
AC 2012-3175: THE ATE CENTER FOR ADVANCED AUTOMOTIVE TECHNOLOGY (CAAT)

Dr. Chih-Ping Yeh, Wayne State University

Chih-Ping Yeh received his B.S. degree in electronic engineering from Taiwan, M.S. degree in biomedical engineering from Northwestern University in Evanston, Ill., and M.S. and Ph.D. degrees in electrical engineering from Texas A&M University in College Station, Texas. Prior to joining Wayne State University, he worked as Senior System Engineer and a data analysis specialist in defense industry. Currently, he is the Director and Chair of the Division of Engineering Technology at WSU. His current research interests are in electric drive vehicle technology and advanced energy storage, including advanced battery systems for hybrid electric vehicles. Yeh is also experienced in developing formal degree programs and professional development programs for incumbent engineers, community college instructors, and high school science and technology teachers. He is the PI and Co-PI of several federal- and state-funded projects for course, curriculum, and laboratory development in advanced automotive technology.

Dr. Gene Yeau-Jian Liao, Wayne State University

Y. Gene Liao is currently Director of the Electric Transportation Technology program and Associate Professor of engineering technology at Wayne State University. He received a B.S. in mechanical engineering from National Central University, Taiwan, a M.S. in mechanical engineering from Columbia University, and a doctorate of engineering from the University of Michigan, Ann Arbor. He has more than 15 years of industrial practices in the automotive sector prior to becoming a faculty member. Liao has research and teaching interests in the areas of multi-body dynamics, hybrid vehicle powertrain, advanced energy storage systems, and CAE applications in products development and manufacturing.

Mr. William Stark, Macomb Community College

William D. Stark is the Director, Center for Advanced Automotive Technology at Macomb Community College. He is a former General Motors Executive with extensive experience in powertrain engineering, global vehicle development, body, chassis, and manufacturing engineering. He has background ranging from concept creation, analysis, business case management, and design to vehicle development, tooling design and development, launch, marketing, and service. Stark received a bachelor's degree in mechanical engineering from Kettering University and a master's degree in engineering science, management of technology, from Rensselaer Polytechnic Institute.

Joseph L. Petrosky, Macomb Community College

Joe Petrosky is the Dean of Engineering and Advanced Technology at Macomb Community College with responsibilities for a breadth of career and technical programs including advanced manufacturing, engineering technology, and automotive for degree, certificate, workforce, and continuing education areas.

Mr. Douglas A. Fertuck, Macomb Community College

Doug Fertuck is the Assistant Director for Automotive and Energy Programs at Macomb Community College. He is currently focusing on managing grant programs involving future automotive propulsion systems. One of several such grants is from the National Science Foundation for the Center for Advanced Automotive Technology.

During his 35 year career with General Motors, he held a number of executive positions in Global Engineering, North America Truck Engineering, Purchasing, and Product Planning. As an independent business adviser and counselor, he has helped many companies refocus their efforts on their core competencies using simplified and standardized processes and systems. He is co-author of the book *The Lean Office Demystified II*, published in 2010.

Fertuck received a B.S. in mechanical engineering from General Motors Institute (now Kettering University), a M.S. in mechanics from the University of Colorado, and a M.B.A. from Michigan State University.

The ATE Center for Advanced Automotive Technology (CAAT)

The Center for Advanced Automotive Technology (CAAT) is a National Science Foundation (NSF) funded regional center for Advanced Technological Education (ATE). The mission of CAAT is to provide leadership for a regional alliance of two-year colleges, school districts, and universities, working in collaboration with industry, professional associations and government agencies, to prepare a 21st century technical workforce for the design, development, manufacturing, service and recycling sectors of the advanced automotive industry.

