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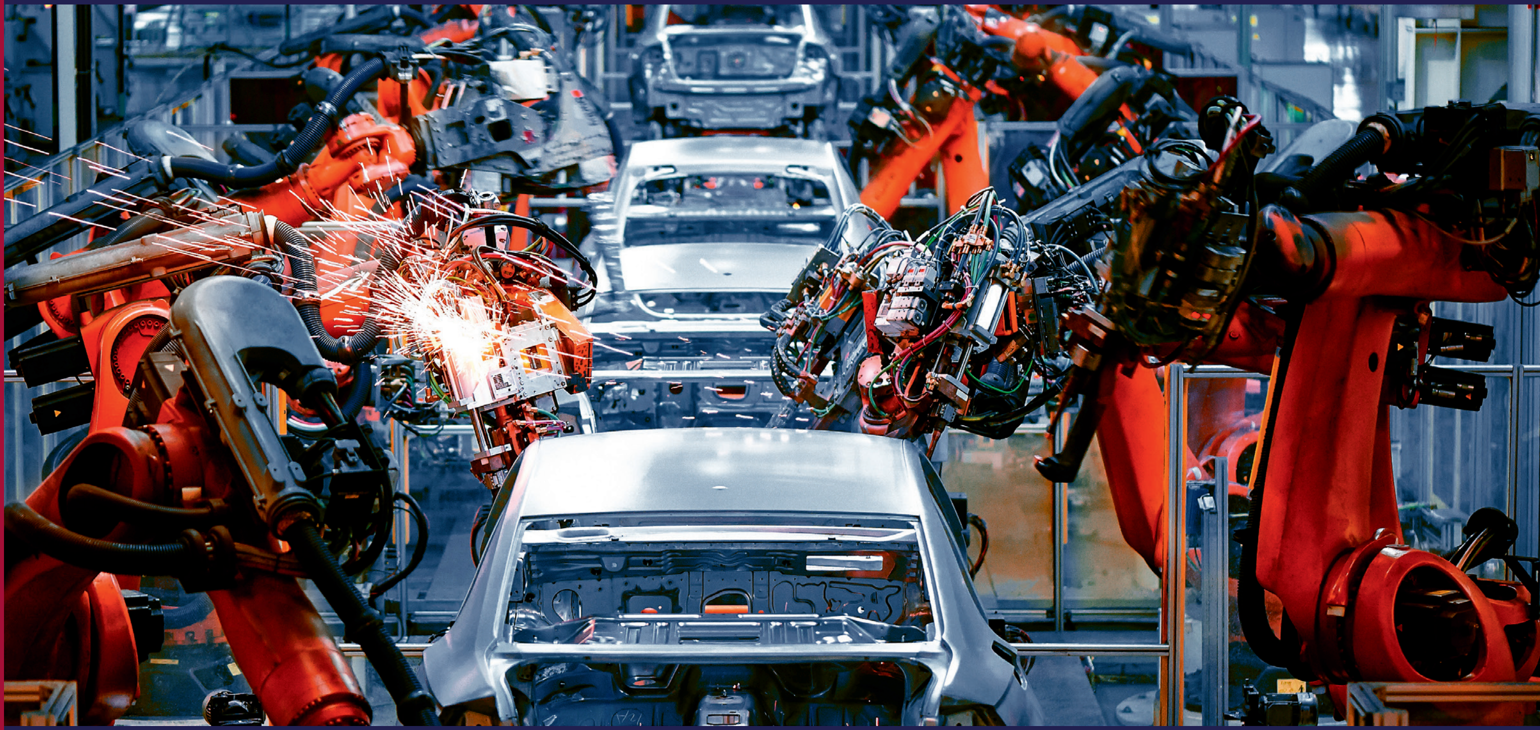
The Roosevelt Project

Electric Vehicles: The 21st-Century Challenge to Automotive Manufacturing Communities



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The Transition to Electric Vehicles from the Perspective of Auto Workers and Communities

by Sanya Carley, David Konisky, Jennifer M. Silva, Shaun Khurana and Naomi Freel

Driving toward Environmental Justice & Health: Challenges, Opportunities & Tools for an Equitable Electric Vehicle (eV) Transition

by Jalonne L. White-Newsome, Colleen Linn and Kira Rib

Maximizing Value: Ensuring Community Benefits from Federal Climate Infrastructure Package

by Amanda K. Woodrum and Kathleen Mulligan-Hansel

Transitioning Coal-fired Power Plant Employees into the Future of Clean Energy

by Christina Hajj

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by Keith Cooley

The Roosevelt Project

Electric Vehicles: The 21st-Century Challenge to Automotive Manufacturing Communities

March 2022

The Roosevelt Project
A New Deal for Employment, Energy and Environment

About the Roosevelt Project

The Roosevelt Project takes an interdisciplinary approach to the transitional challenges associated with progress toward a deeply decarbonized economy. The project aims to chart a path forward through the transition that minimizes worker and community dislocations and enables at-risk communities to sustain employment levels by taking advantage of the economic opportunities present for regional economic development. The first phase of the project involved an analytical assessment of cross-cutting topics related to the transition. The second phase of the project assesses the transition through the lens of four regional Case Studies, working with local partners on the ground in the Industrial Heartland, Southwest Pennsylvania, the Gulf Coast, and New Mexico. The project was initiated by former Secretary of Energy, Ernest J. Moniz, and engages a breadth of MIT and Harvard faculty and researchers across academic domains including Economics, Engineering, Sociology, Urban Studies and Planning, and Political Science.

REPORT SPONSOR

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Contents

Acronyms and Definitions

AA	African American
ATVM	Advanced Technology Vehicles Manufacturing Loan Program
BEV	battery electric vehicle
BIPOC	Black, Indigenous, and people of color
COC	communities of color
COH	culture of health
CSR	corporate social responsibility
DCFC	direct current fast charging
DOE	U.S. Department of Energy
EJ	environmental justice
EPA	Environmental Protection Agency
EV	electric vehicle
EVSE	electric vehicle supply equipment
GHG	greenhouse gas
GIS	geographic information system
HEV	hybrid electric vehicle
ICE	internal combustion engine
L1	level 1 charger
L2	level 2 charger
LDV	light duty vehicle
LIC	low-income community
LMI	low to moderate income
LVC	labor value content
MV	motor vehicle
NREL	National Renewable Energy Laboratory
PHEV	plug-in hybrid electric vehicle
PM2.5	fine particulate matter, 2.5 microns or less in diameter
POC	people of color
RVC	regional value content
TOU	time of use
UAW	International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America, also known as the United Auto Workers Union
VMT	vehicle miles traveled
ZEV	zero emissions vehicle

Industrial Heartland Case Study Executive Summary

Abstract

The Industrial Heartland case study conducts focus groups and interviews of autoworkers, management, community stakeholders, environmental justice advocates, and public health experts in Michigan, Indiana, and Ohio to evaluate past transitions and dislocations in the motor vehicle industry. Based on these findings, we identify challenges and recommend best practices to promote equitable solutions to the anticipated dislocations caused by motor vehicle electrification and other impending clean energy trends in the region.

Introduction

The Industrial Heartland case study evaluates barriers to the electrification of the motor vehicle manufacturing sector in the tristate region of Michigan, Indiana, and Ohio. Our goal is to recommend best practices and public policies that promote equitable solutions to the anticipated disruptions caused by vehicle electrification and other related clean energy transitions in the region.

We undertook this project with a community-first frame, understanding that while economic and industry trends ultimately drive many of those disruptions, solutions arise from the perceptions at the community level. We center principles of equity and justice and strive to provide policy recommendations that are feasible and adaptable.

Listening to Communities and Workers First

Our investigation started in six heartland communities—Detroit and Flint, Michigan; Kokomo, Indiana; and Lima, Lordstown, and Toledo, Ohio. There, our Indiana University researchers recruited current and former autoworkers, managers, and community leaders to share their concerns and aspirations about electrification. The 150 participants in those 67 focus groups understood the momentousness of decarbonization, with some characterizing the impending transition to electric vehicles as the next industrial revolution. At the same time, participants expressed a fear of the unknown, raising questions about whether there will be a market for electric cars, about whether car companies and the government will overpromise and under-deliver, and about equity and access, whether in terms of public infrastructure, workforce development, or affordability.

We also heard stark differences in responses based on the type of participants. For community members, leaders, and managers, a sense of tentative hope emerged about the possibility of agile development, new technological innovations, and community revival. For autoworkers, however, the transition felt much more precarious. While workers believed that the car companies "owe" them a job in return for their years of hard work, they nonetheless seemed resigned to the notion that their loyalty would go unrecognized. They grudgingly accepted that electric vehicle production would be better than nothing at all, yet also feared they would be easily replaced and ultimately left behind.

Dr. Jalonne White-Newsome also interviewed over 30 public health and environmental justice experts in our six targeted communities to inform how the transition to electric vehicles (EVs) will affect the health of the natural environment, the community, and our local economies. While the primary focus of an industrial transition is typically on jobs and workforce, we found that without a conscious effort to identify and accelerate the public health benefits and address racial and environmental justice issues in the impacted community, an important opportunity will be lost.

State of the Automotive Industry

Driven by a fundamental change in vehicle propulsion technology, the U.S. automotive industry is on the verge of a structural transformation. In 2019, the tristate region built 40.9 percent of U.S.-produced vehicles (Wards Intelligence 2021). Only 7.3 percent of those were battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) (LMC Automotive 2021). By 2028, the region is forecast to produce 42 percent of U.S.-built BEVs and 30.9 percent of U.S.-built PHEVs (LMC Automotive 2021).

The shift to BEVs also has critical implications for the region's labor force. The region is home to 34 percent of North American engine manufacturing output, 62 percent of North American transmission production (LMC Automotive 2021), and the country's largest automotive engineering and product development employment cluster (U.S. Department of Labor, Bureau of Labor Statistics 2019). As propulsion technologies shift, both production and engineering jobs are at risk.

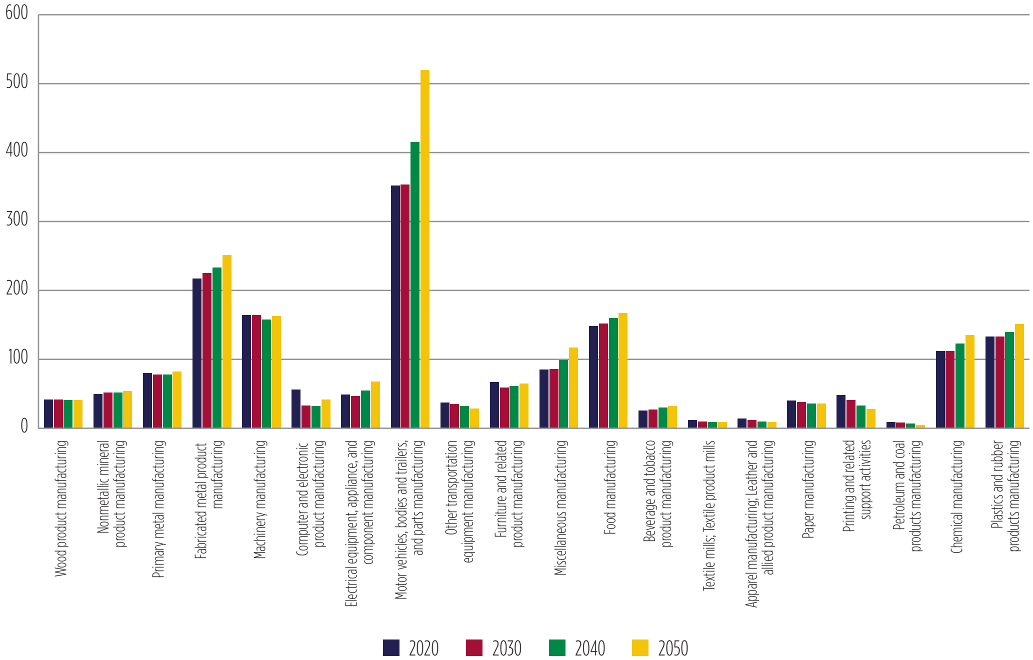
The electrification trend also has potentially significant consequences for suppliers. Smaller suppliers may not have sufficient scale, and in some cases the requisite access to capital, to support newly designed, dedicated EV architectures, otherwise known as vehicle "platforms," designed by automakers to achieve targeted cost reductions via new economies of scale.

Globally, regulatory mandates are the primary driving force behind vehicle electrification, and, as a result, the United States is a laggard compared to international competitors. Typically, development of new technologies occurs in the national markets expected to provide the most significant sales opportunities for those technologies, which, in this case, means China and Europe. Thus, initiating R&D incentives for U.S. auto companies while providing domestic manufacture preferences will be vital to developing the competitive position of U.S. assembly, battery, and drivetrain production.

Modeling Results

Our economic modeling in the Roosevelt Case verified that, with the ameliorating federal policies advocated in our work, over 560,000 more jobs would be created in the tristate area, while reaching net zero emissions by 2050 (Roosevelt vs. Decarbonization Scenario). 50,000 of those jobs would be in motor vehicle manufacturing. With the Roosevelt policies, job growth would also exceed the Base Case Scenario by 150,000. Overall, in the Roosevelt Case, 3,150,000 new jobs would be created in Michigan, Indiana, and Ohio, including 265,000 new manufacturing jobs.

Table 1: Manufacturing Job Growth in Tristate Region (Roosevelt Scenario), Thousands of Jobs



Key Findings

The Industrial Heartland case study finds the transition to motor vehicle electrification in Michigan, Indiana, and Ohio could result in significant job loss without the right supportive policies. Between 75,000 and 100,000 jobs and over 1,000 businesses are linked to the production of internal combustion engine (ICE) components and powertrains in the tristate region. Further, our community research surfaced the deep skepticism among current autoworkers as well as low-income and fence line communities that this transition will benefit them. The legacy pollution in the tristate region from over 180 motor vehicle plant closures since 1980 continues to underscore the challenge. To deal with that skepticism, the federal government must urgently mobilize and coordinate the delivery of its resources with transparency, community input, and accountability. With these stakes in mind, we make the following policy recommendations.

Key Recommendation

We recommend the immediate formation of a national Transportation Electrification Commission (TEC), cochaired by the Council of Economic Advisors and an industry representative to oversee federal resource deployment. This commission should include the secretaries of energy, commerce, transportation, and labor, with deep participation by the motor vehicle industry and its supply chain, labor unions, and impacted communities.

The Transportation Electrification Commission's mandate should be to:

1. Promote strategies and collaborations at the state level for domestic manufacturing development that prioritize current and former motor vehicle communities,
2. Decarbonize manufacturing through innovation, research, and development while ensuring economic competitiveness,

3. Create quality American jobs, accessible to all Americans, while promoting labor/management cooperation,
4. Review the wage, benefit, and other working condition disparities within the motor vehicle industry and make recommendations on how to reduce them, including consideration of labor law reform, sectoral bargaining, and stakeholder representation on corporate boards,
5. Monitor and remediate environmental impacts while accelerating the public health benefits of electrification,
6. Mandate Community Benefit Agreements (CBAs) wherever federal funds are expended for electrification and establish a standard CBA process to provide adequate resources, transparency, accountability, and technical assistance to communities impacted by the transition, and
7. Deploy accessible, low carbon, mass transportation alternatives.

Additional Policy Recommendations

1. **Repurpose Manufacturing Programs.** Repurpose the current Advanced Technologies Vehicle Manufacturing (ATVM) loan program, Manufacturing Extension Partnerships, Industrial Assessment Centers, a new 48C Advanced Energy Manufacturing tax credit, an industry R&D tax credit, and consumer rebates and tax credits to ensure the transition of current and former motor vehicle communities.
2. **Tighten EV Trade Policy and Domestic Content Rules.** Strengthen existing trade agreements, such as the USMCA, and procurement policies to guarantee greater U.S. domestic content in EVs, battery assembly, and supply chains. Institute border adjustments for energy-intensive industries, such as steel, in the supply chain.
3. **Strengthen EV Purchaser Tax Credits.** Ensure that EV tax credits provide added incentives for domestic content, quality jobs, and access to used vehicles in low-income communities.
4. **Advance Equity Access and Opportunity Issues.** Enable inclusive planning processes for new plants, expansions, and closures; access to EV infrastructure in all communities; availability of electrified public transportation; and equity reporting and standards across all impact areas.
5. **Job Quality Assurance and Access.** Utilize project labor and community benefits agreements wherever federal investments are provided for electrification.
6. **Job Training.** Enact a comprehensive energy transition adjustment assistance program, designed at the community level, covering all motor vehicle employees, employers, and related energy employment. Provide incumbent employer tax credits for retraining and retaining existing employees. Prioritize displaced auto and energy sector workers along with low-income communities for new opportunities created by federal investments.

Note: Please see 3.1–3.3 for a correlation between report text and policy recommendations.

Case Study: The Industrial Heartland and the Motor Vehicles Transition

Introduction

The Industrial Heartland case study evaluates barriers to the electrification of the motor vehicle manufacturing sector in the tristate region of Michigan, Indiana, and Ohio. Our goal is to recommend best practices and public policies that promote equitable solutions to the anticipated disruptions caused by vehicle electrification and other related clean energy transitions in the region.

This study begins by asking critical questions about the electrification transition to the people and communities most affected. As described in our research methodology, the Industrial Heartland case study brings together a set of regional experts in Michigan, Indiana, and Ohio to ask those questions and assess the distinct options this region will face during the transition. We undertook this project with a community-first frame, understanding that while economic and industry trends ultimately drive many of those disruptions, solutions arise from the perceptions at the community level. We center principles of equity and justice and strive to provide policy recommendations that are feasible and adaptable.

Context

I. Electrification: State of the Automotive Industry

Driven by a fundamental change in vehicle propulsion technology, the U.S. automotive industry is on the verge of a structural transformation. The tristate region of Michigan, Indiana, and Ohio is at its epicenter. Vehicle manufacturers, component suppliers, and material processors are rapidly changing their technology portfolios to adapt. In 2019, the tristate region built 40.9 percent of U.S.-produced vehicles (Wards Intelligence 2021). Only 7.3 percent of those were battery electric vehicles (BEVs) and plug-in electric vehicles (PHEVs) (LMC Automotive 2021). By 2028, the region is forecast to produce 42 percent of U.S.-built BEVs and 30.9 percent of U.S.-built PHEVs (LMC Automotive 2021). President Biden's executive order identifying a goal of 50 percent zero-emissions vehicle sales by 2030 has set an expectation. The region must now respond.

Vehicle manufacturers are investing in the region. Over the past five years, it has received 36.7 percent of announced electric vehicle (EV) investment for the United States, a critical commitment for the region with significant implications for its labor force. The region is home to 34 percent of North American engine manufacturing output, 62 percent of North American transmission production, and the country's largest automotive engineering and product development employment cluster. But as propulsion technologies shift, both production and engineering jobs are at risk. The region needs to create pathways for its communities and workforce to transition from internal combustion engine (ICE) to BEV transportation and manufacturing.

The electrification trend has potentially significant consequences for suppliers. Smaller suppliers may not have sufficient scale, and in some cases, the requisite access to capital to support these new dedicated EV architectures. For example, a newly designed EV platform by Stellantis is intended to support up to two million vehicles; by comparison, Stellantis supported 1.7 million vehicles produced in 2020 using twelve different vehicle platforms. The added volume requirement (per platform), compounded by globally designed, shared EV drivetrain components, will favor large, multinational suppliers to the detriment of smaller, regional players.

In addition, suppliers face increased competition from both new market entrants and existing suppliers for the EV powertrain business that is replacing ICEs. However, new suppliers within the emerging technology areas of battery systems, electric motors, and power electronics often have greater capital and engineering talent than traditional automotive suppliers, who must also transition their existing businesses.

Lastly, the growing trend by automakers to insource—i.e., increase vertical integration to reduce costs and lessen the impact on their labor force (often union)—will further put conventional powertrain suppliers under pressure. For example, Volkswagen and General Motors are designing and building e-transaxles internally. General Motors has announced they will market their Ultium-branded electric drivetrain components to other manufacturers—thus becoming a competitor to other suppliers. This changing vertical integration has important implications for suppliers in the Midwest region who are dependent on localized powertrain production.

II. Electrification: State of the Utility Industry in the Heartland

The Industrial Heartland still relies heavily on fossil fuels to supply electricity. In 2020, coal-fired power plants comprised 42 percent of installed capacity or 35 gigawatts (GW) and oil- or gas-fired plants another 36.6 percent (31 GW). All other resources—including wind, nuclear, storage, solar, hydro, and geothermal resources—represent 21 percent of system capacity. (Cole et al. 2020). Michigan and Ohio have mandatory renewable energy standards (15 percent by 2021 and 8.5 percent by 2026, respectively), while Indiana has a voluntary target of 10 percent by 2025.

Most electricity sold in the Industrial Heartland is used for commercial and industrial consumption: 62 percent or 208 terawatt hours (TWh). Residential electricity sales make up around 36.6 percent or 120 TWh (U.S. Energy Information Administration 2020).

Electricity demand is projected to increase as consumers shift their use of fuel for home heating and for driving to electricity. The National Renewable Energy Laboratory's (NREL) Electrification Futures Study anticipates that with no change in policy, electricity generation in 2050 for the region will be 53.6 percent higher than today. In NREL's "high electrification" scenario, which models what they categorize as transformational electrification, including vehicle use, electricity demand nearly doubles from 2020 levels by 2050.

III. Electrification: Environmental Justice and the EV Transition

While an industrial transition is typically focused on jobs and workforce, our intent is to offer a framework that will also acknowledge the potential environmental injustices from this transition which may negatively impact the health of the physical environment and the community, if not considered up front.

Systemic and institutional racism have long been the driving factors that have led to many low-income communities (LIC), communities of color (COC), and Indigenous Peoples living in neighborhoods that are hazardous to their health. Multiple sources of industrial pollution, inadequate infrastructure to protect community residents, and lack of environmental enforcement are just a few of the reasons for health disparities in various hot spots (areas with multiple pollution sources) across the country.

One current example drives home this point. In 2019, Fiat Chrysler Automobiles (FCA; now Stellantis) announced a $2.6 billion expansion of their existing Jefferson North Assembly Plant (JNAP) and Mack Engine plant on the East Side of Detroit, Michigan, that would produce the next generation Jeep Grand Cherokee along with plug-in hybrid (PHEV) models (Stellantis 2019). In return, FCA would receive several hundred million dollars in tax relief. In reaction to this proposal, Just Beniteau Residents (residents living on the fence line of the new facility expansion) immediately raised concerns about the project's potential negative impacts on their health and quality of life (Detroit People's Platform 2020).

With the initial support of the Detroit People's Platform, Just Beniteau Residents and a larger network of advocates developed a set of proposals for FCA and the City of Detroit to consider, which could make this East Side neighborhood a model of "true sustainability and an incubator for imaginative work, community respect and dignity" along with the plant expansion.

This vision relied on a Community Benefits Agreement (CBA)—a project-specific agreement between a developer and a broad community coalition—that detailed the project's contributions to the community and ensured community support for the project. Typically, a CBA would include community access to jobs and training and provide guarantees of health and safety for residents. Unfortunately, the Community Benefits Agreement ordinance in the city of Detroit failed to protect the interests of the impacted community, based on a number of factors: political pressure, a rushed CBA timeline and process, a lack of transparency in decision-making structures, the withholding of air monitoring data, a failure to disclose the array of chemicals being used in the facility, and inaccurate modeling of potential air impacts from the expansion. As a result, what could have become a model for environmental justice in the EV transition has become mired in recriminations of environmental racism.

