Automotive Technology: Greener Jobs, Changing Skills

Educational Needs Report

CAR
CENTER FOR AUTOMOTIVE RESEARCH

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EDUCATIONAL NEEDS REPORT

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DRIVING CHANGE
Greening the Automotive Workforce

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For more information, visit www.drivingworkforcechange.org.

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1. Introduction

The educational infrastructure in the tri-state region of Indiana, Michigan and Ohio has been a critical element in supplying a highly qualified workforce to the auto industry. As technology improvements in the vehicles and the manufacturing process dictate that jobs and skills change, so too must the educational offerings. Cars of the future will require ever more sophisticated technology, changing the skills demanded of auto designers, engineers and production workers. The green jobs of the future will belong to those who have the advanced skills necessary for creating tomorrow's vehicles.

To estimate the ability of the educational infrastructure to adapt to changing industry needs, the Center for Automotive Research (CAR) created a database of institutions of higher learning within the tri-state area offering programs related to advanced manufacturing or occupational training in the automotive or automotive services industries. This database, compiled in 2010, includes specific details for the institutions and their program offerings. The database will be available through CAR's website and will be updated to ensure it remains current. Over time, it is anticipated that some programs will be scaled back or discontinued while others will be created or expanded.

The intent of this study was to:

- determine the current automotive education and training infrastructure
- assess how schools and programs respond to industry and employer needs
- measure the demand for this training by students
- measure the demand for graduates by regional employers
- gather information on the transferability of automotive industry skills to other industries

The focus of this study is the region's automotive education infrastructure, which is directly related to the sustainability of the automotive industry and the overall U.S. economy. The motor vehicle industry is the largest manufacturing industry in the United States. No other single industry is linked so closely to the U.S. manufacturing sector or directly generates so much retail business and employment. A competitive workforce with current job skills and career adaptability is the forefront of the industry's competitiveness.

The first section of this study explains the development and depth of the database created to catalog program offerings. To assess auto-related program offerings in the tri-state region, CAR examined the offerings of nearly 900 accredited post-secondary institutions. More than one-third of these institutions offer programs related to the engineering, design, production and maintenance of automobiles. In total, there are more than 1,900 distinct degrees relevant to the automotive industry. These degrees include *certificates, associate of science (AS), bachelor of science (BS), master of science (MS),* and *doctor of philosophy (Ph.D.)* degrees.

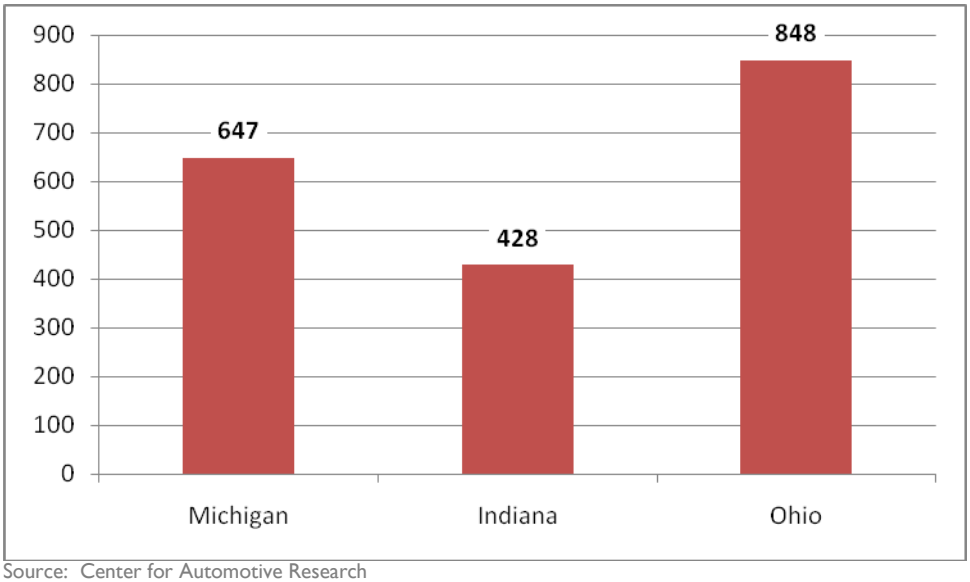
Using information from the database, educators at schools with programs of interest were contacted and interviewed. In this part of the study, the authors examined a number of recurring themes that emerged from the interviews. These themes have particular relevance for understanding how companies and communities in this Midwest automotive region can

maximize the educational infrastructure already available to them and make the most of the potential of the labor force.

2. Educational Programs Offered for Automotive Careers

To assess auto-related program offerings in the tri-state region, the authors examined major offerings at nearly 900 accredited post-secondary institutions and found 850 programs offered in Ohio, 650 in Michigan, and 430 in Indiana (see Figure 1).

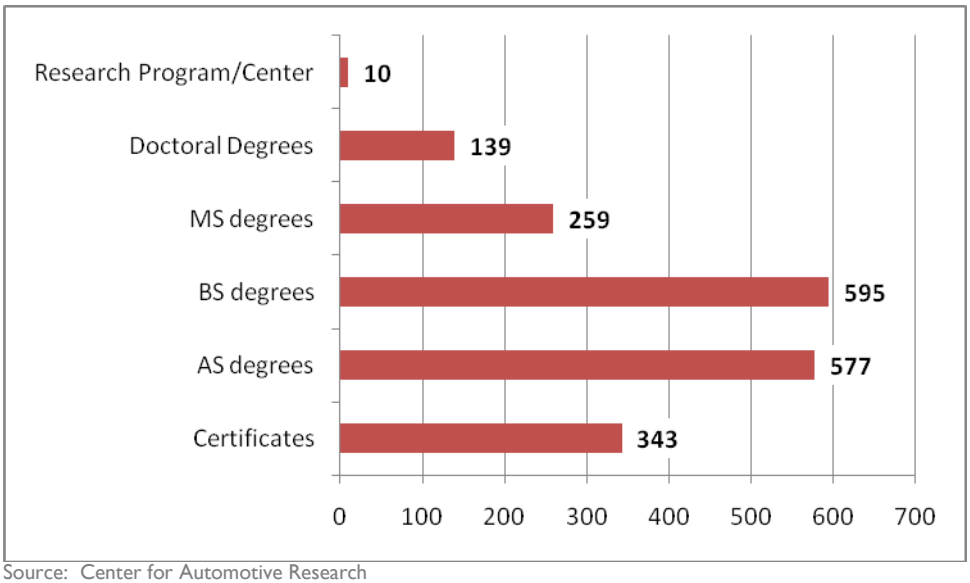
Figure 1: Total Programs



Source: Center for Automotive Research

There are more than 1,900 auto-related programs at these institutions which include 10 research centers, 343 certificate degree programs, 577 associate degree programs, 595 bachelor of science degree programs, 259 master of science degree programs and 139 Ph.D. programs as shown in Figure 2 below.