The CAAT focuses on Michigan, Indiana, and Wisconsin and will expand its reach within the Great Lakes region. It aims to meet the growing and evolving advanced technical education needs of current and future technical workers in the automotive industry, a critically important industry across the U.S. and the prominent employer in our region. The identification of emerging automotive technologies – Hybrid Electric Vehicles (HEV), Electric Vehicles (EV) and derivatives – enables a vision designed to focus curricular efforts on the areas that will properly describe key relevant technologies and provide adequate flexibility to include new technologies yet to be developed. As a model for educating automotive technicians and technologists, CAAT provides leadership and coordination of curricular reform of automotive technician education programs, integrate advanced automotive technology skills, and emphasize Science, Technology, Engineering and Math (STEM) education at the secondary and postsecondary levels in our region and other areas in the U.S. with similar needs for newly skilled automotive technicians in a transformed automotive industry. CAAT also serves as a clearinghouse of educational materials and methods related to advanced automotive technology for partners and other interested institutions and individuals.

The CAAT is a cooperative effort of education, industry and government to create a regional resource for advanced automotive technologies across the lifetime learning continuum. The two major educational partners are Macomb Community College (MCC) in Warren, Michigan, and Wayne State University (WSU) in Detroit, Michigan. Other key partners include the Southeast Michigan Community College Consortium (SMC3), the Macomb Intermediate School District (MISD), the Michigan Academy for Green Mobility Alliance (MAGMA), the Center for Automotive Research (CAR), and the Society of Automotive Engineers (SAE). SMC3 is a consortium of nine community colleges in Southeast Michigan that have joined forces to expand the capability of each to deliver shared programs. MISD is CAAT's key partner in reform of the K-12 curriculum, and a state leader in reform efforts for career technical education. MAGMA, formed by Michigan Workforce Development Agency, Michigan Department of Labor, Energy and Economic Growth (DELEG), educational institutions and more than thirty automotive manufacturing employers, is a state supported response to industry requests to increase the local workforce capable of helping create the hybrid and electric vehicles of the future. CAR is the nation's leading provider of economic research for the auto industry, and SAE International, having life-long learning as the core competency, is a global association of automotive engineers and related technical experts. In order to promote awareness of advanced automotive technologies to diverse audiences, CAAT also includes Excel Institute in Washington DC in the program, and collaborates with the NSF funded Louis Stokes Alliance for Minority Participation

(LSAMP) program and the state funded King-Chavez-Parks Initiative University Bound Program.

The MCC-WSU partnership was awarded the NSF-ATE grant (UDE 1003032) in June 2010 for establishing the CAAT. The center office and a branch office have been set up in Macomb Community College South Campus and the Division of Engineering Technology at Wayne State University, respectively. Prior to receiving this grant, MCC and WSU have implemented a planning grant (DUE 0802135) to investigate automotive workforce needs, automotive education core competencies, existing automotive education curriculum/pedagogy and advanced automotive future trends, and to select educational and industry partners. This paper describes the rationale of creating an ATE center for advanced automotive technology, the finding of the planning grant, the CAAT goals and objectives, and the center activities, including educational material collection and dissemination, a seed funding program, student summer academies, and faculty professional development.

1. Introduction

The automotive industry has been one of the largest and most important industries in the United States, employing more than 1.1 million Americans¹, accounting for 4% of total gross domestic product, and representing the single largest U.S. export (nearly \$121 billion) in 2008². The world economy, however, has shifted over the past year. Today the automotive industry is engaged in a transformational change that incorporates a technological shift from the petroleum-powered engine that drove the transportation economy of the 20th Century to the renewable resource-based electric powered motor that will sustain the dynamic global economy and environmental assets of the 21st Century. In response to a shift in consumer demand towards increasingly fuel efficient vehicles and compliance with the new Corporate Average Fuel Economy (CAFE) standards passed by the U.S. Congress in 2009 to decrease our dependence on fossil fuels by increasing a standard on new vehicles to 35 miles per gallon by model year 2020³, the U.S. auto industry is developing vehicle propulsion systems that will reduce emissions today and provide a platform for further technological advances into the future. The primary developments are Hybrid Electric Vehicles (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Electric Vehicles (EV), Alternative Fuel Vehicles (AFV) including common rail diesels, and Fuel Cell Vehicles (FCV). We will refer to these as Advanced Powertrain Technologies. The impact today and in the long run is an increasing need for trained automotive technicians prepared to support every stage of the product life cycle of these new automotive technologies, which requires acquisition of an expanded skill set for each sector of the industry.

