. The benefits provided through a CBA can vary, depending on the needs of the community, the size and scope of the development project, and the relative bargaining power of the community group and the project developer (Been 2010). Some common benefits include the following:

- **Employment opportunities.** CBAs can increase local hiring by incorporating provisions that prioritize community members for jobs created by the project. Additionally, CBAs can emphasize job quality by incorporating requirements that new jobs pay decent wages and offer benefits. Finally, CBAs can also provide funding to create pipelines for education and workforce development.
- **Infrastructure improvements.** These can include setting aside money to provide for affordable housing, improving schools and other community facilities, and enhancing public access to new development areas.

CBAs are becoming popular. The first major CBA—the Los Angeles Staples Center agreement—was signed in 2001; since then several CBAs between community groups and private developers have been created. A recent poll found that 59 percent of likely voters support the use of CBAs in various development projects and that this support holds across party lines (Fraser 2022).

In a few recent cases, though, local governments have adopted CBAs through ordinances, as has happened in Detroit (more below) and St. Petersburg, Florida. New Jersey is the first state in the country to require CBAs for certain economic development projects with upfront costs of $10 million or more. The Economic Recovery Act of 2020 has created two programs—Emerge and Aspire—to encourage economic development in priority sectors and targeted communities.

When we discuss CBAs in this report, we are referring to CBAs adopted as government policies. Formalizing CBAs into policy can make them more effective by ensuring that development projects that receive public subsidies contribute to the community and the region in ways that are desirable for residents and align with the economic development vision of the local government or state.

Detroit's community benefits ordinance

Detroit voters passed the nation's first municipal community benefits ordinance (CBO) in 2016. It is the first ordinance to "systematize and routinize community benefit negotiations" between communities and project developers and it therefore provides valuable lessons for policymakers (Berglund 2021).

Detroit's CBO applies to projects that are $75 million or more in value, receive $1 million or more in property tax abatement, or receive $1 million or more in a transfer of city-held land. Negotiations are arranged by the city's Planning and Development Department and take place between a nine-member Neighborhood Advisory Council (NAC) and the developer. The NAC includes residents from the project impact area, with two members elected by the residents, four members selected by the Planning and Development Department, two members selected by at-large city council members, and one member selected by the city council member with the largest portion of the project in their district. Once the NAC is formed, there are a series of negotiations between the NAC and the developer regarding the benefits. The city council signs off once an agreement is made. The city's Civil Rights, Inclusion & Opportunity Office enforces the benefits but is not authorized by the ordinance to issue any fines or injunctions when targets are not being met.

Detroit's CBO has been applied to more than 11 projects, with communities able to secure several benefits related to parks and public space improvements, employment and workforce development, public engagement, affordable housing, and parking and public transportation (Berglund 2021). In one example, the NAC that negotiated with Ford for the renovation of Michigan Central Station as a mobility innovation district was able to get Ford to commit $2.5 million to the city's affordable housing fund, $5 million for citywide job training initiatives, and $2.5 million for city neighborhood improvements (Pinho 2018).

Detroit's CBO has also faced criticisms on a variety of fronts. The ordinance requires only one meeting between the NAC and the developer and while the city's planning staff in practice have facilitated more than one meeting, it creates the perception that the city is more receptive to the preferences of developers than the needs of community members (Berglund 2021). Several projects with substantial potential impact on residents did not meet the $75 million threshold and failed to trigger the CBO. As a result, community organizations have been advocating to lower the project value threshold to $50 million (Frank 2022; Mondry 2021).

Other criticisms relate to the lack of an adequate enforcement mechanism, the NACs not being truly representative of the impacted communities, and benefits often being insufficient given the size of subsidies given to project developers. Additionally, it is difficult for communities to create or maintain leverage throughout the process of developing such agreements, whether through media pressure or having a say at points when decisions are made or approved. Detroit's CBO has also been criticized for failing to protect the health and quality of life of nearby residents by allowing Stellantis to violate the state's air quality law (Brooker 2022).

Building blocks of a strong CBA policy

Below are key guidelines that can strengthen CBAs that have been codified into law by local governments. These guidelines can also apply to statewide policy adoption of CBAs.