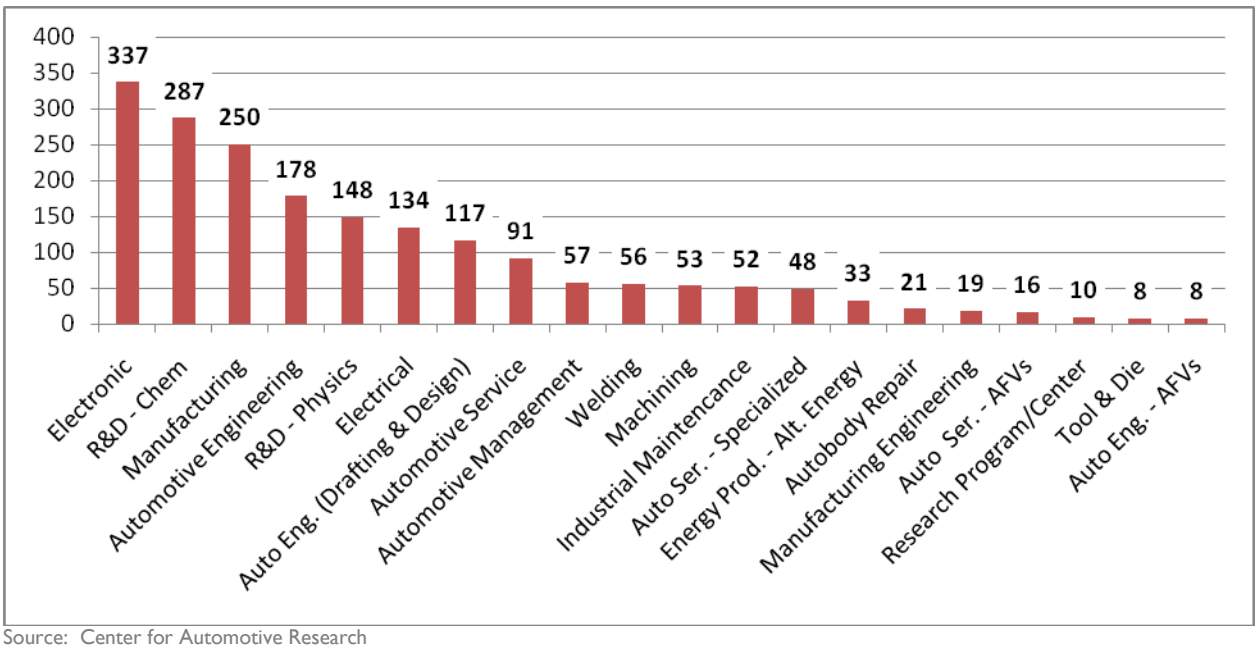
Figure 2: Tri-State Types of Degrees



Source: Center for Automotive Research

For each institution, CAR analyzed program descriptions and placed each auto-related major into one of 20 categories.

Figure 3: Tri-State Automotive Programs



Source: Center for Automotive Research

The following description of the program categories considers the potential employment fields and the recommended courses of study.

2.1 Auto Body Repair

The auto body repair category includes programs for automotive collision repair, auto body repair, and auto collision technology. Each of these programs focuses on the repair of damaged automotive bodies. Automotive body repairers straighten bent bodies, remove dents, and replace crumpled parts. They repair all types of vehicles, including large trucks, buses, and tractor-trailers. The tri-state region has both certificate and associate degree programs in auto body repair. Certificate and associate degree programs in auto body repair are similar; however, associate degree programs normally require courses beyond those specific to auto body repair (e.g., English composition and mathematics).

2.2 Automotive Engineering

Automotive engineering programs include engineering technology, general engineering, and specialized tracks of engineering (e.g., mechanical and automotive engineering). Jobs associated with these majors vary by level of degree earned.

Engineering technology/automotive engineering technology degrees

- Associate degrees are designed to prepare students for entry-level technology occupations related to engineering. These technology programs emphasize creating and interpreting engineering drawings, mastering manufacturing procedures and understanding the principles of product design. Occupations associated with technology degrees include a variety of job titles in the areas of product design, drafting, analysis, manufacturing, quality control and testing.
- Bachelor's degrees are primarily focused on engineering values and ideas, along with the technical skills necessary for typical engineering development projects. Engineering technology involves functions for research, production, operations, and programs that are designed for specific engineering fields. Workers with BS degrees in engineering technology carry out the technical components of engineering (i.e., they implement the plans that engineers create).
- Master's degrees in engineering technology are designed to provide graduate education that prepares students for performing more sophisticated tasks in a technical workplace. As of July 2010, **Wayne State University** has the only MS degree program in engineering technology in the United States.

Engineering/mechanical engineering/automotive engineering

- Associate degrees are generally not terminal degrees; most students who obtain AS degrees in engineering disciplines continue their education and obtain a bachelor's degree. Nevertheless, those with AS degrees in engineering are trained in the basic skills that make them competitive, resourceful, and flexible employees.
- Bachelor's degree programs prepare students to execute various engineering tasks. Most students choose a concentration within one of these majors: chemical, electrical, mechanical engineering, etc. Workers with bachelor's degrees in engineering can serve in high-level research and design capacities, but are also extremely well suited to work at the plant level.

- Master's degree programs provide advanced engineering training and involve the managerial component of engineering. Students gain understanding of a wide spectrum of interdisciplinary engineering activities, are prepared to solve challenging, technical problems and acquire skills to direct projects and lead others.
- Doctoral degrees advance engineering skills beyond master's degree levels and prepare students to lead engineering research and contribute original research to the field. Trained engineering Ph.D.s are highly sought after for automotive R&D and management positions.

2.3 Alternative Fuel Vehicles Engineering

Three schools in the tri-state region—**Michigan Technological University, University of Michigan Dearborn, and Wayne State University**—offer degree programs explicitly related to the engineering of alternative fuel vehicles (AFVs). Each of these schools is located in Michigan. Descriptions of the specific alternative fuel vehicle engineering programs are as follows:

Automotive systems engineering

- The master's degree program in a*utomotive systems engineering*, offered at the **University of Michigan-Dearborn**, is specifically designed to address the new and emerging technology in the automotive industry. Students in this program learn about advanced technologies, and how to apply them in practice for creative design and problem solving.
- Doctoral degree in a*utomotive systems engineering*, offered at the **University of Michigan-Dearborn**, is designed for those who want to work as technical leaders, innovators and research mentors.