The HEV reached the market in 1999 and current projections show that 44 models of hybrid vehicles will be available by 2012, and that sales will exceed 870,000 units⁴. Nearly 20% of U.S. Cars will be HEVs by 2020⁵. The automobile manufacturers, and the Department of Energy (DOE), as well as a number of vehicle conversion companies are actively involved in electric vehicle development through the Partnership for a New Generation of Vehicles (PNGV)⁶. Electric conversions of gasoline powered vehicles, as well as electric vehicles designed from the ground up, are now available that reach super highway speeds with ranges of 50 to 200 miles between recharging⁷. A PHEV is a HEV with batteries that can be recharged by connecting a plug to an electrical power source. The PHEVs have characteristics of both conventional hybrid

electric vehicles and of battery electric vehicles⁸. CEO's of the Detroit three automakers committed that by 2012, half of all vehicles produced will be compatible with ethanol (E85) fuel⁹. The new diesel engine technologies have made diesel vehicles cleaner, quieter and more powerful than past vehicles. J.D. Power & Associates survey shows nearly one-third of consumers would consider a clean diesel engine^{10,11}. The longer term trend of automobiles includes fuel cell vehicles. Fuel cell vehicles represent a future of the development of the automobile. A fuel-cell vehicle will produce zero emissions, while being very fuel efficient, noiseless, vibration free and have a long service life. Fuel cell technologies are projected to experience the greatest growth in the next ten years and may have the broadest implications for industries beyond auto manufacturing.

The undergoing technological transformation to vehicle electrification and other advanced technologies is fundamentally changing the educational requirements for the industry's future workforce. The industry demands highly trained technical workers, of which there is currently a shortage. More than 80% of employers indicate an added need for highly trained technicians and 13% report a severe shortage¹². It was stated in the 2009 Michigan Green Job Report that more than 84,000 positions requiring postsecondary training remain to be filled with the majority in technical fields including the auto industry¹³. There is a clear need of leadership for a systematic curriculum reform to meet the growing and evolving advanced technical education needs of current and future technical workers in the automotive industry, a critically important industry across the U.S. and the prominent employer in Michigan and the Great Lake region.

2. Assessment of Needs

In 2008, the MCC-WSU partnership was engaged by the National Science Foundation to research the current state of some key issues related to the development of an ATE center for advanced automotive technology. These issues include automotive workforce needs, automotive educational core competencies, automotive educational curriculum/pedagogy, and advance automotive future trends. The findings are summarized in the following.

A set of surveys were issued to target the Hybrid Electric and Diesel portions of the industry sector, the education sector and a sector that includes economic developers, non profits, industry associations and industry research groups. The 92 responses received include 21 to the industry survey, 49 to the education survey, and 13 to the government and professional association survey.

The industry survey results indicate the following:

- Advanced Powertrain technology is a top industry priority per all respondents.
- Demand for Engineers and Technicians in advanced powertrain technology is great.
- Skill improvement programs for engineers and technicians will be needed over the next 5 years.
- Staffing skill needs will be met through education of current staff and new educational initiatives in educational institutions.
- Electrical, Electronic, Computer, Controls, and System integration skills at the Expert level will be required of technicians and technologists.
- Technicians will require Associate Degrees as a minimum.

- Engineer education will require specialized preparation in many hybrid and diesel specific areas.
- Technical writing, Teamwork, and Innovation will be top business skill requirements; 9. New programs are needed, and they should include lab or capstone project content.
- A comprehensive educational resource center dedicated to Advanced Automotive Technology would play a role in all the above.

Some of the industry survey data are summarized in Tables 1-4.