- **Make CBAs legally binding and enforceable to hold companies accountable.** CBAs should include clear metrics to measure, implement, and track commitments made by a project developer, as well as public reporting requirements. In addition, CBAs should incorporate clawback provisions requiring companies to return funds for noncompliance along with penalties that are substantial enough to deter companies from violating their agreements. CBAs should also include guidelines on who will be responsible for enforcing commitments.
- **Enact policies establishing baseline community benefits.** While there can be legal limitations to the demands that state and local governments can make as part of the CBA process, policymakers have the power to adopt baseline community benefits for economic development projects. These can include requirements related to prevailing wage, local hiring (especially connecting individuals facing barriers to employment to newly created jobs), and mitigation of negative environmental impacts.
- **Ensure diverse community representation.** Robust CBAs are created by including a representative and diverse group of members from the community impacted by the project. When choosing community representation, effort should be made to nominate and elect those who have deep, active connections to the community and, thus, truly represent their communities. Additionally, the local community should be provided with opportunities to provide input and feedback throughout the process.
- **Provide training and capacity to community members negotiating on behalf of local communities.** Without this, the negotiation process can be biased toward the developers who tend to be more familiar with development practices and policies. Local and state governments can connect community members with regional or national networks that have experience with CBAs and who can provide technical assistance and resources. Allowing for negotiations to be mediated by trained third-party facilitators can also help address this issue.
- **Adopt realistic timelines for reaching benefits agreements.** Project developers and community members may have different timelines for negotiations, with the community needing more time than what the developer would prefer. While CBA negotiations should not unduly impact the project development timeline, adequate time should be given to ensure that community members are able to successfully negotiate benefits agreements.
- **Incorporate a strong focus on environmental sustainability and justice.** Sometimes developers and government, in pursuit of new development, are incentivized to choose communities that are perceived to have less capacity to resist projects. These development projects can impose health and pollution burdens on those living in proximity. CBAs can be a mechanism to promote environmental justice by incorporating requirements for timely and clear information about a project's environmental and health impacts and mitigation of negative impacts on communities.

APPENDIX F: EXAMPLES OF STATE POLICIES AND PROGRAMS TO SUPPORT A JUST AND EQUITABLE EV TRANSITION

Table F-1 provides examples of programs and policies from other states and the federal government that Michigan can consider adopting and/or modifying to address the challenges and seize the opportunities presented by the EV transition.

While the examples under the just workforce and community transition are often related to coal community and workforce transition, they can be adapted for the auto sector transition.

TABLE F-1 | State programs and policies for Michigan to consider

STATE	PROGRAM/POLICY	DESCRIPTION
Just workforce and community transition		
Colorado[a]	Office of Just Transition	In 2019, Colorado created the nation's first Office of Just Transition to help communities transition their economies away from coal. The office has developed a Colorado Just Transition Action Plan, which lays out strategies to help coal communities, and has started disbursing funding from its Just Transition Cash Fund for economic diversification projects and worker assistance programs.
Connecticut[b]	An Act Concerning a Just Transition to Climate-Protective Energy Production and Community Investment (2021)	Renewable energy project developers must provide construction, maintenance, and security workers with prevailing wages and benefits. The law applies to both publicly and privately funded projects. Developers of renewable energy projects that are 5 MW or more must enter into a community benefits agreement and develop a workforce development plan that incorporates apprenticeship and pre-apprenticeship programs to provide workers pathways into trade careers.
Illinois[c]	Climate and Equitable Jobs Act (2021)	This legislation includes robust provisions for workers displaced by the energy transition and "environmental justice communities" that have borne a disproportionate pollution burden. The legislation has created an $80 million per year program for clean energy job training hubs that prioritize displaced energy workers, individuals from environmental justice communities, and underserved individuals. The law requires developers of renewable energy projects to hire a workforce that includes at least 10% equity-eligible people, including displaced energy workers. The legislation has also created an Energy Transition Community Grant Program to provide funding to communities impacted by fossil fuel facility retirement. Finally, the legislation requires utilities and coal mining operators to provide at least two years' notice to workers, local governments, and the Department of Commerce and Economic Opportunity before any mass layoff takes place at a power plant or coal mine.
Maryland[d]	Just Transition Employment and Retraining Working Group	The Climate Solutions Now Act of 2022 directs the Maryland Commission on Climate Change to create the Just Transition Employment and Retraining Working Group to assess challenges and opportunities related to workforce development, job loss, job creation, and potential training opportunities.
Massachusetts[e]	Clean Energy Workforce Equity Program	Administered by the Massachusetts Clean Energy Center, the program promotes employment diversity in the clean energy industry. Equity Workforce Training Implementation Grants of $50,000 each are awarded to community organizations to prepare residents of environmental justice communities and fossil fuel workers for clean energy careers.
Minnesota[f]	Community Energy Transition Grant Program	Established in the Department of Employment and Economic Development in 2019, the program provides grants to eligible communities to address the challenges of economic dislocation associated with the closing of a local electricity generating plant powered by coal, gas, or nuclear energy. Grant money can be used for planning and implementing activities that help with worker reemployment.