Sociologist Dr. Robert Bullard, environmental justice scholar and activist, defines environmental racism as "any policy, practice or directive that differentially affects or disadvantages (whether intended or unintended) individuals, groups or communities based on race" (Bullard 2000). The reality of environmental racism was the impetus for what has become the environmental justice (EJ) movement, akin to the Civil Rights Movement (U.S. EPA 2021).

Environmental justice—as defined by the Environmental Protection Agency—is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. While the foundations of this movement started decades ago, the guiding principles of the movement, created at the People of Color Environmental Leadership Summit in Washington, D.C., in the early 1990s, guide the work of many grassroots organizations today (First People of Color Environmental Leadership Summit 1991). The 17 Principles of Environmental Justice speak to affirming the sacredness of Mother Earth. Several of the principles call for accountability, engagement, and conscious decision-making, as listed below:

- **Principle 2:** Environmental Justice demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.
- **Principle 7:** Environmental Justice demands the right to participate as equal partners at every level of decision-making, including needs assessment, planning, implementation, enforcement, and evaluation.
- **Principle 12:** Environmental Justice affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity for communities and providing fair access for all to the full range of resources.
- **Principle 17:** Environmental Justice requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little waste as possible.

While these principles were crafted in 1991, they remain as relevant in 2021.

IV. Case Study Research Design

To ensure a comprehensive and thoughtful approach to the major issue of motor vehicle electrification in the Industrial Heartland, our team took a three-step approach to this project:

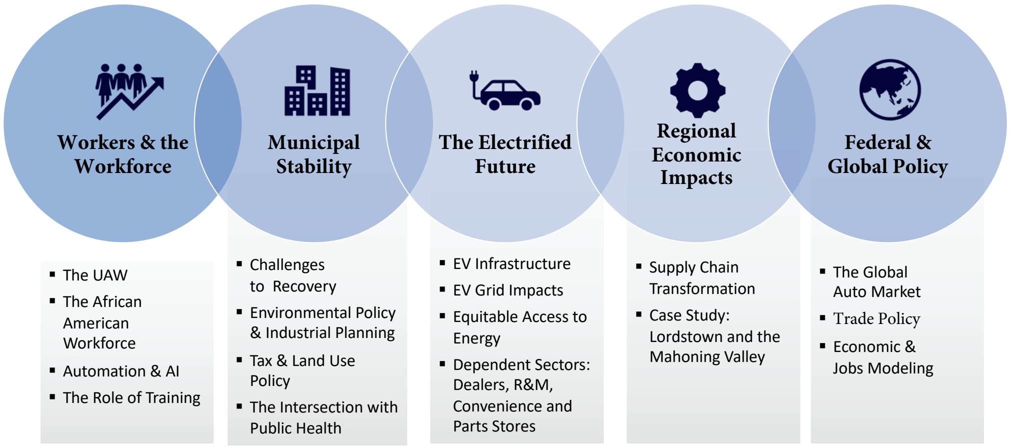
(1) Listen to communities and workers first,
(2) Assess the policy slate, and
(3) Make policy recommendations.

Chapter 1: Listen to Communities and Workers First
Our partners at Indiana University's O'Neill School of Public and Environmental Affairs designed a survey project in partnership with Econometrica, Inc., intended to analyze the responses of autoworkers and community members affected by plant closings and the shift to decarbonization. This survey work includes 67 focus groups in six communities that have experienced or are experiencing plant closures and, in some cases, conversions.

Keith Cooley and Dr. Jalonne White-Newsome, our environmental justice consultants, interviewed an extensive group of experts in both the motor vehicle industry and public health in these same communities. Their studies examine perspectives about the impending transition and perceptions of the community impacts of both past and future transitions.

Chapter 2: Assess the Policy Slate
The core of the Industrial Heartland case study involves identifying the "policy slate," from the most granular level (the individual worker) to the most broad (federal and global policy). For each focus area, shown in Figure 1 and described below, our team assessed (1) the current state of policy, (2) the relevant historical context in that area, and (3) key current policy proposals and controversies.

Figure 1:



Chapter 3: Make Policy Recommendations

The aim of this research is to make policy recommendations from the local to the federal level. Our team utilizes findings from our community focus groups and policy slate analysis to provide recommendations that are rigorously supported, are cognizant of disparate opportunities and outcomes, and can be feasibly implemented. Finally, these recommendations were reviewed by another talented group of experts with decades of experience in the motor vehicle industry and its labor relations, community engagement, and impact investment who make up our regional advisory board.

Woven through each of these chapters and their relevant focus areas are the five themes that emerged from the 67 Indiana University focus groups that provide the human context for how communities manage their transitions. Our study begins with those findings.

Chapter 1: Listen to Communities and Workers First

1.1 Community Concerns and Attitudes: Focus Group Analysis

The purpose of Chapter 1 is to analyze attitudes pertaining to the shift to electric vehicles held by autoworkers and community members affected by both plant closings and conversions. We chose to conduct in-depth interviews and focus groups instead of a more traditional survey because we wanted to discover the relevant categories at work—that is, how people envision the transition to electric vehicles—rather than the "distribution of some larger population across categories that we have a priori chosen" (Luker 2010, 102).

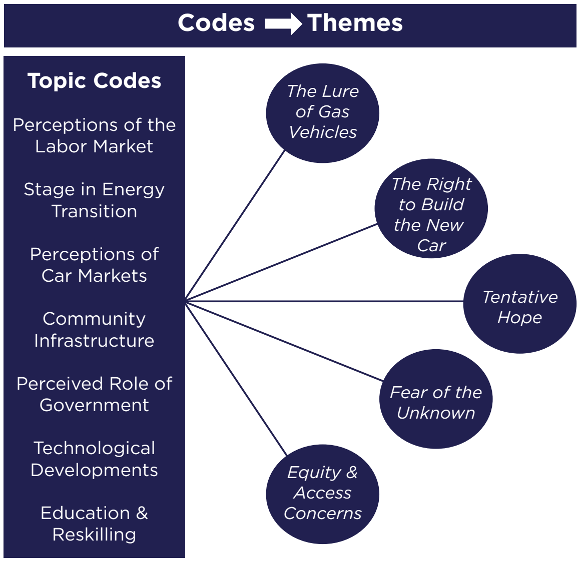
Through deep immersion in six communities, we were able to uncover how people construct and perceive plant closings, decarbonization, and future opportunities or fears. Crucially, whether we judge participants' perceptions as valid, factually correct, or sensible, they are nonetheless important to understand because people "act as if they are true" (Frye 2017) and can thus shape demographic change in a vast array of substantive domains, including marriage, divorce, fertility, political participation, and religious involvement (Johnson-Hanks 2007). Furthermore, policies could fail to reach key populations if they make assumptions about the systems of meaning that underlie behavior (Mathur and Silva 2019).

Focus Group Locations and Analysis

The study focused on six locations across Michigan, Ohio, and Indiana, including Detroit and Flint, MI; Toledo, Lima, and Lordstown, OH; and Kokomo, IN. In the Indiana University (IU) working paper, we provide a summary of each site, including recent developments relevant to electric vehicles where appropriate, along with a few basic demographic statistics for each location and plant-level information.

For a complete description of our analytic process, please also see the IU working paper. That process resulted in the topic codes and themes that emerged across all locations and demographics, as illustrated in Figure 2 below.

Figure 2: Topic Codes and Themes.



Key Findings

The participants in our study understood the momentousness of decarbonization, with some characterizing the impending transition to electric vehicles as the next industrial revolution. At the same time, participants expressed a fear of the unknown, raising questions about whether there will be a market for electric cars, about whether car companies and the government will overpromise and under-deliver, and about equity and access, whether in terms of public infrastructure, workforce development, or affordability.

We also heard stark differences between the type of participants that we spoke with. From community members, leaders, and managers, a sense of tentative hope emerged about the possibility of agile development, new technological innovations, and community revival. For workers, however, the transition felt much more precarious: while workers believed that the car companies "owe" them a job in return for their years of hard work, they nonetheless seemed resigned to the notion that their loyalty would go unrecognized. They grudgingly accepted that electric vehicle production would be better than nothing at all, yet also feared they would be easily replaced and ultimately left behind.

The Lure of Gas Vehicles

Participants expressed concern that American consumers were not ready for the shift to electric vehicles. Older generations emphasized the strength, size, and sensory nature of gas vehicles, particularly the experience of smelling the exhaust and hearing the engine. In a Lima, Ohio, focus group, participants stated that "most people are in love with their cars" and explained that "what ma[kes] a car" is a "big engine" and "lots of horsepower." Doubting consumer desire for electric vehicles, one community member elaborated, "All these tiny little [EVs] that they were all inventing, didn't make the biggest hit in the United States because people like their big vehicles. And we continue to buy big trucks, SUVs, and all of that."

In Detroit, older members also reflected that it would take serious efforts to persuade them to invest in an electric car. As one Detroit manager explained, "I think it's going to be somewhat of a challenge to get old hats like me to believe that they can get into a[n electric] car, make a trip and come back safely home." He concludes: "I have nieces and nephews that don't even care if they own a car or not. And for me like, oh my God, I have to have a car every minute. The car was life itself."

Other respondents commented on the way in which people operate their traditional vehicles as deeply ingrained within their lifestyles and accompanied by a set of habits that simply cannot be broken.

Fear of the Unknown

Participants also conveyed a sense of wariness and suspicion toward the speed of the transition to electric vehicles, fearing that car companies had committed to a rapid timeline that might not prove viable. They saw more "hype" than actual information and planning. Managers, for instance, noted that too many questions—about community infrastructure, workforce development, and organizational structures—have been left unanswered in the race toward an electric future. One manager from Toledo worried that "the electrification movement is moving faster than people thought it would." He explained that he was "not sold on it yet" due to his lack of knowledge, though he accepted that "it seems to be the way of the future. . . . It's just, they need to put more information out there on how this is going to work." This manager attributed the speed of the transition to competition between car companies, though he also questioned if "they're all in cahoots with each other too," possibly at the expense of workers and consumers.

Participants used phrases like "a catch-22" or "a coin toss" to capture their ambivalence toward electric vehicles. Some felt more comfortable with the idea of a hybrid vehicle because "electric, just the infrastructure, having the necessary... quick charging stations is going to be so important because we rely on our cars so heavily," as a Lima community member said. Another Lima community member also worried about the lack of dependability of electric vehicles, especially during emergencies: "So if you need to get in your car to run away from a tornado, not going to happen, because electricity all went out. I'm trying not to be negative at all, but I think there's just a lot of basic things that need to be taken care of before people will buy in."

Another autoworker from Detroit believed that many of the problems that would accompany the EV transition were not being openly discussed out of fear of halting progress: "I'm not trying to be negative but all you hear about is the positives of electric vehicles not using gasoline. But man, there's a lot of other issues that they're not talking about because they haven't really solved those yet. They don't want to kill the progress being made with electric cars as they are. So that's my kind of take on this whole thing."

This fear of the unknown was exacerbated by the perception that auto manufacturers were purposely withholding information from managers, workers, and consumers. A community leader who contracts with Detroit auto manufacturers expressed that a lack of knowledge about where auto manufacturers are in their stage of the transition to EVs creates challenges for other industries and educational programs to adapt: "And the other thing about what would be a barrier for this growth in our area? I really think that the automotive companies, including the battery makers and so forth, they're really going to have to explain what kind of skill sets they need in order to make this industry work."

Concerns about Equity and Access

Participants' fear of the unknown dovetailed with specific concerns about equity and access. These concerns centered on the future of workers and the availability and affordability of appropriately equipped electric grids, charging stations, and wattages available in people's homes. A large number of respondents expressed concern about whether their jobs will still exist in future years, in the event that manufacturing an EV will require fewer assembly workers due to its fewer parts. "[It's] scary because I think some people are going to end up being without a job because they probably won't need as much. But then again, it may need more than what we have now, so it's kind of scary with the unknown," mused a Detroit autoworker.

A similar concern was that the manufacturing of an EV would require specialized knowledge—knowledge that the current employees did not possess. These respondents were dubious about whether their employers would provide opportunities for workforce training, and some assumed that they would simply be replaced by outside specialists. For example, a Flint autoworker explained: "I think that if they have to hire new people to retool it, they'll bring it. They'll try to bring in people from the outside contractors or something else like that. Or they'll set up a dedicated traveling team or something like that."

A Lima, Ohio, community member elaborated, "I think a lot of people don't realize today that some of the jobs that only took a high school diploma to get a job are now taking someone that may have a bachelor's degree." A spinoff concern drew attention to how "the repair community, the mechanics, and the service stations are going to have to become sensitive to different parts of the automobile that they were never sensitive to before."

Participants also questioned whether everyday families would be able to purchase and maintain an electric vehicle. One Lima community member noted, "Most families can afford an internal combustible vehicle. Will the electric used car be [so expensive] that [most families] will [not] be able to afford it? And now what happens if you don't have a garage—you're a renter or something, where do you get [a high] amp charging station?"

"I Earned the Right to Build That Next Car"

A common sentiment expressed by many current autoworkers was a sense of bitter resignation that the transition to electric vehicles is both rapid and inevitable. Alongside this sense of inevitability unfolded deep worries that the transition will result in steep job losses because the manufacture and assembly of electric vehicles will require not only fewer people but also workers with different and more advanced skill sets. Expectations about the impending changes to the size and composition of the auto workforce creates feelings of dread for some autoworkers and specific worries that experienced workers, many of whom have given years to their companies, will lose their job and, with it, economic security for themselves and their families. Altogether, there is a belief that autoworkers have "earned the right to build the next car," but that this is unlikely to happen, leaving some with a sense of betrayal. Laid-off workers in particular note that they are often not the ones being hired into new roles for electric vehicles since more highly educated workers are needed. Although there is a recognition that they may lack the requisite training or skills, there nonetheless is a sense that a social contract has been broken.

Focus group participants frequently mentioned concerns about job losses as the transition to electric vehicles unfolds. A belief has begun to set in that the production of electric vehicles—from the start of the supply chain through final assembly—will require fewer people. For some, there is also a belief that this will result in a decline in union jobs, which they believe may be the desired outcome for auto companies. A participant in a focus group of Detroit autoworkers asserted that the United Auto Workers (UAW) would be primarily impacted by the closing of engine and transmission plants:

> "The vehicle assembly plants will have less labor involved. For every vehicle or two or three vehicle assembly plants, there is an engine plant that does nothing but make the engines. They're huge and they're very complex. It's all very expensive machinery. They have to cast the blocks and they're machining the engine blocks. There's a lot of work involved at these engine plants that are no longer needed. That plant, and it's all UAW, is not needed. Same thing for the transmission plants. Transmissions are fairly complex and there's machining and electrical on there. There's a lot going on in those transmission plants. Well, there's no more transmission in these cars. No engine, no transmission, no gas tank, and some of those chassis' components. So that work is not needed, it's not in any of these new cars. What's replacing it are probably components built outside of UAW."

Alongside this fear of loss of union jobs is a more general concern that current workers will not be hired for the new electric vehicle jobs. To illustrate, a former employer at the GM Lordstown plant reflected on General Motors' decision not to convert the plant where he previously worked to electric vehicle manufacturing: "I was thinking about, I mean, for instance for us, I think that General Motors very easily could have retooled our plant and shifted towards the electric, but I don't believe that they wanted to deal with us anymore."

Another former GM Lordstown worker talked about the frustration of not being prepared to compete for work in the EV sector and how this lack of training left him feeling betrayed, having dedicated years of life, and his physical well-being, to manufacturing GM cars. He said: "I'm trying to work and do what I want to do for the rest of my life. I mean, it's not easy at 48. I'm not exactly coming out of college. And when I go to interviews, it's different, that's all…It's not where I want to be… I felt I earned the right to build that next car. That's where I am on it. I mean, I earned it. I have knees that don't work now because of it, because I gave my life to that company."

For other autoworkers, the adverse workforce effects of the transition to electric vehicles seems not inevitable but a matter of priority. That is, while workers filling roles in the current manufacture of ICE cars may not currently have the skills needed to produce electric vehicles, they are willing learners and desire an opportunity for retraining and retooling. A current autoworker in the Detroit area commented, "So there's a lot of things and someone recently said you don't have to have a four-year degree to do good, you just need basic training. I think there's a lot to that."

Tentative Hope

Many focus group participants expressed guarded optimism about the transition to electric vehicles. This sentiment was most pronounced among community members and people serving in management roles within the auto industry, but it was also noted by some autoworkers. As an example, a community member from Lordstown, Ohio, describes his feelings when regularly passing the new Lordstown Motors operation: "I live in Lordstown, so I live a mile and a half from the plant. I pass by it every day—I ride my bike by it on every bike ride I go on. So, at the end of the day, you see this monstrous structure that two years ago, three years ago was like a sign of death. It was done. You know what I mean and now to have something come back and just even see the old Chevy sign, the Cruze sign that was on there replaced with [the] Lordstown Motors sign. Just the hope that I think that brought is pretty tremendous."

In Lima, a community participant expressed faith in American industries to conduct thorough research and flexibly adapt their products to meet consumer needs: "I am all about agile management and agile development," he stated. "And I think that this push for electric may end up with some other direction that will be better, because I do believe that the one thing in America that industry does, at least the industry that sustains itself, is that they develop, and they do R&D work. And so what they think the direction they may be going might start to slide off in another direction, and then another direction, and it will only get better. So, I think industry that has good research and design will gain on what's happening with this concept for electric cars."

The optimism noted by many community leaders and company managers did not come without caution and recognition that the composition of auto plant jobs and the skills required to fill them might differ in substantial ways, with adverse effects for the current workforce. Some managers believe that there will be an increase in non-assembly roles, but they also note that any such predictions about the composition of the future electric vehicle workforce are fraught with uncertainty. For example, a manager from one of the Detroit focus groups observed: "I know there's a concern that the union says, well, it's going to be fewer people assembling it. Well, yes and no. I think when you look at the whole supply chain, you may find in other areas, there's going to be jobs created, but it won't be in the assembly plant. It'll be somewhere else." This view reflects an overall attitude that there will be winners and losers in the transition, without much focus on how those are adversely affected will be treated.

People's degree of confidence seems to be shaped, at least in part, by perceptions of the scale and speed of the transition. A community leader from the Detroit area emphasized that the changes will be gradual rather than sudden, giving time for workers, auto companies, and communities to adapt. They noted: "So, you know, again, that's, that's a transition period. I don't know what that's going to be like. I think it's going to take time. I wouldn't, uh, I wouldn't expect it to be a real problem because [the EV transition is] going to be evolutionary versus, you know, revolutionary where something happens really fast." Compare that view with one from a current autoworker from Detroit who perceived that the transition from ICE cars and trucks to electric vehicles will be a massive transformation: "I mean, this is almost at the level of the original Industrial Revolution, if you would, in terms of how it can affect everybody in this country and other countries around the world."

1.2 Environmental Justice Stakeholder Interviews

Semi-structured stakeholder interviews were also conducted to better understand how the EV transition will affect the physical environment, community health, and transportation access and affordability in low-income communities. A total of 32 leaders were interviewed. Their representation by state and sector is described in Working Paper #2.

Legacy Environmental Pollution

Interviewees were asked to comment on the legacy and current environmental issues impacting public health, including waste, toxic materials, and other health concerns that are connected to the auto industry, and how those issues would or should influence the EV transition. They shared several concrete legacy issues that related directly to environmental injustice: the construction of highways through Black communities that disrupted neighborhood and culture, the number of brownfields that remain in communities, the manufacturing processes that exposed workers to dust and contaminants, and the remnants of pollution and contamination that still exist today. A current worker in a Pontiac facility shared,

> "Back in the day—the Central Foundry was where you made cylinders for the car; we had 3 or 4 smokestacks, giving out a chemical dust; it would be dust that would corrode your car; they had no environmental process to control and people were breathing in soot; it was a big concern with no respirator when you worked. People were getting sick from black lung; they would give you extra 5 years seniority when you started because the work was so dirty. They tore down the foundry in 1985…but the dirt and the environment is still dirty and around is still here today."

An environmental justice leader called the legacy of the former auto industry "destructive," highlighting the need for a "clean, green approach" to making new factories. It was noted by several interviewees that low-income communities and communities of color are exposed to the most pollution.

> "Those who have money, who have economic well-being, often are not the same people who are experiencing environmental injustices because they can afford to move away from, out of the epicenter of areas where there is, where there's high levels of pollution."

A Toledo health expert connected the legacy of inequitable infrastructure design with the current air pollution hazards and the legacy of traffic-based depositing of lead from gasoline into neighborhood soils, causing current lead toxicity challenges for children across neighborhoods.

> "As long as we get away from combustion engines, and as long as we don't have power plants that are coal fired, we will be making a significant impact on asthma morbidity and mortality; and it's significant for our children. Moving to electric vehicles could also minimize other health impacts beyond the respiratory system, including the cardiovascular system and reproductive health."

Health Impacts and Opportunities

The chain of direct and indirect impacts of dirty air is well studied, both from point sources (i.e., manufacturing facilities, energy-generating plants, etc.) and mobile sources (i.e., cars, trucks, public transportation vehicles, etc.). Interviewees acknowledged the disparate impact, particularly on communities where factories are located, of poor air quality and its disproportionate impacts on people of color, particularly driving negative health outcomes related to infant mortality, asthma, and juvenile diabetes.

> "Improving the infant mortality, specifically the disparity between the black and the white. Currently in Toledo, Lucas County, black babies are dying at three times the rate of white babies. And we define infant mortality as reaching your first birthday. So, we have a huge disparity in this, and it has nothing to do with socioeconomic [status], insurance, any of that. When you tease all that out the disparity still exists. So, there's really nothing genetically wrong with black women that they can't carry their babies. So, it's the environment and the other issues, more specifically the racism [causing this]." —Public health practitioner

Interviewees commented that the auto industry has an opportunity to influence and improve health through providing jobs.

> "I think that, again we talked a little bit about social determinants of health, and I think that plays back into industry or just jobs in general. There's a lot to say about you know, having industry in a community. As long as we can regulate it, so that again it causes least impact on the environment or people's lives as possible. But you need to have those jobs, because if you don't there's no way that you're going to have a community be as healthy or productive as it possibly could or can be. The associated children's health are directly related and impacted by the jobs industry that are in that community whether it's the school systems that you have available to you." —Environmental justice advocate

Equity Frameworks and Just Transition Guidance

To achieve an equitable transportation transition, interviewees raised the need for more people of color to be engaged and lead conversations related to the EV transition.

> "As we know, historically, marginalized communities have not been included in these conversations. And so we are looking at figuring out how do you get representatives that are being impacted the most by climate and environmental factors, into the conversations about clean energy planning, and policymaking? Policies are being created or devised or implemented, that are impacting those voices that have no representation."

An energy advocate suggested using the Jemez Principles.

> "You have to ensure you are doing bottom-up organizing and shifting from a hierarchical to a more horizontal way of organizing. Engagement with Black, Latinx & Indigenous communities to inform the transportation framework, ensuring EJ and frontline communities are the decision-makers in the process, and operationalizing equity as a social value are other key parts of the process."

Other interviewees acknowledged the need to account for injustices in the development, production, and deployment of EV technologies to break away from inequitable patterns of embodied injustice:

> "I think that the term is kind of riffing off of embodied energy. Let's say a solar panel has embodied energy, meaning it took energy to make that solar panel, it didn't just show up. And if we, if it makes a certain amount of energy or takes a certain amount of energy to make a product, and that product also generates energy like a solar panel. You could say oh it takes a year of that solar panel in the sun to generate the energy that it took to make it. So, is it possible to have embodied injustice, meaning that, even if all phases of manufacturing are done very, very well but some of that cobalt came from an artisanal mine that was using child labor, while it brings a lot of community benefits back, you can say that there's embodied injustice in that particular material." —Energy justice advocate

Defining Who Benefits (or Not) from EVs

The point of discussion that was raised by all of our interviewees was unpacking the range of benefits that could be experienced by the ecosystem of stakeholders in the EV transition.