Hybrid electric drive vehicle engineering

- Certificates provide training on the mechanics of electric drive vehicles. Students must have a bachelor's degree in an engineering field in order to earn a certificate.
- Bachelor's degrees provide students with training to solve problems in industry and business related to advanced vehicles. Graduates work with engineers, either independently or in supervisory capacities.
- Master's degrees provide advanced knowledge and hands-on laboratory experiences in the design, analysis, control, calibration, and operating characteristics of hybrid electric vehicles.

2.4 Drafting and Design

Various academic programs are related to drafting and design. This category includes majors in computer-aided design, vehicle engineering design technology, mechanical design and more. Drafters create the visual guidelines that show how to construct a product or structure.

Computer aided design

Most drafters use computer-aided design and drafting (CADD) systems to prepare drawings. With CADD systems, drafters can create and store drawings electronically so that they can be viewed, printed, or programmed directly into automated manufacturing systems. CADD systems also permit drafters to quickly prepare variations of a design.

- Certificates and associate degrees both prepare students to use CADD technology. CADD certificate programs focus almost exclusively on understanding the software and technology; AS degree programs offer additional concentrations, such as vehicle design, and also require general education requirements (such as math, science and English) to be fulfilled.
- Bachelor's degrees provide advanced training for students to pursue computer-aided design and computer-aided manufacturing careers. In addition to learning to operate CADD technology, students receive training in programming the technology and further examine the math and science behind design.

Industrial design/transportation design/vehicle engineering design/computer-aided engineering/mechanical design

Industrial design deals with the planning and development for production of a variety of objects and interrelated systems. Vehicles, tools, business machines, furniture, and architectural products are all areas of specialization in industrial design.

- Certificates and associate degree programs provide students with the basic mathematical, scientific, and engineering foundations necessary to mechanically design products for industrial, commercial and personal applications.
- Bachelor's degree programs prepare students for planning and developing a wide variety of objects and spaces. Students learn to balance problem solving, aesthetics, and business principles in the design and development of commercial and consumer products. They explore materials, processes, rendering, model making, human factors, and the legal and ethical implications of design. **Lawrence Tech's** Transportation Design major, and **Central Michigan University's** Vehicle Engineering Design Technology major both allow students to blend creative design talent with a comprehensive understanding of automotive technology concepts.
- Master's degree programs in computer-aided engineering, mechanical design, and technology are designed to prepare students with competent backgrounds in the engineering principles and computer-based tools and techniques for all engineering functions and processes. The graduates generally work in engineering analysis, product design and automated manufacturing using computer-aided engineering tools. In addition, the curriculum includes the study of engineering management, quality control, geometric dimensioning, plastic mold design and manufacturing.

2.5 Automotive Industry Management

Programs listed under automotive management relate to the management of the automotive manufacturing and sales processes. Students who obtain these degrees are trained in the technical components of manufacturing and are also trained to lead others. In addition to the

programs categorized here, most MS and Ph.D. degrees listed in other categories also prepare students to work in managerial positions. A few of the automotive management majors are highlighted below.

Advanced manufacturing management

- The certificate in advance manufacturing management program provides training for working professionals who seek knowledge for career advancement in management and ownership roles in various manufacturing sectors, including automotive manufacturing. This is a post-baccalaureate certificate.

Automotive technical translation

- Certificates provide students with an intermediate to advanced level of technical training in using translation, editing and copywriting protocols. The program prepares students to develop communication and cultural competence so they can effectively participate in today's global economy.

Automotive management/automotive engineering technology

- Bachelor's degree programs emphasize managerial skills while ensuring students receive a firm understanding of automotive operations, learn to solve technical problems through analysis and gain knowledge in computer applications and information management. Programs include instruction in vehicular systems technology, automotive design, automotive development testing, instrument calibration, automotive test equipment operation, automotive technology maintenance and report preparation.

Automotive technology (industrial technology management)/engineering management/engineering technology management

- Bachelor's degree programs in automotive technology management, engineering management, and engineering technology management combine technical and business classes. Typical business classes include accounting, finance and management. The technical classes have a manufacturing flavor. Typical technical classes include calculus, robotics technology, advanced quality methods, programmable logic controllers and automated manufacturing systems.
- Master's degree programs in automotive technology management, engineering management and engineering technology management focus on management of technology and intellectual property, research and development, engineering and technical projects, design and manufacturing, people, resources and organizations, quality control and lean enterprise systems. Study in these areas provides solid preparation and an advanced degree for promotion to management levels.

Industrial technology management/industrial technology/manufacturing management technology/manufacturing operations engineering

- Bachelor's degree programs in industrial technology, industrial supervision or operations management prepare students for employment in a broad range of industries where the efficient integration of machines, people and computers are critical to the success of organizations. These degrees prepare individuals to be involved in the design, installation, improvement, and management of integrated systems in diverse industries

such as computer systems, education, finance, government, health care or manufacturing.

- Master's degree programs in industrial management or industrial technology provide opportunities to obtain advanced training and the credentials necessary for advancement in positions in industry. These programs are designed for the professional who is interested in pursuing a managerial position or updating knowledge and skills through advanced coursework in technical topics.
- Ph.D. programs in technology provide advanced study with a strong focus on the research aspects of technology-related fields. The program prepares graduates for increased responsibility in a variety of settings such as high-level management positions in industry and government, faculty careers in higher education and occupations in policy analysis and research.

2.6 Automotive Service, Alternative Fuel Vehicles Service, and Specialized Automotive Service

Please see the description in the references (see Section 5).

The automotive service category entails programs that prepare graduates to be general automotive technicians. The tri-state region also offers programs that train automotive technicians to service alternative fuel vehicles (AFVs).

Furthermore, schools in the region offer various automotive service certificates and AS degrees that prepare automotive technicians to work on specific types of vehicles. Manufacturer-specific automotive service programs include **BMW, Chrysler, Ford, GM, Honda, Mercedes-Benz, Toyota, Volkswagen, and Volvo**. There are also automotive service programs for diesel and high performance vehicles.