TABLE F-1 | State programs and policies for Michigan to consider (Cont.)

STATE	PROGRAM/POLICY	DESCRIPTION
New Mexico[g]	Energy Transition Act (2019)	The legislation created an Energy Transition Displaced Worker Assistance Fund that can be used to develop job training and apprenticeship programs in impacted communities. The legislation also created the Energy Transition Economic Development Assistance Fund to support economic diversification opportunities in affected communities.
New York[h]	Electric Generation Facility Cessation Mitigation Program	Created in 2015 by Senate Bill S6408C, the program provides up to seven years of revenue replacement funding to local government entities (counties, towns, cities, school districts) impacted by the closure of an electricity generating facility. As of April 2021, New York had authorized $140 million for the program.
United States[i]	Four Corners Rapid Response Team	Created by the federal government's Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization, the Rapid Response Team coordinates activities across 11 federal agencies and their regional staff to partner with local government officials and community organizations in Arizona, Colorado, New Mexico, and Utah to help them navigate the energy transition. The Rapid Response Team assists with mapping their existing assets and opportunities and accessing federal programs and resources, especially those available through the IIJA.
Equitable EV and charging infrastructure deployment		
Colorado[j]	ReCharge Colorado program	The program provides coaching services to consumers, local governments, workplaces, and owners of multiunit dwellings to help them identify monetary savings, grant opportunities, and other EV benefits.
Connecticut[k]	Electric Vehicle Charging Program	The program requires utilities to offer incentives to reduce the cost of installing charging infrastructure, including EVSE and fast-charging stations, in addition to accompanying rate design offerings. The program increases incentive amounts for underserved communities to help deploy EV charging infrastructure in such communities.
Delaware[l]	Vehicle-to-Grid Energy Credit	The credit provides retail electricity customers with at least one grid-integrated EV to receive kilowatt-hour credits for energy discharged to the grid from the EV's battery at the same rate that the customer pays to charge the battery.
Maryland[m]	EV Charging Station New Construction Requirement	Builders must provide buyers with a Level 2 EV charging station or electric pre-wiring to support a Level 2 EV charging station in all new homes with a garage, carport, or driveway. The builder must provide buyers with information about EV charging station make-ready options and all available rebate programs for EV charging station purchases and installation.
Massachusetts[n]	Multiunit Dwelling EVSE Grants	The grants cover 60% of the cost of Level 1 or Level 2 chargers installed in multiunit dwellings, capped at $50,000, for private, public, or nonprofit multiunit dwellings with 10 or more residential units.
Oregon[o]	House Bill 2180	The bill amended the state building code to require that 20% of parking spaces at all newly constructed commercial buildings, multifamily residences with five or more units, and mixed-use developments have the electrical capacity to support Level 2 EV charging stations.
Virginia[p]	Mileage Choice Program	A voluntary opt-in program for drivers of EVs and fuel-efficient vehicles to pay their highway use fees on a per-mile basis instead of as an annual fee, capping the total paid at the price of the annual fee.
Innovation-oriented economic development		
Connecticut[q]	Governor's Innovation Fellowship	Created to help retain more outstanding college and university STEM graduates in the state, the program was launched in 2019 as a pilot in Stamford and was expanded statewide in 2022. Fellows receive a $5,000 grant and a growth-track position in an innovation-based Connecticut company.
Georgia[r]	Electric Mobility and Innovation Alliance	Created in 2021 and led by the Georgia Department of Economic Development, the statewide initiative is focused on growing the state's electric mobility ecosystem and strengthening Georgia's position in EV-related manufacturing and innovation. The initiative includes government, industries, electric utilities, education, nonprofits, and other relevant stakeholders. Five committees will develop policy recommendations related to supply chain, infrastructure, workforce, innovation, and policy/initiative categories.

