Advanced Electric Drive Vehicle Education Program: Development and Implementation of Degree Programs in Electric Drive Vehicle Technology

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Macomb Community College

NEXTENERGY

Economic Security through Energy Diversity

Wayne State University

Electrifying the Economy

Educating the Workforce

Overview

Timeline

- Start – Jan 2010
- Finish - Dec 2012
- 75% Complete

Barriers

- Funding for Internship

Budget

- Total project funding
  - DOE - $5.0 M
  - WSU/MCC - $1.25 M

Partners

- Macomb Community College (William Stark)
- NextEnergy (Jim Saber)

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Objective/Relevance

To prepare our current and future workforce with the education and skills necessary for the advancement and maintenance of electric-drive vehicles.

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Objective/Relevance

Develop and implement a comprehensive set of advanced educational programs in electric drive vehicles, including:

- a Master's Degree in Electric Drive Vehicle Engineering (EVE),
- a Bachelor's Degree in Electric Transportation Technology (ETT),
- an Associate's Degrees (AAS) in Automotive Technology and Electronic Engineering Technology,
- an undergraduate concentration and a graduate certificate program (GPC) in EVE

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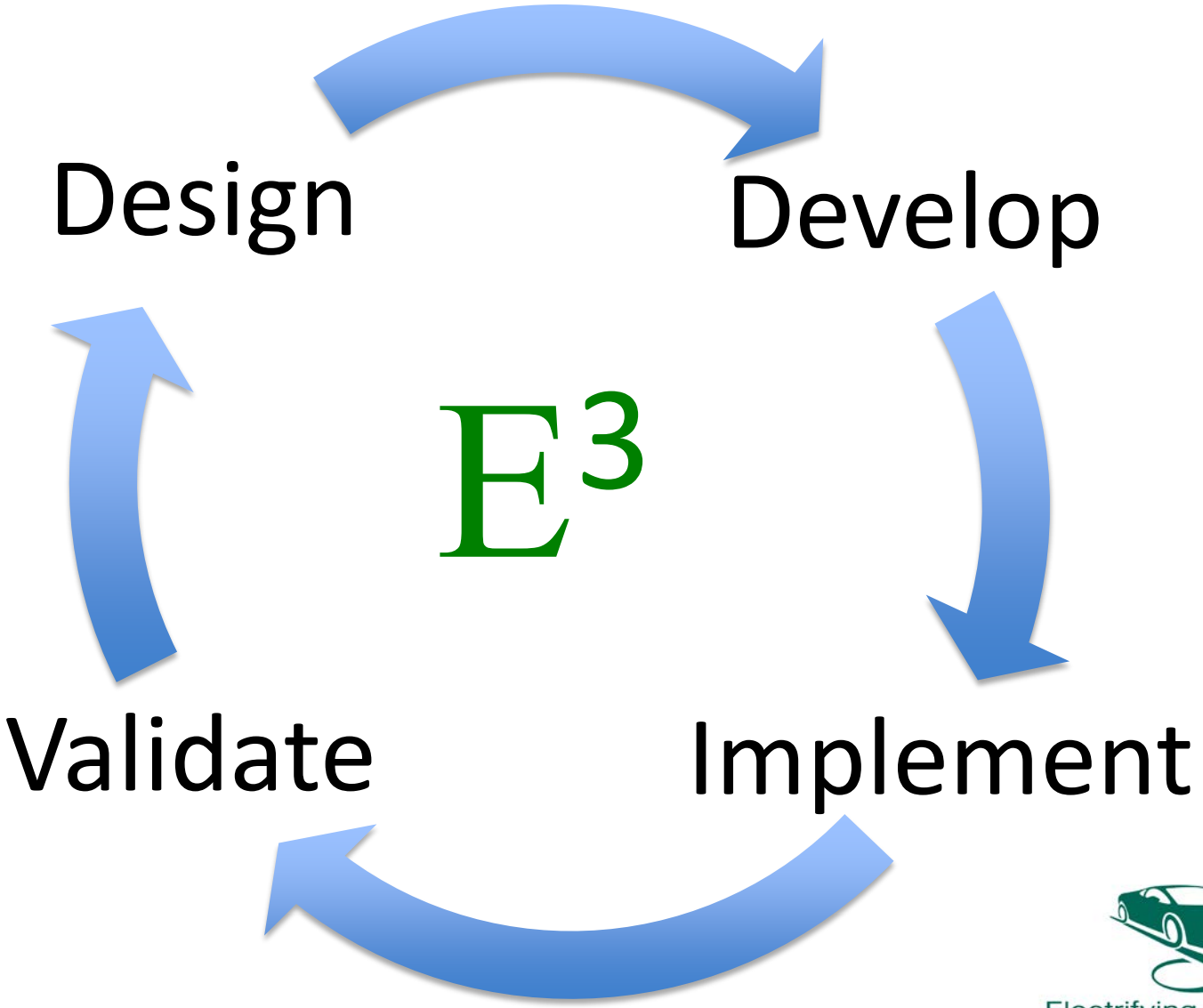
Approach