Certificates and associate degrees in automotive service prepare students for entry level servicing operations in the automotive field. Automotive technicians are the people that can either manufacture cars or service them. Most AS degree automotive service programs include additional course requirements (e.g., English composition) in the technical courses that are the staples of automotive service programs.

2.7 Electrical Programs

The electrical category includes programs that relate to hard-wiring for electricity. These programs are offered at the certificate and associate degree level. Students with electrical degrees have skills that are important both to the operation or maintenance of automotive factories and the design of vehicles. Electrical majors include the following:

Electrician, industrial/constructional electricity, applied industrial technology, electrical maintenance technology

- Certificates and associate degree programs provide graduates with the skills to be entry-level electricians who can install, maintain, operate, and repair electrical equipment.

Electrical engineering/electrical engineering technology

- Associate degrees in electrical engineering prepare graduates to plan, design, and analyze electrical systems; ultimately, these degrees prepare students to be entry-level electricians.
- At the bachelor's degree level and above, electrical engineering degrees include training on electronics; there is little distinction between the electrical and electronics categories. As autos become more reliant on interconnected electronic equipment, electrical engineers are coming to the forefront of research, design and the actual manufacturing of autos.
    - Bachelor's degree programs in electrical engineering provide graduates with training to plan, design, and analyze electrical and electronic systems. Graduates develop a broad base of knowledge that is adaptable to other fields.
    - Master's degree programs in electrical engineering provide graduates with advanced training to plan, design, and analyze electrical and electronic systems, as well as the skills and experience to assume managerial leadership positions.
    - Doctoral degrees in electrical engineering provide graduates with all of the skills of lower level electrical engineering degrees as well as preparation to be leaders in innovative research.

2.8 Electronics Programs

Programs included in the electronics category are computer engineering, computer science and electronic engineering. These programs build skills in electronic and digital circuit design, software design and microprocessor design. Like other categories, the occupations associated with majors included in the electronic category vary by level of degree earned.

- Certificates and associate degree programs prepare graduates to apply electrical and electronic theory and related knowledge to design, build, repair, calibrate, and modify electrical components, circuitry, controls and machinery. Usually, these individuals work under a managing engineer.
- Bachelor's degree programs train students in electronics and prepare them for careers such as applications engineer, controls engineer or electrical engineer. Individuals with a bachelor's degree in electrical engineering often become managers.
- Master's degree programs provide advanced electronic engineering training and put students on track for leadership positions.
- Doctoral degree programs require students to contribute original research to the field. Individuals with doctoral degrees in electronics are of increased importance in today's automotive industry as vehicles become more integrated with electronics.

2.9 Energy Production—Alternative Energy

With the emergence of alternative fuel vehicles (AFVs), the importance of alternative energy production to the automotive industry has increased. Many educational institutions in the tri-state region offer majors related to alternative energy production. These programs include

courses in fuel cell technology, alternative energy systems design, electric power engineering and more. As alternative energy production is an emerging field, it has varying career paths.

Alternative energy/renewable energy technology/fuel cell technology

- Certificate programs prepare graduates to work as energy technicians or installers of fuel cell, wind turbines, photovoltaic or solar thermal technology. Students learn fundamentals of sustainable alternative energy sources and basic engineering principles.
- Associate degree programs prepare graduates with skills to work in different emerging fields of renewable and alternative energies. These programs train students for careers in energy efficient power generation, heating and cooling systems or alternative fuels vehicle propulsion.
- Bachelor's degree programs prepare graduates to be energy engineers. Career paths include alternative energy design, manufacturing or sales.
- Master's degree programs provide education in a number of renewable energy technologies such as solar, wind, hydropower, fuel cells, hydrogen fuels, clean coal and nuclear energy. Graduates are knowledgeable about the science of energy, energy conversion and energy efficiency.

2.10 Industrial Maintenance

The industrial maintenance category includes programs related to the operation and maintenance of industrial facilities. Majors in this category include electromechanical technology, industrial maintenance and mechatronics. Graduates of these programs are prepared to design and test basic power and control systems, as well as troubleshoot and repair failed mechanical components. Graduates of industrial maintenance certificate and associate degree programs work as technicians in a number of industries including energy, transportation equipment and aerospace.

2.11 Machining

The machining category includes certificate and associate degree programs that train students to be machinists. Trained in technical disciplines, machinists set up and operate a variety of machine tools to produce precision parts and instruments used by the automotive, aircraft and other manufacturing industries.

2.12 Manufacturing

Similar to the industrial maintenance category, certificate and associate degree majors in the manufacturing category prepare graduates to operate and repair machines used in manufacturing processes. Manufacturing certificate and associate degree programs differ from industrial maintenance programs by including training for graduates to enter careers such as quality control technicians and production supervisors. Several two-year schools have specific vocational programs sponsored by the original equipment manufacturers (e.g., **Ford, GM, Honda and Toyota).** These programs permit students to study at the school while working in

one of the companies' facilities and then be hired as a manufacturing employee for that company.

2.13 Manufacturing Engineering

The manufacturing engineering category includes majors that prepare graduates to design, analyze and apply manufacturing methods and processes so that quality products can be produced at competitive costs. Majors such as industrial engineering, manufacturing engineering and systems engineering are included in this category.

- Bachelor's degree programs prepare graduates to design, analyze, and improve integrated systems for the production of goods by considering the interfaces between people, materials, information, equipment and costs. Graduates apply appropriate mathematical, computer and engineering models to improve integrated systems and processes from both theoretical and practical aspects.
- Master's degree programs provide advanced competencies in areas such as computer-aided manufacturing, design, and analysis. The focus of these programs is often on the integrated processing of polymers, metals, and composite materials.
- Doctorate graduates have in-depth knowledge of manufacturing engineering and contribute original research to improving manufacturing engineering processes. They hold research and development, management, and teaching positions.

2.14 R&D for Chemical Processes

The R&D chemical processes category includes fields of study related to fuels and materials use. Academic majors of chemistry, materials engineering and chemical engineering are included in this category. While the majors differ from one another, these programs all train individuals who can contribute to research that will advance the automotive industry. Individuals trained in chemical processes are particularly valuable for explaining complex systems with chemical formulas, designing chemical plant equipment and devising processes for manufacturing chemicals and products such as gasoline, synthetic rubber, and plastics. Chemical process researchers conduct chemical and physical laboratory tests to develop new products or processes. They may also work in the areas of quality control or the maintenance of environmental standards. Bachelor's degree programs provide training for laboratory assistants, while master's and doctoral degree programs train chemists to conduct and lead original research.