TABLE F-1 | State programs and policies for Michigan to consider (Cont.)

STATE	PROGRAM/POLICY	DESCRIPTION
Illinois[s]	Reimagining Electric Vehicles in Illinois Act (2021)	The legislation offers tax incentives for businesses that manufacture EVs and their parts. Businesses can receive a state income tax credit of 75 or 100% of payroll taxes withheld from each new employee and 25 or 50% for current employees. It also provides tax credits to defray the cost of training new or current employees. Finally, the legislation creates an EV Permitting Task Force to ensure a streamlined permitting process.
Illinois[t]	The Electric Vehicle-Energy Storage Manufacturing Training Academy (EVES MTA)	Heartland Community College (HCC) provides certificates and degrees in EV and energy storage technologies. The EV component trains individuals for employment in advanced manufacturing, installation, final assembly, inspection, diagnosis, service, and repair. The EVES MTA is a partnership with Rivian and other regional manufacturing, economic development, and education partners. The Department of Commerce and Economic Opportunity has provided a $7.5 million capital grant to HCC for the construction of the EVES MTA facility. HCC and employer partners will contribute $1.5 million to cover curriculum development, equipment, and student support.
Indiana[u]	Innovation Voucher Program	A partnership between the Indiana Economic Development Corporation and Elevate Ventures, a private venture development organization, the program provides up to $50,000 in funding for innovation-driven research and product development to Indiana-based startups and small businesses. Eligible companies can purchase services from higher education institutions and nonprofit research providers to support R&D, product development, and commercialization.
North Carolina[v]	Clean Energy Youth Apprenticeship Program	This is a pre-apprenticeship program for high school juniors and seniors to prepare them for careers in clean energy. Students get a combined 96 hours of classroom instruction with 80 hours of paid on-the-job training and five industry certifications on completing the program. Students enrolling in a registered apprenticeship program after graduating from the pre-apprenticeship program receive a tuition waiver at a state community college.
Wisconsin[w]	Vehicle Battery and Engine Research Tax Credits	A corporation involved in qualified research is eligible for a tax credit equal to 11.5% of the qualified research expenses that the corporation incurs in Wisconsin during the taxable year.

Note: R&D = research and development.

Sources: a. CDLE n.d.; b. Connecticut Senate 2021; c. Pruitt and Munson 2021; d. MDOE n.d.; e. MassCEC n.d.; f. MDEED n.d.; g. New Mexico Senate 2019; h. NYS n.d.; i. DOE 2022a; j. CEO n.d.; k. CDEEP n.d.; l. DOE n.d.a; m. DOE n.d.b; n. DOE n.d.c; o. ODCBS 2022; p. VDMV n.d.; q. CTNext 2021; r. GDED n.d.; s. IGA n.d.; t. HCC n.d.; u. Elevate Ventures n.d.; v. NCBCE n.d.; w. DOE n.d.d.