> "I think we all stand to gain. There are no losers in this except maybe DTE, but, you know, they can adapt, right? The vast majority 90 percent, not the 1 percent but the 90 percent, well 95 percent of us are going to win and be at an advantage when our air is cleaner, and our water is less polluted, and our soil is cleaner. And so…we have less asthma issues, less heart disease issues, fewer strokes. And these are things that plague Black people and Black people in Detroit, and low-income people probably everywhere. So, I don't see a downside."

There are those that might not benefit from EVs due to the source of power being used, as well as the sourcing of components across the supply chain.

> "Well, ideally, all electric vehicles will be powered by clean energy. I mean that is where those two things connect, and they intersect, and I, my

> opinion, my wish would be, is that that's a goal, because if I know that my EV is powered by dirty coal, it's true. It's not benefiting as much. Yeah, there's no emissions coming out the tailpipe, but you know there are a lot of emissions, created in order to power that plug."

Interviewees also expressed concerns about access to electric vehicles in Black, Brown, and Indigenous communities, as well as about low-income whites who might not be able to afford an electric vehicle.

> "I think financing is often thrown around as a like, oh, if costs are a barrier let's offer financing. But that doesn't necessarily recognize that people might not want to take on debt, and it's not really reasonable to say, oh, we think there's societal benefits of EVs, therefore you need to take on debt so you can purchase an EV when that might not be someone's priority. So I think there's like, this big question of imposing the values of EVs being a societal benefit onto individuals, and asking them to pay more, or take on debt to purchase something that we value as a society."

For a summary of the inequities that were raised regarding the EV transition based on these interviews, please refer to Table 5 in Working Paper #2. Table 5 also describes the reality for Black and Brown communities and potential solutions to address the root cause of the concerns.

Chapter 2: Assess the Policy Slate

2.1 The Worker and the Workforce

Our review of the policy slate starts at the point of most immediate impact—the worker. Industrial transitions in the United States have had a checkered past, especially in the industrial Midwest and particularly in the auto industry. Approximately 187 motor vehicle plants have closed in the tristate area alone since 1980, largely with devastating impacts on communities and relatively few success stories (CAR database). Participants in the case study focus groups repeated their doubts that this transition would be any different.

Chapter 1 explores four key areas of the motor vehicle workforce and examines steps that should be considered to improve the outcomes for both the individual worker and this unique industry workforce. Those areas include the role of the industry's most important union, the United Automobile, Aerospace, and Agricultural Implement Workers of America, also known as the United Auto Workers Union (UAW), the very particular role that African Americans played in building the industry and its culture, the current state of technology and its future impacts on motor vehicle manufacturing, and finally the role of workforce training and the possibility to retrain the existing workforce during a transition.

We begin with the industry's union.

2.1.1 United Auto Workers Union (UAW)

The tristate region of Indiana, Michigan, and Ohio is the heartland of U.S. automotive production, especially internal combustion engine (ICE), transmission, and related parts manufacturing. These three states made 40 percent of all U.S.-built ICE vehicles, half of all U.S. vehicle engines, and two-thirds of all U.S.-built transmissions in 2019 (LMC Automotive 2019). In the United States overall, roughly 102,000 motor vehicle and parts workers are tied to building ICE engines, transmissions, and parts—and over three quarters of those workers are in Indiana, Michigan, and Ohio (U.S. Department of Labor, Bureau of Labor Statistics 2019). This region of the country has more at stake in the transition to electric vehicles than perhaps any other in terms of the potential for job displacement and economic disruption.

Many automakers and suppliers manufacture ICE vehicles, engines, transmissions, and parts in the region, including Honda in Indiana and Ohio and Subaru and Toyota in Indiana. However, the bulk of the ICE vehicle, engine, and transmission output from the tristate region comes from just three companies: Ford, General Motors, and Stellantis—and workers at all three companies are represented by the UAW. As a result, the union faces a lot of risks—and opportunities—in the transition to electric vehicles.

The UAW has a long history of supporting environmental causes, going back to the 1960s and 1970s (International Union, UAW, n.d.), as evidenced by this quote from then-UAW president Walter Reuther:

> "I think the environmental crisis has reached such catastrophic proportions that I think the labor movement is now obligated to raise this question at the bargaining table in any industry that is in a measurable way contributing to man's deteriorating living environment." (Oldham 1972)

However, the leaders' and 23rd UAW Convention delegates' environmental support was not always echoed by the rank-and-file members—many of whom see greening the environment and moving away from fossil fuels as a threat to their livelihoods. Based primarily on economic concerns, the union has, in the past, stood with the automotive industry to oppose amendments to the Clean Air Act and increases in Corporate Average Fuel Economy (CAFE) regulations.

In the 2000s, UAW leadership again embraced environmental goals, rejecting the "jobs or the environment" dichotomy. The union joined the BlueGreen Alliance, a labor-environmental group that seeks "both-and" solutions to a cleaner environment built by workers who have good-paying union jobs (BlueGreen Alliance, n.d.). The UAW also stood firmly with President Obama and the automakers in supporting new CAFE and greenhouse gas emissions targets in 2011 (Reuters 2011).

The UAW also worked with the automakers to land investment in new EV technologies. When the 2011 Chevrolet Volt, an extended-range hybrid vehicle, was launched, GM converted an old warehouse to become the Brownstown Battery plant to supply battery packs for the Volt. The UAW negotiated a separate agreement with lower pay rates and different work rules to secure the future of electrified vehicle jobs. However, when the Volt went out of production and the automaker launched the all-electric Chevrolet Bolt BEV, the company sourced battery packs directly from LG Chem in South Korea—and not from Brownstown. It was not clear that the bet on future jobs would pay off.

In 2019, the UAW released a white paper entitled "Taking the High Road: Strategies for a Fair EV Future" (International Union, UAW Research Department 2020). In this document, the union makes a case for the inevitable transition to EVs, lays out the disruptive implications of the shift—including the need for fewer labor hours, the emergence of new EV automakers and suppliers, and the potential for worker displacement. In this paper, and a March 2021 update (International Union, UAW Research Department 2021), the UAW makes a case for a national industrial policy that will "secure the future" for its members. The policies promote domestic manufacturing for EVs by calling for:

- Manufacturing U.S.-developed technologies in the United States (U.S. DOE),
- Providing more significant EV incentives for vehicles made in the United States by union workers (Detroit News 2021),
- Requiring companies that receive federal incentives to provide "quality jobs and freedom of association" (International Union, UAW Research Department 2021),
- Passing the PRO Act, a series of pro-labor reforms that would make it easier for workers to organize their workplaces, and
- Promoting public EV procurement to prime the pump for UAW-made EVs (White House 2021).

While the current administration and Congress broadly support the UAW's goals in the EV transition, it will not be an easy climb. The unionized automakers—Ford, GM, and Stellantis—are forming joint ventures for their battery production operations, and these plants are not guaranteed to be unionized. In addition, many other players in the market are gaining market share in BEV and plug-in hybrid (PHEV) vehicles, such as Tesla and Toyota. Finally, the simultaneous phasing out of ICE production and ramping up of BEV/PHEV output will mean a long period of disruption and low productivity that puts many jobs in the tristate's automotive communities at significant risk.

2.1.2 The African American Workforce inside the Motor Vehicle Industry

The U.S. motor vehicle industry and the UAW have both played an important and complex role in the African American (AA) community which, in turn, has been pivotal to the success and economic prosperity of the industry. This section of the case study highlights important elements of that history and underscores the importance of maintaining the progress that has been achieved while noting the opportunities to address ongoing racial and environmental inequities during the EV transition.

1914–1950s

At the turn of the last century, when Henry Ford declared that he would pay qualified workers the unheard-of salary of $5 per day (Boyd 2020), he set the automotive industry on a path to dominate manufacturing in the heartland. In time, Ford was joined by General Motors and Chrysler (now Stellantis) as leaders in motor vehicle production nationally and globally.

It was during this time that a powerful and socially conscious UAW prodded the automotive industry to provide groundbreaking benefits for the represented workforce, including wages, supplemental unemployment insurance, health insurance, and pension plans. (*New York Times* 2015). By 1955, wages across the so-called "Big 3" autos were competitive (*New York Times* 1981) with each other and 35 percent higher than average salaries for the national workforce (US Census 1956). Automotive jobs were seen as the path to "the middle class" (*USA Today* 2009).

The prospect of landing one of those jobs spurred a migration (Boyd 2020) from the South of hundreds of thousands (Rainbow Push Automotive Project 2012) of Blacks seeking opportunities beyond the limitations of racist Jim Crow–era policies following the end of the Civil War and slavery, as well as an influx of Polish, Italian, German, and English (*Crain's Detroit* 2014) immigrants from overseas.

African American workers in auto plant (YouTube 2018)

As has often been seen in other sectors of American society, while white workers, including immigrants, were quickly assimilated into the automotive work environment, Blacks were routinely forced to work at the dirtiest and often the most dangerous jobs (Boyd 2020). Even though labor unions like the UAW worked with civil rights organizations, limited progress was made through the 1960s in reducing racial bias in job assignments with the traditional hiring of AAs in foundries, janitorial, and other menial work. While the UAW fought to win better jobs for AAs at this time, the union was also felt by many of those same workers to be paternalistic, not accepting "Negroes as equal" (Lattimore 1969).

William Lattimore (Lattimore 1969), an AA auto worker in the 1930s and 40s, observed that even though he was a chief steward in the UAW at Dodge Foundry, "we were sort of frustrated as Negro union members because of the many—because the white elements within the Dodge plant refused to accept the Negro brothers and sisters as equals." Mr. Lattimore eventually quit the union in the 1950s because, as he related to the oral interviewer, he "got tired of seeing the people he trained promoted over his head."

1960s–Present Day

Today, thanks to civil rights legislation and grassroots activism in both communities and the UAW, Black auto workers occupy jobs in almost every sector of the workforce (*New York Times* 2008), both union and salaried, from the lowest rung of the workforce ladder into the leadership ranks. That activism in the 1960s and '70s, embodied by the "Revolutionary Union Movements" in Detroit (Georgakas and Surkin, 1975) was critical to opening these doors. Today, the UAW is led by Ray Curry, its second African American president.

In addition, the UAW has increasingly played a leadership role in communities impacted by motor vehicle assembly operations (Planet Detroit 2021). One example can be found in recent air pollution complaints against a Stellantis (formerly Fiat/Chrysler) plant in Detroit. As chair of the Neighborhood Advisory Council, UAW member Jerry King (Bridge Detroit 2021) leads the enforcement efforts under the Community Benefits Ordinance (CBO), passed by the city of Detroit, that Stellantis has agreed to follow. This CBO, enacted in 2016, is one of the first community benefits agreements (CBAs) addressing the health and welfare of fence line communities in the country. Despite some of its regulatory shortcomings, such CBAs should become standard for manufacturing facilities located in close proximity to neighborhoods.

Additionally, the Big 3 have:

- Provided corporate education programs (*New York Times* 2008) that allow Black workers to attend college and move into management jobs,
- Become leaders in philanthropy (2009) to AA communities,
- Created jobs for the "hard core" unemployed (Sugrue 2004–10),
- Developed diversity and sensitivity training programs for all employees (FCA 2021; GM 2020; Ford 2021), and
- Developed programs to encourage Black-owned businesses to become "tiered" suppliers to the industry (e.g., Minority Business Development Councils whose board chairs were often Big 3 executives).

Herb Boyd, writing for the Institute of the Black World 21st Century (IBW21) found that Black workers, who were estimated to make up 30 percent of the automotive workforce in the 1960s, became increasingly invisible in the 1970s and 1980s as automation, global supply chains, imported vehicles, and eventually non-union transplant auto companies reduced the number of AAs in the unionized industry. By 1995, the first year for which government data is available, AAs made up just 14 percent of the automotive manufacturing workforce. While better than the overall AA workforce participation of 11 percent, this decline mirrored the growing wage gap in America between whites and AAs as the gains of the Civil Rights Movement waned.

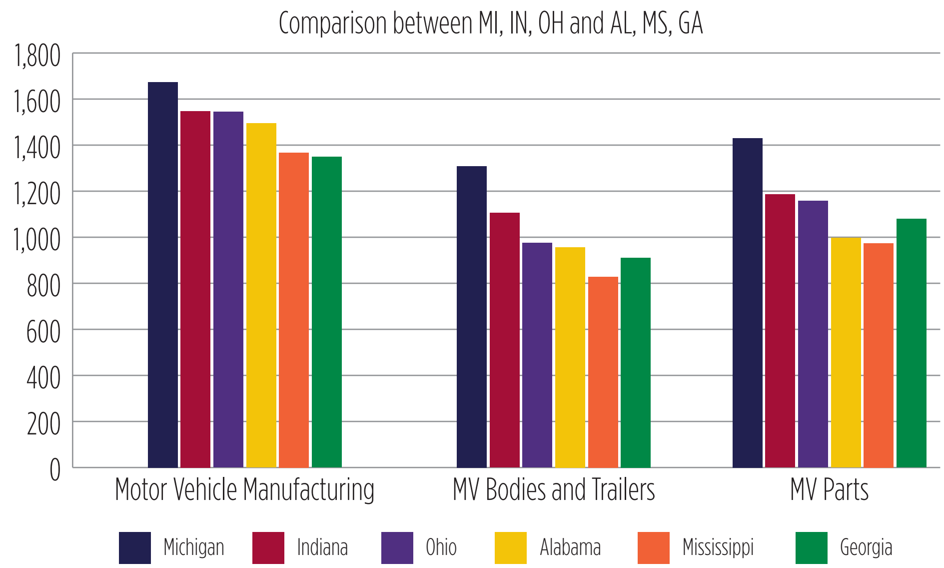
In her book *The Sum of Us*, Heather McGhee documents how the decline of labor union membership in the United States generally during the 1970s and 1980s, and the auto industry in particular, led to lower wages and benefits for both whites and Blacks. This phenomenon was in sharp display in her 2017 interviews with Nissan workers in their non-union plant in Canton, Mississippi. McGhee describes the "informal ranking of jobs at Nissan."

First, there was a hierarchy of job status. On the top tier were the so-called "legacy" workers, who started at Nissan when the company first came to Canton, making front-page news by offering a pay and benefits package that was generous by Mississippi standards. A few years later, the company contracted out those exact same jobs to subcontractors like Kelly Services, at about half the pay, a practice I still can't believe is legal. Kelly is a temporary employment agency, and Nissan classifies the jobs as such—but I spoke to workers who had been full-time "temps" for more than five years. These workers earning about $12 an hour with no benefits, were on the bottom tier. (McGhee 2021)

McGhee documents that 40 percent of Nissan's workers were classified as temporary and were not allowed to vote in a recent union election. She also noted, "Everyone I spoke to—white, Black, management, and production—admitted that the positions got whiter as the jobs got easier and better paid."

Table 2 below indicates the wage disparities that exist today between automotive manufacturing jobs, largely unionized, in Michigan, Indiana, and Ohio and those non-unionized automotive jobs in Georgia, Alabama, and Mississippi (QCEW 2019).

Table 2: Average Weekly Wages in MV Sectors by State



From an economic point of view, AA fortunes in the auto industry have been mixed. In 2020, AAs made up 18.1 percent of the automotive manufacturing workforce, 50 percent higher than in the overall American workforce at 12.1 percent (CPS 2020). In 2019, automotive manufacturing jobs paid an average of $1,597 per week, 40 percent above the national average of $1,138 for all workers and double the average weekly pay of $794 for Black workers (QCEW 2019).

On the other hand, these relative gains in the automotive workforce have taken place within a context that U.S. economic experts (*New York Times* 2021) say shows a persistent, troubling, and growing wage gap (Bayer and Charles 2017) from 1940 (~12 percent gap) to our present day (~20 percent gap) for Black workers vs. white. Again, while these are general data for all employment across the country, there is nothing in the data to suggest that the trending is any different for the automotive industry overall. At the same time, unionization rates have declined in motor vehicle manufacturing as transplants and startup companies have grown. The motor vehicle industry was 62 percent unionized in 1983; it was 15 percent unionized in 2020 (Unionstats).

Finally, it is important to note the wage differential across the world. In 2014, the most recent year for which data is available, the Conference Board reported that average wages, bonuses, and benefits totaled: $63.07/hour in Germany, $46.95/hour in the United States, and $31.99 per hour in Japan.

2.1.3 Workforce: Automation and Artificial Intelligence (AI)

In addition to the transition to EVs, the motor vehicle industry workforce is also being changed rapidly by new product and process technologies that are increasing the need for highly skilled workers and continuing to reduce the need for less skilled labor. More efficient and streamlined manufacturing processes and automation present both opportunities and challenges that will impact existing and future workforces. The following section highlights how changing manufacturing technologies known as “Industry 4.0” or “Industry X” are changing the automotive industry.

Summary of Technologies

The fourth industrial revolution, Industry 4.0, is the basic principle of connecting machines and systems to create intelligent networks along the value chain that control and interact with one another autonomously—a merger of cyber and physical systems. Due to the rapid pace of technological advancement, many have begun to use the term “Industry X” in referring to this ecosystem. The Industry X ecosystem is massive, complex, and rapidly evolving. The following section highlights the critical technologies that are building blocks of Industry X.

Additive Manufacturing: Automotive companies increasingly rely on additive manufacturing (i.e., 3D printing) for prototype and test parts, 3D visualization and modeling, and tooling, gauges, jigs, and fixtures. For most production processes, additive manufacturing is on a long-term pathway. To achieve broader use in automotive and parts manufacturing, 3D printing cycle times will have to improve significantly (Dziczek et al. 2017).

Augmented Reality: Augmented reality can support tasks in the manufacturing system by enhancing technology through a digital overlay of information over equipment. This technology can help various services, such as finding parts in a warehouse or sending updates over mobile devices. Currently, this technology is in the early stages; with time, companies will begin to use augmented reality for real-time decision-making (Fiorelli, Dziczek, and Schlegel 2019).

Autonomous Robots: Autonomous robots are automatically controlled, reprogrammable, and multipurpose machines. Many automotive companies use these machines for a variety of routine, programmable tasks across their facilities. Automakers are also beginning to deploy collaborative robots (“cobots”) that work side-by-side with humans to enhance their capability or the precision with which humans can perform tasks (Fiorelli, Dziczek, amd Schlegel 2019).

Big Data and Analytics: Big data and analytics include collecting and evaluating data from various sources, including equipment, systems, and management systems. This data will be necessary to support real-time decision-making.

Cybersecurity: In an Industry X ecosystem, the need for connectivity will increase. As this connectivity increases, companies will need to protect industrial equipment and manufacturing lines from cyber threats. As a result, high levels of cybersecurity and sophisticated identity and access management of machines and users are essential.

Horizontal and Vertical System Integration: Industry X will support the integration of companies, departments, functions, and capabilities. This new ecosystem will become much more cohesive as data integration evolves and enables genuinely automated systems. Horizontal integration connects networks of cyber-physical and enterprise systems that present automation, flexibility, and operational efficiency into production processes (Manufacturing Business Technology 2019). Horizontal integration can take place at several levels, such as on the production floor, across multiple production facilities, and across the entire supply chain. On the other hand, vertical integration aims to link together all appropriate layers within the organization, from the production floor through R&D, quality control, IT, sales, etc.

Internet of Things (IoT): Industry X will support more devices with embedded computing capabilities. These capabilities will allow equipment to interact and communicate with other machines and enable real-time responses and decision-making.

Challenges to the Workforce

Impact on Future and Existing Workforces. Due to the continually advancing technologies, manufacturers seek a workforce with new competencies, such as computer science skillsets. These skills are transferable and support many different industries and business models, which makes the competition for talent fierce. As Industry X continues to push businesses to a network integration across the organization's value chain, these companies will rely on individuals with expertise in software development, data analytics, cybersecurity, and related skillsets.

As the industry evolves, manufacturing environments will become more digital, and the existing workforce will need to adapt accordingly. The equipment inside of these factories will empower workers and operators to accomplish more from their workstations. Companies will require their workforces to have more responsibility, citing the need to hire individuals with problem-solving skills, adaptability, a collaborative mindset, and an openness to change (Smith et al. 2020).

Convergence of Information Technology and Operational Technology. The emphasis on digital and technical expertise has become increasingly more relevant in the automotive industry. In particular, there is a shift in information technology (IT)—the employees and skills that support a company's operations—and operational technology (OT)—employees and expertise in industrial equipment (Smith 2020). As the integration of systems and facility equipment continues through Industry X, the convergence of these two areas is inevitable. As manufacturing companies expand their IT workforce, other departments within the company need to understand their work and vice versa (Smith 2020).

Talent Attraction and Retention. As the industry seeks to obtain the necessary skillsets for future technology adoption, attracting and retaining highly skilled individuals is imperative. Automakers will compete with other companies as well as other industries when pursuing candidates. Due to the need to attract digital experts, companies will need to compete with tech hubs that attract younger workers to the innovation environment. Another challenge to overcome is fighting the stigma associated with the automotive industry. Many younger generations see the automotive industry as a historically outdated industry, unaware of the innovation occurring in this sector. Automakers and suppliers in the Industrial Heartland need to make the case that their industry is at the forefront of technology and combatting climate change to change the industry's stigma and the companies' employment "brand" in the labor market.

2.1.4 Workforce: The Role of Training in Energy Transitions

In the Roosevelt Project white paper "Energy Workforce Development in the 21st Century," the authors tracked the history of workforce training in the United States, noting the federal government's shift away from its obligation to provide employment for all Americans to simply providing job training. In evaluating that transition, the authors concluded:

> The history of workforce development at the federal level illustrates an evolution away from a focus on maintaining full employment through public spending, industrial policy and/or economic development to creating a workforce system focused on providing educational and training opportunities for the individual. Unfortunately, as the critiques of TAA [Trade Adjustment Assistance] have shown, a singular focus on retraining the individual cannot address the underlying failure of labor markets whether due to globalization, automation, or resource depletion. (Foster, Nabahe, and Ng 2020)

As noted in 2.1.3, the motor vehicle industry is embracing multiple new workplace technologies, both information technology (IT) and operational technology (OT), at the same time it shifts from mass production of ICEs to BEVs and PHEVs. Both the products of work and the processes of work are shifting rapidly. In addition, a significant new charging infrastructure to support motor vehicle electrification will be required. In our case study's economic modeling, this charging infrastructure, along with the additional electrification of the economy, will require the expansion of U.S. generating capacity by 2.2 million GWhs by 2050, roughly 41.3 percent, and will require considerable growth and modernization of the electrical grid. As noted earlier, an NREL study predicted that demand could double in the Industrial Heartland during that period.

Some of these infrastructure investments will be funded directly by state and federal governments; others will be supported by utility ratepayers; still others will be shared jointly by taxpayers through tax credits with private company investors, including the motor vehicle companies and their suppliers. As we evaluate the shortcomings of our existing workforce training system in dealing effectively with past worker dislocations, we should also look to examples of how government investments have been effectively structured to produce more socially equitable outcomes and how private sector companies have been incented to retain and retrain employees during technological transitions such as the motor vehicle industry is currently undergoing.

Section 2.1.4 provides some examples of how to structure infrastructure spending to achieve maximum social benefits, including training residents of low-income communities (LICs). It examines how employers—in this case, DTE Energy—can deliver on a pledge to provide continuing employment and retraining during an energy transition. "Retire with PRIDE" is their program to provide training and job offers to all its employees as it closes its remaining coal-fired power plants and delivers on its net zero pledge for 2050.

Infrastructure Spending.

Table 3.

