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Electric Vehicles: *Connecting Michigan's Past and Future*

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Researched and Written by: Lyndsay De Carolis

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Executive Summary

Michigan is at a crossroads. For over 100 years, it has been the center of the automotive industry, creating an empire and a heritage that successfully dominated the field. The recent decline in automotive jobs, however, paired with the continuing high unemployment rate in Michigan, all indicate that the state must diversify its economy and even its most famous industry. Electric vehicles present an ideal opportunity with remarkable benefits. Fortunately, Michigan is already well on its way in building the connection from its deep automotive past into its electrifying future.

The electric vehicle (EV) industry presents an optimal solution because it utilizes Michigan's automotive legacy and experience in a new and positive way. Michigan's existing manufacturing infrastructure, proximity to educational institutions, and wealth of engineering talent make it the best possible location for an EV industry cluster. It is an investment that will bring sustained job creation and economic growth to the state.

Since the early 18th century, Michigan has been the epicenter of vehicle manufacturing and, as a result, possesses the greatest wealth of automotive infrastructure and skill in the world. In turn, this existing capacity attracts players that are involved in the EV industry. Companies such as Johnson Controls, Magna Electronics, and A123 Systems either traveled to Michigan or expanded operations within the state as a direct consequence of these advantages. Michigan is the ideal location for this industry as it provides the automotive expertise that only 100 years of experience can produce.

Moreover, Michigan's educational institutions are working around the clock to provide the necessary training to supply this burgeoning industry with experienced graduates. These new programs, with their historic engineering excellence, are helping to foster partnerships between industry and academia, advancing the technology at a rapid rate, and further convincing companies to locate their operations in close proximity. Additionally, the EV industry is providing students with novel avenues of study, and thus, new opportunities to stay in the state after graduation. This budding industry is effectively bringing in new companies and fighting the debilitating brain drain, simultaneously.

Federal and state incentives have also paved the way in preparing Michigan to be the nation's leader in the EV industry. As a result of these significant investments, the state is now the advanced battery center of North America, and other components of the supply chain are following. This new industry promises sustained jobs and economic growth due to its potential to become an industry cluster - a concentration of special industrial activity.

Put simply, Michigan is the best location for this new industry cluster. It has the manufacturing history and infrastructure, concentration of excellent educational resources, and capacity for production that no other state can offer. However, more work remains to be done. It is now in Michigan's interest to develop policies designed to encourage EV usage on the consumer side, which will help guarantee a sustained EV industry cluster within the state. It is time to electrify Michigan's future.

Sparking Demand for Electric Vehicles

Michigan has already made incredible progress in establishing the foundation for a successful EV industry cluster. The next step focuses on continuing this momentum by encouraging consumer demand for this vehicle. Ideally, Michiganders will not only produce these vehicles, but will drive them as well. The following is a list of existing policies in Michigan designed to this end, state and local policies that have proven successful elsewhere, and other approaches the state may consider.

Existing Michigan PEV Policy and Incentives:

- Consumers Energy, DTE, and Indiana-Michigan Power were among the first utilities in the country to adopt dedicated Time-Of-Use rates to encourage off-peak vehicle charging. Other utilities with time-of-use off-peak rates for EV charging include
    - *Hawaii Public Utilities Commission*
    - *Pacific Gas & Electric*
    - *San Diego Gas & Electric*
- Up to $2500 reimbursement is available for Consumers Energy, DTE, and Indiana-Michigan Power customers for charging and metering infrastructure installation
- One-stop-shop website for prospective buyers and owners hosted by MPSC
    - *www.pluginmichigan.org*
- Municipal utility EV pilot projects
    - *Lansing Board of Water & Light*
- Building code adjustments to facilitate separate meters for EV charging stations

Additional State Level PEV Policy and Incentives For Consideration:

- Purchasing preferences/commitments for PEVs in state fleets
    - *Washington – Biofuel/Electricity Use Requirement*
- Grants for local governments to purchase PEVs for fleets
    - *Hawaii - EV Ready Rebate Program*
    - *California - Clean Vehicle Rebate Project*
    - *Colorado - Alternative Fuel, Advanced Vehicle and Idle Reduction Tax Credit*
    - *New Jersey - Zero Emissions Vehicle (ZEV) Tax Exemption*
    - *Georgia - Electric Vehicle and Charging Equipment Tax Credit*
- Free parking in state-owned lots/garages for PEVs
- Free charging at state-owned charging stations
- Reduce/waive vehicle registration fees
    - *Illinois - Electric Vehicle Registration Fee Reduction*
    - *District of Columbia - Electric Vehicle Registration Fee Reduction*
- Streamline/expedite/waive fees for charging station installation permits
- Offer innovation grants for charging stations powered by renewable energy (or direct offsets) and the development of sustainable business models

    - *University of Iowa – Solar eCar Charging Station*
    - *CarbonDay Automotive – Solar Charge Port*
    - *Tennessee Valley Authority – Solar Assisted Charging Stations*
- Low Carbon Fuel Standard

Additional Local Level Policy and Incentives For Consideration:

- Purchasing preferences/commitments for PEVs in local government fleets
    - *Bay Area, CA – Project Get Ready*
- Facilitate zoning approvals and public right-of-way access for public charging stations
    - *Thurston County, WA – Zoning Modifications*
- Streamline/expedite/waive fees for residential charging station installation permits
    - *Portland, OR - ChargePortland*
    - *Chicago, IL - Electric Vehicle Infrastructure Project*
- Free parking in metered spaces and publicly-owned garages for PEVs
    - *Cincinnati, OH - All-Electric Vehicle Free Parking Program*
- Free charging at publicly-owned charging stations
    - *Salt Lake City, UT - Reserved Parking-Free Charging for EVs*
- Level 2 charging infrastructure requirements for new construction
    - *Vancouver, BC Single and Multi-Family Building Standard*

Additional Utility Level Policy and Incentives For Consideration:

- Develop a green energy PEV rate available to at residential and public charging stations to finance utility-owned solar installations
    - *Green Mountain Energy – Pollution Free EV Plan*
- Develop utility-owned or third party-owned solar arrays to "virtually" offset peak-period vehicle charging at multiple public charging stations. Consider business models that charge premium rates for an all-solar electricity product.
- Create a single meter TOU tariff option for household and EV consumption in DTE territory (Consumers already offers this option). Allow solar customers to offset EV electricity consumption with direct or net-metered solar energy.
- Vehicle-to-Grid (V2G) planning and pilots, net metering eligibility for PEVs, secondary battery market development

The information in this section is taken from the Policy Menu designed by the Michigan Plug-In Electric Vehicle Preparedness Task Force.