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Approach

Comprehensive

- Multidisciplinary
- Existing Strength

Industry Oriented

- Input from Industry
- Laboratory Intensive

Broad Impact

- Integrated 2 + 2 + 2 Curriculum
- Distant Learning
- ABET Accredited

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Milestone

Key Milestones	Date	Remarks
EVE Advisory Board Formed	February 15, 2010	14 Board Members
Launch EVE Website	April 1, 2010	10,247 visits (as of March 15, 2012)
E3 Workshop: *Meeting the Educational Needs of the Electric Vehicle Industry*	May 25, 2010	Over 100 participants
A Two-day Short Course for K-12 Science Teachers Offered	June 24 - 25, 2010 June 20 - 21, 2011	30 participants 50 participants
M.S. Degree Program in EVE Offered	Fall Semester, 2010	11 courses offered with 162 students enrolled
Graduate Certificate Program in EVE Offered	Fall Semester, 2010	
B.S. Degree Program in ETT Offered	Winter Semester, 2011	4 courses offered
Energy Storage Laboratory Completed	Winter Semester, 2011	Laboratory modules developed
Control and Integration Laboratory Completed	Winter Semester, 2011	Laboratory modules developed
Electric Propulsion Laboratory Equipment Completed	Fall Semester, 2011	Laboratory modules developed
E3 Workshop: *Taking Charge of Electric Vehicle Industry's Educational Needs*	April 19 -20, 2011	Over 200 participants
Course and Program Validation	Winter Semester, 2012	Design Student and Employer Survey

Accomplishment/Progress (MS EVE)

Course #	Course Title	Class Enrollment							*Cumu-lative*
		W/10	S/10	F/10	W/11	S/11	F/11	W/12	
EVE 5110	Fundamentals of Electric-drive Vehicle Engineering			15			19		*34*
EVE 5120/ AET xxxx/ ME 5215	Fundamentals of Battery Systems for Electric and Hybrid Vehicles	24			31			30	*85*
EVE 5130/ AET 5110	Fundamentals of Cell-powered Systems for Transportation			22			27		*49*
EVE 5150/ AET/ET	Advanced Energy Storage Systems	71	10	23	24	9	27	15	*179*
EVE 5310	Electric-drive Vehicle Modeling and Simulation				8		5		*13*
EVE 5410/ ECE 5410	Power Electronics and Control		18			23			*41*
EVE 5430/ AET 5330/ ECE 5330	Dynamics and Control of Electric-drive Powertrains / Renewable Power Sources and Power Electronics			32			26		*58*
EVE 5450/ ECE 5470	Control and Optimization for Integrated Electric-drive Vehicle Systems				11			24	*35*

Accomplishment/Progress (MS EVE)

EVE 5600/ AET 5600/ IE 6405	Electric-drive Vehicle Product and Infrastructure Development / Fuel Cell Product Realization System			11			7		*18*
EVE 5620/ CHE 5620	Energy Economics and Policy				8			22	*30*
EVE 5640/ AET 5640	Energy and the Environment			8			23		*31*
EVE 5700/ AET 5250/ ME 5330/ ME 4300	Electric-drive Vehicle Capstone Design / Alternative Energy Technology System and Design				15			13	*28*
EVE 5810	Power Management of Advanced Energy Storage Systems				17	8		16	*41*
EVE 7310	Material Science Aspects of Lithium Ion Batteries		7						*7*
EVE 7450	Embedded Systems for Vehicles						5		*5*
EVE 7990	Directed Study			1				8	*9*
EVE 7991	Internship: Industry								*0*
EVE 7996	Directed Research								*0*
EVE 8999	Master Thesis Research								*0*
	Sub-total:	*95*	*35*	*112*	*114*	*40*	*139*	*128*	**663**

Accomplishment/Progress (MS EVE)

Tasks	Status
Task 2.0 Development and Implementation of MS Program	Submitted the university-internal MS degree program proposal, and successfully and expeditiously obtained unanimous approvals from the College of Engineering, the Graduate School, and WSU Board of Governors.
Subtask 2.1 Program Objective	Posted the program vision, mission statement, program goals and program outcome, which will regularly be reviewed and revised as necessary based on inputs from the constituents. Policies on admissions requirement, program requirement, and graduation standards have all been established in the proposal submitted.