Table 1: Anticipated Workforce Demand in Advanced Powertrain Technology Over the Next Five Years

	Low	Medium	High
Engineers	4.8%	28.6%	66.7%
Technicians	9.5%	33.3%	57.1%

Table 2: How Well the Educational Institutions Have Addressed the Needs For Qualified Employees in Advanced Powertrain Technology

	Not Well	Somewhat Well	Moderately Well	Well	Very Well
High schools	57.9%	26.3%	10.5%	5.3%	0.0%
Community Colleges: Career Tech education	10.0%	35.0%	30.0%	20.0%	5.0%
Community Colleges: General education	15.8%	36.8%	31.6%	15.8%	0.0%
Colleges/Universities: Bachelor	0.0%	21.1%	31.6%	42.1%	5.3%
Colleges/Universities: Master	0.0%	5.3%	21.1	52.6%	21.1%
Colleges/Universities: Doctorate	0.0%	0.0%	33.3%	55.6%	11.1%

Table 3: The Importance of Having An Industry Supported Educational Resource Center for Advanced Powertrain Technologies

Not very important	Slightly important	Important	Very important
0%	10.5%	47.4%	42.1%

Table 4: The Anticipated Functions of the Educational Resource Center

	Yes	No	Don't know
Preparing new advanced powertrain engineers	100.0%	0.0%	0.0%
Enhancing skills of current engineers	84.2%	0.0%	15.8%
Preparing new technicians/technologists	94.7%	0.0%	5.3%
Enhancing skills of current technicians/technologists	78.9%	0.0%	21.1%

The survey among automotive educators indicates:

- Automotive courseware, lab equipment and industry based knowledge is not available to many educational institutions.
- Course materials and lab equipment is critical to the education process in this area, and current industry knowledge would be very beneficial.
- The Center would be viewed as “extremely beneficial” to education efforts.
- Educational pathways and articulation agreements need improvement.
- Internship programs are not well developed per half of the respondents.
- While many institutions have good communications with industry, a Center is viewed as very beneficial to the communication process, to the creation of linkages between industry, educational institutions, and professional associations, and to the curriculum development process for schools.

Some of the education survey data are summarized in Tables 5-8.

Table 5: The Status of Existing Automotive Education Programs
(1: Not Well Developed, 4: Well Developed)

	1	2	3	4
Course Materials	30.6%	16.3%	16.3%	36.7
Functional Laboratory Equipment	31.3%	14.6%	18.8%	35.4%
Industry Supported Knowledge Library	41.7%	18.8%	20.8%	18.8%

Table 6: The Existing Educational Pathways and Articulation in
Advanced Powertrain Technology Programs

Not Well Developed	Developed Enough	Developed	Well Developed
51.1%	8.5%	36.2%	4.3%

Table 7: Feedback and Communication Between Education and the Automotive Industry

Non-existent	Weak	Somewhat strong	Strong
8.7%	41.3%	28.3%	21.7%

Table 8: Benefit of Having An Industry Supported Educational Resource Center
for Advanced Powertrain Technologies

Not beneficial	Somewhat beneficial	Beneficial	Extremely beneficial
0%	13%	30.4%	56.5%

The government and professional association survey indicates:

- A Center would be important in improving the linkages between industry, education, and professional associations to promote economic development, and workforce development initiatives.
- A Center would help attract business to the region.
- A Center would have a positive impact on providing workers in this sector with the new knowledge requirements of the industry.

The project team also obtained findings from the CAR's Program for Automotive Labor and Education (PALE) report: *Beyond the Big Leave: The Future of U.S. Automotive Human Resources*, and IBM Institute for Business Value report on the industry: *Automotive 2020, Clarity Beyond the Chaos*.