Michigan's Unique Advantages

First Look

Michigan is poised to become the leader in the emergent EV industry. No other state enjoys the unique advantages that Michigan does after such a rich automotive history, nor does any state have the potential to thrive like Michigan does in the future of transportation. As the home of the Motor City and of the Big Three, Michigan boasts the automotive heritage, manufacturing expertise, and proximity to talent along the automotive supply chain necessary to make it the leader in this new industry. All of these characteristics come together in a way that attracts new businesses to locate in Michigan and persuades existing ones to expand their operations. In this new age of electric vehicle innovation, only Michigan provides the complete package that companies seek. Continuing the development of this industry will only serve to enhance Michigan's economy and prolong its robust automotive legacy.

Introduction

Michigan's control of the automotive industry began almost as quickly as the automobile itself. The first automotive dealer independent of a manufacturer was founded in Detroit in 1898, a short six years after the invention of the vehicle powered by an internal combustion engine.[1] By 1905, Michigan's dominance on the automotive industry solidified. Indeed, between 1900 and 1910, 125 automakers located themselves within the state, altogether producing just less than 50% of the vehicles in the nation.[2] By 1929, roughly 75% of annual American auto sales belonged to Michigan's "Big Three;" General Motors, Ford, and Chrysler.[1]

The Michigan automotive industry maintained this lively growth and success until the past decade. For example, between 1999 and 2009, motor vehicle manufacturing employment decreased by more than 50% in the US.[2] Moreover, in 2008, all three of Michigan's automotive giants threatened bankruptcy, with both GM and Chrysler unable to ultimately avoid the process.

While the recent plight of Michigan's automotive industry is certainly discouraging, there are a great many reasons to believe the recent surge in hiring and quality of production is durable. Among the primary reasons for this optimism is the opportunity that electric vehicles represent for the state to reinvent itself while simultaneously capitalizing on its natural heritage.

Michigan remains the leading state for vehicle related research and development, spending $11.8 billion annually in the process.[4] Forty-seven of the top 50 global automotive suppliers are located in the state, and it ranks fourth in research intensity (the ratio of expenditures to gross state product).[4] Moreover, 24% of US transformers, generators, electric motors, relays, switchgears, and controls are manufactured in Midwest, joining roughly 37% of US transmission and powertrain part manufacturers.[2] Most importantly, Michigan is now considered the North American center for advanced battery manufacturing as a result of aggressive initiatives by the Granholm administration and Michigan's Congressional delegation, an essential building block of the EV industry.[5] With this foundation, Michigan is attracting prestigious companies along the electric vehicle supply chain to develop the industry inside its borders.

"The invention and re-invention of the automobile industry has impacted American society like nothing else."[1] Electric vehicles present an opportunity to impact it once again.

Quick Quote

"The electrification of transportation also presents tremendous opportunities for automakers in Michigan to leverage their skilled workforce, supplier networks, and engineering human capital in the development of the next-generation automotive product."

-Creating a Plug-in Electric Vehicle Industry Cluster in Michigan: Prospects and Policy Options[2]

Case Study: Magna Electronics

Magna Electronics is one company engaged in reinventing the industry and the state. Although headquartered in Troy, MI, the company looked to neighboring states when deciding where to locate its new facility designed to produce electric drive components. In the end, the proximity to other automobile companies and the resulting synergy convinced Magna to stay within the state. "It's the center of automotive excellence, so what better place to bring a company and have it grow in the emergence of this new market?" remarked Kevin Pavlov, Vice President of Magna Electronics.[6] Beth Sommers, Government Affairs Manager of the company, agrees. "While federal and state incentives, tax rates, and other regional costs of doing business are definitely taken into account, relative proximity and the ease of actively partnering with our suppliers and customer OEMs [original equipment manufacturer] is very important to us."[7]

Michigan makes the regular interactions of these different groups efficient due to its automotive infrastructure and concentration of engineering talent. The available synergy among these players keeps Magna competitive and forward thinking, an advantage over competitors in other locations. "The electric vehicle has seen numerous generations and is being continually approved," Sommers remarks. "The components and technologies that go into these vehicles are very competitive and must improve their respective performance and specifications even more aggressively."[7]

Magna received both federal and state incentives to expand its operations in Michigan. Its new facility dedicated to hybrid and electric vehicle systems development employs 200 workers and is located in Auburn Hills.[8] The company currently has nearly 15,000 employees in the United States, and over 5,000 of them are located in Michigan.[7] As a manufacturer of components and systems utilized in the electric vehicle, Magna is well-positioned in this developing sector and continually looks for new engineering talent to continue its innovation.

Case Study: Bright Automotive

Even companies headquartered in other parts of the country have expanded operations to Michigan looking to gain a foothold in the developing EV industry. Bright Automotive, a company based in Anderson, Indiana, chose to develop its hybrid electric vehicle in Michigan instead of nearer locations due to Michigan's concentration of engineering talent. "We want to grow and expand rapidly," said Michael Brylawski, Executive Vice President of Bright Automotive. "There is no better place to do that than in the Detroit area when you're talking

about high-quality auto engineers."[9] The facility will bring an $11 million investment into the state and will create up to 530 jobs upon completion, including 200 directly at the facility.[9]

Case Study: Ford Motor Company

Established in Michigan in 1903, Ford Motor Company is one of the most renowned automobile companies anywhere in the world.[10] Ford affected the automobile industry tremendously and became a household name with innovations such as the Model T in 1908, one of the most popular cars of its time.[10] Today, Ford continues to innovate in the automotive world, particularly with EV technology, by capitalizing on the existing infrastructure that it, and Michigan, offers.