Sector	Annual Investment	Jobs Created*
Repair the damage from the last century Plug orphan oil & gas wells, reclaim abandoned mine lands, repair dams & levees, repair leaks in gas pipelines	$2.7 billion	20,000
Modernize the electric grid Upgrade the grid, e.g., with underground power lines, distributed generation and utility-scale renewable energy	$4.2 billion	297,000
Create universal broadband access Bring fast, affordable, reliable broadband to rural areas & city neighborhoods	$2.4 billion	12,000
Grow clean, efficient manufacturing Repurpose shuttered coal plants for energy efficient manufacturing, become a leader in sustainable production	$2.6 billion	37,000
Build a more sustainable transportation system Public transit expansion and upgrades, including rail; expand access to electric vehicles and EV charging stations	$2.3 billion	37,000
Relaunch the Civilian Conservation Corps Update 1930s CCC to restore forests & waterways, repair damaged lands, and create pathways to meaningful careers in the process	$9.5 billion	119,000
	$23.6 billion	523,000

Infrastructure spending, including transportation electrification and grid modernization, is an essential element of motor vehicle electrification and can be used to create jobs, strengthen workforce training systems, and promote social equity through a set of community and labor requirements.

Policy Matters Ohio, in partnership with ReImagine Appalachia and the Political Economic Research Institute (PERI), analyzed the effects of recent infrastructure projects in the Ohio, Pennsylvania, and West Virginia region to identify effective policies to create those outcomes, such as the Cincinnati Solar example highlighted in Working Paper #3.

These policies are summarized in the modelling exercise in Table 3, which illustrates that a $23.6 billion federal investment into Ohio, Pennsylvania, and West Virginia could alone create more than a half million jobs.

Community and Labor Requirements Infrastructure investments, as laid out here, should be designed to maximize their benefits to communities and workers—with federal policies in place that:

1. Maximize creation of good union jobs.
2. Target benefits of job creation to impacted workers and communities left behind with engaged training programs.
3. Ensure successful implementation, tracking, reporting, and accountability.

Maximize creation of good union jobs by requiring Project Labor Agreements on all construction projects receiving more than $100,000 in federal funds and that have a total project value of at least $1,000,000. Project Labor Agreements are collective bargaining agreements between unions and contractors for a construction project, lasting the duration of the project. They typically incorporate wage and benefit requirements among other protections that support job quality and the community.

Target benefits of job creation to impacted workers and communities left behind. The workforce can pivot to meet the needs of our 21st-century economy. We need to recognize that workers in manufacturing and extractive industries—mine workers, union electricians, laborers, and assembly line workers—have foundational skills that remain critically important in the work needed for the energy transitions. Jobs created from public investments should give priority in hiring and training to dislocated workers, as well as female, Black, and Indigenous workers and other workers of color shut out by past discrimination in hiring, education, or opportunity.

Ensure successful implementation, tracking, reporting, and accountability. To set priorities for publicly funded construction projects, state and local governments should create regional Community Benefit Advisory Boards with the help of federal policy guidance. These advisory boards should be required to include union, contractor, environmental, and community representatives. They should be charged with (1) considering a proposal's emissions reduction benefits, as well as health, racial, and social equity impacts of proposed economic projects, (2) ensuring workers have rights on the job, and (3) developing hiring pipelines and on-the-job training opportunities. Over time, these advisory boards can study best practices and implement new policies based on lessons learned.

Worker Retraining

DTE Energy Retiring with PRIDE: Transitioning Coal-Fired Power Plant Employees into the Future of Clean Energy

Background. DTE Energy, a Michigan-based utility, has set a course to achieve net zero carbon emissions by 2050. A key part of DTE's clean energy generation transformation and net zero carbon emissions goal involves the sequential retirement of coal-fired power plants (Hajj 2021).

In preparation for plant retirements in 2021 and 2022, DTE senior leaders and the Fossil Generation department leaders overseeing power plant operations established a vision to retire coal-fired power plants with PRIDE (People, Respect, Integrity, Dignity, Engagement). This is rooted in the concept that the plants, and the employees who operate them every day, have been partnering with the communities for nearly 75 years. The initiative seeks to ensure a thoughtful, dignified transition of these power plants, the employees, and their host communities.

A key commitment DTE has made in the transition of the legacy coal plants is to avoid layoffs. Through the Retire with PRIDE initiative, this would be managed through transitioning impacted employees within the company as the coal plants retire.

Supporting DTE Employees through the Transition. DTE, in conjunction with union leadership, developed an employee transition strategy for three coal plants closing in 2021 (River Rouge Power Plant) and 2022 (St. Clair and Trenton Channel Power Plants) that puts employees first. That strategy, along with the broader framework for Retiring with PRIDE, is supported by a cross-functional Transition Team made up of representatives from Operations, Human Resources, Strategy, Public Affairs, Corporate and Government Affairs, and Corporate Communications.

The Transition Team established a new framework and governance structure (see Working Paper #4, Appendix) to ensure high employee engagement, continued strong relationships within the communities, and timely execution of project deliverables. Relative to employees, the Transition Team had a dedicated effort planning for the transition of impacted employees, so they might remain engaged and informed throughout the retirement process and as they transition to different roles.

Progress to Date and Key Learnings. To date, Retire with PRIDE has transitioned 47 employees from the River Rouge Power Plant and is preparing to transition 167 employees from Trenton Channel and St. Clair Power Plants in 2022. Much of the current transition is focused on reskilling and redeploying employees to other plants, with an attempt to prioritize geographic needs (e.g., redeploying South-area plant employees to nearby plants rather than relocating them to plants in the North area). Overall, the feedback has been positive around the efforts of the transition team and their caring approach. The transition team conducted a series of after-action reviews following the retirement of River Rouge and continues to adjust and improve the process based on their learnings.

For employees that wish to relocate to positions outside of the power plants, a skills matrix was developed to help employees match their current skills to those in other departments. The Organizational Ambassador program supports this effort. Processes, learnings, and progress from the Retire with PRIDE initiative are well documented and will inform future plans as DTE continues to decarbonize and retire coal-fired power plants.

Looking Ahead. While utility-led internal programs are expected to continue to support coal-plant employee transitions, the scale of change needed to support decarbonization requires a larger effort. Expanding efforts to reskill, redeploy, and transition employees will be critical, as transitioning to existing similar jobs becomes more limited over time. Additionally, continued labor union partnerships and support will be critical as the industry continues to transition.

Economic modeling in this study (see 2.5.3) shows that overall utility jobs in the Industrial Heartland region could increase significantly in the Heartland region under the Roosevelt Scenario as the economy transitions to higher levels of EV adoption and greater electrification overall. However, the skills needed to operate a power plant in 2021 compared to those needed to support the energy sector in 2050 will require reskilling and retraining over an extended period of time. For example, transitioning from the role of a coal power plant operator to that of a substation operator in electric distribution operations within the same company may take three to four years of reskilling. This reskilling and redeployment should also be supported by a broader effort to align skilled trades hiring practices across departments.

Future policies, initiatives, and processes to support the transition of employees from coal facilities to new opportunities should be informed and guided by defining what the employee experience will be in the process. Cross-sector collaboration with both utility and non-utility partners to meet future challenges can facilitate a thoughtful and just transition for employees. This may include labor, government, and regulatory bodies; apprenticeship programs; community colleges; education institutions; community partners; and the business community. Policy initiatives to support this approach are highlighted below.

2.1 Policy Recommendations

- **Employment Disparities.** Refer employment disparity issues to the Transportation Electrification Commission, including:
  - **Union Access.** Reform access to unions by enacting the Protect the Right to Organize (PRO) Act. **2.1.1, 2.1.2**
  - **Use of Temporary and Contract Employees.** Reduce the use of temporary, contract employees in EV assembly plants and supply chain companies by redefining the legal definition of an employee. **2.1.2**
  - **Sectoral Bargaining.** Require the Department of Labor to create a commission on the benefits, structure, and implementation of sectoral bargaining in the motor vehicle industry within the jurisdiction of the USMCA, mandating delivery of a report to Congress within 18 months. **2.1.1, 2.2.2**
- **Government Procurement and Federal Infrastructure Investments. Use government procurement of EVs** and federally funded infrastructure investments to promote job quality, **on-the**-job training opportunities, and domestic manufacturing**. 2.1.1, 2.1.2**
- **EV Tax Credits. Use consumer EV tax credits to enhance job quality. 2.1.1, 2.1.2, 2.1.3**
- **Job Training. 2.1.4**
  - **ETAA.** Establish a federal Energy Transition Adjustment Assistance program for displaced motor vehicle and energy workers.
  - **Cross-Sector Collaboration.** Promote cross-sector collaboration for employee training between growing and declining sectors.
  - **Incumbent Employer Tax Credit.** Encourage employers to "retain and retrain" their existing employees for new roles with retraining tax credits.
  - **Utility Industry Job Training Study.** Require DOE to perform a 30-year assessment needs study of the utility workforce.

2.2 Municipal Stability

2.2.1 Municipal Stability: Challenges to Repurposing Auto-Dominated Communities

Communities need to consider that if automotive plants in their region cannot shift to electric vehicle manufacturing, it could result in product reallocation from the facility or, worse, the loss of the plant. A comparable shift occurred between 2005 and 2010 when international companies, so-called "transplants," established multiple new facilities in the United States and expanded their existing plants, including manufacturing, R&D centers, distribution facilities, and administrative offices.

During that period, international automakers announced five new manufacturing facilities in the United States. Four out of five of those new manufacturing plants were located in the South. Honda was the only international automaker to announce a new manufacturing plant outside the southern states during this timeframe, located in Greensburg, Indiana (Center for Automotive Research 2021). Domestic automakers announced thousands of job cuts across their facilities during that period (Maynard 2005). These new entrants to the U.S. built plants in states eager for their investments, most of them located in the South, and hired workers seeking a stable work environment. The geographic distribution of this capacity replacement (with layoffs more likely to take place in the North and hiring of new workers in the South) resulted in workforce inefficiencies: experienced autoworkers had to be trained for other jobs in one part of the country. In contrast, significant resources and time had to be invested in training new autoworkers in another. Workers laid off in the North were predominantly higher-paid union workers, while those hired in the South were lower paid and non-union.

There are many challenges that communities need to overcome to reuse former automotive sites. Not surprisingly, a strong economy is vital to encourage redevelopment, but this alone is not enough. Based on past experience, when confronting the challenges of motor vehicle electrification, communities must also:

- Work regionally,
- Engage their community residents,
- Understand local politics,
- Customize local and state policies,
- Streamline regulatory and financial processes, and
- Capitalize on their assets to successfully repurpose former automotive sites (Brugeman, Dziczek, and Cregger 2012).

For communities with declining populations, high unemployment, and many former automotive manufacturing facilities, repurposing is incredibly challenging. Beyond economic factors, communities face additional challenges when trying to repurpose a former automotive plant. Manufacturers razed many closed facilities, often leaving behind expensive foundations to remove and potentially difficult environmental issues. Environmental remediation presents a cost challenge for the landowner and the surrounding stakeholders. There are various regulatory requirements that these areas need to be compliant with, which could complicate the cleanup process (Brugeman, Dziczek, and Cregger 2012).

The socioeconomic welfare of communities and their residents critically depends on the fortunes of their key industries. Few communities have been able to meaningfully recover from the decline of or disinvestment by their primary industry. Decline and stagnation are vastly more common than the successful reinvention of local or regional economies. Even "success" stories experience continued population outflows at the level of both the given city and its metropolitan statistical area. The state and local strategies that enable successful community redevelopment are an area of ongoing research and active debate (Bartik 2021).

The focus group interviews performed by the Indiana University research team illustrate the dilemma of the transition to electrification. Interviewees expressed concerns about whether traditional automotive communities will have the opportunity to produce electrified vehicles and components. Interviewees also articulated a fear of the unknown during this transition. They did express hopefulness for benefits stemming from the rapid growth of electrification. For communities to transition to electrification while addressing these concerns, they must overcome all the factors listed above. In addition to those, however, is the possibility that the traditional powertrain supply chain will move away from the current automaker-manufactured model to a supplier-manufactured one, such as that implemented by GM in Lordstown, bringing with it the risk of declining wages and employee benefits.

The cumulative experience of 187 auto plant closures in the tristate region since 1980 provides a stark reminder that a priority for maintaining municipal stability will be early engagement and a collaborative process between the industry, all levels of government, and community and labor constituencies to focus first on reinvestment in the existing motor vehicle manufacturing communities. For this reason, our number one policy recommendation is to establish a federal Transportation Electrification Commission to help coordinate this effort and its resources.

2.2.2 Municipal Stability: Environmental Policy and Industrial Planning

A key element of motor vehicle electrification and transitioning to EV manufacture in the tristate region will be the harmonizing of environmental policy with industrial planning. Michigan, Indiana, and Ohio, combined, represent almost 11 percent of carbon emissions nationwide, a sizeable share of the nation's emissions and more than its share of the nation's population, roughly 8.6 percent (US Census 2021).

To meet the region's decarbonization challenge, however, we must first understand how the region uses energy and where emissions come from. In the tristate region, 86 percent of emissions come from the electric power sector, industry, and transportation combined. One-third of all energy is consumed by the industrial sector. For details on tristate energy usage, see Working Paper #5.

By making our manufacturing sector cleaner and more energy efficient, industries, including the motor vehicle sector, can reduce their energy costs and emissions while increasing productivity, expanding plant capacity, and increasing wages and jobs. On average, manufacturers spend roughly 40 percent of their energy expenditures for fuels consumed on site and 60 percent on electricity. (Annual Survey of Manufacturers 2018). Policy and investment incentives can encourage and assist manufacturers in adopting better practices. Outlined below are four strategies for harmonizing environmental policy and industrial planning.

1. **Energy efficiency in the manufacturing process.** For energy-intensive industrial consumers, such as the steel, aluminum, and chemical sectors, energy can represent from 20–60 percent of total costs (EIA 2009). For most manufacturers, it represents less than 5 percent of total operating costs. But in all cases, it is a much higher percentage of controllable costs (ASE 2003). It is in the interest of manufacturing firms and their employees to ensure the availability of capital financing for these specific purposes through public financing and tax credits. The result will be increased efficiency, more jobs, and reduced emissions. The report, "Impacts of the ReImagine Appalachia & Clean Energy Transition Programs for Ohio: Job Creation, Economic Recovery, and Long-Term Sustainability," details how a $1.1 billion federal investment into Ohio's manufacturing sector for industrial efficiency and research and development would leverage an estimated $990 million in private investments and create more than 17,000 jobs. See Figure 5 in Working Paper #5.
2. **Combined Heat and Power (CHP).** Where there is a significant need for both heat and power at an industrial location, adopting CHP will result in more efficient use of scarce resources and lower associated emissions by burning smaller amounts of fossil fuels. Where there is a need for both electricity and process steam at an industrial location, CHP facilities use fuel to make steam, which is then used to turn an electric generator for power. The remaining steam is used in the factory's processes. According to a study of untapped CHP potential conducted by the Department of Energy in 2016, Michigan, Indiana, and Ohio, combined, have roughly 23.6 gigawatts of CHP potential, enough to power more than 12.9 million homes, more than the number of housing units in these three states (12.8 million) (US DOE 2016).

3. **Eco-Industrial Parks.** We can break down market barriers to industrial efficiency and CHP technology by bringing industry together with the right partners and services, along with the right policies, requirements, incentives, and capital financing. The United Nations Industrial Development Organization defines an eco-industrial park as a “community of businesses located on common property in which businesses seek to achieve enhanced environmental, economic and social performance through collaboration in managing environmental and resource issues. This is known as industrial symbiosis, which is a means by which companies can gain an economic advantage through the physical exchange of materials, energy, water and by-products, thereby fostering inclusive and sustainable development” (UNIDO 2021).

   CHP technology requires colocation of electricity production with consumers of heat energy, such as commercial businesses and industrial parks, something that can be achieved in eco-industrial parks. With the right public policy and dedicated resources, shuttered or shuttering coal plant sites or motor vehicle plants, with their existing infrastructure, can be turned into eco-industrial parks that provide businesses and manufacturers access to clean and efficient energy. Depending on their condition and efficiency, boilers and turbines at these sites can sometimes be repurposed for use in CHP facilities. Figure 4 in Working Paper #5 provides examples of eco-industrial parks in communities across the country, as well as the basic elements of eco-industrial parks.

4. **Industrial Innovation Hubs.** With an aggressive policy strategy to invest in industrial efficiency and CHP technology and to repurpose former coal plants and motor vehicle plants into eco-industrial parks, the Heartland could become a hub for the products of the future. With additional federal investments to develop supply chains and expand research and development, there are opportunities for the region to lead in next-generation industries, such as alternatives to single-use plastic, energy storage technology for renewable energy resources, and EVs.

   As a global leader in plastics, the tristate region can also lead in the next generation of single-use plastic alternatives that can be grown from agricultural products produced in the region, such as soybeans and hemp. Particularly relevant to the motor vehicle industry, Goodyear, headquartered in Akron, Ohio, recently committed to replace its petroleum-based rubber with soy-based rubber by 2040 (*Daily Record* 2021). In addition to solid foundations in the plastic industry, and assets like the University of Akron’s Polymer Institute, Indiana and Ohio also rank in the top ten states for production of soybeans (4th and 7th respectively) (ASA 2017).

   There are also important assets in the region for the production of next-generation battery technology, an essential component of both electric vehicles and renewable energy storage. Warren, Ohio, is home to an energy tech incubator, BRITE, focused on battery technology and related energy storage opportunities for the region. The region also has a strong chemicals sector, positioning it to play a role in the production of batteries and fuel cells for renewable energy storage. As a result, Ohio is home to a strong Fuel Cell Coalition devoted to exploring these opportunities.

Regional economic development practitioners in the tristate region should prioritize building partnerships between existing businesses, manufacturers, and research institutions to develop industrial innovation hubs and eco-industrial parks. New EV technologies, their supply chains, and the conversion of existing manufacturers to produce new products and new materials should become the priorities of these regional innovation efforts.

2.2.3 Municipal Stability: Tax and Land Use Policy

Maintaining municipal stability should be a key goal of policymakers at all levels of government. While each tax jurisdiction will be unique, when evaluating potential tax impacts of economic shifts, identifying who is being impacted is critical to addressing potential challenges and designing policy mechanisms to address those challenges. This section introduces the current tax policy structure in Michigan as an example and identifies areas of government budgetary impact that may occur as the Industrial Heartland transitions to an EV economy if no policy action is taken. For an overview of Michigan tax policy, see Working Paper #6. Two particular areas of concern for the EV transition are discussed below: property taxes and gasoline taxes.

Potential Tax Impacts of Motor Vehicle Electrification

Property Taxes. Typically, when a new business locates within a community, that community recognizes new subsequent tax revenue. Depending on the level of revenue increase from the economic activity, local governments may choose to begin funding projects, programs, or infrastructure with that new tax revenue. The local government will often include this tax revenue in budgetary forecasts, with the presumption that the business presence and subsequent tax revenue will continue indefinitely. While local governments can allocate money for reserves, in practice, this does not always occur. Under the presumption that the manufacturing and business environment will shift in the move from internal combustion engine (ICE) manufacturing and its supply chains to an electric vehicle (EV) economy, host communities may experience subsequent shifts in property tax revenue.

For communities that currently host businesses that support ICE manufacturing and supply chains, if those businesses are not replaced, the potential loss of business presence may cause a loss of revenue and subsequent budget constraints if left unaddressed. The impact may mean an inability to sustain funding for services (e.g., schools, community programs, police, fire, etc.) or infrastructure (e.g., roads, public spaces, etc.) at the same level. The budget risks created may then result in both budget reductions and the remaining fixed costs of maintaining government services, programs, and infrastructure being reallocated to the remaining residents and businesses, likely creating tax increases. This problem may then be compounded by the fact that tax burdens are being paid by a smaller population of taxpayers due to past tax incentives/exemptions to small businesses and manufacturers.

Transportation Tax—Gas Tax. In 2021, the average taxes and fees on gasoline levied by the states and the District of Columbia was 30 cents per gallon (¢/gal). These taxes and fees range from a low of 8.95 ¢/gal in Alaska to a high of 58.7 ¢/gal in Pennsylvania. Gasoline buyers in the United States pay these taxes in addition to the federal tax of 18.4 ¢/gal (EIA 2021).

Michigan gas prices include three types of taxes:

- Federal gasoline tax: 18.4 ¢/gal
- Michigan sales tax: Levied at a rate of 6.0 percent on a base that includes the federal tax
- Michigan gasoline tax: 26.3 ¢/gal

During 2018, the price for gasoline in Michigan averaged $2.746 per gallon, and Figure 1 in Working Paper #6 breaks down the cost components per gallon of gas (SFA 2019). In the future, over the long term, with the transition to electric vehicles, states will see decreasing revenues from gas taxes as fewer people rely on gasoline as a fuel source. However, revenue to fund programs—including roads and the School Aid Fund—supported by the Michigan gas tax will still be required.

Left unaddressed, programs supported by this tax revenue will become increasingly underfunded, and what is already considered a regressive tax will grow in burden. In other words, growing the gas tax to make up for lost sales will require those who may not yet be able to afford the up-front cost of transitioning to an electric vehicle to subsidize those who can afford an EV, via an increasing gas tax. However, while these issues will present themselves over the long term, we are also facing immediate gaps in highway funding. These gaps are currently driven by the gas tax not keeping pace with increases in fuel efficiency, not by EVs.

Additionally, taking inflation into account, the flat to declining cost of gasoline could also be a contributing factor to lower sales tax revenues (EIA 2021). Some states are looking at alternative policy mechanisms to gas taxes within the context of increased electric vehicle adoption:

- **Road Charge**: In 2014, the State of California passed Senate Bill 1077, initiating a process to study an alternative policy mechanism to a gas tax, a road charge, which was supported by the launch of a road charge pilot in 2016 (CalSTA 2017).
- **Mileage Charge**: In July 2015, Oregon developed a pilot program, OreGo, to test the feasibility of a mileage charge program. As an alternative to the 36-cent fuel tax, EV drivers who opt into the program report mileage and pay 1.8 cents per mile they drive on Oregon roads to support state highway infrastructure (OreGo 2021). Additionally, Utah has a similar pilot program called Utah's Road Usage Charge (Utah 2021).

EV Tax Policy Principles

In the near term, overreacting and shifting costs to EV drivers through disproportionate fees, etc., can counterproductively disincentivize consumer adoption. The following principles should be considered when designing tax policy in response to EV adoption and transition.

- **Equality.** Taxpayers ought to contribute, as nearly as possible, in proportion to their respective abilities, weight class, and usage.
- **Certainty.** A tax should be certain and not arbitrary or ambiguous. The tax rules should clearly specify how the amount of payment is determined, when payment of the tax should occur, and how payment is made.
- **Convenience.** It should be easy and convenient to pay taxes.
- **Fairness.** The tax should be fair or have economy of collection. A tax should be structured to take as little as possible from the taxpayers to fund the public treasury or project at issue.

Progressive vs. Regressive Tax. Relative to the principle of equity and fairness, the concept of progressive and regressive tax policies is critical when evaluating alternatives to potential future gas or property tax shortfalls. A progressive tax refers to a tax that rises with the rise in income of the taxpayer, whereas a regressive tax is one wherein the effect of the tax decreases with the increase in the taxable amount (Northeastern University). For example, sales taxes are generally regressive because they have a larger economic effect on lower-income taxpayers. This is also true of gas taxes, as a low-income individual presumably has a more constrained budget for fuel and is likely more price sensitive to increases in per-gallon taxes for fuel. Conversely, federal income taxes are generally progressive because they have a graduated tax rate system that increases as income increases. During the electrification transition, it is important for policymakers to consider a progressive system in order to better protect lower-income communities.