2.15 R&D—Physics

The R&D—physics category includes physics programs and engineering physics programs. Engineering physics programs blend courses from engineering, physics, and math to build an understanding of how these areas interact and support each other. Engineering physicists perform research and development in high-technology industries in the fields of telecommunications, microelectronics, micro-devices and lasers. Additionally, the engineering

physics curriculum applies to other industries such as automotive, biotechnology, nanotechnology, communications technology, computer design and software development.

2.16 Tool and Die Programs

Tool and die makers are among the most sought after, highly skilled manufacturing workers. Academic programs typically offer four- or five-year apprenticeships or postsecondary programs; some may be obtained through an employer. Apprenticeships typically provide a combination of hands-on and classroom training. Hands-on training includes the operating of milling machines, wire electrical discharge machines, lathes, and grinders. Classroom training usually includes a rigorous curriculum of mathematics, science, engineering, and computer-aided design. Upon completion of an apprenticeship, the status of journeyman tool and die maker is achieved. Tool and die makers analyze specifications; lay out metal stock; set up and operate machine tools; fit and assemble parts; and make or repair dies, tools, jigs or gauges.

Toolmakers

Toolmakers typically create tools used to produce products (e.g., lathes, milling machines, grinding machines, and jigs). In addition, toolmakers produce fixtures that hold metal while it is being stamped or drilled.

Die makers

Skilled die makers make metal molds for die-casting, mold plastics, ceramics and composite materials. In addition, they construct metal dies that are used to shape metal for stamping and forging operations. Die makers are well known for their precision, as machine die-sets are often made with a tolerance of less than one thousandth of an inch.

2.17 Welding Programs

Welding degree programs are offered at two-year community or vocational schools. Trained welders are well prepared for work in the automotive industry, as welding is an important process in the production of automobiles. According to the Bureau of Labor Statistics, the employment outlook for professional welders is predicted to have little growth over the next decade with a decline in employment of approximately two percent from 2008 to 2018. This may be a result of the advent of robotic welding. Professional welders work as welding engineers, sheet metal workers, structural metal fabricators and fitters, precision instrument and equipment repairers, brazing machine setters, operators and tenders.

Commercial and industrial welding

- Certificate and degree programs are offered through community and vocational schools. These programs prepare an individual to become a professional, certified welder with specializations in commercial or industrial welding. The most common degree offered is an AS in welding technology. This program employs both classroom lessons and hands-on experience in using metal and welding equipment. Programs mainly offer specialization in three types of welding: ARC welding, TIG welding and pipe welding. ARC welding is a type of welding that uses a welding power supply, in the form of direct

currents (DC) or alternating currents (AC), creating an electric arc between consumable and non-consumable electrodes. TIG welding stands for tungsten inert gas welding. It is a type of arc welding process that uses a non-consumable tungsten electrode to heat the weld point; Argon gas protects the weld puddle from airborne contaminants. Pipe welding employs a base material used to melt the metals at a specific welding point.

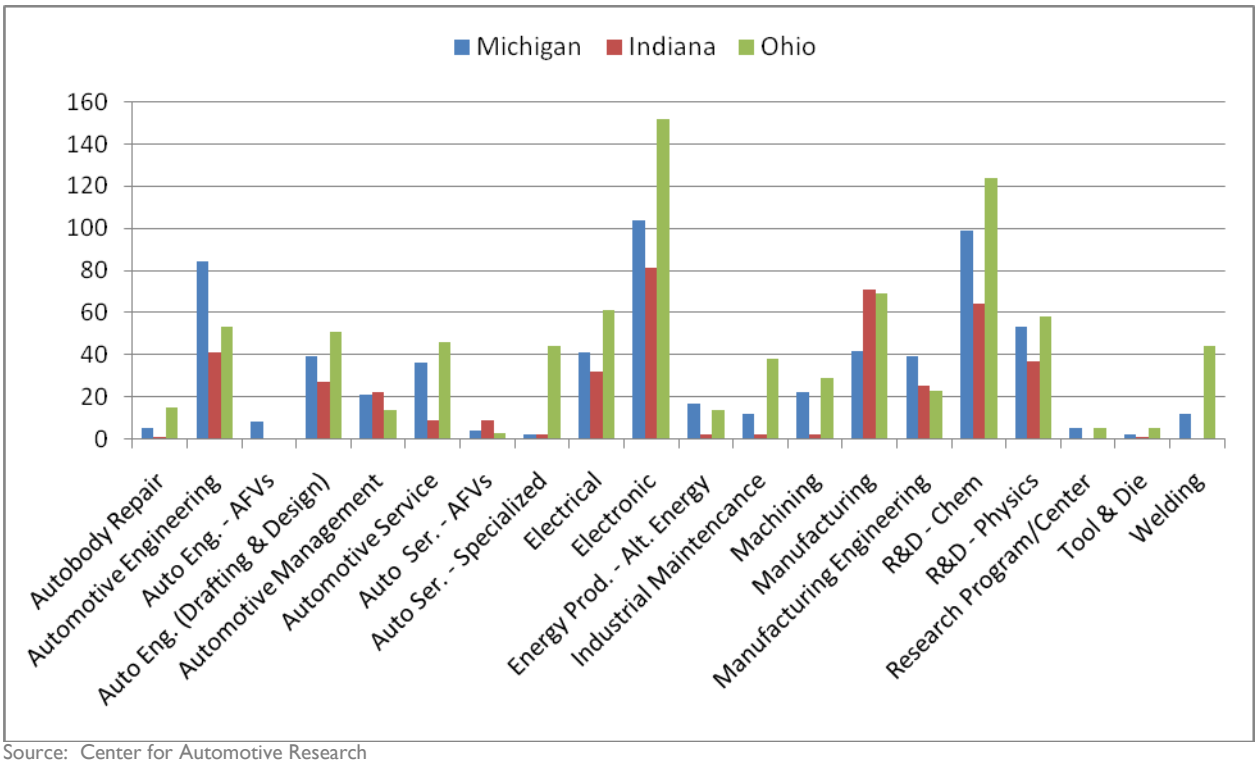
Welding engineering

- In addition to the AS, there are a few colleges and universities that offer bachelor's and master's degree programs in welding, particularly in the welding engineering field. Welding engineers focus on the manufacturing process of items such as robots, pipelines, automobiles, and pressure vessels as they relate to materials selection and structural integrity evaluations. Welding engineers most frequently work in design teams with other engineers.