For more than a decade, Ford has been researching EV technology and helped popularize hybrids in the United Stated with the introduction of the first hybrid SUV.[11] Currently, Ford offers one fully electric vehicle, the Transit Connect EV, which is designed for large company or municipal fleets rather than personal use. However, five fully electric consumer vehicles are expected to be unveiled within the next two years.[12] First is the Focus Electric, projected to be released late this year, complete with eco-friendly seats, regenerative braking, and even an electric vehicle app for smartphones.[11] Another expected EV, the C-MAX Energi, is predicted to be revealed in Fall 2012 and will also be available in a plug-in hybrid version.[11] Both of these vehicles will employ advanced batteries developed and assembled in Michigan.

Ford's involvement with electric vehicles is most exciting at its Michigan Assembly Plant, located in Wayne, MI. In March of this year, the company announced that it will produce all four types of vehicles – gas-powered, hybrid, plug-in hybrid, and fully electric – on a single assembly line.[13] The plant is the first in the world to be able to do so, and shows how Michigan's existing manufacturing infrastructure can be effectively altered to incorporate new EV technology.

Indeed, the plant has been in operation since 1957, but required only several changes to make this new production line possible.[13] Most notably, the body shop received reprogrammable tooling, at least 500 new robots with high welding rates were added, and the final assembly transformed into a common-build sequence.[13] The facility demonstrates how other Michigan automotive plants can take advantage of existing facilities and manufacturing operations to rapidly integrate the production of electric vehicles.

The plant also houses 10 EV charging stations, which are utilized by electrical-switch trucks that travel among facilities on the Ford compound.[13] By using an electric system instead of a traditional internal combustion engine (ICE), these trucks are estimated to save 86,000 gallons of gas on an annual basis.[13] Moreover, the recent investment in electric vehicles has spurred other related activities around the plant. As part of its transformation, the plant installed 500 kilowatts worth of solar panels, including a 50-kilowatt hour (kWh) pilot project that demonstrates how old EV batteries can be used for stationary storage.[14]

From all of its current initiative and future plants, it is clear that Ford Motor Company is actively involved in the EV sector. The company provides an excellent example of how old players can make a new mark on the automotive industry simply by utilizing the infrastructure already enjoyed in Michigan.

Quick Quote

"There [are] only three [automobile] sectors around the world. It's either Japan, Germany, or the US. And it's absolutely here in the Detroit area. There's such a rich density of automotive design here in southern Michigan; that's why we need to be located here."

- Clive Wotton, VP Ricardo, Inc.[39]

Case Study: General Motors

General Motors is another universally known automotive company investing in the EV industry. Located in Michigan for over a century, GM is able to take advantage of the empire it created to begin innovating with this new technology. As early as 2006, the company made a commitment to be a leader in the EV industry by announcing plans for what became the Chevrolet Volt.[15]

In December 2000, the Volt first became available for sale and immediately provoked outstanding enthusiasm, even in locations initially not listed as "launch" sites. For example, a Chevrolet dealership owner from Atlanta flew to New York City within the first week of the Volt's availability in order to purchase the vehicle for himself.[15]

As Atlanta was not selected as a launching site, the dealer was not able to sell a Volt in his own showroom until a year later, in December 2011. After driving the vehicle back to Atlanta, however, he was bombarded with 25 to 50 people on a daily basis, asking to be able to test drive the ground-breaking automobile.[15] Clearly, the enthusiasm for the Volt is widespread, and will only grow as GM continues to innovate. Indeed, Chevrolet expects 10,000 Volt sales in the United States by the end of this year, and 45,000 in the year 2012.[16]

Since GM's headquarters have always been in Michigan, it has a wealth of facilities and brain power to draw from within the state's borders to be successful in this new EV industry. Sites such as the Milford Proving Grounds, where the equivalent of 132 miles of two-lane highway allow for car safety tests, give GM a unique manufacturing capacity within the state and the nation as a whole.[17] Similar facilities unquestionably aid in electric vehicle innovation on a separate basis, but it is really the concentration of these sites that gives GM and Michigan the upper hand in the advancement of the electric vehicle.

Moreover, the intellectual capital that is available at these facilities is even more valuable. Robert Peterson, Communications Manager of the Chevrolet Volt, agrees. "We have a wealth of places in which we can draw people from," he remarked.[15] Recognizing the importance of worker proximity, GM made a commitment to further facilitate its engineers by opening its Vehicle Technology Center in 2003, located in Warren, MI.[18] This facility brought together over 8,000 engineers to a single location, in order to facilitate productivity, collaboration, and efficiency among GMs brightest minds.[18]

The question of proximity is critical when looking at reasons why Michigan should be the center of the new EV industry. To that end, GM is able to attract the brightest and most innovative

people from its multitude of facilities and university partnerships to better advance this type of technology. GM's progress also benefited from the Michigan Economic Development Corporation's (MEDC) work in developing the advanced battery sector. In 2007, when the Volt was first officially revealed, there were no battery cell manufacturers in the state of Michigan. Now, the first full year that the Volt is available, there are over five.[15] The easy access to these suppliers allows GM to be able to work regularly and efficiently to better develop these new technologies.

While important, GM's heritage is not the only reason why the company flourishes in Michigan. Peterson points to the manufacturing, engineering, and vehicle development expertise that resides in Michigan as another essential reason for the success of the automotive industry. When asked why, he notes that "it is part art, it is part science, and it is something that we do better than anybody else, anywhere in the world, period. It is something that we should be proud of; it is a base by which we should build off of."[15]

As one of Michigan's Big Three, GM acts as a bellwether of automotive innovation. Its investment in the Volt is therefore indicative of an increasingly electrified transportation system. The wealth of existing facilities and engineering talent that it possesses undoubtedly make it one of the most interesting players to watch as it works to reinvent the automobile, its image, and Michigan as a state.

Bottom Line
The electric vehicle presents an opportunity for Michigan to lead in an industry with the promise of reinvigorating the state while capitalizing on its existing heritage of engineering and manufacturing excellence. It has the resources, the affinity for manufacturing, and the engineering talent that is required for any industry cluster, especially that of electric vehicles. The EV industry offers a tailored solution for Michigan's struggling economy because it draws on the automotive legacy of the state, while providing a new sector for jobs and opportunity. In order to make this industry sustainable, however, it is necessary to provide a stable foundation for its growth and a steady supply of experienced workers. In the case of electric vehicles, Michigan's educational institutions provide these necessities.