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Accomplishment/Progress (MS EVE)

Tasks	Status
Subtask 2.2 Curriculum Design	A curriculum development workshop entitled "EV's in Higher Education: Meeting the Educational Needs of the Electric Vehicle Industry" was held on May 25, 2010. An advisory board meeting was held on February 15, to seek inputs and feedback on the curriculum.
Subtask 2.3 Development	Established a total of 15 new graduate level courses, all with responsible faculty and instructors identified. Integrated the 3 centralized labs with most of the 15 new courses. A proposal for graduate certificate program was submitted and approved by WSU Board of Governors.

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Accomplishment/Progress (MS EVE)

Tasks	Status
Subtask 2.4 Implementation	A year-round course offering schedule has been posted on the web, a total of 28 courses have been offered in Year 1 and 2.
Subtask 2.5 Validation	Held E3 conference "Electrifying the Economy - Educating the Workforce: *Taking Charge of the Electric Vehicle Industry's Educational Needs* April 19-20, 2011 to begin validation process. An advisory board meeting was held on June 2, 2011 to validate the curriculum and seek inputs and feedback courses and programs. Design student and employer survey on EVE courses and programs.

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Accomplishment/Progress (BS ETT)

Tasks	Status
Task 3.0 Development and Implementation of BS Program ***Subtask 3.1 Curriculum Design***	Submitted the university-internal BSETT degree program proposal, and successfully and expeditiously obtained unanimous approvals from the College of Engineering, and WSU Board of Governors.
Subtask 3.2 Courses and Laboratory Development	Nine proposed BSETT technical courses have been designed and developed by program development team. The course syllabus for each proposed course, including course description, learning objectives, and course outlines, have been developed. All necessary laboratory equipments have been installed.

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Accomplishment/Progress (BS ETT)

Tasks	Status
Subtask 3.3 Implementation and Validation	Fourteen courses were offered from the Fall 2010 semester to Winter 2012. A total of 18 students enrolled in the BS-ETT program.
Subtask 3.4 Outreach	A two-day short course for K-12 science and technology teachers, community college instructor, or incumbent engineers or displace workers was delivered to 30 participants June 24 – 25, 2010; and to 50 participants June 20 – 21, 2011. Offered four professional development short courses for 62 incumbent automotive engineers, August, 2011.
Subtask 3.5 Provide Educational Pathway for Community College Graduates	The 2+2 Course Sequence for community college transfer students has been developed.

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Accomplishment/Progress (AAS)

Tasks	Status
Task 4.0 Development and Implementation of Associate Degree Program.	Delivered 3 originally planned Courses as experimental classes, Winter 2011 semester. Delivered AES courses during Winter 2011, 2012 semester as non-credit offerings convertible to credit upon request of students in the EET program. The AES courses became a credit course by Fall 2011. The Capstone Course is being delivered as an experimental course, Winter 2011 semester. This course was created around the build of a plug-in electric vehicle, in concert with an industrial partner; with 42 students.
Task 5.0 Expand Automotive and Electronic Engineering Technology Laboratories to provide hands on instruction for new courses.	Lab experiments for the 3 original courses are defined and installed.

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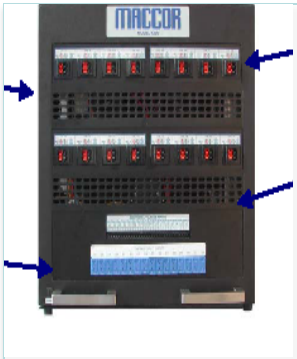
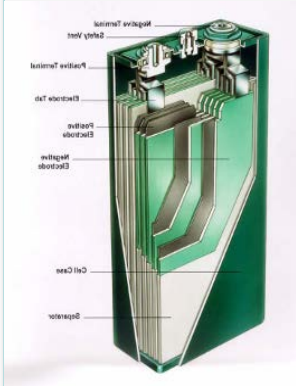
Technical Accomplishments: Energy Storage Laboratory