2.18 **Research Centers**

Engineering research laboratories make it possible for both faculty and students to work on the next generation concepts and products. There are specialized research laboratories at many large universities in the region. The **University of Michigan** has a collaborative research center with **GM** focused on advanced powertrain technology for alternative fuels. **The Ohio State University Center for Automotive Research** is an interdisciplinary research facility housed in the college of engineering, and is sponsored in part by **Honda**. Research focuses on intelligent transportation systems and autonomous vehicles, vehicle chassis systems and vehicle safety. Various other universities in the tri-state region have research centers that contribute to the advancement of the automotive industry.

Figure 4: Programs by State



Source: Center for Automotive Research

3. Findings from the Case Studies

Using the database discussed in Section I, educators at schools with programs of interest were contacted and interviewed. A number of recurring themes emerged from these interviews. This section includes a discussion of those themes and an overview of unique programs and noteworthy successes.

Many universities contacted for this study have embraced STEM principles. STEM schools focus on science, technology, engineering and mathematics, hence the acronym (STEM). A typical interview with each of the educators began with an overview of that program's focus on STEM curriculum. By emphasizing these subjects, these schools hope to better provide opportunities for students to gain skills in critical thinking, complex problem solving and research. These skills contribute both to the individual's success in today's competitive job market and company success in a competitive global market. **Youngstown State University**, in particular, has created an individual college for STEM education.

In his recent State of the Union Address, President Barack Obama spoke of the need to focus on STEM education to ensure that the U.S. can retain its global competitiveness.

> "Meanwhile, nations like China and India realized that with some changes of their own, they could compete in this new world. And so they started educating their children earlier and longer, with greater emphasis on math and science. They're investing in research and new technologies... Now it's our turn. We know what it takes to compete for the jobs and industries of our time. We need to out-innovate, out-educate, and out-build the rest of the world."[1]

Students who have been educated by programs with a STEM focus will have an advantage when it comes to competing for the high-tech, high-wage jobs of the future. Since the National Science Foundation (NSF) brought the term into wider usage a decade ago, STEM schools have emerged across the nation, although funding remains scarce. In recent years, substantial lobbying to raise awareness of STEM issues has been undertaken in Washington, DC. The STEM Education Coalition works to support programs for teachers and students through the U.S. Department of Education, the National Science Foundation, and other agencies.[2] While there is a strong emphasis in the tri-state region on STEM subjects, schools must strike a balance between offering broad general courses and providing students with specialized skills of particular interest and need to the auto industry. Having specialized knowledge can be an important competitive edge in the job market. However, this expertise is valuable to employers

[1] Obama, Barack. (2011). "Remarks by the President in State of Union Address." The White House, Office of the Press Secretary. United States Capitol, Washington, D.C. January 25, 2011. <http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address>.

[2] STEM Education Coalition. Website. Accessed February 6, 2011. <http://www.stemedcoalition.org/>.

only if accompanied by a strong foundation in basic knowledge. Overspecialization can lock students into professions that may have few openings or become obsolete.

During the course of CAR's interviews on education, the following three overarching discussion topics emerged:

- Industry-Education Interaction
- Community-Education Interaction
- Program Funding

3.1 Industry and Education Interaction

3.1.1 Advisory Boards

Across the board, automotive programs at the schools CAR contacted had industrial advisory boards comprised of local business leaders who bring their real-world expertise to these programs. At the college level, department level, and even individual level, faculty members rely on advisory boards when making decisions regarding curriculum, collaborative opportunities, student training, community outreach, and technology transfer efforts. The individuals who comprise the advisory boards provide information on how businesses are utilizing tools and which processes or pieces of equipment are considered top of the line or leading edge by industry. By providing expert opinions and offering new ideas, industry advisory boards help keep schools and their graduates competitive.

3.1.2 Internships and Class Projects

Student projects are one conduit for interaction between education and industry. Local companies present real-world problems and learning environments for such courses as senior design or various engineering technology programs. Student internships provide another opportunity for students to earn hands-on experience. Every educator interviewed stated that company demand for student interns is so high that every student who seeks an internship is able to find one. Upon graduation, students frequently join the companies for which they have interned. Not only have they gained experience working in real-world environments, but they have valuable knowledge of these companies. In addition, through their internship experiences, graduates have developed a track record of their capabilities, established a work ethic, and often made important company and industry contacts.

3.1.3 Networking

Networking efforts were found in many forms. While there is little doubt that networking activities occur, there appears to be little coordination or direct career motivation (for professors) for these efforts. Types of networking efforts ranged from informal networking between professors and their industry contacts to research partnerships between companies and universities to outright sponsorship of programs by companies. Many universities have long established ties with strong industry partners that have endured for decades. Large universities (such as **Purdue)** may have relationships with hundreds of companies including automakers,

electronics manufacturers, power supply companies, military contractors and battery companies.

Faculty efforts at networking with their industry colleagues and community leaders are less coordinated at a higher level, but are ubiquitous across schools. These relationships can rise more organically from within the university through professor involvement with small local businesses or even with startup companies. Often these small organizations benefit greatly from student interns or graduate students working on thesis research. In addition, professors often do consulting work outside of their university obligations; these connections can create opportunities for students to work on company research projects.

There are a number of programs which train people for specific jobs in all levels of the automotive industry. **Purdue University** has a Center for Laser-Based Manufacturing which focuses on developing new laser-based processing techniques (along with predictive models for these processes) for one of the most rapidly growing areas in manufacturing. Several universities have student solar car teams. These teams design and engineer solar-powered cars, which the teams then build to compete in international events. In addition to these activities, the following programs stood out for the high level of company-school interaction and for the rapid response the schools provided to corporate needs.

3.1.4 GM/MTU Program

General Motors (GM) approached **Michigan Technological University (MTU)** to design a distance learning program. In developing this program, **GM** and **MTU** partnered with the **Engineering Society of Detroit** to offer retraining courses for displaced automotive engineers. The partnership resulted in a one-semester, three-credit course in advanced propulsion technology, offered free of charge to the displaced workers. The course was held at **Engineering Society of Detroit** headquarters in Southfield, Michigan and included online lectures by **Michigan Tech** faculty located hundreds of miles away in Houghton, Michigan. Labs run by volunteer **GM** engineers were hosted at the **GM Milford Proving Ground and Pontiac Powertrain Headquarters**.