The Importance of Educational Institutions

First Look
Proximity to educational institutions is one of the most common reasons that companies cite when asked what factors attracted their business to Michigan. Electric vehicles require a new way of thinking about automobiles, and the corresponding technology calls for brilliant, innovative minds for their research, design, and improvement. Students, specifically those who study engineering, will be needed to contribute and bring new ideas to this industry in order to help it grow and compete with traditional transportation alternatives. Continuing to develop this industry will only lead to more outlets and opportunities for these students, keeping them in Michigan after they graduate to fight the destructive and ongoing "brain drain." Furthermore, the universities themselves not only offer access to talented youth, but also provide rich research opportunities for industry, allowing companies to experiment in an exceptional academic setting.

Creating partnerships between the two sectors, educational and industrial, can therefore help retain Michigan talent and attract industry to the state at the same time. Convincing graduates to stay in Michigan will have a positive effect on the economy, on the strength of the communities around these universities, and on Michigan's continued leadership in the automotive sector.

Introduction

While Michigan's universities produce 300,000 graduates annually, roughly half of those students leave the state in order to enter the workforce.[19] As of 2009, Michigan had the 8th worst migration rate in the nation, continuing an unsustainable pattern that has plagued the state since at least 2001.[20] In 2007, Michigan lost the second largest number of students ages 22-29, with a minimum of bachelor's degree. Only Louisiana, who was ravaged by Hurricane Katrina the summer before, lost more.[19]

While the numbers may fluctuate, one thing is consistently true. The young people leaving the state are the ones that the state most desperately needs to retain; they bring brain power and fresh ingenuity that can help reinvent and reinvigorate Michigan's economy. Indeed, Michigan ranks fourth in the nation in number of engineering graduates produced.[4]

With this type of talent available, Michigan must do better in keeping these youth in the state. The electric vehicle industry provides an excellent new attraction for their long-term retention. In a report compiled by Michigan Future and U-M's Institute of Research on Labor, Employment and the Economy it was noted that "the auto industry is still the engine that drives the Michigan economy."[20] The state must capitalize on this by continuing to by reinvigorating this cornerstone industry in order to hold on to graduates.

The federal government recognized the value of educational institutions in the development of the EV industry when it granted awards to three of Michigan's finest schools as part of the $2.4 billion Department of Energy (DOE) grant. Wayne State University, Michigan Technological University, and the University of Michigan received $5 million, $2.98 million, and $2.5 million respectively to develop workforce training programs to assist the burgeoning industry.[21] Each of these institutions, and several others, responded to the federal grant by establishing programs, creating curriculum, and generally preparing graduates for the new demands of the EV industry.

Indeed, in 2010, GM announced that it would hire an additional 1,000 engineers in Michigan to work on EV-related technologies, like advanced batteries and electric motors.[22] The need for engineers with this experience and interest in these technologies will only continue to grow as EVs gain popularity and acceptance.

Quick Quote

"It's not only that it's an automotive center, it's the educational facilities that are close by as well."

-Clive Wotton, VP of Ricardo, Inc. on why Michigan is a superior location for business[39]

Case Study: Wayne State University
Located in Detroit, Wayne State University has a rich history of collaborating with the automotive companies in order to make students competitive for jobs within the industry. "Electrifying" the average American's vehicle only presents another opportunity to do so. "We see a new era coming and we want to be a player," remarked Interim Dean of Engineering Mumtaz Usmen. "Armed with this knowledge, our students will be sought after by the OEMs and their suppliers."[23]

The higher education institution that received the highest amount of federal grant money, WSU certainly responded with enthusiasm to the federal call for an electrified transportation system. It now offers the nation's first Electric-drive Vehicle Engineering Master's degree and graduate certificate programs.[24] In addition, WSU provides training for a Bachelor of Science in Electrical Transportation Technology (ETT) as well as an Associate's Degrees in Automotive Technology and Electronic Engineering Technology, with a focus on Electric Drive Vehicles.[24] In total, it provides 19 EV engineering (EVE) courses at the graduate level. These new degree options, unique to WSU, add to Michigan's advantage of being the center of automotive research and development. Future students interested in automotive engineering are now able to work alongside industry in theses specifically tailored programs; an attraction that is exclusive to Michigan. Providing these educational opportunities is thus beneficial to WSU, Detroit, and the state as a whole.

Educational outreach programs for the general public, along with a user-friendly website, are also associated goals of the programs. These two aspects of the program will help garner acceptance among the public for electric vehicles, and educate consumers on how they work. These programs may also serve to foster an interest in EV technology and engineering among younger students, who can then turn to WSU to provide them with the university-level training required. Thus, these new programs are broadly affecting both current and future university students.

Simon Ng, a professor in the Department of Chemical and Materials Science Engineering predicts that these new degrees will allow manufacturers to employ workers who are already trained in EV systems, rather than having to train them after hire. "The auto manufacturers are training their EDV [electric drive vehicle] engineers and technicians mainly in-house," he says.[25] Eventually, they will need expertly trained engineers with experience in this kind of technology. Accordingly, he believes, the companies will turn to WSU graduates.

Armed with four new degrees related to the EV industry, it is quite clear that WSU is already investing heavily in fighting Michigan's brain drain by preparing graduates for the new world of EVs. According to Usmen, this was the goal from the outset. "Our vision is to make this program strong and accessible," he observed during the announcement of the new degree programs. "We are leading the education effort in the nation by teaching and training people across the automotive supply chain and help make the transition to renewable energy sources more efficient and systematic. Our goal is to teach students to continue to learn even after they graduate and equip them to seek out the resources they need to remain current and job-ready for the future."[23]

Case Study: Michigan Technological University
Michigan Technological University also provides students with the education they need to be competitive in an ever-evolving technological world with the simple mission statement of "We prepare students to create the future."[26] Accordingly, it comes as no surprise that Michigan Tech expanded into EV technology.