2.2.4 Municipal Stability: The Intersection of Health, Justice, and the Automotive Industry

The transition to EVs could result in more plant closings and the creation of additional brownfields. The unfortunate reality is that brownfield sites are more likely to be located near minority and low-income neighborhoods. The remediation of brownfield sites is often subject to several hyperlocal forces, including political will of local leaders, community pressure, and/or the viability of the site for economic investment. Minority residents end up bearing the burden of this slow-moving bureaucracy (Eckerd and Keeler 2012). Brownfields can have a negative impact on community health (Litt, Tran, and Burke 2002; Wilson et al. 2013) and housing prices (Woo and Lee 2016), imposing further detriment to these areas.

While minority populations may be perceived as benefitting economically from local industry, often having a higher share of employment in industrial facilities, they are more likely to suffer health-wise from their presence by living and working in close proximity to polluting industries. Even with more employment opportunities, the potential exposure risks for Black and Hispanic populations is greater than the benefits of employment and higher-paying jobs (Ash and Boyce 2018). Therefore, any economic benefits of industrial presence for LIC and Black, Indigenous, and people of color communities are challenged, particularly when taking into consideration long-term health effects, access to health care and health insurance rates of these populations.

In spite of the auto industry's legacy of brownfields, its connection to its workforce, and its potential impacts on the physical and economic health of communities, there are few studies that address the intersections of health, justice, and the automotive industry. However, we offer two examples that can begin to make this connection: The U.S. Environmental Protection Agency's Roadmap for Auto Community Revitalization and Robert Wood Johnson's Culture of Health in the Auto Industry Framework, which is summarized in Working Paper #2.

The U.S. Environmental Protection Agency's Roadmap for Auto Community Revitalization

In 2011, about 350 auto manufacturing and supplier plants had closed in the United States, forcing these communities to grapple with the challenges posed by the presence of idled and contaminated plants or "auto brownfields" (EPA Roadmap to Revitalization). In 2013, the U.S. Environmental Protection Agency's

Office of Solid Waste and Emergency Response Program and several other federal and private-sector partners created a Roadmap for Auto Community Revitalization to help local officials identify a range of supports to clean up brownfields and put contaminated properties back into productive use after auto transitions.

Brownfield cleanup can be a significant burden on cash-strapped communities due to a combination of factors: the loss of a significant source of jobs and property tax revenue, population flight, and blight. However, the Roadmap (Table 4) provides a set of 12 steps—and tools—that should be considered for large economic transitions. The Roadmap addresses the potential contamination of air, land, and water that can negatively impact human health and also stresses the importance of creating a consistent opportunity to engage impacted communities in the planning and decision-making processes.

Table 4: Roadmap for Auto Community Revitalization (EPA 2017)

1. Assess the community's status, prioritize resources, and match the best strategies.
2. Provide leadership from the top, backed by the right team.
3. Form a multistakeholder, intergovernmental team.
4. Connect to community and regional priorities, assets, and economic clusters.
5. Use and upgrade infrastructure assets.
6. Begin with the end in mind.
7. Involve citizens and workers from the start.
8. Use local resources and build local capacity to leverage further investment.
9. Partner with state and federal agencies.
10. Attract private sector support.
11. Stay tough and persistent for the long road—and build on small successes.
12. Reach out to other auto communities and partner organizations.

This roadmap highlights the importance of creating a consistent opportunity to engage impacted communities in the planning and decision-making processes. Leveraging multiple financial resources to provide the proper environmental site assessments, cleanup, site preparation, and redevelopment activities to catalyze new and additional community development was offered as a critical piece of the transition of former auto communities.

Frameworks Centering Equity and Justice Related to Clean Energy and Transportation

As the United States and the Midwest move toward vehicle electrification, centering the Principles of Environmental Justice (see Appendix, Working Paper #2) requires us to examine how communities will benefit or be harmed by the EV transition. Other countries and geographies offer a set of foundational frameworks and guidance that could be useful as the states and cities in our case study transition to EVs and embrace economy-wide decarbonization, the process of reducing "carbon intensity" by lowering the amount of greenhouse gas emissions produced by the burning of fossil fuels. Five unique resources are summarized in Working Paper #2; however, we will focus on two examples offered from Norway and California.

Energy Justice and EV Transition in Norway

In a paper by Sovacool et al. (2019), the authors analyze four cases of decarbonization, one of which is related to the EV transition in Norway. Using the four dimensions of “energy justice” (distributive, procedural, cosmopolitan, recognition), the authors offer a set of recommendations via policy solutions that underscore the spirit of several of the Principles of Environmental Justice, particularly how we consume resources, work to minimize waste, and uphold the right for people to participate as equal partners at every level of decision-making.

Table 5: Dimensions of Injustice in the EV Transition: Learnings from Norway

Dimension	Definition	Examples of Injustice in Norway	Recommended Policy Solutions
Distributive Justice	Equitable distribution of social and economic benefits and costs, fair and open access	EV ownership limited to those with higher income Increased traffic congestions for buses Elitism Future implications on the grid Occupational hazards Public subsidies for EVs cost tax payers and the state Increase in EVs will be a challenge to the grid	Increase consumer knowledge of cheaper EVs, less subsidies for those on high-incomes, compensation for disrupted sectors (toll roads, ferries, charging)
Procedural Justice	Adherence to due process, fair and adequate public participation, inclusion and consent	Procedural exclusion of e-bikes Planning bias towards motorized cars Policy decided unilaterally: tax payers not consulted Exclusion of public transport users/ advocates from policy (diversion of funds from public transport)	“Better inclusion of entire population in EV policies (e.g., public charging infrastructure coverage), more comprehensive transport policy”
Cosmopolitan Justice	Protection of global human rights, accounting and mitigation of global externalities	Global pollution generated by the manufacter of C02 Waste generated by old EV batteries Economic/social injustice of natural resource extraction by foreign firms Legacy of fossil fuel cars ending up in developing countries	Certification programs for materials, make car manufacturers responsible for emissions from EV manufacturing and battery lifecycle waste streams
Justice as Recognition	Appreciation for the vulnerable, marginalized, poor or otherwise underrepresented groups	The elderly People living in colder climates People living with hearing problems Working families The differently abled Low-income people Fossil-fuel dependent people	Avoid regressive EV subsidies, encourage lower-cost EV development, provide access to EV infrastructure

The Greenlining Institute Clean Mobility Equity Framework

Based in Oakland, California, the Greenlining Institute is a significant thought leader in guiding equitable and just transitions. They worked with a coalition of over 50 partners to develop the Clean Mobility Equity Framework, originally developed to evaluate the equitability of California clean mobility policies and programs. However, this framework as presented in Table 6 presents six standards of equitable investment in clean transportation that not only serve as a method for evaluation, but also function as a guide toward designing just and equitable clean mobility plans in general. Most notably, the standards presented build on foundational elements of the Principles of Environmental Justice.

Table 6: Six Standards of Equitable Investment. The Greenlining Institute (2021)

Standards	Definition	Best Practices
Emphasize Anti-Racist Solutions	"Address underlying inequities with anti-racist solutions that target and prioritize the most impacted communities, centering anti-racist approaches in internal planning, power and decision-making."	Mobility equity programs should be built to benefit communities most harmed by systemic racism.
		Race should be a key indicator for targeting investment based on need, and should be included in analysis tools.
Prioritize Multi-Sector Approaches	"Provide co-benefits by addressing multiple issues and sectors at once, such as outreach, engagement, capacity-building, wealth-building, climate adaptation, anti-displacement and more, because piecemeal approaches do little to foster transformative systems change."	Create mobility equity programs that show co-benefits across sectors (health, housing, etc.) and issues at once (outreach, engagement, capacity building, climate adaptation, anti-displacement).
Deliver Intentional Benefits	"Rather than expecting benefits to trickle down to communities, programs can ensure they go directly to the people most in need in the most impactful ways, while not increasing or creating new burdens."	Benefits should be considered for different community members, based on what is needed. Don't only offer financial incentives for EV purchases, but also toward carsharing and bikesharing participation, and prepaid cars and vouchers for public transport and charging stations.
		Avoid risk of displacement as a consequence of investing in low-income communities of color through community-driven anti-displacement planning.
Build Community Capacity	"Prioritize capacity-strapped communities by building in and requiring technical assistance, long-term training and skills development. This should include contracting mechanisms to pay residents, community-based organizations and local leaders for their participation."	Sufficiently fund bottom-up, proactive capacity building and technical assistance in planning, application, implementation, and evaluation of new clean mobility programs.
		Evaluate technical assistance provider's effectiveness in relieving barriers to grant and resource aquisitiion for communities and organizations underrepresented in planning and implementing clean mobility solutions.

Standards	Definition	Best Practices
Be Community-Driven at Every Stage	"Truly community-centered investment requires lifting up community-led ideas and sharing decisionmaking power . . . make community members and organizations part of every phase of the program or policy."	Support existing programs that already have community buy-in where possible, and work with them to reduce emissions from their activities. Support and uplift existing and new ideas of community residents.
		Identify who experiences barriers to participation in community-driven approach development, and find means to overcome this.
Establish Paths Toward Wealth-Building	"Address the racial wealth gap, which continues to grow today. In addition to cost savings, clean mobility programs must create jobs, workforce development and training opportunities, protect workers from exploitative labor practices, and help communities build assets and economic infrastructure.	Establish policy measures that build wealth in the community (contracting with women and minority-owned businesses, rules stipulating transfer of mobility assets to communities at no cost if the program is discontinued, etc.)
		Contract with local CBOs to compensate community members for outreach and engagement activities.

Each of these resources offer concrete examples and steps that could be operationalized to ensure a just, equitable transition to EVs.

2.2 Policy Recommendations

- **Establish a Federal Transportation Electrification Commission (TEC).** Strengthen local transition efforts with federal supports. 2.2.1, 2.2.2
- **ATVM Program.** Retool the ATVM loan program to specifically support industrial transitions. 2.2.1, 2.2.2
- **48C Tax Credit.** Reauthorize and expand 48C to support ICE plant conversions. 2.2.1, 2.2.2
- **Federal/State Partnerships.** Establish a grants program to fund federal/state partnerships. 2.2.2, 2.2.4
- **Develop Eco-Industrial Parks.** Utilize the ATVM, 48C, and other supports to encourage the development of eco-industrial parks. 2.2.2
- **Establish an R&D Innovation Hub Tax Credit.** 2.2.2
- **State Tax Policy.** Support state impact analyses of state tax policy. 2.2.3
- **Gas Tax Policy.** Support state and federal analyses of gas tax impacts. 2.2.3
- **Equity Based Planning.** Ensure equity-based planning at all levels of EV impacts. 2.2.4
- **Expand and Electrify Public Transportation.** 2.2.4

2.3 The Electrified Future

2.3.1 The Electrified Future: EV Infrastructure

One of the most critical enablers for the widespread adoption of electric vehicles is the availability of electric vehicle supply equipment (EVSE). Currently, there are three main types of EVSE: level 1 chargers (L1), level 2 chargers (L2), and direct current fast chargers (DCFC). Level 1 chargers generally serve one vehicle per day and fully charge an EV battery in 18–24 hours. Level 2 chargers can provide (close to) full power in 6–8 hours. In contrast, a DCFC can offer the same amount of energy in under one hour.

Level 1 systems are used mainly for residential (and workplace) applications due to their slow charging speeds, especially for smaller batteries. Level 2 is beneficial for residential, public, and workplace installations. DCFC is intended for non-residential use but does have some inherent drawbacks, despite its apparent convenience. Installation is costly, the energy requirements can be challenging for distribution providers, and rapid charging leads to quicker battery degradation. Therefore, DCFC may not be the go-to solution for many EV charging situations. While DCFC will continue to increase, Level 2 chargers currently make up most EVSE installations and will likely do so going forward.

A review of projections of EVSE needs suggests that for the country as a whole, one public or workplace L2 charge plug is needed for every 14 PEVs. One DCFC plug is necessary for every 236 PEVs (Hsu, Peter, and Nic, 2021; Nicholas, Hall, and Lutsey 2019; U.S. Department of Energy, n.d.; Natural Resources Defense Council 2020; Hardman et al. 2018; Crisostomo, Krell, Lu, and Ramesh 2021). Projections for the tristate region of Indiana, Michigan, and Ohio are rare. The Department of Energy's Alternative Fuels Data Center EVI-Pro Lite, benchmarked to 2016 data, suggests that when plug-in electric vehicles constitute 10 percent of total vehicles in use, the region will need one public or workplace L2 charge plug per 38 PEVs and one DCFC plug for every 466 PEVs (U.S. Department of Energy, n.d.).

A newer source, an ICCT publication from 2019, anticipates that by 2025, within major metropolitan areas in this tristate region, open public or workplace L2 charge plugs will be needed for every 14 plug-in electric vehicles. One fast-charge plug will be required for every 210 plug-in electric vehicles (Nicholas, Hall, and Lutsey 2019).

There are currently 3,069 public L2 charge plugs in the region (568 in Indiana, 1,193 in Michigan, and 1,308 in Ohio) and 871 DCFC plugs (220 in Indiana, 322 in Michigan, and 329 in Ohio) (U.S. Department of Energy, n.d.). Cumulative sales of plug-in electric vehicles in these states were 60,661 through February of 2021:10,808 in Indiana, 25,027 in Michigan, and 24,826 in Ohio (Alliance for Automotive Innovation, n.d.). With the projections of needed charging plugs relative to PEVs in use, the data suggest the region is currently running ahead of EVSE needs. However, by the time PEVs reach 30 percent of all registered vehicles, the area will require 550,000 public and workplace L2 charging plugs and, depending on the source considered, between 16,500 and 36,500 public DCFC plugs.

Construction of EVSE can be expensive, and expansion of the charging network will require extensive investments by both the public and private sectors. Household chargers are relatively inexpensive, public and workplace Level 2 charging systems cost roughly $1,000 to $6,000 per plug and DCFC, dependent upon station voltage (and thus speed of charging possible), can range from $20,000 to $150,000 per plug (Crandell 2020; New West Technologies, LLC 2015; Melaina et al 2016; Hsu, Peter, and Nic 2021; Gordon 2021).

Assuming an average L2 cost of $3,000 per plug and an average cost of $95,000 per DCFC plug, the cost of installing the additional public and workplace L2 and DCFC chargers in the tristate region is $3.1 to $5.0 billion, of which L2 costs total $1.6 billion and DCFC costs range between $1.5 and $3.4 billion.

Beyond cost, a myriad of barriers exists in the development of robust charging infrastructure. Local permitting processes can delay the construction of a charging station for months or even years (Gordon 2021). Some suggest the absence of a standardized charging port, which makes finding a compatible charger more difficult, is delaying EV sales. However, mandating interoperability may lessen the profitability of EV manufacturing and decrease private investment in EVSE by destroying the premium revenues provided by "walled gardens" (Li 2019). Charging network reliability has proven challenging as well, with an abundance of discussion of broken or inoperable chargers on social media (Voelcker 2021; Ramsey 2021). Other barriers include a shortage of electricians and high-voltage DCFC stations, challenges pertaining to site-specific electrical service levels, and potential challenges for portions of the electrical grid.

Finally, a recent study from MIT (Cole, Droste, Knittel, Li, Stock 2021) measured the relative impacts of consumer EV purchase rebates and subsidized charging stations on EV adoption rates. This study found, on a cost basis, that government support of charging stations was significantly more effective than individual purchase rebates in accelerating the rate of EV adoption. However, overall, the most effective policy combined individual rebates with subsidized charging stations. Providing the proper level of support for charging station buildouts at the federal, state, and local levels will be critical.

2.3.2 The Electrified Future: Grid Impacts

To accurately predict the impact electric vehicles will have on the distribution system, planners will need:

1. Knowledge of the penetration rate of these vehicles at a much more granular level (i.e., at the circuit, household, or business/organization level),
2. Knowledge of when customers will charge their vehicles (during the day or at night), and
3. What type of charging will be utilized (base charging, L2 fast charging, advanced L2 charging, or direct current fast charging [DCFC]).

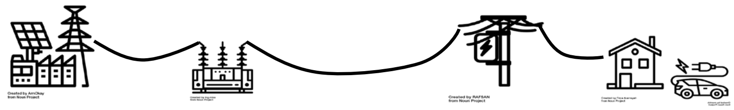
While advanced metering infrastructure (e.g., smart meters) has enhanced forecasting capabilities at the hourly level, the adoption of electric vehicles is still in its infancy, and much can change. Interest in electrification of fleets is also growing, with companies such as Amazon, FedEx, and Uber committing to electrify their fleets (Amazon, n.d.; FedEx, n.d.; Uber, n.d.). As of April 2021, there were 48 medium-duty electrified models, 29 heavy-duty models, and 40 bus models available, and these options are expected to grow (MJ Bradley & Associates 2021).

As the industrial heartland continues to transition its grid infrastructure to support EV adoption, the following Figure 3 highlights some central considerations that will impact potential system upgrades.

Figure 3: EV Adoption Drives Need for System Upgrades

In aggregate, EV adoptions will drive the need for upgrades across the entire electrical system

Generation and Regional Distribution Assets	Local Distribution Assets



EV ownership can increase a household's peak demand by as much as 50%, increasing demand on substations and circuits…	*…while high-speed (level 2) charging can increase a household's demand peak by 2-4x, potentially straining final mile distribution assets with risk of overloading*

Example of changes that may be needed to support EV growth
- Additional generation capacity
- Distribution voltage level increases
- Upgraded distribution circuits and transformers
- Rate structures that incentivize optimal charging times

Changes in generation planning will largely depend on overall penetration of EVs, while local distribution asset management will depend on charging patterns and charging technologies. Rate design and customer programs such as time of use (TOU) rates, or variable electric rates dependent on the time of energy use, could influence the shift of load to optimize charging time periods. This would reduce the need for additional generation capacity to be added based on current generation mix to meet peak demand. In other words, the existing generation assets could be optimized to meet charging needs if demand were shifted to off-peak times.

Grid Planning Considerations

Utilities will need to evolve the processes and standards that are fundamental to planning and investing to meet the changing customer needs that will come with an increased adoption of electric vehicles. Three core considerations in grid planning that may evolve are the integration of EV forecasts into planning, changes to standards, and the increased importance of grid reliability and resiliency.

1. Integrating EV Forecasts into Planning:
   An accurate load forecast is fundamental to grid planning and to efficiently investing in grid infrastructure. Forecasting informs the need for upgrades to the grid, such as new substation construction or expansion, circuit upgrades, or other area upgrades to support loading. There are multiple facets of EV loading that will make forecasting more complex, including initial localized adoption of vehicle purchases, timing of charging, and even location of charging (e.g., home vs workplace).

2. Electric Utility Planning Standards:
   After understanding the potential loading impacts indicated by a forecast with integrated EV impact, utilities may need to make updates to standards to account for increased overall loading or increased loading density. As much of

the grid infrastructure equipment has a lifespan of decades, prudent changes to upgrades today may prevent rework in the future.

3. Grid Reliability and Resilience:
   There are two key reasons that grid reliability and resiliency may increase in importance over the next 10–20 years as adoption of EVs increases. The first is the increased threat of extreme weather, potentially due to climate change. If the frequency and intensity of storms increases, the impact on customers and the outages they will experience could increase without additional measures to strengthen grid infrastructure. The second reason is the increased dependency on electricity to meet customer needs. Over the last couple of years, customers have come to depend on reliable electric service not only to keep their lights and appliances on but also to enable remote work and remote schooling. Looking forward to a future where mobility is also tied to reliable electric service, customers will be even less likely to tolerate frequent or lengthy outages.

Moving forward, the regulatory construct should continue to serve the goal of aligning stakeholders to meet changing energy needs while maintaining a clear focus on safety, reliability, affordability, and innovation of the system and electric vehicle integration. Rate design should support customers in a smart and affordable way—it should align the costs of the grid with how customers use the grid, signaling the optimal approaches to integrating new technology.

Regulatory mechanisms should support changing customer and grid requirements and align policymakers, electric utilities, industry, and other stakeholders. TOU rates and other incentives to influence charging patterns, optimized for utility planning purposes, are going to be important elements in reducing this risk. Finally, ensuring consistency across the state for building codes and standards will ensure safety in the deployment and continued buildout of EV infrastructure planning and development, which eventually will reduce the chance of overloading circuits in homes, businesses, and garages.

2.3.3 The Electrified Future: Access to Electric Charging Infrastructure in Low-Income Communities

Moving away from traditional ICE-powered vehicles to EVs will provide health benefits to most Americans. The pollution spread by burning fossil fuels (especially fine particulate matter and oxides of nitrogen) has for many years been directly linked to higher rates of asthma, bronchitis, and heart attacks.

While African Americans are roughly 14 percent of the country's population, statistics show:

- 24 percent of Blacks live near highly trafficked roads, contributing to racial disparities in exposure to traffic-related air pollution (Vaidyanathan, Malilay, Schramm, and Saha 2020).
- 9.7 percent of Black adults and 13.5 percent of Black children have asthma vs. 8.1 percent and 6.4 percent of whites, respectively (CDC 2019). Blacks also have the highest rates of asthma mortality (22.3 percent vs. 8.2 percent for whites) (CDC 2019).
- AAs disproportionately represented 19 percent of total heat-related deaths from 2004–2018, driven by climate change (Vaidyanathan, Malilay, Schramm, and Saha 2020).

On the surface, the transition to EVs should be readily accepted in AA communities. Unfortunately, while the health outcomes would be beneficial, in LICs, the EV purchase process is often stacked against those residents. Low-income Black households spend a significant portion of their pretax income on transportation, with racial disparities such as higher markups on auto loans and higher auto insurance premiums putting many vehicles beyond their reach (CBC 2021). Other obstacles only add to the burden:

- One-third of low-income African Americans live in a zero-vehicle household (CBC 2021), limiting their ability to reach jobs, education, healthy food, and other critical services.
- 14 percent fewer jobs (CBC 2021) are located near Black residents in major metro areas as gentrification, rising housing costs, and decreasing affordable housing stocks make for longer commutes, limited transportation options, and increased transportation costs.
- 17 percent of Black households are "unbanked" (no bank or credit union access) and 30 percent are "underbanked," which often makes loan securitization difficult (CBC 2021).

These challenges are insurmountable without outside intervention, something that policymakers must address for decarbonization to move forward quickly and equitably. The electrification and expansion of public transportation will be another important piece of the climate solution.

Of course, acquisition and use of EVs is only one step in this process. Recharging is the next biggest barrier to access in LICs and must be as abundant as it is in any other community. Electric charging/recharging infrastructure issues that must be addressed in LICs include:

- Lack of home garages and shared spaces to charge batteries (Grist 2021).
- Length of time required to charge EVs, which is presently far longer than the time it takes to refuel an ICE vehicle.
- Keeping the inside of the vehicle warm in winter, which is usually the biggest drain on EV range, raising energy costs in LICs (DEV 2020).
- Disproportionate impacts on low-income households, which spend three times as much on utility bills as higher-income households (CUB 2020).
- The classic "chicken and egg" problem for public investment (ACEEE 2021). There is less interest to invest in public charging stations where EV sales/leases are low, but that very lack of charging infrastructure is what keeps EV sales/leases at a minimum.

A series of pilot programs are already underway to address many of these issues, with state government, public service commissions, and utilities working together in California, New York, Colorado, and Oregon.

These programs cover a range of interventions, including:

- California utilities have underwritten charging infrastructure programs in disadvantaged communities (C2ES 2017) to expand EV installations and access programs by more than $1 billion.
- Several cities have experimented with EV sharing programs (CUB 2020) where vehicles can be centrally housed in optimal locations and charged overnight.
- The U.S. Department of Energy is spurring the deployment of charging infrastructure at workplaces (ICCT 2017), enabling electric vehicle drivers to double their daily electric commute range.