LIST OF ABBREVIATIONS

BEV battery electric vehicle
BLS US Bureau of Labor Statistics
CBA community benefits agreement
CFME Council on Future Mobility and Electrification
CFS clean fuel standard
DOE US Department of Energy
EGLE Department of Environment, Great Lakes, and Energy
EIA US Energy Information Administration
EPA US Environmental Protection Agency
EV electric vehicle
EVSE electric vehicle supply equipment
GM General Motors
ICE internal combustion engine
IIJA Infrastructure Investment and Jobs Act of 2021
IRA Inflation Reduction Act of 2022
kWh kilowatt-hours
LDV light-duty vehicle
LEO Department of Labor and Economic Opportunity
MDOT Michigan Department of Transportation
MEDC Michigan Economic Development Corporation
MSRP manufacturer's suggested retail price
MW megawatts
MWh megawatt-hours
OFME Office of Future Mobility and Electrification
R&D research and development
STEM science, technology, engineering, and mathematics
TCO Total cost of ownership

ENDNOTES

1. We round numbers to the nearest thousand. The total may not be equivalent due to rounding. Exact results can be found in Appendix D.

2. The total net effects presented here do not include the jobs effects of renewable energy to support EVs or of Inflation Reduction Act EV tax credits because our figures for these were based on a back-of-the-envelope analysis rather than a full modeling analysis.

3. The transportation sector was the second-largest source of greenhouse gas emissions in 2021 in Michigan, accounting for 28 percent of total emissions (Rhodium Group 2022). While the transportation sector accounts for emissions from sources beyond LDVs—such as medium- and heavy-duty vehicles, aviation, rail, and others—LDVs are the largest contributor in Michigan as well as in many other states. Michigan has a goal to reduce statewide emissions by 28 percent by 2025 and 52 percent by 2030, relative to 2005 levels, and to achieve economy-wide carbon neutrality by 2050.

4. OFME has six objectives: increase mobility investment in Michigan; expand Michigan's smart infrastructure; engage more mobility startups; further enable Michigan's mobility workforce; accelerate vehicle adoption in Michigan; and bolster Michigan's mobility manufacturing core (OOTG 2020).

5. Since the creation of the SOAR Fund, Michigan has secured $7 billion in investment from GM and $2 billion from Ford to support EV manufacturing and $375 million from Hemlock Semiconductor Operations to improve the semiconductor supply chain (Pohl 2022).

6. These incentives take the form of tax breaks or grants given by the government to companies to influence the latter's decisions about business location, expansion, and even job retention.

7. Research from Mazerov and Leachman (2016) noted that states are better off producing more homegrown businesses and helping fast-growing startups already in their state rather than luring businesses from other states. Their analysis found that the vast majority of jobs are created by companies that are already present in a state and that startups are the fundamental drivers of job creation when the US economy is doing well.

8. Bartik (2015) noted that incentives are more effective when they apply to the following: new investments and not to businesses that are already in the state; jobs that provide a high wage premium, which boosts multiplier effects and raises average state earnings per worker; and businesses that create jobs that go to state residents. Incentives can also be made more effective by aligning economic development policies with equity and inclusive growth goals (Germán and Parilla 2021).

9. One analysis estimated that emerging mobility trends around autonomous vehicles (AVs) and electric cars could create an additional 115,000 jobs in the US automotive industry by 2028 (Mosquet et al. 2019). Of these, 30,000 jobs would be in computer engineering, 15,000 in traditional engineering, and 70,000 in skilled trades including mechanics for AVs and EVs. With less than 1 percent of college graduates with degrees in computer science, computer engineering, and software engineering entering the automotive industry, the analysis further estimated that the national demand for engineering graduates in the AV and EV industry could be six times greater than the available supply (Mosquet et al. 2019).

10. This analysis was done by Boston Consulting Group as part of a presentation titled "Improving Michigan's EV Competitiveness" from October 2021 and shared with WRI.

11. Another study estimated that EV owners can save up to $1,000 annually on fuel costs compared with driving an equivalent gasoline car. They can also save up to $4,600 on maintenance and repair over the lifetime of the vehicle (assuming 200,000 miles) (Preston 2020).

12. For a more detailed understanding of how EVs differ from ICE vehicles, please see Appendix A in UAW (2019) and Küpper et al. (2020).