Beginning in January 2010, Michigan Tech began its new Professional Master of Engineering program, which consists of more than 30 courses that involve mechanical, electrical, material, and chemical engineering disciplines.[26] The program derives from an online course created through collaboration among Michigan Tech, General Motors, and AVL, an engineering company with its North American location in Plymouth, MI.

In addition to the Master of Engineering program, there are several other ways for students at Michigan Tech to engage themselves in EVs. The university offers an undergraduate certificate in Hybrid Electric Vehicle Engineering (HEV), a 15 credit program designed to allow students to focus on their planned engineering degree while simultaneously gaining experience with electrified transportation. Students are also able to receive a graduate certificate through another 15-credit program, and even non-degree seeking students are encouraged to take HEV courses.

Michigan Tech also houses a new mobile laboratory with EV-related capacity at the Keweenaw Research Center, built to be utilized in an outreach program that will reach more than 1,000 middle and high-school students on an annual basis.[27] The program is part of the federal initiative GEAR UP (Gaining Early Awareness and Readiness for Undergraduate Programs). Designing and implementing these kinds of programs will not only prepare students for working in the EV industry, but will also increase education among youth and incoming students, therefore fostering interest in this area.

Case Study: The University of Michigan
As one of the largest research institutions in the United States, the University of Michigan is well prepared to positively influence the EV industry and continue its progress. It has the largest base of patents in clean energy of any university in the nation, as well as a consistently rated Top 5 College of Engineering.[28, 29] Furthermore, its long history of collaborating with industry makes it a strong asset to automotive companies in the area. In short, it is well equipped to assist the development of the EV industry through research, innovation, and employees.

Before receiving funding through the American Recovery and Reinvestment Act (ARRA), U-M was already partnering with industry to gain a solid ground in the development of the EV industry. In May 2009, it announced the formation of the GM/U-M Institute of Automotive Research and Education.[31] The Institute has a special focus on research that is reinventing the automobile and creating high-efficiency vehicles through several key areas, namely advanced batteries and vehicle manufacturing. Upon its announcement Tom Stephens, GM vice chairman for Global Product Development, specifically noted student skill as the motivation for the partnership. "GM is leveraging the finest faculty and students at the University of Michigan and our own talented researchers and engineers to accelerate the pace of innovation."[31]

The Institute's concentration on advanced batteries led to the formation of the Advanced Battery Coalition for Drivetrains (ABCD). The ABCD brings together industry, education, and government in an effort to research electrifying the vehicle's drivetrain, advanced batteries, and related performance matters. ABCD is associated with the College of Engineering's Master of Energy Systems Engineering, the first of its kind in the nation that offers a specific focus on transportation power. Graduates undergo thirty credits of rigorous interdisciplinary study that will help students "respond to expanding global environmental and energy needs."[32] As of 2009, 144 students were enrolled in this program.[30]

In August 2009, U-M received $2.5 million as part of the Advanced Electric Drive Vehicle Education Program grants.[33] Huei Peng, professor of mechanical engineering and executive director of Interdisciplinary and Professional Engineering Programs, heads the programs created from the grant. "We want to develop all opportunities so the workforce in Michigan can be transformed," he remarked upon the grant announcement.[31]

In total, 10 courses are offered, or are in the process of being offered, across U-M's three campuses. These include six classes at the undergraduate level and four at the graduate level.[30] In winter 2010, 246 students enrolled in four of the offered classes including Control of Batteries and Electrified Vehicles and Modeling.[30] Peng also developed three laboratories under the grant funding: the Power Electronics Laboratory, Hybrid in the Loop Laboratory, and the Green Mobility Laboratory.[30]

The grant is also contributing to the development of a summer camp dedicated to teaching high school upperclassmen about the developing technology.[30] This three-day camp is designed to introduce students to electric vehicles and foster an interest in studying them once they enter college.

Overall, the program is expected to impact 300-500 students and 100-200 professional engineers, on an annual basis, not including the 1,000 other Michigan citizens to be reached through the K-12 and other consumer education.[30]

Case Study: Western Michigan University

Although it did not receive any share of the ARRA electrification funding, Western Michigan University applied other federal funding to that end. In 2009, WMU received $1 million as part of the Energy and Water Appropriations Act for green engineering studies. The University then used the grant in part to power their Green Manufacturing Initiative.[34] The GMI, part of the College of Engineering and Applied Science, works to create partnerships across industry, professional, educational, and governmental lines in order to better involve green manufacturing practices into their curriculum to give students experience with these new technologies before entering the workforce.

The consortium allows students to be visionary and creative with the issues they tackle and with the hope of solving the next industry's green manufacturing dilemmas. "We're looking ahead to what issues they'll have in seven years that can be solved now so they don't waste time," said Carey Schoolmaster, program coordinator. [35] "With students being creative and out-of-the-box thinkers, we'll be able to nail some of those problems early." The students respond well,

particularly in the EV industry, by working diligently on creating reuse and recycling programs for old lithium-ion batteries, a business that will certainly come into play as EVs continue to gain popularity among consumers. “We see a great potential for the reuse of the lithium ion battery for energy storage use after their useful life in vehicles,” said WMU senior Trevor Williams.[36] “We’re working on a project where the batteries can be collected from cars and put into use for the storage of wind energy power, a developing green energy.” The project comes at the perfect time. These kinds of solutions must be available the moment that they are needed and, by looking ahead, WMU is helping to solve those potential issues today. “By the time a functioning wind-power energy source is in wide use here, the batteries will be available for second-generation use,” observed WMU graduate student Gary Nola.[36]

By working together with industry on these issues, WMU and the other universities are also helping to bring more components of the EV supply chain to this area. The excitement of research possibilities, and the bright young minds working to solve them, is certainly attractive to those who want to push ahead in the sprouting industry. “I think as companies develop a better understanding of the lithium ion battery industry developing here, we will see clusters of suppliers, product providers, and other industries developing,” remarked Jeff Disher, president of Disher Design and Development.[36]