- The ability to have electricity flow both into and out of plugged-in vehicles (CUB 2020)—known as "V2G"— turns school buses into potential sources of electricity during peak demand, an extremely useful capability in LICs, lowering consumer costs.

2.3.4 The Electrified Future: Dealerships, Repair and Maintenance, Gas Stations, and Parts Stores

One of the unique features of the motor vehicle manufacturing industry is the highly dependent structure of its downstream retail sales, repair and maintenance, gasoline stations, and vehicle parts stores. Unlike other manufacturing sectors that sell their goods through diversified retail distribution networks, the motor vehicle industry depends on a large number of required complementary products sold by unique distributors. Appliances, by contrast, are sold through a wide range of big box stores, traditional department stores, and online vendors. Very few appliance-only dealers still exist.

As a result, the effects of motor vehicle electrification will have discrete and significant impacts far beyond the motor vehicle assembly and parts manufacturing workforce and their communities. In 2019, the motor vehicle industry employed 1,007,000 Americans in manufacturing, 532,000 in wholesale distribution, and 71,000 in professional services (USEER 2020). In addition, automotive and other motor vehicle dealerships employed 1,461,000, with 1,134,000 of those in new car dealerships alone (QCEW 2019). Automotive repair and maintenance employed another 944,000, while gasoline stations employed 941,000 (QCEW 2019). Finally, auto parts, accessories, and tire stores provided jobs to another 564,000 (QCEW 2019). In all, 5,520,000 Americans were employed in these sectors that are directly and solely dependent on motor vehicles, approximately 4.4 percent of the U.S. private sector workforce (BLS 2020).

However, both the size and the unusual interdependency of each of these identified sectors will pose a unique set of transition issues to states and communities when motor vehicles are largely electrified. Below, we outline some of these issues.

Dealerships

The 16,682 franchised automotive dealerships in the United States rely heavily on repair and maintenance for their business model, typically making 46 percent of their net profits from regular services and repairs—such as oil changes, tire balancing, and parts replacements—supplied to their customers (NADA 2020). These services and parts sales make up only 12.4% of their revenue (NADA 2020). Thus, customer relations are key. In 2019, typical net profit from a new vehicle sale was 2.3 percent, or approximately $828 from the average new car transaction price of $36,000 (NADA 2020).

Vehicle electrification will challenge this business model. Without internal combustion engines, electric vehicles need less service: for instance, fewer oil changes. Fewer parts means less wear and tear and consequently fewer replacements. The Industrial Heartland case study estimated a decline in average automotive maintenance spending at $300 per unit per year. Modeling this spending decrease resulted in the loss of roughly 400,000 repair and maintenance jobs in the United States by 2050 from 2019 levels.

Average weekly pay in dealerships in Michigan, Indiana, and Ohio ranged from $1,038 to $1,151 in 2019. Overall, average weekly pay in the United States was at $1,138, compared to $1,148 nationally for dealerships (QCEW 2019). The average dealership employed 68 workers, of whom 46 percent performed service, parts, or technician jobs (NADA 2020). Auto dealerships employ 21 percent women, 10 percent Blacks or African Americans, 3 percent Asians, and 19 percent Hispanics or Latinos (CPS 2020).

Repair and Maintenance

Automotive repair and maintenance firms outside of dealerships are also significant employers, with over 163,000 businesses employing 944,000 Americans. In Michigan, Indiana, and Ohio, these companies employ 29,070, 21,475, and 33,635, respectively. Average weekly wages for this sector were $789 in Ohio, $753 in Indiana, and $782 in Michigan, roughly 32 percent below the national average (QCEW 2019). The repair and maintenance workforce is 9 percent female, 7 percent Black or African American, 3 percent Asian, and 27 percent Hispanic or Latino (CPS 2020).

Gas Stations

Today, gas stations are largely merged with convenience stores, with over 90 percent of their 941,000 employees working in these combined operations. Estimates of store revenues from gasoline sales vary from 70 to 80 percent, with their net profit margin contribution below 40 percent, while food sales make up only 21 percent of revenue while generating 34 percent of profits (Simurda 2018). While profit margins from gasoline remain slim at 1.5–2 percent (NuWire Investor 2018), without the volume of fuel sales and the resulting traffic, most of these convenience stores are not viable. Thus, the question of where electric charging stations will be located, who will collect electricity revenues, and the length of charge times will become significant issues. At a recent meeting of the National Association of Convenience Stores, three different models of ownership were identified: direct fleet ownership, such as Tesla maintains; lease arrangements with providers like EVgo; or outright third-party networks (NACS 2020).

Average weekly pay in gas stations is $424 (QCEW 2019), well below the average wage in the United States. In 2019, gas stations employed 36,848 in Ohio, 23,953 in Indiana, and 27,486 in Michigan. As reported by the 2020 Current Population Survey, the workforce in gas stations and convenience stores was 52 percent female, 12 percent Black or African American, 15 percent Asian, and 14 percent Hispanic or Latino.

Auto Parts Stores

Auto parts stores employed 24,622 in Ohio, 17,717 in Michigan, and 13,479 in Indiana in 2019. These parts stores paid an average weekly wage of $633 in Indiana and $660 in Ohio. However, Michigan paid $781 (QCEW 2019). Overall, the average national weekly wage in this sector was $693. The demographic distribution of employees was most similar to that of repair and maintenance, with 17 percent female, 9 percent Black or African American, 2 percent Asian, and 22 percent Hispanic or Latino.

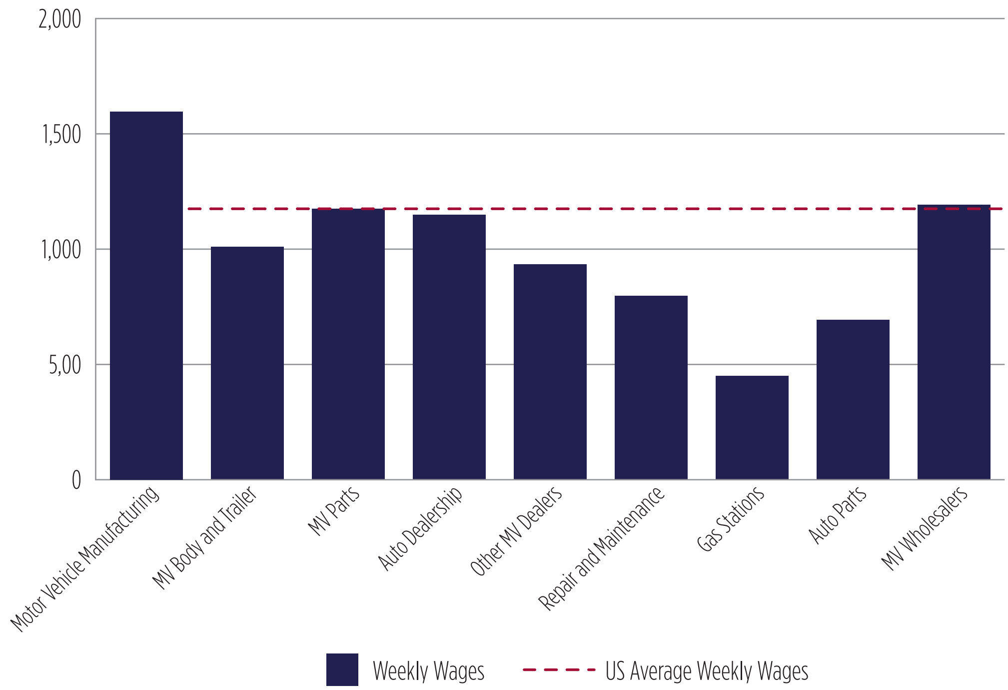
Conclusion

The motor vehicle manufacturing industry sits at the top of a unique transportation ecosystem within the United States, with a web of retail and service businesses that employ over four-and-a-half million Americans, whose jobs and incomes are dependent upon distributing and servicing those vehicles. It is apparent that the shift to electric vehicles will, over time, have a significant impact on the need for repair and maintenance services. In addition, the business models for automobile franchise dealerships, retail fuel sales, independent repair and maintenance shops, and auto parts stores may be seriously challenged, albeit for different reasons.

Collectively, these sectors support over 387,000 establishments, many of them small businesses. For instance, the average size of the 163,000 automotive repair and maintenance establishments in the United States is only six employees. In modeling the pace and impacts of vehicle electrification, it will be important for policymakers at the local, state, and federal levels to establish business diversification simulators to provide alternative pathways for these sectors that are so dependent on the existing internal combustion technology.

It is also important to note the wage differential and racial, ethnic, and gender makeup of these different sectors. As indicated in Table 7 below, in 2019, motor vehicle manufacturing jobs paid, on average, significantly higher wages than any others at $1,597 per week—40 percent above average U.S. weekly wages (QCEW 2019)—followed by the manufacturing jobs in automotive parts, then body and trailers. Average dealership wages are slightly above the lowest paid in automotive manufacturing in the MV body and trailer sector.

Table 7: MV Sector Average Weekly Wage Comparison



It is equally important to note that the motor vehicle manufacturing industry is over 18 percent African American, 50 percent higher than the U.S. workforce as a whole, in a sector that pays well above the average weekly wage of $1,138. Table 8 below shows the demographic makeup of the various motor vehicle and dependent sectors as compared to national demographic averages.

Table 8.

	National Workforce Average	MV Manufacturing	Automotive Dealerships	Repair and Maintenance	Gas Stations	Parts Stores
Black or AA	12	18	10	7	12	9
Hispanic	18	10	19	27	14	22
Asian	6	7	3	3	15	22
White	78	73	84	87	70	85
Women	47	26	21	9	52	17

As discussed elsewhere in this paper, the access to family-supporting jobs in the motor vehicle manufacturing sector by African Americans was a product of both unionization and the Civil Rights Movement of the 1960s and '70s. Providing guidance on the preservation of these gains is a key focus of the Industrial Heartland case study policy recommendations.

2.3 Policy Recommendations

- **Inequitable Rates of EV Adoption**
  - **Used EV Tax Credits.** Accelerate EV adoption with used EV tax credits. **2.3.3**
  - **EV Swap Program.** Accelerate EV adoption in LICs with an EV swap program, replacing old ICEs with new or used EVs. **2.3.3**
  - **Charging Infrastructure.** Provide federal support to build out EV charging infrastructure in LICs. **2.3.1, 2.3.2, 2.3.3**
  - **Low-Income Ride Share Programs.** Fund pilot projects for EV ride share programs in LICs. **2.3.3**
- **Create a Regional/State-Based Initiative to Finance and Build Out Heartland EV Charging Stations.** Accelerate EV infrastructure buildout in historic MV manufacturing states. **2.3.2, 2.3.3**
- **Small Business Initiatives**
  - **Dealership, Repair and Maintenance, and Convenience Store Impacts.** Provide monitoring, business model assistance, workforce training, and small business transition loans. **2.3.4**
  - **Small Business Energy Transition Loans and Technical Support.** Support repair and maintenance, parts shops, and related auto businesses. **2.3.4**
  - **Minority- and Women-Owned Businesses.** Require baseline reporting on participation in the EV supply chain, with federal government procurement supports to ensure minimum participation. **2.3.3, 2.3.4**

2.4 Regional Economic Impacts

2.4.1 Regional Economic Impacts: Supply Chain Transformation

Suppliers are central to automakers' strategies to improve vehicle performance, reduce systems costs, and boost overall consumer EV acceptance. Currently, the supply chain for vehicle systems and subcomponents is highly complex and global, albeit with some critical regional geographic "areas of excellence" (notably the Industrial Heartland region for combustion engine and transmission design, engineering, and assembly for the North American market), a legacy of the Detroit Three automakers.

Traditional powertrain suppliers are concentrated within Michigan, Ohio, and Indiana, as illustrated in Table 9. Furthermore, as noted below, the drivetrain and engine suppliers are most at risk of being disrupted by the electrification trend.

Table 9:

Parts Category	Supplier Count by State*		
	Michigan	Indiana	Ohio
Axle/Brake/Body Control	107	29	50
Body and Exterior	224	59	73
Clean Energy System	33	8	8
Climate Control	57	15	18
Drivetrain	94	37	41
Driving Support and Telematics	50	3	8
Electronics/Electric Parts	168	38	28
Engine	209	71	90
Interior	189	45	57
Small/General Parts	278	114	165
Suspension/Steering/Wheel & Tire	116	37	58
TOTAL	**796**	**271**	**379**

*Suppliers can be listed in multiple categories; therefore, the summation is not equal to total.
Source: CAR analysis

Electric vehicles are already beginning that disruption in several ways. The following factors in particular are driving that transformative change within the Industrial Heartland.

First, as EV sales continue to rise, electric powertrain systems are displacing conventional internal combustion engine and transmission systems. This means the share of battery systems, electric motors, and power electronics is growing—requiring a new, emergent supply base in many cases—and attracting new suppliers from outside the automotive industry, particularly for batteries and electric motors. Consequently, this also means fewer traditional ICE systems are required from conventional automotive suppliers, including numerous engine subsystems and components related to air/fuel/exhaust, ignition, thermal management, valvetrain, emissions controls, and turbochargers, as well as transmission assemblies, including clutches, gears, power take-off units, differentials, and related housings.

Table 10 below shows the number of EV-specific component suppliers by state. The EV component includes fuel cell systems, electric motors and drivetrains, electric power control units, EV batteries and capacitors, and other electric vehicle components. Note that California and Massachusetts are among the highest EV-supplier-clustered states.

Table 10:

STATE	Number of Suppliers
MI	34
CA	31
MA	10
IL	8
OH	8
NC	8
IN	7
TX	7
OR	6
TN	6
NY	6
GA	5
NJ	5
CO	5
PA	4
VA	4
FL	3
KY	3

STATE	Number of Suppliers
DE	3
NV	3
CT	3
WI	3
WA	2
RI	2
MO	2
MN	2
VT	1
NM	1
DC	1
NB	1
IA	1
KS	1
AL	1
SC	1
AZ	1
HI	1

Source: CAR Research

Second, EV powertrain systems require approximately 85 percent fewer moving parts overall, as compared to conventional ICE powertrains, as well as 20 percent fewer vehicle assembly hours, according to a recent study by the Fraunhofer Research Institute (Fraunhofer 2021). These combined factors are motivating many global automakers to insource the production of critical EV drivetrain systems to offset the impact on their workforce (often unionized): for example, electric drive modules and battery systems, which are either brought in-house entirely or coproduced together with joint-venture partners—in most cases partners outside of the traditional supply chain. Although potentially a near-term phenomenon, this practice of additional vertical integration by select automakers will have critical long-term repercussions for displaced suppliers along regional lines.

Third, automakers' electrification strategies call for significant cost savings via increasing economies of scale—creating additional hurdles for traditional suppliers. The economies of scale are taking two forms, including (1) newly developed, dedicated EV architectures (otherwise known as the vehicle "platforms" and sometimes referred to as "skateboard platforms"), which have been designed to be more flexible and therefore support substantially higher vehicle production volumes (per platform) compared to those being replaced, and (2) globally developed EV drivetrain systems, (e.g., electric motors, drive modules, and battery systems), which utilize standard components wherever possible and can be shared across automakers' aforementioned EV platforms. For example, electric motors may have a wider operating band than ICEs, allowing fewer variations to cover the required performance range. Instead of needing a 4-cylinder, 6-cylinder, and 8-cylinder family of engines, companies may need to design only two families (i.e., a small and a large) of electric motors to cover the performance requirements.

The added scale requirements could have significant consequences for suppliers. Generally, a larger scale should favor large multinational suppliers, to the detriment of their smaller peers, including regional, tier 2–3 suppliers, who in many cases are dependent upon localized engine and transmission design, engineering, and production—in some cases, within the Heartland region in particular. Correspondingly, supplier displacement and industry consolidation are also likely repercussions, following along similar regional lines.

There are emerging legislative and regulatory dimensions affecting the supply chain as well. National governments in China and Europe, for example, are providing financial incentives to encourage the development of regional battery supply chains—as well as proposing additional localized content requirements. The United States-Mexico-Canada Agreement (USMCA), which went into effect in 2020, will likely result in a somewhat greater concentration of U.S. content in North American–built vehicles. However, critical parts of the law are still being interpreted and debated by the automotive industry and lawmakers. To ensure capacity availability, automakers are likely to balance production capacity between continents and regionally within continents.

Given the factors mentioned above, divergent pathways are taking shape for conventional ICE powertrain suppliers—concentrated in the Midwest region—compared to a new supply chain for EV batteries. Suppliers of traditional engine and transmission components will likely experience disruption or require transitioning into other industries, as ICE engines are eventually phased out by government policy or regulations, as proposed in Europe beginning in 2035 (Insideevs 2021). This, in turn, will also threaten manufacturing and engineering at existing powertrain suppliers. At the same time, however, the battery supply chain currently represents one of the most dynamic and significant growth opportunities in the automotive industry. The newly forming "ecosystems," including joint ventures, tech start-ups, and supply patterns and business relationships with automakers, will ultimately transform the next generation of the automotive supply chain.

2.4.2 Regional Economic Impacts: The Lordstown and Mahoning Valley Challenge—Transitioning to Voltage Valley

The Mahoning Valley in northeast Ohio—anchored by Youngstown and Warren and including Lordstown, where GM closed its assembly plant in 2019—provides a compelling example of the opportunities and obstacles presented to regional economic development consortiums that are hoping to transition to an electrified future.

The Mahoning Valley grew with the rise of the steel industry in the United States, becoming known as Steel Valley (Gabbatt 2019). People flocked to the region in the late 19th and 20th centuries to secure jobs in the steel mills (Beverly 2002). The automobile industry, with steel being its "material of choice," also boomed in the region (Brasher 2018). General Motors' Lordstown plant produced its first car in 1966, and two years later GM opened a metal fabricating plant on the same property, at one point employing 12,000 workers (*Tribune Chronicle* 2021).

But by the late 1970s, the U.S. steel industry began to collapse. On September 19, 1977, known as "Black Monday," Youngstown Sheet & Tube announced it was shutting down its largest mill in the Mahoning Valley, putting more than 5,000 employees out of work (Belt 2017). It was just the first of five major steel mills in the Mahoning Valley to close within a few years of each other. (Carnegie 2018.) Other employees in businesses connected to the steel mills—rail, steel fabrication, trucking, construction—were soon laid off, along with workers in restaurants, grocery stores, and other service industries.

The region's saving grace was continuing as an important player in the automobile supply chain. The GM Lordstown plant employed as many as 12,000 workers at one point (Tribune Chronicle 2021). A number of local companies also supplied parts to the Lordstown plant, as well as other auto plants in the Northeast Ohio region.

However, over many years, federal trade policy and industry decisions whittled away at these automotive industry jobs. In 2006, Delphi Automotive relocated from Warren, Ohio, to Juarez, Mexico (*LA Times* 2017). After successive waves of layoffs, GM shut down their Lordstown plant entirely in March 2019. Today, the Mahoning Valley bears the consequences of the North American Free Trade Agreement and the inability to meet rapidly changing market demands with innovation.

Mahoning Valley: Community Left Behind

As the steel mills closed, many people left the Mahoning Valley. The population in Youngstown is half what it once was. The city of Warren, Ohio, lost a third of its population. The people of the region are also older, on average, than in other parts of the state, as young people continue to leave (Eastgate Regional Council of Governments 2020). The unemployment and poverty rates are higher, while median income and labor force participation rates are lower than the state average. The poverty rate for the Black and Latino population is particularly high. As a result of the relatively low standard of living in the region, people in the Mahoning Valley tend to live shorter lives and report having a lower quality of life. Substance abuse has become a serious issue. (For more demographic information, see Figure 1 in Working Paper #8.)

Despite these hardships, the Mahoning Valley has chosen to reimagine itself as Voltage Valley in the coming decades and is focused on using the assets of the region to realize that vision. As consumer demand grows for environmentally friendly and socially responsible goods and services, such as electric vehicles and alternatives to single-use plastics, the sustainable manufacturing capacity needed to produce these goods and services will also increase. With the proper resources, the Mahoning Valley can play a key role in meeting that demand. Key to this vision is the critical infrastructure for manufacturing that still exists in the valley—facilities, industrial sites, and freight rail and its river transportation network.

The region is also home to several legacy assets and initiatives which, if properly mobilized and coordinated, can serve as the foundation for a new manufacturing ecosystem. One such asset for the transition from Steel Valley to Voltage Valley is BRITE Energy Innovators, Ohio's only energy tech incubator, headquartered in Warren, Ohio (BRITE 2020). BRITE focuses on helping clients develop, launch, and grow entrepreneurial initiatives in battery technology, energy storage, grid resiliency, and electric mobility. It provides founders with mentorship, sales and marketing support, and access to advanced equipment to test technology. In 2020, BRITE's support helped to create nearly 400 jobs, secure over $100 million in investment, and generate nearly $20 million in startup revenue, including the launch of Electrada, an innovative charging system for electric vehicles.

Recently, Ultium Cells, a GM joint venture with LG Energy Solutions, chose the Mahoning Valley to construct a $2.3 billion electric battery plant in Lordstown. The decision to locate in the region is part of a national trend toward reshoring manufacturing to escape continued reliance on battery cells for electric vehicles produced in China (Grant 2021). The GM venture has plans to hire more than 1,100 people, and recent agreements suggest a willingness of this joint venture to support United Auto Workers' effort to unionize the plant (Grant 2021; Krisher 2021).

Another opportunity for the region is in the production of electric vehicles themselves. Lordstown Motors Corporation purchased the Lordstown GM plant with plans to convert the facility to build a battery-powered pickup truck for commercial fleet purposes (such as those used by electric utilities) (Grant 2021; Krisher 2021). The company, however, has gotten off to a rocky start, with both financing and leadership issues, including claims the company misled investors and an associated investigation by the Securities and Exchange Commission (Grant 2021; Krisher 2021; Wayland 2021). More recently, Lordstown Motors Corporation and Foxconn announced a deal for the Taiwanese company to purchase the Lordstown manufacturing facilities as well as $50 million in Lordstown Motors Corporation stock and the right to use the company's electric vehicle technology. Foxconn has indicated plans to produce the Lordstown Motors Corporation EV pickup truck at the Lordstown manufacturing facilities, alongside other electric vehicles (Arehart 2021). Despite this, people in the region remain optimistic for Voltage Valley and determined to make it happen (Grant 2021).

The expectation is that jobs in these new industries will pay decent wages if they are union jobs. They will, however, require some new and advanced skills in addition to some of the existing skills in the region (Grant 2021). In early 2020, the federal Department of Energy funded Youngstown State University (YSU), in partnership with the Oak Ridge National Laboratory (ORNL) and labor unions, to establish a workforce energy training center for energy storage technology (ENN 2021). GM also provided a $5 million grant to train 1,500 workers in electric vehicle and battery technology (Grant 2021). This training complements existing courses and union apprenticeship programs in solar, wind, robotics, electric vehicle infrastructure, and IT networks (ENN 2021).

YSU also houses the Center for Innovative Additive Manufacturing (YSU 2021). Additive manufacturing, more commonly referred to as 3D printing, is used to produce prototypes, parts, and tools made from a wide variety of materials, from metals to plastic. The center develops industry partnerships, advances research, and provides education and workforce training.

Another industry-led training partnership—WorkAdvance—exists between the Mahoning Valley Manufacturers' Coalition, Eastern Gateway Community College, Goodwill Industries, and the Mahoning Youngstown Community Action Program. This is an exciting asset in the Valley that, with the right resources, could be scaled up (Solley 2019). By partnering with local manufacturers like Nordson Corporation, WorkAdvance targets unemployed and underemployed low-paid workers, including second-chance residents with past convictions from their youth, offering paid on-the-job training opportunities coupled with classes to increase math and communication skills.