13. The Economic Policy Institute study modeled various scenarios to estimate jobs impacts. In a basic scenario in which BEVs reach a 50 percent national market share by 2030, 33,147 jobs are lost in auto assembly and 40,668 in auto parts. The study then layered on additional assumptions to this analysis. If the domestic production of components that make up the EV powertrain such as the battery pack and the electric motor increase to the same level as the domestic content of ICE powertrains, the job loss in auto parts is only 2,515 by 2030, while the job loss in auto assembly is unchanged. If in addition to that change, the share of US-made cars sold domestically increases by 10 percent, there are positive jobs impacts in both auto assembly (+3,184) and auto parts (+149,401). This study was conducted prior to the passing of the Inflation Reduction Act, which does aim to increase domestic content in EV production.

14. The current policy scenario from Baldwin et al. (2021) assumes that EVs will comprise 45 percent of new LDV sales, 38 percent of MDV sales, and 12 percent of heavy-duty truck sales in 2035. The clean electricity share is 47 percent by 2035 in this scenario. This does not consider the impact of the passing of the Inflation Reduction Act.

15. The Michigan Healthy Climate Plan has separate goals for vehicles sold and EV charging Infrastructure. Its goal for light-duty vehicle sales is 50 percent by 2030, which is closest to our Current Policy scenario discussed in Appendices C and D and amounts to about 1.2 million EVs on the road by 2030. However, the plan also has a goal of deploying charging infrastructure to support 2 million EVs by 2030, which is closest to our All Electric by 2033 scenario and the goal we sought to highlight here.

16. An alternate option would be to compare the All Electric by 2033 scenario to a less ambitious EV penetration scenario instead of to a No Transition scenario, but we decided not to do this as it would be less insightful. Even a less ambitious EV penetration scenario entails profound changes to Michigan's jobs, so we wanted to capture those effects in our results too. Comparing an All Electric by 2033 scenario to a No Transition scenario allows us to understand the total difference between the old way of producing vehicles and the new way, rather than just the difference between a high EV penetration scenario and a lower EV penetration scenario.

17. The BEAN tool provided cost projections for only 2020, 2025, 2030, and 2045, so we estimated costs in the intervening years based on the trend. The market shares of compact cars, midsize cars, sport-utility vehicles, and light-duty trucks are held constant at 2020 levels over the full 2024–40 period. See Appendix C for more detail.

18. Our modeling for electricity purchases considers the jobs effect of operation of electricity generation, transmission, and distribution but not new construction. Our modeling does not consider the effects of a shift to renewable energy in electricity generation, but we present indicative results of a related thought experiment on the topic.

19. Our results for the rest of auto manufacturing except batteries encompass not only manufacturing but also the transport, wholesale, and retail dealership jobs that go along with manufacturing. The vast majority of the jobs effects will be in manufacturing itself. Our modeling applies a simple ratio to the changes in manufacturing expenditure to determine the effect on transport, wholesale, and retail dealerships based on the past economic relationship, and we do not add any specific assumptions about how the shift to EVs will change these jobs beyond changing costs.

20. Throughout this section, we generally round numbers to the nearest thousand. The total may not be equivalent due to rounding. Exact numbers can be found in Appendix D.

21. In input-output models such as the DEEPER model used for this report, a decrease in spending in a sector automatically translates to a decrease in jobs.

22. Some gas stations, for instance, have installed Level 3 chargers in a bid to appeal to both EV drivers and those driving gas-powered cars. However, installing chargers at gas stations can be expensive for a small business, and gas stations will face intense competition from other public EV chargers (Heilweil 2022).

23. The Sustainable Transportation Education Program provides middle and high school students training and curricula related to EVs, plug-in hybrid vehicles, alternative fuels, and the smart grid, among other things. The curricula are STEM-based and emphasize problem-solving, critical thinking, and inquiry-based learning. The program is funded by Duke Energy (NCSU n.d.).

24. Forty-nine percent of Michigan residents had either a post-secondary degree or an industry credential in 2020, which is slightly lower than the national average of 52 percent (MISD n.d.). Since then, the number of students heading to college has been declining due to disruption caused by the pandemic (Steel 2022).