WMU is also partnering with Eaton, a company associated with South Coast Air Quality Management District, which received $45.4 million from the ARRA grant. WMU and Eaton have come together in a five-year agreement to invest and jointly staff a CHEAR lab, Center for Hybrid Electric Applied Research.[37] The primary purpose of the lab is to evaluate electric motors and other related components of the vehicles, as well as testing batteries and innovating with power electronics equipment. Dimitri Kazarinff, VP and General Manager of Eaton’s Hybrid Power Systems Division, points to WMU’s strong history of engineering excellence as the reason for collaboration. “Western Michigan has a first-rate engineering program, and we’re looking forward to collaborating with them in this endeavor,” he remarked.[37] John M. Dunn, WMU President, agrees. “Our College of Engineering and Applied Science is a center for research that focuses on the battery technology that makes the electric vehicle possible.”[38]

The university further commits to the developing EV industry with its installation of several EV charging stations around campus.[38] Placing EV stations on campus not only shows dedication to this growing technology, but it also brings education and awareness to the rest of campus, who may not be as familiar with EVS as engineering students. Moreover, it demonstrates WMU’s high interest in the future of Michigan’s economy. It means that the university is actively supporting the growth of this industry in the state, because it finds the technology worthy enough to place on campus as a first adopter. It is a step towards electrifying Michigan, and creating a sustainable industry with the state.

WMU, then, not only supports the industry by providing educational opportunities to prepare students, it also allows for infrastructure to encourage consumers on the opposite end of the supply chain. Senator Debbie Stabenow sees the greater implications of the installation as well. At a reception announcing the new charging stations, she remarked “This is a strategy for us that [is] about jobs in Michigan. It's about innovation. It's about getting us off of foreign oil and having a strategy for controlling our own destiny in terms of energy. And we're on a campus of

people that are very smart who are contributing to this both in the innovation and the vision for the future." [38]

Quick Quote

"The fact that we are the automotive R&D capital of North America, the fact that we have universities who have focused on engineering degrees that have helped populate those marketplaces… provides an incredible opportunity not only to train, to understand, but then to work in that field."

- Doug Parks, SVP of MEDC on Michigan's advantages in regard to the automotive industry[39]

Bottom Line
For any industry to be successful long-term, there must be a steady flow of ingenuity and enthusiasm that can help it progress and survive through time. In the case of electric vehicles, Michigan's universities serve this purpose. By providing expert automotive experience, fresh EV-related curriculum, and a constant supply of innovative students, Michigan universities take an active role in preparing for Michigan's future. They developed research laboratories, industry-education consortiums, groundbreaking degree programs, and even charging stations as a response to the call for electrified transportation solutions. Their commitment to this industry attracts companies and businesses to Michigan, creating employment opportunities for graduates and helping to fight the brain drain.

Continuing the Momentum

First Look
Both the state of Michigan and the federal government contributed to creating an advanced battery industry within the state, providing the foundation for the entire EV supply chain to be developed here. Universities, automotive companies, and other businesses are coming to Michigan or expanding operations to be a part of this evolving sector. With Michigan's automotive infrastructure, access to engineering talent, and affinity for manufacturing, it is the perfect scene for an EV industry cluster. Michigan must continue to encourage the growth of this industry if it is to receive all of the benefits it could potentially harvest.

Federal and State Incentives
Across governmental levels, Michigan has been the primary choice for investment in electrifying the vehicle. It received the most funding out of any state in the American Recovery and Reinvestment Act (ARRA) award to support advanced batteries and electric vehicles: $1.35 billion out of $2.4 billion to fund twelve different projects. The Department of Energy (DOE), which awarded the grants, highlighted Michigan's concentration of engineering talent as a key reason for the favorable allocation.[40] "A concentration of Michigan's engineers, workers, and managers are innovating more quickly because they are near one another – and drawing in more and more advanced vehicle expertise each day," the agency remarked.[40] Over 6,800 new jobs

were estimated to be created as a result of this funding by the end of 2011, with 40,000 more expected by 2020.[41] With the distribution of these awards, the federal government clearly looked to Michigan as the leader in this developing industry.

Quick Quote

"There is no reason why the United States of America cannot lead and will not lead the 21st century in the manufacture of automobiles again."

-Vice President Joe Biden at a reception in announcing federal grants under the ARRA[39]

The state of Michigan exerted no less effort in establishing itself as the center of the developing EV industry through the Granholm administration. Seeing advanced batteries and electric vehicles as an opportunity for new economic growth, Michigan created the advanced battery tax credits, the first of its kind in the nation.[5] "We said we are going to put in place $700 million worth of advanced battery credits so that we can be the place where the lithium-ion battery is produced in the United States," Granholm stated during a reception for Johnson Controls, an advanced battery company that received a $100 million credit from the state.[42] "Now, all of those cells and the packs and the research and development and integration with the vehicle will be happening in Michigan, in the United States of America, employing American workers to make American energy independent. That is fantastic!"[42]

Under these tax incentives, dozens of companies either located or expanded operations within the state, including other big names such as A123 Systems, KD Advanced Battery Group (otherwise known as Dow Kokam), and LG Chem-Compact Power. Michigan's commitment marks a new direction for the advanced battery industry that, up until these recent developments, was overwhelmingly concentrated overseas. Indeed, as recently as November 2009, the top eight producers of lithium-ion batteries, who together accounted for 88% of the total market, had no headquarters in the United States.[43]

A report by the Electrification Coalition, a group of industry professionals committed to reducing American's foreign oil dependence, released a report explaining the benefits of electrifying the transportation sector and the consequences of not keeping pace with the rest of the world. "Throughout the electrification value chain, new markets are rapidly developing in Europe and Asia – in battery technology in particular – and the United States in likely to forfeit the income, manufacturing capacity, jobs, and economic growth associated with these markets if the status quo approach remains in place."[43]

Michigan, however, made a conscious effort to not let the United States lag behind. As the new North American center for advanced battery manufacturing, it now possesses the critical foundation required to build an entire EV industry cluster, something that will create sustained job creation and economic opportunity. Similar to how the advanced battery is the critical component for the electric vehicle itself, this advanced battery concentration serves as a foundation for the entire EV industry.

Quick Quote

"These last two years are an example of positive national and state policy working in tandem. What that can bring…is more investment, more research and development, and, most importantly, jobs."

- Former Governor Granholm[44]

New Employment Opportunities

As of February 2011, Michigan's unemployment rate stood at 10.4% as the fifth highest in the nation, behind California, Florida, Nevada, and Rhode Island.[45] Although the rate fell 1.5% since September 2010, it undoubtedly remains an immediate concern.[46] A significant infrastructure now exists that enables the development of the EV industry in Michigan, promising to create hundreds of jobs and new career opportunities around the state.