Bioplastics and other alternatives for single-use plastics present another opportunity for the region to produce socially responsible goods. In March 2021, Goodyear Tire and Rubber Company, headquartered in Akron, Ohio, announced its commitment to make all its tires from U.S. soybean oil by 2040, as part of their new policy for responsible sourcing of raw materials (*Agdaily* 2021). Even more recently, LG Chem announced a new joint venture with a Chicago-based agricultural company to produce corn-based bioplastic by 2025 for use in food packaging and disposable silverware.

Ohio has long been a global leader in plastic production. With the right support, the state can now become the leader in the next generation of plastic alternatives. Struthers, a former steel town on the Mahoning River, is working with partners to create a regional development plan for green industrial manufacturing, reviving dormant physical and social infrastructure in the process. City leaders envision redeveloping a former steel site into processing facilities to convert industrial hemp fibers, grown on adjacent farmland, into bioplastic and paper.

Regional collaborations such as those outlined in the Mahoning Valley will be critical to a successful transition throughout the tristate region. Indeed, the Mahoning Valley effort provides a blueprint for how the entire region should work jointly with the federal government to create a regional R&D collaboration to support the accelerated adoption of EVs and their infrastructure and related technologies. For its part, the federal government should use its existing programs—such as the ATVM loan program, a restructured 48C tax credit—and collaborations, such as that between YSU and ORNL, to repurpose the legacy assets of the Mahoning Valley and similar communities.

In addition, technical assessment programs should be expanded in the Mahoning Valley. The Department of Commerce's Manufacturing Extension Partnerships (MEPs) and the Department of Energy's Industrial Assessment Centers (IACs) both provide technical expertise and education to manufacturers. The federal government should allocate additional resources for:

- Assessing opportunities for energy savings and emissions reductions and financial tools and incentives to implement efficiency and carbon-reduction measures.
- Mapping opportunities for local companies to enter new markets and providing services that enable companies to enter new markets.
- Promoting capital investment in companies for any necessary retooling or upgrades.
- Offering union apprenticeship, preapprenticeship, and training services.

2.4 Policy Recommendations

- **ATVM Program.** Update the ATVM program to prioritize existing MV and parts plants for conversion. **2.4.1, 2.4.2**
- **48C Tax Credit.** Reauthorize a new 48C tax credit to assist with conversion of existing ICE parts plants to new products. **2.4.1, 2.4.2**
- **USMCA.** Revise USMCA to address specific issues related to the EV supply chain, ensuring resilience and security. **2.4.1, 2.4.2**
- **EV and Battery Domestic Content.** Institute domestic content requirements on all federal government vehicle procurements. **2.4.1, 2.4.2**
- **R&D EV Tax Credit.** Promote domestic R&D on next-generation EV development through tax credits to maintain industry leadership and engineering jobs. **2.4.1, 2.4.2**
- **Expand Technical Assistance Programs.** Increase federal funding for the MEPs and IACs. **2.4.2**

2.5 Federal and Global Policy

2.5.1 Federal and Global Policy: The Global Auto Market

Various factors are driving electric vehicle demand globally, the most significant of which are regulatory pressures. Europe and China have been at the forefront thus far and to a lesser extent Japan, followed by the United States (California) and Canada. So far, the global regulatory framework remains complex, creating planning uncertainty for automakers and divergent EV growth strategies, with the most aggressive proposed legislation timeline coming from Europe. The region is calling for ICE bans (100 percent CO2 emissions reduction from cars) for new vehicles to be sold beginning in 2035, with 55 percent CO2 emissions reduction by 2030 (Reuters 2021). Among Europe, China, and North America, proposed EV percent-penetration targets by government regulators and policymakers appear to range from 15 to 25 percent by 2025 and 40 to 60 percent by 2030 (IEA 2021). The current Biden administration target is for 50 percent market penetration of BEVs and PHEVs combined by 2030.

Despite the COVID-19 pandemic, global consumer demand for EVs appears to be accelerating. According to IHS Markit, global EV vehicle sales increased 41 percent year over year in 2020 (IHS Markit 2021), led by Europe, where combined sales of BEVs and PHEVs more than doubled in 2020 to 1.4 million units. In contrast, comparable sales in China were 1.37 million units, up 10.9 percent year over year (CAAM 2021). Globally, the share of combined EVs remained comparatively small at 4.6 percent but growing due to increasing consumer demand, supported by ongoing government sales incentives in most developed economies (IEA 2021). This compares to 2020 U.S. BEV and PHEV sales of 298,000 units, down 9.4 percent year over year and 2.1 percent market share (Wards Intelligence 2021).

In response to increasing regulatory and consumer demand, automakers are aggressively accelerating their vehicle electrification strategies globally, including vehicle development and capital investment—although they differ somewhat concerning timing (i.e., either front-loaded through 2025 or spread throughout the next decade), as well as by geographic region, to account for local consumer preferences. Also, the combination of comparatively low production volumes, lower barriers to entry, and attractive long-term demand prospects vs. ICEs are attracting new start-ups throughout the United States, China, and Europe—further increasing competitive pressures.

Europe has a head start within select areas, including overall EV production, which currently exceeds industry-leading Tesla, GM, and Ford combined, as well as regulatory framework, which includes comprehensive EU investment directives for localized battery supply, vehicle charging infrastructure, and consumer purchase incentives that exceed those offered in the United States. The United States is also playing catch-up with European corporate investments, led by VW and Stellantis. Such investment spending is accelerating EV drivetrain systems' development across these corporations' global vehicle platforms, reinforcing European automakers' and suppliers' leadership.

China has the lead in accessing and processing battery raw materials, battery assembly, and EV manufacturing capacity, while setting benchmarks for global competitiveness in the areas of cost, productivity, and economies of scale. China's energy policy has targeted a carbon emissions peak by 2030, which, in turn, led to an aggressive motor vehicle electrification transformation policy. China's latest New Energy Vehicles (BEVs and PHEVs) target by 2030 is 40 percent (CAAM

2021), approximately 10–12 million EV units per year. Korea and Japan also maintain sizeable leads over the United States in advanced battery technology development and well-established battery supply chains.

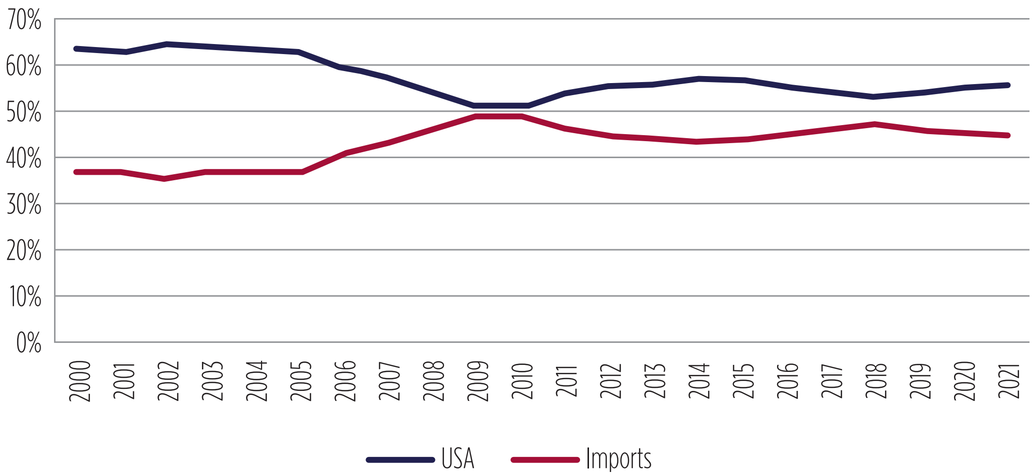
The Midwest region faces other unique competitive challenges in the context of global competition. First, combined pickup/light truck production in the region accounts for approximately a 30 percent share of total North American vehicle production (40 percent domestically) and a disproportionately higher percentage of automakers' profits. The existing USMCA trade agreement and other tariffs currently support localized output as a result. The challenge, however, will come from consumer demand for EVs and whether consumers ultimately embrace them as forecast. This trend is especially true regarding the pickup/light truck contribution to profits (i.e., an orderly transition to/from high volume, high yield) with domestic automakers struggling to gain market share in EV segments.

Second, the Midwest region supply chain for drivetrain systems will face greater competition globally, as automakers shift design work to global regions most supported by the aforementioned government regulations that are driving EV demand.

2.5.2 Federal and Global Policy: U.S. Trade Policy

The United States-Mexico-Canada Agreement (USMCA), Section 301 tariffs, and the now-defunct threat of Section 232 tariffs on automotive imports all sought to reshape the global supply chains supporting the North American automotive industry by encouraging or requiring increased manufacturing in the United States. However, to the extent that trade policy succeeds in this regard, the cost of manufacture will likely increase. Due to the low profitability of the automotive industry, there is little potential to absorb cost increases without raising consumer prices. Thus, policy-induced supply chain changes may well lead to higher prices, lower domestic sales, and reduced motor vehicle and motor vehicle parts exports.

Table 11: U.S. Light Vehicle Sales Market Share by Manufacturing Origin



Source: IHS Markit North America Vehicle Sales Import (IHS Markit 2021)

Despite attempted protectionist policies, the United States is unlikely to become a core region for developing or manufacturing advanced vehicle technologies without a wholesale change to U.S. industrial and trade policy, much of which is outlined in Chapter 3. Regulatory mandates are the primary driving force behind vehicle electrification, and even accounting for recent policy developments, the United States lags international competitors. Development of new technologies occurs in the national markets expected to provide the most significant sales opportunities for those technologies, currently China and Europe. Providing R&D incentives to U.S. auto companies coupled with domestic manufacture preferences will be key to developing the competitive position of U.S. assembly, battery, and drivetrain production.

The design of the USMCA automotive rules of origin specifically encouraged the localization of manufacturing and research, development, and engineering activities in the United States or Canada. This emphasis on localization results from the increased regional value content (RVC) of USMCA compared to NAFTA, rising from 62.5 to 75 percent for completed vehicles, and the adoption of separate RVC requirements for various categories of parts. In addition, the USMCA's new labor value content (LVC) requirement, which originated from a demand that the agreement feature a U.S. content minimum, set minimum wages for certain jobs in the three countries.

However, these changes in trade policy, intended to preserve domestic automotive manufacturing and encourage localization of supply chains, are unlikely to meaningfully alter current arrangements or overwhelm other sourcing and location factors, such as existing capacity or expected market size and growth for new technologies. Indeed, manufacturers with operations in Mexico have responded to USMCA's LVC requirement by dramatically raising wages paid to Mexican workers—not re-sourcing to American or Canadian factories (Nakayama and Asayama 2020). However, private interviews with companies do suggest an active reevaluation of global supply chains, with an eye toward resilience, due to a "perfect storm" of disruptions—natural disasters, COVID, constraints on shipping capacity, the microchip shortage, shortages of raw materials, and perceptions of increasing geopolitical risks and protectionism (Center for Automotive Research 2021).

2.5.3 Federal and Global Policy: Economic Modeling in the Industrial Heartland

There is a growing accumulation of literature evaluating the economic effects of decarbonization in the United States. The Roosevelt Project does not seek to simply replicate the results of other studies but rather to provide new analysis that shifts the focus of that exercise from a broad national assessment of electrification and decarbonization technologies toward an understanding of the ability of major policy to mitigate substantial impacts, across the country and down to the community level. Much of the extant literature on this topic assesses technological and policy drivers for decarbonization. Rather than focus on the granular questions around the technological nature of the transition (e.g., how many megawatts of solar will Michigan build?), the Roosevelt Project hopes to illuminate broader, structural trends in demographic and workforce dynamics (e.g., how will industrial Midwest communities fare in an electrified economy?).

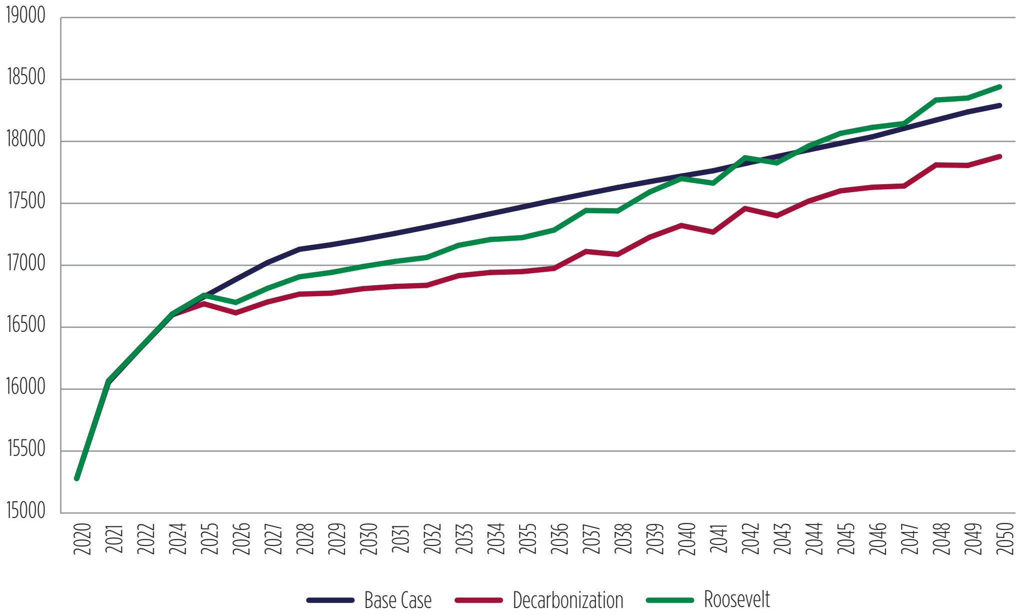
To that end, the Roosevelt Project worked with FTI Consulting to perform an economic impact study assessing three possible energy and economic policy scenarios for the U.S. economy, two of which achieve net zero decarbonization by 2050. The analysis also breaks out the results in the Project's four case study regions. National level results and a detailed modeling methodology are available via the Roosevelt Project online portal.

Scenarios
The Roosevelt Project's analysis considers three different scenarios. The first scenario (Base Case) uses Annual Energy Outlook 2020 assumptions and would not achieve Paris Climate Agreement goals of 80 percent emissions reductions until 2098. The second scenario (Decarbonized) includes a set of updated technology assumptions (e.g., renewable capital cost reductions) and new policy programs, including a nationwide renewable portfolio standard and escalating carbon price, that together achieve a net zero economy by 2050. The final scenario (Roosevelt) maintains all of the net zero assumptions, but layers on a set of federal policy recommendations that we have identified as critical to enabling more equitable transitions in the regions under consideration. Those recommendations, noted here through the lens of modeled assumptions, include:

- Recycling carbon price revenues according to regional carbon intensity, rather than on a per-capita basis,
- Implementation of a border adjustment for energy-intensive trade-exposed industries,
- $1.5 trillion in domestic infrastructure investments over a 10-year period beginning in 2025, coincident with the introduction of a carbon price and dividend, distributed based on regional emissions and projected population growth,
- 1 percent of carbon tax revenues set aside for regionally targeted retraining for negatively impacted workers,
- An exogenous increase in domestic battery production from, for example, Buy America procurement requirements or from increased incentives for domestic manufacturing of a strategic industry,
- A 50 percent decrease in the cost of direct air capture of CO2, resulting from substantial federal and private R&D support, and
- A 25 percent reduced carbon intensity of liquid fuels by 2050, to simulate the potential emergence of a hydrogen economy.

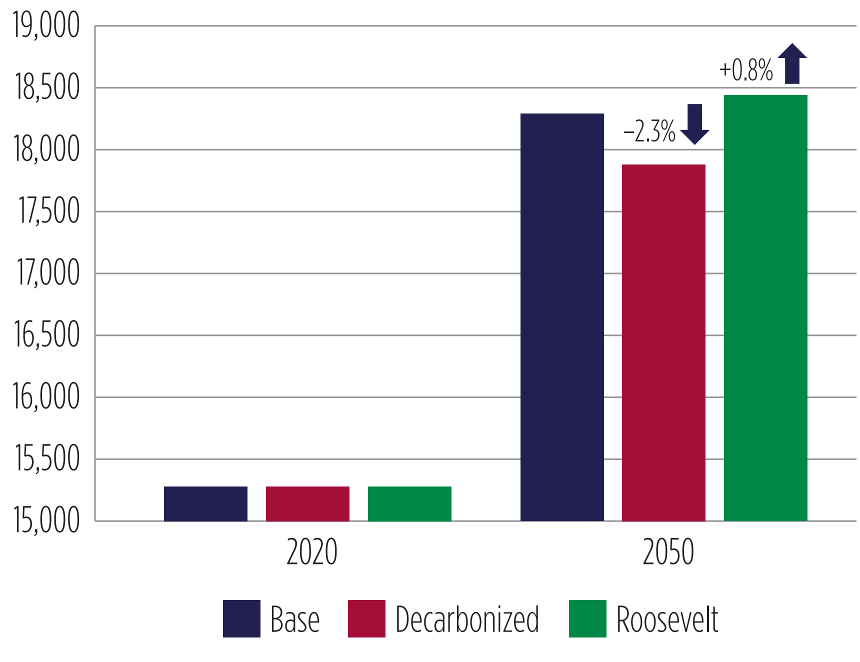
Results
Ultimately, the Project's modeling exercise finds that a Decarbonized pathway with no accompanying policy supports would lead to a slower growth rate in total employment in the Industrial Heartland, or around 410,000 fewer jobs than in the Base Case in 2050. However, the Roosevelt scenario, which incorporates the comprehensive set of federal policies listed above, reverses that slower growth rate and overtakes the Base Case in 2040 (Table 12). As noted in the Roosevelt Project's "Energy Workforce in the 21st Century," most climate policy economic models show employment loss and/or slower growth following implementation of a carbon price, absent ameliorating policies.

Table 12: Industrial Heartland Employment Scenarios. Carbon price triggers job loss in 2025, but Roosevelt scenario recovers for fastest growth.



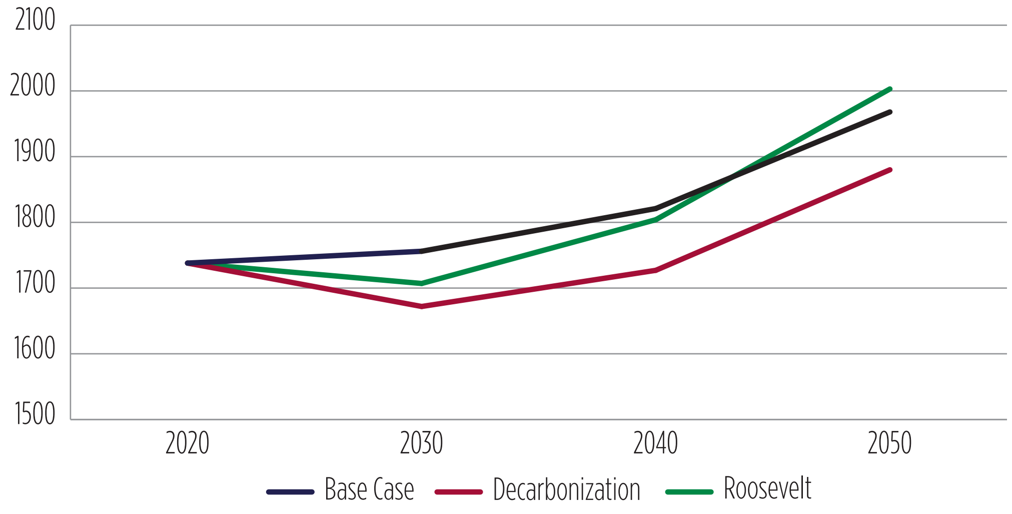
By 2050, under the Roosevelt scenario, the Industrial Heartland sees an increase in employment over the Base Case of 0.8 percent, or around 150,000 additional jobs gained, and 560,000 more jobs than in the Decarbonized scenario, while still meeting net zero targets. Overall, between 2020 and 2050, 3,150,000 jobs are added in Michigan, Indiana, and Ohio under the Roosevelt scenario (Table 13).

Table 13: Heartland Employment in the Base Case, Decarbonized, and Roosevelt Scenarios, 2020 and 2050



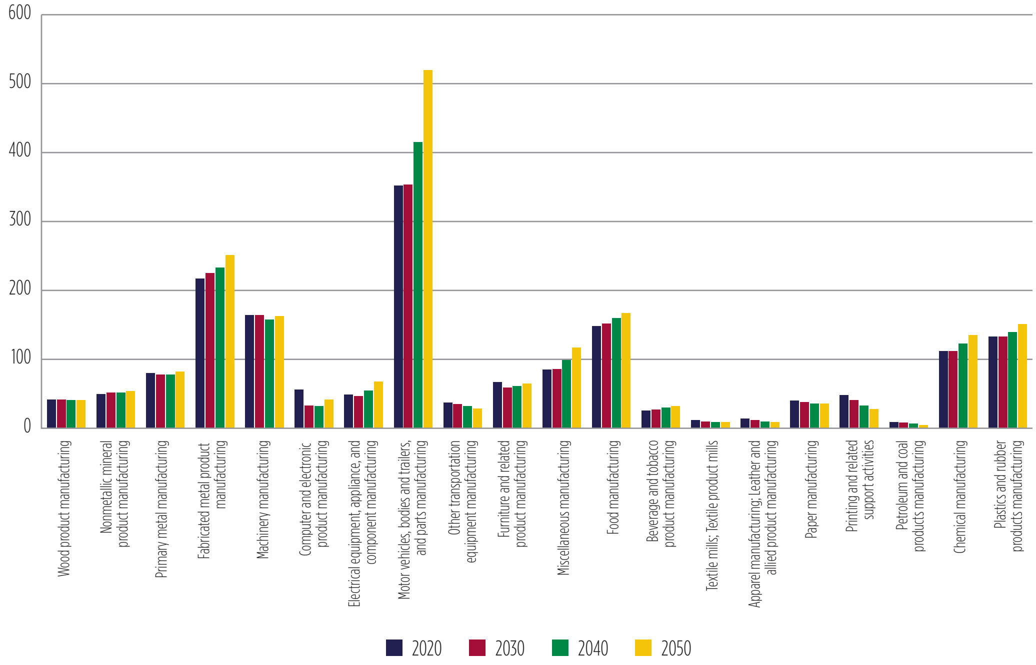
Especially important to the Industrial Heartland are the employment sectors that are strengthened by the Roosevelt policy interventions. Manufacturing, currently the largest employment sector in all three states, increases more rapidly than in the Base Case, adding 35,000 more jobs. Overall, manufacturing adds 265,000 jobs under the Roosevelt scenario between 2020 and 2050 (Table 14). All seven of the Roosevelt policies contribute to this growth of manufacturing, but the domestic content rules, hydrogen fuels, CO2 capture, and energy-intensive trade-exposed industry border adjustments were of particular importance (Foster, Nabahe, and Ng 2019).

Table 14: Industrial Heartland Manufacturing Job Scenarios. Domestic content rules, hydrogen fuels, CO2 capture, and EITE border adjustments allow the Roosevelt scenario to overtake the Base Case and Decarbonization scenarios for jobs.