25. The R&D tax credit is a dollar-for-dollar credit that can be claimed by companies to offset costs spent on research and development to benefit their businesses. Michigan currently does not have this, while many states offer it. House Bill 5601, which has not been enacted, provides a tax credit equal to 15 percent of qualified research expenditures incurred by businesses in Michigan (Sanchez 2022).

26. Ninety-six of the top 100 automotive suppliers in North America have a presence in Michigan, with 60 of them headquartered in Michigan (MICHauto 2021).

27. In August 2022, Ford and DTE Energy entered into an agreement for the utility to add 650 megawatts of new solar power through its MIGreenPower. This is the largest renewable energy purchase made from a utility (Pearl 2022).

28. One study assessing the effectiveness of state-level financial incentives for BEV adoption found that there is an 8 percent increase in BEV registrations per thousand dollars of incentives offered. Considering the total value of incentives, there is an 11 percent increase in total BEV adoptions compared with a counterfactual scenario where there are no state-level incentives (Clinton and Steinberg 2019).

29. At least 30 states have established some kind of fee, which range from $50 in South Dakota to $235 for EVs over 8,000 pounds in Michigan. Michigan charges an annual base fee of $100 for EV owners. In addition, it charges $5 more for every 1 cent increase in state gas tax (Igleheart 2022).

30. AB 970 states that permitting for projects with less than 25 charging stations at a single site will be deemed complete if after five business days the city or county has either not found the application to be incomplete or issued a written deficiency notice. If the project has 26 or more charging stations at a single site, then the application will be deemed complete after 10 business days and will be deemed approved 40 business days after deemed complete (TrackBill 2021).

31. A few Michigan localities such as Ann Arbor and East Lansing have passed zoning ordinances requiring EV readiness. However, a statewide EV readiness code could be more transformative. The installation of EV chargers in parking lots requires the construction of a conduit through concrete to connect the electric vehicle supply equipment with electrical connection. It is more cost effective to do this when a building is being built or undergoing a major renovation.

32. For more information on New Jersey's Model Statewide Municipal Electric Vehicle (EV) Ordinance, see NJDCA (2021). For more information on Oregon's HB 2180, which amended the state building code to include charging stations for EVs, see OSL (2021).

33. For more information, see CARB (2022).

34. Both DTE Energy and Consumers Energy incentivize EV drivers to charge at home during off-peak hours. DTE Energy, for instance, offers three EV electric pricing options while Consumers Energy offers a "nighttime savers rate" (DTE Energy n.d.; Consumers Energy n.d.).

35. Make-ready programs can vary in design. However, they typically require the utility to cover all or a portion of the cost of installing equipment and wiring on the utility side of the meter and sometimes on the customer side of the meter (Hernandez 2022). Utilities can recover the cost by adding the infrastructure to their rate base or using another recovery mechanism.

36. The MassHire Rapid Response Team, for instance, is part of Massachusetts' Department of Career Services. It helps employers and employees during layoffs across sectors by facilitating meetings between employers and staff, helping workers understand the rights and benefits afforded to them, and connecting workers with other career services as needed (COM n.d.).

37. This recommendation is geared toward helping workers employed in large auto manufacturing facilities and facing the potential of mass job displacement. The diffuse nature of workers employed at gas stations and maintenance and repair shops—which are located across the state, are typically small businesses with fewer workers, and will face different timelines of closure—makes it more difficult to target this recommendation to help those workers.

38. Michigan had prevailing wages from 1965 until the legislature repealed them in 2018 after a statewide petition drive. Governor Whitmer reinstated them in October 2021, requiring that prevailing wages be paid for any construction project funded with state money (OOTG 2021a). In March 2023, Michigan enacted a law restoring a construction industry prevailing wage.

39. There are concerns that a wage increase as a result of policies like prevailing wages could raise the cost of clean energy projects, slowing their development. However, evidence so far suggests that there are modest increases in cost, which are often offset by productivity improvements as higher wages lead to more efficient work (Mayfield and Jenkins 2021; Jones 2020).