The EV industry represents an optimal combination of two of Michigan's strengths: automobile manufacturing and clean energy manufacturing. For example, 41% of Michigan's green jobs come from the "Clean transportation and fuels" sector, according to a recent report by the Department of Energy, Labor, and Economic Growth (DELEG).[47] Moreover, while there was a 3.6% reduction in overall job growth in the year 2009, there was a simultaneous 10.7% job growth in clean energy sector investments, signifying the job creation potential of these new industries.[48] Indeed, Michigan businesses engaged in clean energy technologies are predicted to create over 89,000 jobs in the next decade.[44]

The intersection of automobile and clean energy manufacturing makes the EV industry a hotbed for job creation. Although no universally accepted formula for predicting EV-related job currently exists, these facts paint a promising picture for Michigan's future economic growth in this industry.

Case Studies: Toda America, Fortu PowerCell, and P3 North America

State and federal tax incentives can be an invaluable asset in establishing an industry within a particular location for the purpose of job creation. While Michigan's manufacturing expertise and proximity to engineering capacity are no doubt important within these companies' decision making process, governmental incentives can play a critical role in the first stages of developing an industry cluster.

For example, Toda America, a Japanese battery company, choose Michigan after receiving a brownfield tax credit as well as a Michigan Business Tax credit.[50] As a result of the company's new development in Battle Creek, 148 direct and indirect jobs are expected.[50] Upon completion of the facility, Toda America will have the capacity to supply advanced batteries for thousands of electric and hybrid-electric vehicles, assisting in the development of the entire EV supply chain in Michigan.

Competition among locations can also happen on a global level. Fortu Power Cell is a company that provides another valuable aspect of the EV supply chain; research and development of rechargeable batteries.[51] Instead of expanding operations near its current facilities in Switzerland or Germany, the company was persuaded to locate in Michigan after receiving state tax credits, specifically a battery cell manufacturing tax credit of $100 million over four years.[51] It is the company's first large-scale project located in North America, and it is bringing jobs to the local economy. After completion, the project is expected to create over 1,900 jobs, including 726 directly at the facilities.[51]

Another company, P3 North America, was also convinced to expand operations in Michigan after receiving a state tax credit.[52] Headquartered in Troy, MI, the company seriously considered a site in New Jersey for the expansion, but remained in Michigan following the receipt of governmental support. In all, the project is expected to created up to 129 jobs, including 65 directly at the facility.[52]

Case Study: Johnson Controls

One of the biggest names that came to Michigan as a result of the recent investments in advanced batteries, Johnson Controls, is already creating a profound impact on Michigan's community. The company received the largest grant from the ARRA, $299.2 million, as well several state awards and grants. [5, 42] The awards have culminated in a new facility located in Holland, MI, that will employ 500 people upon completion.[53] Additionally, the new facility has been estimated to create 3,261 both direct and indirect jobs during construction and opening, as reported by the White House Council of Economic Advisors.[54]

With over 142,000 employees serving 150 countries worldwide, Johnson Controls had a multitude of options when deciding where to locate its newest facility. In the company's own words, "the real enabler to us putting this facility in Michigan was the grant award that we received through the recovery act combined with incentives from the state of Michigan," said Vice President and General Manager of Hybrid Battery Systems Ray Shemanski.[55] Mark Wagner, Vice President of Government Relations, prefers to put it in more straightforward way. "If it wasn't for the stimulus grant and tax incentives that were put in place in Michigan by Governor Granholm, we would not have put the plant in Michigan. Let me repeat that. If it were not for those policies and the stimulus grant, we would have built our plant somewhere else," he frankly remarked during a recent panel discussion at UM's Law School.[28]

Mary Ann Wright, CEO of Johnson Controls-Saft, remarked positively about how Michigan's overall manufacturing attitude encouraged the choice to come here as well. "It's not only the incentives, but it's the whole culture and attitude of the people in Michigan, the legislature and the MEDC, that have made it an absolute delight for us to be able to come to Michigan and do business here."[42] She notes that MEDC's actions are "unrivaled" and "unmatched" in terms of the effort it puts forth to bring companies to Michigan. "They've made a commitment. Michigan is going to be the leader in the next generation of transportation solutions."[42]

On a personal level, Elizabeth Rolinski saw firsthand what bringing EVs to Michigan can do for a community. As the plant manager for the old owner of the facility, Rolinski was present for the original opening of the plant as well as its subsequent closing. "It's a team I knew very well, a

team I was with for a lot of years, so when the time came and the decision was made to close the plant it was a very emotional event for me," she remarked.[55] However, enabled by the state and federal incentives Johnson Controls received, that same plant has now reopened for business, again with Rolinski as plant manager. Immediately after the announcing of the plant's opening, Rolinski began to receive calls from former employees, asking about potential job opportunities.

The plant is once again attracting workers to the community, and moreover, convincing people to stay. "So to come back now and open this plant and have some of the same people calling, very interested in coming back and excited about the opportunity, is an emotional event for me and it's just a huge deal for all those people in the community as well." Rolinski speaks of the hope that this new venture has created in the community, a hope that will keep more employees in Holland and give Holland's students more career opportunities in the future. "You know we don't want to see the kids go, to grow up and leave the community necessarily; we want them to grow up and have a good technical basis, and support the industries here where we're going to need them."[55]

Case Study: Dow Kokam

Another primary recipient of federal and state incentives, Dow Kokam is a veteran battery operation that has come to Midland, MI to be a part of the developing EV industry. "The state of Michigan has been unwavering in its support of the development of a vibrant advanced energy storage industry and because of that, in only ten months, we have built the foundation for the flourishing enterprise that is Dow Kokam," remarked Ravi Shanker, CEO.[56]

Formally called the Dow Kokam Midland Battery Park, the facility is expected to create more than 720 employment opportunities when fully operational.[57] Construction of the plant is predicted to involve over 2,000 construction jobs from start to finish, meaning a total of 2,720 direct and indirect jobs.[57] At the beginning of the facility construction, the company committed to ensure that 80% of building construction labor hours occur in Michigan, in order to promote local employment opportunities and the economy. Ultimately, it exceeded this goal, instead achieving 95% of these hours in Michigan.[58] Local integration is therefore an important part of Dow Kokam's process, and it will continue to draw upon local resources as it continues to develop within the state.