MTU has offered the course three times, each time with 90 to 100 students in the class. Originally it was offered only to displaced engineers from **GM**, but the second offering was open to engineering employees from **GM, Ford, Chrysler, Nissan, Denso, Lear and TACOM** with funding provided by the Michigan Academy of Green Mobility. This funding supports the original course objective of giving students full scholarships to cover the cost of tuition and materials. The course was offered a third time with funds from the Michigan Works program and was open to **Michigan Tech** students, displaced engineers, and currently employed engineers.

Based on the experience of teaching this course, **Michigan Tech** was able to secure a $3 million grant from the Department of Energy to expand the program. **Michigan Tech** is

creating a full curriculum with undergraduate certificates and a graduate degree. The program is slated to begin in the fall of 2011.[3]

3.1.5 MTU Enterprise Program

The **Michigan Tech Enterprise program** brings together teams of students who work to prototype and engineer a product, create a business plan and ultimately take the product to market. While in this program, students take related courses for credit. These courses include leadership, teamwork, and communication modules. The program involves students during their sophomore year. Because students are involved for several years instead of just a semester, they learn to think long-term and gain experience in all phases of business development. Industry sponsorship is a component of the program; companies sponsor teams, evaluate reports and presentations, give guest lectures, and mentor teams.[4]

3.2 Community and Education Interaction

3.2.1 Recruiting and Outreach

Partnering with high schools is an effective method used by technical schools to recruit students. Sometimes, technical schools will offer courses that are not available at high school technical centers. The schools ensure that these courses meet high school curriculum requirements, allowing students to take college courses concurrently. **Jackson Community College** in Michigan has an outreach effort that also doubles as a recruiting tool. The school hosts an automotive service skills competition for high school students. The program itself is oversubscribed (it does not have enough openings for all of the students who wish to enroll). In a similar vein, **Lansing Community College** offers visits for high school students one day each month. **Lansing** faculty also visit area high schools where they offer a short class focusing on providing students with skills they can put to use in their current high school classes. This approach creates the opportunity for students to begin a dialogue with the college.

Lansing Community College connects to the community through an annual car show. The car show, now in its fifth year, occurs in the fall and showcases between 90 and 200 participating cars. Car show attendees judge cars in various categories. There are prizes, food vendors, assembly/disassembly competitions and awards. This year the school will add a go-kart course. The college also offers Saturday morning seminars on a monthly basis. These seminars are open to the general public and focus on current industry topics such as hybrid vehicles or biodiesel fuels.

Seminars for high school teachers are used by many colleges to connect with local high schools. Teachers from high schools attend these seminars and learn more about topics that they can

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[3] MTECH. (2009). "Mechanical Engineering – Engineering Mechanics 2009 Annual Report Energy and Health Systems." Michigan Technological University. <http://www.me.mtu.edu/annual_report/2010/Mechanical_Engineering_Report.pdf>.

[4] MTECH. (2011). "The Enterprise Program." Michigan Technological University. Accessed February 7, 2011. <http://www.enterprise.mtu.edu/>.

share in the classroom. Subjects for seminars may focus on specific vehicle components such as controller area networks, air conditioning systems, starters and alternators or take a more theoretical approach discussing powertrain or advanced battery systems.

Jackson Community College provides training to a wide array of students, many of whom hold jobs while attending classes. As many of the students need to be free during the work week, Jackson has implemented innovative scheduling methods. They offer semester plans where, for example, students may attend classes for just one day each week, and work the other days. These plans were developed in conjunction with area dealerships so that the majority of locally employed students could seamlessly arrange their work and school schedules.

3.2.2 Research and Technology Transfer Efforts

Technology transfer efforts—bringing university-sponsored research to commercial use—involve a number of difficult decisions. Most research to be commercialized requires development on a case-by-case basis. A professor at **Notre Dame** has created a company, **SlipStream, LCC**, using technology developed at the university. The process involved important considerations such as defining when continuing technology developments can be claimed by the company; what university resources can be used by faculty members and for which purposes; and how much time faculty may spend away from the university.

The start-up company, **SlipStream, LLC**, is working to create an ultra-efficient hybrid vehicle system. The company is housed at Innovation Park, a business accelerator space owned by the **University of Notre Dame** to provide space and advisory services to businesses that emerge from university research. The founders of **SlipStream, LLC,** included the community by hosting public relations events, meeting with the mayor, and appearing on television. Funding for the company was acquired through the Irish Angels network, a group of **Notre Dame** alumni investors. The company has internship or project opportunities for up to seven students.

3.2.3 Demand for Graduates

Most educators stated that there is high demand from auto companies for program graduates and that it can be difficult to provide enough graduates to fill available positions. This is particularly true for positions working with emerging technologies: employers seek people with knowledge of electric powertrains, battery recycling, electric vehicle safety and recharging knowledge. Simultaneously, many universities find it challenging to expand their programs to meet student demand for enrollment. One constraint to program expansion is the faculty time and effort needed to ensure students are able to participate in hands-on projects. While many engineering degree programs have a senior design component, this is not generally considered to be an adequate level of company-based experience. In order to offer students opportunity for more project experience, universities are creating programs like **Lawrence Tech's** Transportation Design or **Central Michigan University's** Vehicle Engineering Design Technology Program.

In addition to requiring new employees to have knowledge and experience in specific and highly technical areas, employers need workers with communication skills and the ability to work in teams. Because the green automotive jobs of the future deal with complex systems, employees will necessarily need to work on teams and effectively communicate with each other. Such skills

can be learned only through repeated practice, making team projects a necessity for academic programs.

3.2.4 Program Funding

As might be expected, new program development and current program expansion require stable and considerable funding. Many schools in the tri-state region form consortiums. These consortiums allow the work to be divided up in such a manner that schools can specialize in certain areas. The consortiums also afford schools the opportunity to create larger and highly competitive project ideas for government and foundation funding consideration.

3.2.5 Consortiums

The **Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec)** is a team of universities and colleges in Indiana working to establish an educational program focused on designing, manufacturing and servicing advanced electric vehicles and the electric vehicle infrastructure. The Consortium was funded by an $8.1 million grant from the U.S. Department of Energy. **I-AEVtec** schools offer associate, bachelor, master and certificate programs focusing on electric vehicle (EV), plug-in electric vehicle (PHEV), and fuel cell vehicle design and manufacturing. They have also created a certificate program for emergency responders for understanding rescue operations involving electric vehicles. New programs are being developed to include web-enabled courses in batteries, fuel cells, electric motors, hybrid engines, smart grid technology and consumer issues.