The PALE report is the result of an effort by the CAR, the nation's leading auto industry analysis organization, to do research that will benefit automotive region labor and educational institutions deal with the shift in demand for auto related labor skills, from rote technical skills and mechanical engineering emphasis to a knowledge based multi-faceted technical workforce and electrical engineering emphasis. The PALE report is a compilation of interview comments from the leaders of the OEM and supplier businesses that anchor the industry. The PALE report concludes that future engineers and technicians will require specialized technical education, and education that includes practical and hands on experiences is favored over theoretical instruction for many positions. The PALE report also concluded that engineering and technician candidates will require more education in the future, including 4 year degrees for development technicians and 2 year degrees for service technicians, and that powertrains and vehicle integration will be the "core" fields demanding new hires.

The IBM report was conducted by IBM Global Business Services to provide insights for senior management around critical public and private sector issues, and to provide information to assist in the strategic planning of the company. The IBM report looks forward to 2020 and concludes the major automotive challenges will be global integration and execution, with technology and sustainability at the top of the list of forces impacting the industry. It also places fuel efficiency and eco-friendliness at the top of the purchase decision criteria for autos, and states that software and electrical systems need the most innovation. They call for a "multiplex workforce" (workforce of multidisciplinary technical staff) to develop the intelligent vehicle of the future, and foresee a shortage of appropriate talent.

Advanced Automotive Future Trends

Advanced automotive future trends for technical skills and hiring needs is well documented. Our research, which was substantiated by the MAGMA workgroup, indicates technical skills will be needed in Power Electronics, Motor Control Electronics, Power Electronics Cooling, Controller Software, HEV and Diesel Electrical Systems, and Battery Systems and Controls. PALE research indicated a hiring rate for Engineering and Technical workers, from 2007 through 2016, of 8846 for GM, Ford and Chrysler, despite projected declines in overall employment. While the climate in the automotive industry may delay the forecasted hiring, at some point the hiring will take place as the new domestic companies emerge. In addition, the creation of the DELEG Michigan Academy for Green Mobility initiative, with an objective of educating incumbent engineers, engineering students, and technicians, is evidence of the need for educational institutions to be on the forefront of the technologies employed in the vehicles of the future. Further, recent federal government actions to promote the electrification of the automobile and create education programs to build capability in electric transportation (Development and Implementation of Degree Programs in Electric Drive Vehicle Technology, DE-FOA-0000028) has created a nationwide calling for expansion of education programs in new technology advanced automotive education where the CAAT team is positioned to lead the country.

3. Implementation of the CAAT

The comments from both the industry and educators pointed to the need of leadership for statewide articulation and collaboration on curriculum. Specifically, the suggestion was to have a central clearinghouse that drives communication, strategic planning, and communication that will foster change/evolution of the current training programs and alignment between the organizations involved, as well as facilitating instructor training and technical updates, and recommending equipment and technology for student training.

In June 2010, Macomb Community College and Wayne State University partnership was awarded the NSF-ATE grant to establish the CAAT. The primary goal of Center is to increase the pool of automotive production specialists, technicians, engineering technologists, and engineers with education/experience in advanced automotive technologies and industry identified and desired skills by identifying the technology demands of the auto industry, and responding to those demands by collecting and offering the latest industry driven educational materials for secondary, post secondary and graduate level students and faculty, and to offer educational opportunities to the industry's production, technician and engineering workforce and to the community support organizations that must handle these new technologies in the field.

In order to reach this goal and make a positive, continual, and lasting contribution to advanced automotive technology education, the CAAT has set the following objectives for the project:

- Create an advanced automotive technology learning environment for automotive production specialist, technicians and engineering technologists, across the automotive sectors, through systematic curriculum reform, seamless 2+2+2 educational pathways, and faculty professional development.
- Increase awareness of the technologies, impact of the technologies, and need for understanding of the technologies by educating first responders and the general public through workshops and seminars on safety and technological concepts of EV and HEV design and operation.
- Engage regional educational institutions and businesses in collaborative activities to acquire and disseminate the latest knowledge, technology and industry needs in the green mobility field for research, design, development, production, assembly, service and recycling.
- Create the most comprehensive and up-to-date educational resource available with the latest knowledge and materials, syllabi, job specific programs, news and concepts, delivery methods and options, for the CAAT partners and clients.
- Develop and implement a sustainability plan to keep CAAT the source of vital curricular content, technical expertise, and new technologies in the automotive industry beyond the period of NSF ATE funding.