"The lithium ion battery market represents an emerging and potentially large global market opportunity for Dow Kokam, Midland, and the state of Michigan especially in the competitive realm of clean energy technologies," said Ravi Ramanathan, Vice President of Business Development and Government Affairs.[56]

Quick Quote

"Governments have to be proactive to create the incentives to bring these clusters of knowledge to the United States, to Michigan. They're everything. I am a great advocate of public-private partnerships for that reason. And I think the state legislature, with the work they've done already and they just need to keep doing that work to enable industry to proliferate back here."

-Andrew Liveris, Chairman and CEO of Dow Chemical, Co.[39]

Creating an Industry Cluster
Industry clusters are the optimal outcome for this budding EV technology sector in Michigan because they create more powerful and sustained economic growth. The concept relies heavily on the fact that clusters produce synergy among supply chain members, which in turn makes industrial activity more effective and profitable. In short, each individual component of the industry cluster works less productively in an independent or semi-connected system than in a cluster.

Already, Michigan has the potential to become an EV industry cluster. The supply chain components of the electric vehicle are slowly developing, but still just beginning.[2] Further investments by industry, and potentially government, is necessary if the significant investments made this far are to grow to fruition.

Bottom Line
Federal and state incentives already paved the way for a much-needed rejuvenation of Michigan's automobile industry and economy through investments in EVs, but work remains to be done. Michigan has the opportunity to become an industry cluster and a chance to create a sustainable business model instead of important, but still scattered, jobs. It must seize upon this moment and continue the momentum. The electrification of transportation is what Michigan's economy, and its workforce, needs. It is the bridge that will connect its automotive roots with its new, sustainable economy.

Conclusion

Michigan could not be better prepared for the emergence of an EV industry cluster. More than a century of automotive excellence, Michigan truly leads the nation as the optimal location for this burgeoning industry. The state must capitalize on this momentous progress. Numerous companies have either located or expanded operations here, bringing more money into the state economy and more opportunities for employment. Michigan's universities' commitment to training their engineers in the necessary experience with this technology, and their ingenuity in continuing its progress, presents new opportunities for living in the state after graduation. So great an investment is already present, in fact, that it would be an immeasurable loss if it were to end before becoming self-sustaining in the form of an industry cluster.

The electric vehicle is Michigan's opportunity to use its greatest strengths to reinvent itself in for the future. The EV industry takes advantage of Michigan's automotive legacy and reinvents it for the future, promising significant job creation and economic growth. Michigan must realize the importance, potential, and long-term promise of this industry and continue to support it until it is fully realized.

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Appendix

Number of Jobs Created due to Federal Funding

Name of Company	Specific EV Sector	Federal Funding	2012 Direct	2012 Indirect	Permanently Expected	Construction Alone	Reported Thus far	Total Expected	Locations
A123 Systems[a]	CBM	$249,100,000	2715						Wayne, Brownstown, Romulus, Flat Rock, Brownstown Twp (applying to Livonia as well)
GM	CBM	$105,900,000	1154						Brownstown
	EDC	$105,000,000	144						Oakland, Wixom, MI; Baltimore, White Marsh, MD
	AVE; TSE	$30,500,000	332						MI
Johnson Controls[b]	CBM	$299,200,000	550					3261	Holland, MI; Lebanon, OR
Dow Kokam (KD ABG MI, LLC)[c]	CBM	$161,000,000	320		800	1,000	300	2,720	Midland
Ford	EDC	$62,700,000	683						Macomb, Sterling Heights
	AVE; TSE	$30,000,000	327						MI, MO
Magna[d, e]	EDC	$40,000,000	525	1,241			200	1,766	Holly, MI; Vermillion, Muncie, IL
Compact Power, Inc./LG Chem, Ltd.	CBM	$151,400,000	1650		300	300	70		Holland, Saint Clair, Ottawa, Oakland, Pontiac
Chrysler LLC	AVE	$70,000,000	763						Macomb, Warren
Eaton: South Coast Air Quality Management District Building Corporation	AVE	$45,400,000	495						Kalamazoo and Galesburg MI; Others outside of MI
	TOTAL	**$1,350,200,000**	**9133**	**1241**	**1100**	**1,300**	**570**	**7,747**	

Key: CBM: Cell, Battery, and Materials; EDC: Electric Drive Component; AVE: Advanced Vehicle Electrification; TSE: Transportation Sector Electrification

Sources:

(a) A123 Systems. (2010, September). *A123 Systems Opens the Largest Lithium Ion Automotive Battery Manufacturing Plant in North America*. Retrieved February 20, 2010 from http://ir.a123systems.com/releasedetail.cfm?ReleaseID=506787

(b) Westaby, Robb. (2009, August). Governor Takes "Victory Lap" For Johnson Control Jobs. *The Chicago Tribune*. Retrieved February 20, 2010 from http://www.chicagotribune.com/news/fox17-governor-takes-victory-lap-for-jobs,0,7017403.story

(c) Dow Kokam. n.d.*Midland Battery Park Fact Sheet*. Retrieved March 5, 2010 from http://www.dowkokam.com/presskit/english/Dow_Kokam_Midland_Battery_Park_Fact_Sheet.pdf

(d) Magna. (2010, September). *Magna E-Car Systems Opens New Hybrid & Electric Vehicle System Development Center.* Retrieved March 5, 2010 from http://www.magna.com/xchg/ecar_systems/XSL/standard.xsl/-/content/news_news.htm?rdeLocaleAttr=en&action=show&EnReleaseID=01_1487&DeReleaseID=02_1487&JaReleaseID=

(e) Michigan Economic Development Corporation. n.d. *Advanced Energy Storage Systems Investments: September 2008 thru June 2010*. Retrieved March 5, 2010 from http://www.michiganadvantage.org/Targeted-Initiatives/Advanced-Manufacturing

(f) All other information not specified found from Recovery.org