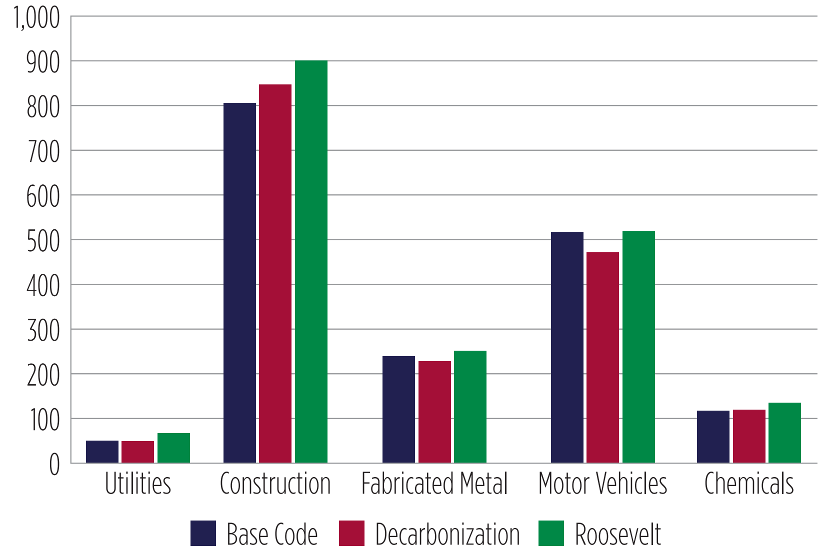
The job increases were notable in most manufacturing subsectors but were most prominent in fabricated metal manufacturing, motor vehicles, primary metals, and chemical manufacturing (Table 15).

Table 15: Industrial Heartland Manufacturing Job Growth, 2020–2050.
The Industrial Heartland under the Roosevelt scenario adds 265,000 new manufacturing jobs over 30 years.



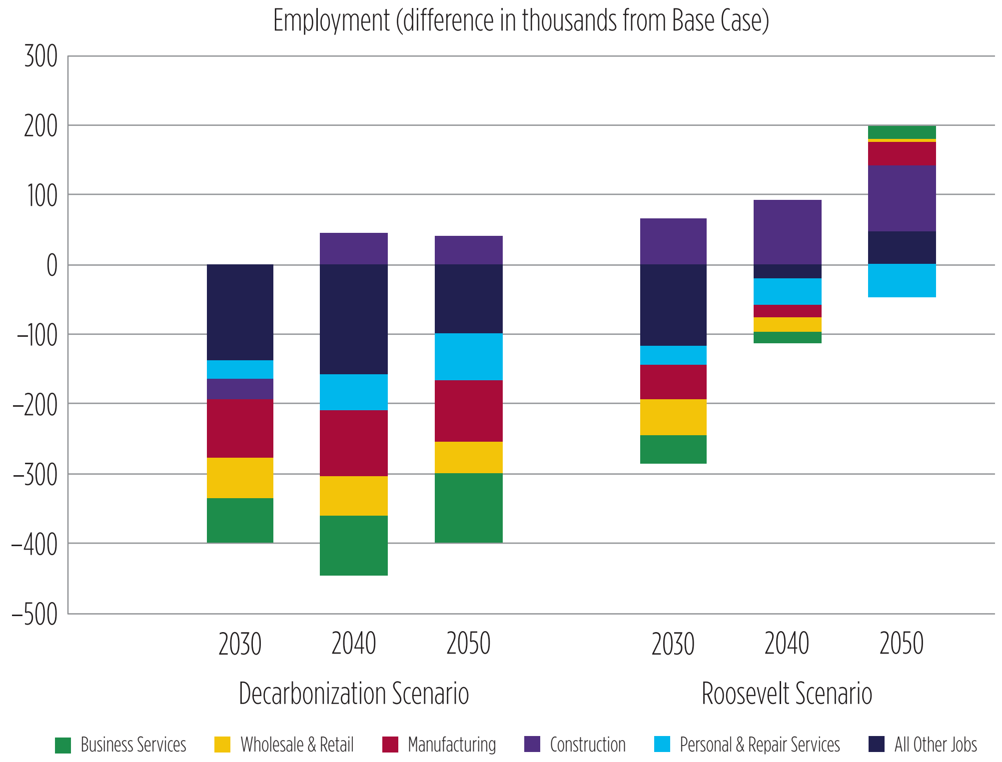
The largest incremental growth sector over the Base Case was in construction, driven by the redistribution of infrastructure spending by carbon intensity. Construction, under the Roosevelt scenario, added 100,000 more new jobs than in the Base Case (Table 16). The different outcomes between the Decarbonization and Roosevelt scenarios offer convincing proof that targeted policies, applied to geographies with hard-to-decarbonize sectors such as manufacturing, will result in economically fairer outcomes.

Table 16: Roosevelt Policies Create More Jobs in Key Energy and Manufacturing Sectors



In all scenarios, employment and other macroeconomic growth is concentrated in the final decade of the study. In the first decade of analysis, the Industrial Heartland sees an initial decline, in the early years, of the carbon price, before reaping the benefits from the transition to a clean economy under the Roosevelt scenario. (See Table 17.) Early employment losses are primarily concentrated in business services, retail, and personal/repair services. In the Decarbonized scenario, losses in those sectors continue through the period, though construction employment increases as a result of infrastructure spending. The Roosevelt scenario sees early losses in the same sectors but also sees immediate growth in the construction sector, which continues through the period and exceeds Decarbonization construction jobs as a result of greater distribution of infrastructure spending to the Industrial Heartland based on its carbon intensity. By 2050, the only sector that sees major declines in the Roosevelt scenario is personal and repair services, at about 47,000 jobs across the region, as well as some legacy mining and oil/gas sector jobs.

Table 17: Percent Difference in Industrial Heartland Employment in the Base Case vs. the Decarbonized and Roosevelt Scenarios by Sector, 2020–2050



The Roosevelt Project is foundationally interested in how to set policy that protects communities and American jobs while promoting public health and social equity during the decarbonization of the economy. The particular scenarios in this modeling exercise rely on significant electrification of certain sectors, including transportation and industry, and the widespread adoption of renewable generation and storage. The importance of this analysis, however, is not in the particular suite of technologies used to decarbonize, but in the interaction of a specific set of protective policies in a unique region of the country that has historically been heavily dependent on fossil generation and manufacturing and the motor vehicle industry in particular.

By demonstrating that, under challenging timelines, the economic outcomes for regions most at risk in this transition can be managed successfully, we hope to set a standard for regionally driven analysis based on local circumstances. It is not our goal to identify prescriptive measures that are to be applied universally to different regions, without direct community engagement. Such an approach would be unlikely to work as well as this hypothetical model. The policy recommendations that conclude this report are based on the decades of research and experience of our partner organizations and the intensive process of community and individual interviews carried out over the last 18 months.

2.5 Policy Recommendations
• **Establish a Federal Industrial Policy Commission (IPC).** Establish an IPC to coordinate MV electrification. **2.5.1, 2.5.2, 2.5.3** • **USMCA.** Modify the USMCA to address EV and battery domestic content. **2.5.1, 2.5.2, 2.5.3** • **Carbon Border Adjustments.** Levy border adjustments for energy-intensive trade-exposed industries to accelerate industry decarbonization and protect jobs. **2.5.3** • **EV Purchase Tax Credits.** Accelerate EV adoption, enhance job quality, and promote domestic production. **2.5.1, 2.5.2, 2.5.3** • **Government Procurement Rules on Domestic Content.** Use government procurement to enhance domestic production of EVs. **2.5.2, 2.5.3** • **Critical Minerals.** Identify domestic sources of critical minerals for EV production. Establish domestic supply chains with responsible mining practices. **2.5.2, 2.5.3** • **R&D Incentives.** Establish tax credits for EV R&D activities in the United States. **2.5.1** • **Hydrogen and Direct Air Tax Credits.** Create tax credits for hydrogen production and direct air capture of CO2 to encourage industrial decarbonizaion. **2.5.3**

Chapter 3: Policy Recommendations and Options

In the 30 years since the passage of the North American Free Trade Agreement, the permanent normalization of trade relations with China, and the relaxation of global trade rules to facilitate the integration of global supply chains—all combined with automation—the American economy lost over 7 million manufacturing jobs (BLS 2021). Meanwhile, in just the last 20 years, the global economy has gained over 63 million (ILO 2021). 2.8 million manufacturing jobs were lost from the United States to China alone between 2001 and 2018 (EPI 2020).

As many studies have noted, the decline in unionization rates and the number of jobs in the manufacturing sector in the United States over the past three decades has been a major contributing factor to the growth of inequality in America (Grabowski 2017; Autor et al. 2016). In 2021, the global pandemic sharply revealed the vulnerability of this economic model to public health and national security risks, and, as the semiconductor shortage has demonstrated, business risks as well. The U.S. Congress, the Biden administration, American-based corporations, and the public are facing a generational opportunity to rewrite America's industrial policy and harmonize it with our energy and environmental policies in a way that addresses the growing inequality and divisions in our society.

The next decade in the motor vehicle electrification transition provides us with this opportunity—one which can instruct us how to manage other transitions as we move toward a decarbonized economy. If we fail to take this opportunity, we risk another industrial transition in which the electrification of the motor vehicle industry will be driven by economic forces outside the influence of American workers, their businesses, and their communities. We cannot afford to make this mistake again.

The signs of that missed opportunity are already on the horizon as our Chinese, European, and Asian competitors are leading in the race for battery and drivetrain technologies. At the heart of this decision will be the immediate adoption of a conscious 10-year collaborative policy to electrify our transportation system in a way that prioritizes the existing motor vehicle workforce, the growth of its companies and communities, the jobs that both need, and the remediation of historic environmental impacts.

The Roosevelt Project and its partners propose the rapid formation of a federal Transportation Electrification Commission (TEC) to lead this effort, cochaired by the Council of Economic Advisors and an industry representative, with the support of the secretaries of energy, commerce, labor, and transportation and the full participation of unions, key manufacturers, related businesses, and environmentally impacted communities. The mission of the TEC should include the following urgent priorities:

1. Promote strategies and collaborations at the state level for domestic manufacturing development that prioritize current and former motor vehicle communities,
2. Decarbonize manufacturing through innovation, research, and development while ensuring economic competitiveness,
3. Create quality American jobs, accessible to all Americans, while promoting labor/management cooperation,
4. Review the wage, benefit, and other working condition disparities within the motor vehicle industry and make recommendations on how to reduce them,

including consideration of labor law reform, sectoral bargaining, and stakeholder representation on corporate boards,
5. Monitor and remediate environmental impacts while accelerating the public health benefits of electrification,
6. Mandate Community Benefit Agreements (CBAs) wherever federal funds are expended for electrification and establish a standard CBA process to provide adequate resources, transparency, accountability, and technical assistance to communities impacted by the transition, and
7. Deploy accessible, low carbon, mass transportation alternatives.

Based on our extensive community and policy research, the Industrial Heartland case study also recommends additional policies to ensure that the transition to vehicle electrification results in stable communities, more equitable treatment of and participation by LICs and COCs, and employer incentives to retrain existing employees. These recommendations grew out of the profound skepticism we encountered from the autoworker focus groups and interviews with community leaders, most of whom doubted that the transition to EVs would benefit them or their communities. We are convinced that without strongly articulated policies that aggressively address those concerns, that skepticism could become a real obstacle to the goal of widespread adoption of EVs by 2030. For this reason, we also believe that the TEC should report to the American people on an annual basis on how its priorities are being met.

We were also guided by a desire to maintain access to quality jobs in the manufacturing sector of the motor vehicle industry by the African American community and to avoid the displacement that occurred in earlier decades when the unionized automotive workforce declined along with AA participation in it. Our policy recommendations include ways to address that challenge, particularly through leveraging public investments in this transition.

Finally, we tested our fundamental premise that decarbonization can result in greater social equity if the right policy framework is created. In 2.5.3, our modeling exercise demonstrated that supportive policies at the federal level can make it more possible for resilient communities to succeed. While we did not include all those policies in our recommendations (carbon pricing and dividend distribution, for instance), we did include those that were directly relevant to this case study, such as domestic content requirements for EVs, border adjustments for energy-intensive industries, worker retraining, hydrogen fuel credits, and direct air capture.

Below we offer our policy recommendations at the community, state, regional, and federal levels. (Text references refer to material leading to recommendations.)

3.1 Policy Recommendations: Community-Based

1. **Equity-Based Planning.** An equity-based, people-centered transition to electric vehicles will require inclusive planning (i.e., involving a diverse set of voices), creating metrics and systems of accountability that both industry and government will subscribe to, and shaping a process for an equity analysis. We offer seven questions that can be adjusted to fit and provide a starting point for local, state, and federal decisionmakers who are responsible for leading planning and making decisions about all aspects of the vehicle electrification ecosystem. **(2.2.4)**

a. Who will benefit from this change?
b. Who could be negatively impacted by the proposed change?
c. Are there other pathways that offer a more equitable solution?
d. Have we engaged all the voices we need—at all stages of the process—to ensure that all perspectives are represented and influence the solution?
e. Have we set up a process to "check in at various frequencies" to ensure the process is working?
f. What is the data that we need to collect or begin collecting to validate "no harm" is being caused by our actions?
g. What is the frequency of communication—and to who/whom—that is needed to ensure an inclusive process from start to finish?

2. **Community Benefits Agreements (CBAs).** CBAs should be established in all communities where plants are being transitioned to EVs or closed to address community, public health, and workforce needs. The federal government should establish baseline standards for transparency, adequate funding, and equitable outcomes. **(2.1.4)**
3. **Convenience Store Impacts.** Community-based assessments should be conducted on the potential impacts to and opportunities for food access in LICs as convenience stores transition from gasoline sales to longer time charging requirements. **(2.3.4)**

3.2 Policy Recommendations: Regional and State

1. **Require State Government Regulatory Agencies to Form Community Tables.** Where state agencies are responsible for environmental review of MV plant conversions receiving state or local tax support, require community input processes that are transparent and adequately funded for independent technical support.
2. **Perform an Annual State Assessment of EV Transition Health Impacts.** Require each state to perform an annual assessment of the beneficial and negative environmental and public health impacts associated with MV electrification.
3. **Dealership, Repair and Maintenance, and Convenience Store Impacts.** Require state-funded assessments to identify the impacts to communities caused by loss of businesses and jobs in the supply chain, dealerships, repair and maintenance, and convenience stores, and implement adjustment, recovery, and diversification strategies. **(2.3.4)**
4. **State Tax Policy.** State-level studies should be authorized, analyzing potential impacts of EV transition on state and local tax revenue and subsequent effects on government funds, programs, or services. Based on findings, state and local policymakers and stakeholders should identify and evaluate alternative tax mechanisms consistent with progressive tax policy principles to make up for lost or shifting revenue. **(2.2.3)**
5. **Create a State-Based Labor/Management Partnership Incentive Program.** In order to promote successful labor/management transition collaboration, establish a federally funded "race to the top" transition program. Eligible states, defined as those with existing OEM assembly plants and ICE supplier companies, would work jointly with labor unions, motor vehicle and tier one supplier companies, and community partners to create transition partnerships designed to use federal resources to promote job stability, economic growth, environmental improvement, and defined equity outcomes. **(2.2.2)**

6. **Create a Regional/State-Based Initiative to Finance and Build Out Heartland EV Charging Stations.** Research shows that Michigan, Indiana, and Ohio may need nearly 600,000 L2 and DCFC charging stations by 2030 to maintain its leadership in both manufacturing and deploying EVs, at a cost of billions of dollars. Expanded charging infrastructure has been shown to be the most cost-efficient deployment strategy for EV adoption. Consequently, a regional deployment strategy for the Heartland will be a critical enabler to maintain its leadership in manufacturing, engineering, and design of next-generation motor vehicles. In addition, regional time of use charging programs and fleet adoption planning would accelerate EV adoption rates. **(2.3.1, 2.3.2)**
7. **Create a Tristate Regional Innovation Alliance.** EV manufacturing innovation will play a critical role in preserving jobs in the United States, which is lagging behind Europe and China in the key sectors of batteries, powertrains, electric motors, and power electronics. A tristate innovation alliance could play a key role in preserving both manufacturing and engineering jobs. **(2.5.1, 2.4.2)**

3.3 Policy Recommendations: Federal

1. **Establish a Federal Transportation Electrification Commission (TEC).** Establish a federal TEC to lead the motor vehicle electrification effort over the next decade, cochaired by the Council of Economic Advisors and an industry representative, with the support of the secretaries of energy, commerce, labor, and transportation and the full participation of unions, key manufacturers and related businesses, and environmentally impacted communities. The mission of the TEC should include the following priorities:

    i. Promote strategies and collaborations at the state level for domestic manufacturing development that prioritize current and former motor vehicle communities,
    ii. Decarbonize manufacturing through innovation, research, and development while ensuring economic competitiveness,
    iii. Create quality American jobs, accessible to all Americans, while promoting labor/management cooperation,
    iv. Review the wage, benefit, and other working condition disparities within the motor vehicle industry and make recommendations on how to reduce them, including consideration of labor law reform, sectoral bargaining, and stakeholder representation on corporate boards,
    v. Monitor and remediate environmental impacts while accelerating the public health benefits of electrification,
    vi. Mandate Community Benefit Agreements (CBAs) wherever federal funds are expended for electrification and establish a standard CBA process to provide adequate resources, transparency, accountability, and technical assistance to communities impacted by the transition, and
    vii. Deploy accessible, low carbon, mass transportation alternatives. **(2.2.1, 2.2.2; 2.5.1, 2.5.2, 2.5.3)**

And oversee the following programs:

   a. **ATVM Program.** Restructure and expand the existing Advanced Technologies Vehicle Manufacturing (ATVM) program to focus exclusively on existing plant transitions to electric vehicles and their component parts. (2.2, 2.4)

b. **48C Tax Credit.** Reenact and expand significantly the 48C Advanced Energy Manufacturing Tax Credit with a unique program office dedicated to transitioning existing ICE component part plants into a range of advanced energy and manufactured products. (2.2, 2.4)
c. **Develop Eco-Industrial Parks and Industrial Innovation Hubs.** Provide federal funding via a dedicated redevelopment program within the Partnership for Workforce and Economic Revitalization (POWER) Initiative, to create eco-industrial parks from repurposed industrial sites and power plants, including existing brownfield and Superfund sites. Coordinate use of ATVM and 48C tax credits to encourage EV supply chains to locate in such parks. (2.2.2)
d. **Hydrogen and Direct Air Capture Research and Deployment Tax Credits.** Provide federal support for the development of these two critical decarbonization technologies. **(2.5.3)**

2. **EV Trade Policy and Domestic Content Rules.**

   a. **EVs.** Institute a new U.S. domestic content requirement of 75 percent for EVs to receive new purchaser tax credits, effective in 2025. **(2.1.1, 2.4.1)**
   b. **Batteries.** Require domestic content of EV batteries to be over 80 percent for EV tax credit eligibility, starting in 2025. **(2.4.1; 2.5.1, 2.5.2)**
   c. **Critical Minerals.** Require the Departments of Energy, Agriculture, and Interior to deliver a report to Congress on the availability of domestically produced minerals in the United States to meet 21st-century demand for a range of current and next-generation battery, transmission, and charging station minerals to supply mobility demands, including but not limited to: copper, cobalt, lithium, iron ore, and bauxite. Include also the mining technologies and regulatory standards necessary to remediate any related water pollution or other public health issues while also meeting 2050 net zero emissions targets. **(2.4.1; 2.5.2, 2.5.3)**
   d. **Border Adjustments.** Establish border adjustments for energy-intensive industries in the automotive supply chain, including steel and iron, aluminum, copper, and glass. **(2.4.1, 2.4.2, 2.4.3)**
   e. **USMCA.** Review and revise the United States-Mexico-Canada trade agreement to reflect the EV domestic content rules for tax credit eligibility. Also, require an escalating percentage of EV charging equipment to be manufactured and assembled in the United States by 2027. **(2.5.1, 2.5.2)**

3. **EV Purchaser Tax Credits.**

   a. **New EVs.** Create a sliding scale EV tax credit for new purchases based on purchaser income to accelerate EV adoption with add-on credits for (1) domestic assembly of EVs, (2) domestic manufacture of batteries, and (3) payment of EV manufacturer average hourly wages in the top 50 percent of the industry. **(2.1.1; 2.5.1, 2.5.2)**
   b. **Used EVs.** Establish both a low-income and a used-EV tax credit program with a sliding scale to accelerate EV adoption in low-income communities. This program should be reviewed for efficacy every five years as used EVs become more prevalent. **(2.3.3)**
   c. **Swap Program.** Create a low-income swap program to encourage low-income ICE owners to exchange older ICE vehicles for new and used EVs. **(2.3.3)**

d. **Government Procurement.** U.S. government purchase of EVs will be restricted to those vehicles eligible for all EV tax credits. **(2.1.1; 2.5.1, 2.5.2, 2.5.3)**

4. **Opportunities to Advance Equity.**

   a. **Charging Infrastructure.** Establish a low-income charging infrastructure grants program to subsidize both construction and operations in LICs and rural areas, utilizing both urban utilities and rural electric cooperatives. **(2.3.3)**
   b. **Low-Income Ride Share Programs.** Fund 20 LIC ride share pilot projects in geographically diverse areas to test new mobility models. After 24 months, DOE and DOT should issue a report on findings and recommendations. **(2.3.3)**
   c. **Equity Report.** Provide federal funding under the guidance of the Departments of Commerce and Treasury for each state to produce an annual EV equity report, outlining the adoption rates of EVs in LICs and COCs, insurance costs, finance costs, charging accessibility, and electric rates. Require DOC and Treasury to compile a best practices summary on an annual basis. **(1.1.2)**
   d. **Gas Tax Policy.** Require the Energy Information Administration to perform an annual federal and state gas tax impact study to analyze the potential impacts of changing gas tax revenues based on expected EV adoption rates to understand potential changes to and impacts of transition. Based on these findings, federal and state policymakers may identify alternative tax mechanisms, consistent with progressive tax policy, to replace necessary revenues. **(2.2.3)**
   e. **Minority- and Women-Owned Businesses.** Require annual baseline reporting of minority-owned business participation in automotive supply chains over the last five years, with manufacturers' eligibility for government vehicle procurement restricted to the top 50 percent. **(2.3.3, 2.3.4)**
   f. **Small Business Energy Transition Loans and Technical Support.** The Small Business Administration should establish a special division to support the EV transition of dealerships, repair and maintenance shops, auto parts stores, and convenience stores with technical services, training programs, and low-interest loans and grants. **(2.3.4)**

5. **Job Quality.**

   a. **Use of Temporary and Contract Employees.** Reduce the use of long-term temporary contract employees in EV assembly plants and supply chain companies by redefining the legal definition of an employee. **(2.1.2)**
   b. **Project Labor Agreements.** Require use of Project Labor Agreements (PLAs) for all federally funded motor vehicle electrification projects, including ATVM, 48C, commercial and residential charging infrastructure, eco-industrial parks, and any projects developed by independent power producers. **(2.1.4)**
   c. **Community Benefits Agreements.** At the federal level, local CBAs should be required for all federal grant and loan programs designed to assist MV electrification and infrastructure. CBAs should include training components for neighboring LICs. **(2.1.4)**

6. **Job Training.**

   a. **ETAA.** Create an Energy Transition Adjustment Assistance job retraining program with an extended supplemental unemployment insurance program, tuition reimbursement, adequate relocation expenses when necessary, and all supportive services. **(2.1.4)**
   b. **Cross-Sector Collaboration.** Establish federal and/or state incentive programs for cross-sector employee retraining collaboration focused on transitioning employees of retired fossil fuel facilities to new colocated economic development sites. **(2.1.4)**
   c. **Incumbent Employer Tax Credit.** Federal funding or employer tax credits for reskilling and retraining energy, utility, motor vehicle, dealership, repair and maintenance, or related industry employees who wish to remain within the industry or with their incumbent employers. Programs may include access to financial support for the formal education and training needed to successfully transition to jobs within the industry. **(2.1.4)**
   d. **Utility Industry Job Training Study.** Commission a national study through the Department of Energy to analyze the impact of decarbonization on the utility workforce and identify transition and training opportunities; private-public partnerships, including with community colleges and registered apprenticeship programs; and policy recommendations to support the transition of the utility workforce to areas of new growth and opportunity, with a special focus on the load growth anticipated from vehicle electrification. **(2.1.4)**

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