40. For instance, the manufacturing of internal combustion engines can serve as a comparable job for the manufacturing of battery cells. A recent analysis comparing the skills requirement for the two jobs found that "the skill requirements for manufacturing BEV powertrain components lie within the range of skill requirements for ICE vehicle powertrain components" (Cotterman 2022).

41. In the past, some EV companies, like some employers in other industries, have used different tactics, sometimes illegally, to discourage unionization among employees. For example, the National Labor Relations Board upheld a ruling against Tesla for illegally firing an employee attempting to organize other workers (NLRB 2021), while the chief executive officer of Fuyao Glass was filmed discussing employees that had been fired for attempting to unionize as well (Schladen 2020). At a Nissan plant in Mississippi, the National Labor Relations Board also formally charged the company with 24 counts of lawbreaking, including banning the distribution of pro-union literature and interrogating employees about their intentions to vote for unionization (NLRB 2017).

42. In December 2020, workers at the Ultium Cells battery plant in Lordstown, Ohio, voted to join the UAW by a margin of 710 to 16, the first successful union vote at a battery cell plant, of which there are currently relatively few in operation.

43. Wage boards set multiple minimum pay standards by industry and occupation, which are arrived at via consultations with stakeholders. These can set wages above state or local minimum wages and can provide pay differentials for workers with additional skills. A handful of states, including Arizona, Colorado, California, New Jersey, and New York, have passed legislation that allows for creating wage boards, but they have been used infrequently. The most recent example is from New York where a wage board raised the minimum wage for fast food workers to $15 per hour (Wall and Madland 2021; Dube 2020).

44. In 2016, Mitsubishi closed a facility in Illinois, though it has since been bought by Rivian and employs nearly 6,300 people, which is double the number of people employed by Mitsubishi at the same facility (Whalen 2022). Additionally, GM closed a facility in Lordstown, Ohio, in 2019 that employed about 1,500 people, despite having received millions of dollars in tax credits for opening and operating the facility through 2027 (Vanac 2021). Because of the closure, GM has agreed to invest millions in the local community and repay the money it received. In December 2022, Stellantis announced plans to "idle" a manufacturing facility in Belvidere, Illinois, in February 2023, which resulted in indefinite layoffs for over 1,300 employees. Importantly, temporary closures are a natural part of the auto industry due to factors such as shortages of parts or supply disruptions, though such events can have a significant impact on workers and communities (Mahoney 2022).

45. As part of the Economic Recovery Act of 2020, New Jersey has created a seven-year, $14 billion package of tax incentives, financing, and grant programs. For projects that exceed $10 million in total project costs, project developers are required to enter into a CBA with the New Jersey Economic Development Authority, the county, and the municipality (NJEDA n.d.).

46. Detroit's Community Benefits Ordinance is triggered when a project is $75 million or more in value, receives $1 million or more in property tax abatement, or receives $1 million or more in a transfer of city-held land. The Planning and Development Department establishes a nine-member Neighborhood Advisory Council to work with the project developer to secure community benefits (COD n.d.). Critics of the ordinance have put forth several recommendations to strengthen it. Groups like Detroit People's Platform and Equitable Detroit Coalition have recommended lowering the monetary threshold for projects, changing the composition of the Neighborhood Advisory Council, and making the agreements legally enforceable.

47. In 2012, Senate Bill 535 established requirements for minimum funding levels to disadvantaged communities and gave the California Environmental Protection Agency (CalEPA) the responsibility for identifying those communities. In May 2022, CalEPA released its updated designation of disadvantaged communities, which is based on the latest iteration of CalEnviroScreen 4.0, the state's environmental justice mapping tool (CEPA n.d.).

48. The New Jersey Department of Environmental Protection (NJDEP) published draft rules for implementation of the state's Environmental Justice Law in June 2022. The legislation defines an overburdened community as one in which at least 35 percent of the households qualify as low-income households; at least 40 percent of the residents identify as minority or as members of a state-recognized tribal community; or at least 40 percent of the households have limited English proficiency. To determine whether a project is in an overburdened community, NJDEP developed the Environmental Justice Mapping, Assessment, and Protection Tool (NJDOE n.d.).

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Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

OUR VISION

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

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