The consortium is working to establish the "Electric Vehicle Hub," an online information center offering materials covering EV, PHEV, and fuel cell vehicle technology. The Hub's resources will be available for researchers, educators, and the general public. It is based on the same technology that was used for the "NanoHub" a web portal for nanotechnology that receives 90,000 visitors annually. The Hub will be used to disperse educational material produced by **I-AEVtec** such as lecture notes, reading lists, homework, exams, simulations and streaming videos of experiments and demonstrations. It will also serve as a secure website for research discussions, wikis and blogs.[5] The site will be available in mid-2011.

Partnerships between universities, industry and government to produce educational content to meet the needs of employers are another aspect of the consortium. These partnerships focus on workforce development, internships and research. As part of its role in the consortium, **Purdue** is developing courses for **Delphi** workers. Faculty members developed a "Hybrid Vehicles 101" class which has been taken by 100 students. Eventually the entire **Delphi** workforce will take the course. **Purdue** is also working with **Naval Surface Warfare Center, Crane Division**, a company specializing in naval warfare technology and products. Training on battery testing and design has been provided for **Crane** employees.

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[5] I-AEVtec. (2010). "Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec)." Presentation. Statewide Energy Curriculum Workshop, Purdue University. January 13, 2010. <http://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2010/technology_integration/tiarravt032_caruthers_2010_o.pdf>.

Members of the Consortium are also developing course modules in electric vehicle technology for high school students and undergraduates in non-science majors. These modules include topics such as batteries, fuel cells, motors, controls, electric vehicles, and environmental considerations. The modules are created according to Indiana's state education requirements. Summer courses are offered to high school teachers to familiarize them with the new courses. These efforts help colleges reach younger students to interest them in STEM subjects and are greatly appreciated by teachers.

3.2.6 Electric Go-Kart

Purdue took advantage of a go-kart track that already existed on campus and created the EV Grand Prix, a competition to design, build, and race electric go-karts. The project received grant money in December 2009 and held a race in April 2010. The race attracted more than 2,000 spectators and was broadcast on 70 television stations. It consisted of 100 laps and lasted about 12 hours. Fifteen teams participated, involving 90 students directly with another 100 students and staff in supporting roles. **Purdue** has been invited to host its next race at the Indy 500 in May 2011. The competition has already attracted teams from across the nation and one team from England. Scoring is based on four different categories: fastest time, energy efficiency, technical design and community outreach—each category representing 25 percent of the total score. Teams are required to obtain corporate sponsorship, making the competition an opportunity not just to compete against other schools, but also to develop relationships between students and corporate sponsors. Graduates complete the program with experience in electric vehicle systems and relationships with industry contacts that could provide internship and research opportunities.

Because of this new program, **Purdue** expanded its offerings to provide courses that students take while on an EV Grand Prix team. These courses teach students to design and plan their vehicles as well as how to outreach to corporate sponsors. Another class provides instruction on electromechanical systems so that students are able to build their electric go-karts. **Purdue** offers a go-kart laboratory that has the needed equipment for doing full electrical diagnostics.[6]

[6] Ibid.

4. Conclusion

The traditional automotive region of the Midwest, particularly Michigan, Indiana and Ohio, has enormous educational assets providing training to the labor force in STEM subjects—a requirement for the advanced manufacturing and automotive workforce of the future. The database compiled for this study has an important role in helping to bring together educators, companies and tri-state communities to make the best use of these educational programs—particularly in the areas of program outreach and regional networking. Outreach, primarily to younger students and older unemployed workers, remains a challenge. Networking efforts are both highly successful in maximizing resources and highly dependent on individual initiative.

Interaction with industry is essential to produce talented graduates with valuable experience and strong programs able to attract students. Networking can provide money for new or expanded programs, internships, sponsorships, and other opportunities for both schools and students. While some networking is formally integrated into the operations of schools, much of it is fragmented, occurring through faculty members' personal interactions. Interviews with educators revealed a plethora of innovative ideas and new approaches, yet individuals interviewed cited lack of time as the main reason for not developing new possibilities in programs and educational offerings. Today's educator must balance the needs of maintaining a current curriculum with meeting the demands of school administrations, managing budgets, assisting students and maintaining program accreditation. Providing more opportunities for meeting colleagues across the region and interacting with community and industry leaders has the potential to significantly expand the use of the region's strong technical educational infrastructure. Partnering with other schools, the local community, or businesses can be a source of growth for schools. As expertise and resources are developed through partnerships, they can be leveraged for further funding and growth. Partnerships assist in the sharing of assets and are often a major advantage if not a requirement in attracting many federal grants.

Finally, education aimed at people training for careers in the automotive industry suffers from a stigma. The popular perception of the industry is that it is a relic of the past that is lacking in innovation or good career opportunities. Green technologies bring the promise of revitalizing the industry, however, and courses in advanced powertrains, electronics, alternative fuel and battery technologies are big draws at universities. Student demand for courses focusing on emerging technologies is growing faster than schools can expand programs.

5. References

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Appendix A: List of Contacts Interviewed

Person Contacted	School	City	State	Reason(s) to Target
Leslie Coxon	Jackson Community College	Jackson	MI	• Has an Altenative Fuel Vehicle Service Program • Has a total of 5 auto related degree programs
Marvin Argersinger	Lansing Community College	Lansing	MI	• Receives funding from National Alternative Fuels Training Consortium (NAFTC) • Has a total of 5 auto related degree programs
Marty Cala	Youngstown State University	Youngstown	OH	• Receives funding from Research and Innovative Technology Administration-University Transportation Centers Program (RITA-UTC) • Has a total of 11 auto related degree programs
Peter Bauer	University of Notre Dame	Notre Dame	IN	• Receives funding from Indiana Advanced Electric Vehicle Training and Education Consortium (I-AEVtec) • Has a total of 6 auto related degree programs
Liberty Pelter	Purdue University Calumet	Hammond	IN	• Receives funding from I-AEVtec • Has a total of 15 auto related degree programs
Jeff Naber	Michigan Technological University	Houghton	MI	• Receives funding from NAFTC
Carl Anderson				• Receives funding from RITA-UTC • Receives special funding ($2.98M for elective vehicle (EV)**** educational programs from Department of Energy (DOE). Partnering with Argonne National Laboratory, AVL, GM, Eaton, Horiba, MathWorks, Schweitzer Engineering Laboratories, Woodward) • Has a total of 18 auto related degree programs • Has a Research Center/Program: Materials in Sustainable Transportation Infrastructure
James Caruthers	Purdue University	W. Lafayette	IN	• Receives funding from I-AEVtec • Has a total of 12 auto related degree programs

Source: Center for Automotive Research