The CAAT is conducting the following activities to realize the stated objectives:

1. Create easily-accessible course and curriculum database:

The CAAT project team is in process of collecting and evaluating existing and developing courses, curricula, educational tools and training programs. These components will be organized into a comprehensive and current database, and make it accessible from the CAAT website.

2. Facilitate course and curriculum adoption for curriculum reform:

To promote and facilitate curriculum reform, CAAT provides “seed grants” for course and curriculum improvement. The CAAT seed grants will be made for one year periods, or less, and will give preference to community colleges and secondary schools. The curriculum reform will be first carried out within the eight community colleges in the SMC3 and the K-12 schools in MISD. The CATT will host curriculum reform workshops annually to explain the application, review, and approval process of the “seed grant”, the available resource, and the deliverables that will assure other institutions will benefit from the individual reform efforts. To assist the grant applicants to prepare proposals, each workshop will include work sessions to review current courses, curricula, and teaching aids in the regional community colleges and schools, and identify areas for improvement. The CAAT will strategically apply the SMC3 model to have each partner college focus on certain areas in the advanced automotive technology spectrum and share the results for others. Through these projects, and the inter-college collaboration, a systematic curriculum reform in the region will be achieved.

3. Integrate advanced automotive technology skills at the secondary level:

CAAT and its regional partners will adapt and integrate curricula at the secondary school level, aligning new and emerging advanced automotive technologies to national, and more specifically, new state curriculum requirements that emphasize STEM disciplines. The purpose is to promote student STEM skills at the secondary education level via reformed course objectives by working with science and mathematics educators, local Intermediate School District (ISD) education partners, and postsecondary automotive technician educators. Specifically, CAAT project team is working with MISD to develop a secondary educational program for juniors and seniors that adapts content knowledge of advanced automotive technologies in STEM curricula. This pilot program will be provided as a secondary instructional model for high school automotive technician programs.

4. Develop articulation agreement to provide seamless educational pathways:

To provide 2+2+2 educational pathways, the CAAT provides coordination to facilitate the development of transfer plans and articulation plans connecting K-12, two year colleges and baccalaureate programs. WSU will expand the MCC/WSU articulation agreements across the SMC3 community colleges to provide seamless transfer from AAS degree to BSET or BS in Electric Vehicle Technology programs. MCC will work with MISD to create a HS-CC articulation agreement for Electric Vehicle Technology. By combining the HS-CC and AAS-BSET articulation agreements and transfer plans, MCC, WSU and MISD will further develop a pilot 2+2+2 curriculum for advanced automotive technology. These agreements and pilot curriculum will be offered on the website as models for other K-12, CC, and Baccalaureate agreements.

5. Support faculty professional development:

The CAAT currently provides three professional development opportunities each year for community college instructors and K-12 STEM teachers:

- Two-day short course for electric drive vehicle technology
- Two-day short course for advanced energy storage system technology
- One-day workshop for grant opportunity and proposal preparation.

The two short courses provide the most updated technology information and training for laboratory equipment and software tools for science and technology educators. The one-day workshop aims to familiarize science and technology faculty with existing funding sources, such as the NSF CCLI program, for course, curriculum and laboratory improvement, and provide guidelines for proposal preparation and forming partnerships for collaborative projects.

6. Conduct outreach activities to promote the concept of green transportation:

The CAAT outreach activities include:

- Annual conferences to promote the CAAT, its activities, and technology developments.
- Summer academies for K-12 students to introduce advanced automotive technologies.
- Workshops and seminars for first responders, industry professionals, and the general public to expose the technologies and related impacts to key groups.
- Presentations at industry and educational symposia to promote the awareness and use of the CAAT resource.
- University Bound program to encourage transferring from community colleges to four year universities

7. Coordinate internship and undergraduate research programs

The CAAT network of educational and industry partners promote the internship and undergraduate research opportunities of students as gateways to full time employment. Undergraduate research opportunities will be used to further the student understanding of advanced automotive technology, and connect students to employers through advisory committee activities. To assist the promotion of the Detroit Regional Chamber as a key member of the CAAT project team we will emphasize the connection as we employ interns.

8. Conduct market assessment and core competence survey:

The Center for Automotive Research, a key CAAT member, is responsible for conducting periodic market assessments to include industry expectations of educational institutions, technical worker demand, and demand in growing sectors of the industry.

4. Seed Grants and Professional Development Programs

Seed Grants

Providing seed grants to establish regional alliance is a new idea that has never been done in other NSF ATE center. The CAAT has conducted much work and research to develop a process for awarding seed grant contracts for the development or adaptation of educational materials in the advanced automotive technology space ranging from modules and artifacts to courses and complete curricula. The application template and cover letter explaining the seed grant were sent to secondary schools, community colleges and universities in the region. The applying institution completes the application for consideration and decision by the CAAT.

During the first year, the CAAT have received 12 proposals for seed funding. Three proposal have been approved :

- “Modify Automotive Service Excellence certification classes to include Hybrid EVs,” Lewis & Clark Community College, \$27,540

- “Battery manufacturing job training curriculum,” Grand Rapids Community College, \$8,403
- “Hybrid EV based modules for 2 mechatronics courses,” Lawrence Tech University, \$22,278

In addition, three proposals are being considered for funding:

- “Development of innovative “Off Grid” Energy Center to educate students in renewable energies, smart grid integration, installation/maintenance of EV charging stations,” Ivy Tech Community College, \$24,800
- “EV modules for community delivery,” Lansing Community College, \$13,200
- “Battery reclamation project,” Grand Valley State University, \$20,000

Faculty Development Program

The CAAT, through its WSU Partner, has sponsored a two-day short course for community college and university engineering technology faculty and high school science or technology teachers interested in electric-drive vehicle development, design, modeling, manufacturing and marketing. The short course covers four topics related to hybrid and electric vehicle technology:

- Electric Drive Vehicle Fundamentals
- Power Electronics and Charging Systems
- Advanced Energy Storage
- In-Vehicle CAN Embedded Systems

The short course also included lab sessions in each day to provide hands-on experiences:

- Demonstration of GM and Ford Hybrid Vehicles on On-Board Diagnosis Systems
- Demonstration of Traction Motor and Battery Testing Systems

The short course was offered each Summer. To encourage community college and high school faculty to participate the professional development program, the CAAT has provided a \$200 for each program participant incentive stipend. There were 30 participants in the 2010 program, and 46 participant in the 2011 program.

Professional Development Short Courses

In responding to industry request, Wayne State University has also developed four professional development short courses for incumbent automotive engineers:

- Fundamentals of Electric Drive Vehicles
- Battery Systems for Electric Drive Vehicles
- Motor Drives and Power Electronics for EV/HEV/PHEV
- Automotive Direct Injection Engines

Each course includes 14 hours for lectures and 4 hours for laboratory experiences. All of the four courses are endorsed by the MAGMA. The program was first offered in August 2011 for 62 engineers and professionals sent by local auto makers and suppliers.

5. Conclusion

This paper describes the rationale for the creation of the Center for Advanced Automotive Technology, the finding of the planning grant for creation CAAT, our vision for curricular reform, and the center activities, including educational material collection and dissemination, a seed funding program, student summer academies, and faculty professional development. The automotive industry is critically important to the economy of the nation, and its reach and influence on related industries such as steel, plastics, machine tools, computers, electronics, transportation and others is greater than any other industry in the country. Technicians play a key role in the industry and the CAAT will fill the educational needs of those technicians in the design, development, service and recycling sectors of the market. In doing so, the CAAT compliment the NSF funded the Automotive Manufacturing Technical Education Center (AMTEC) which focuses on the manufacturing and assembly aspects of the industry.

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