Cell Characterization/Fabrication



Maccor and Arbin Cell Testers

Glove Box for Li-Ion Cell Fabrication

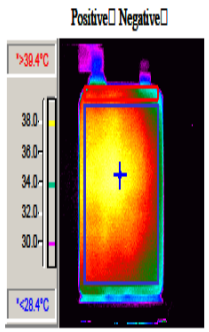


Gamry Cell Performance and Life Tests

Pack/System Characterization

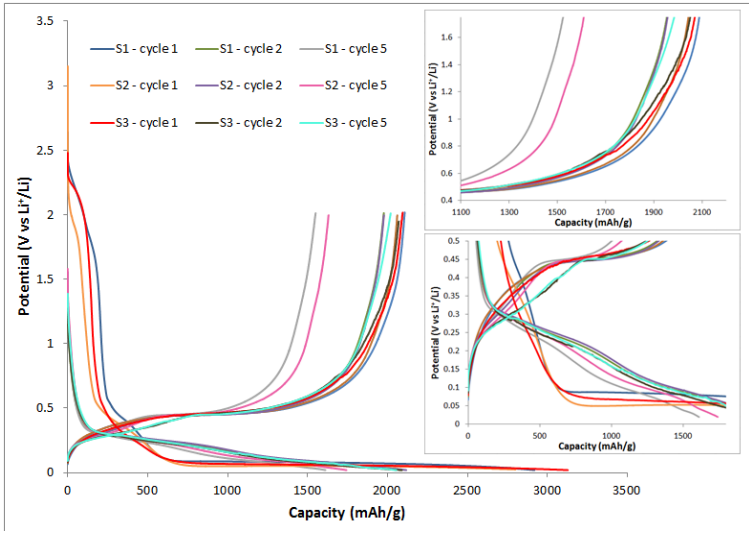
Bitrode Pack and Module Tester

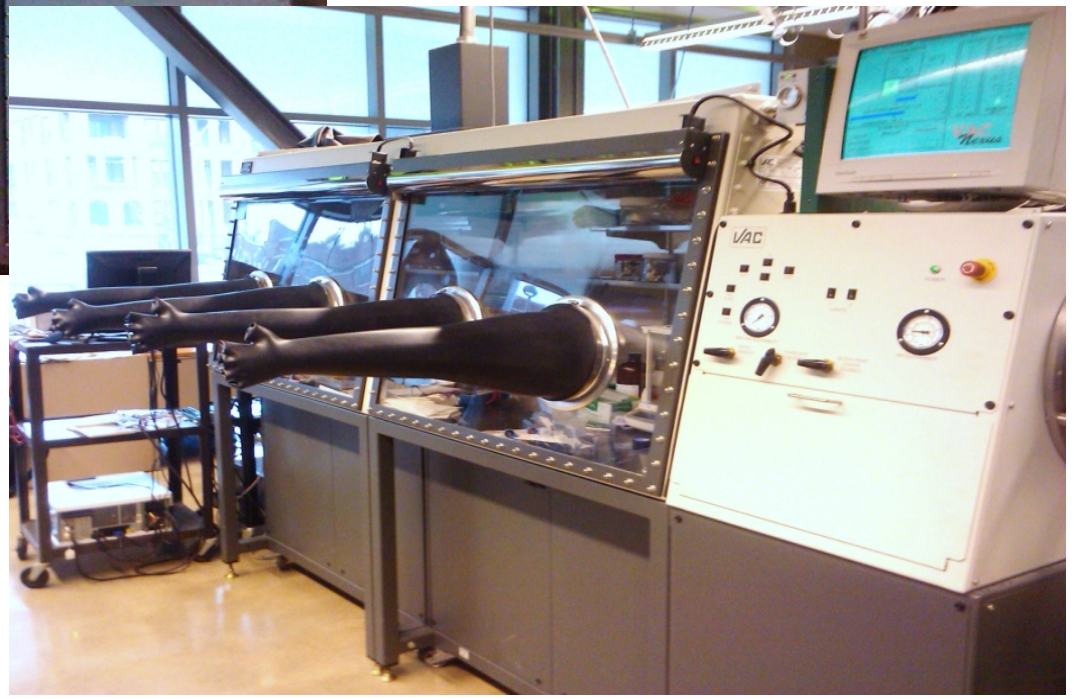
Thermotron Controlled Environment Chamber

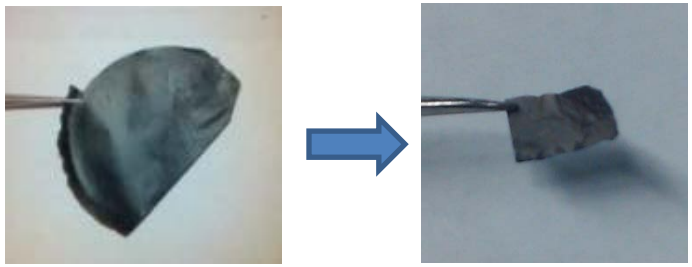


FLIR Thermal Imaging instruments

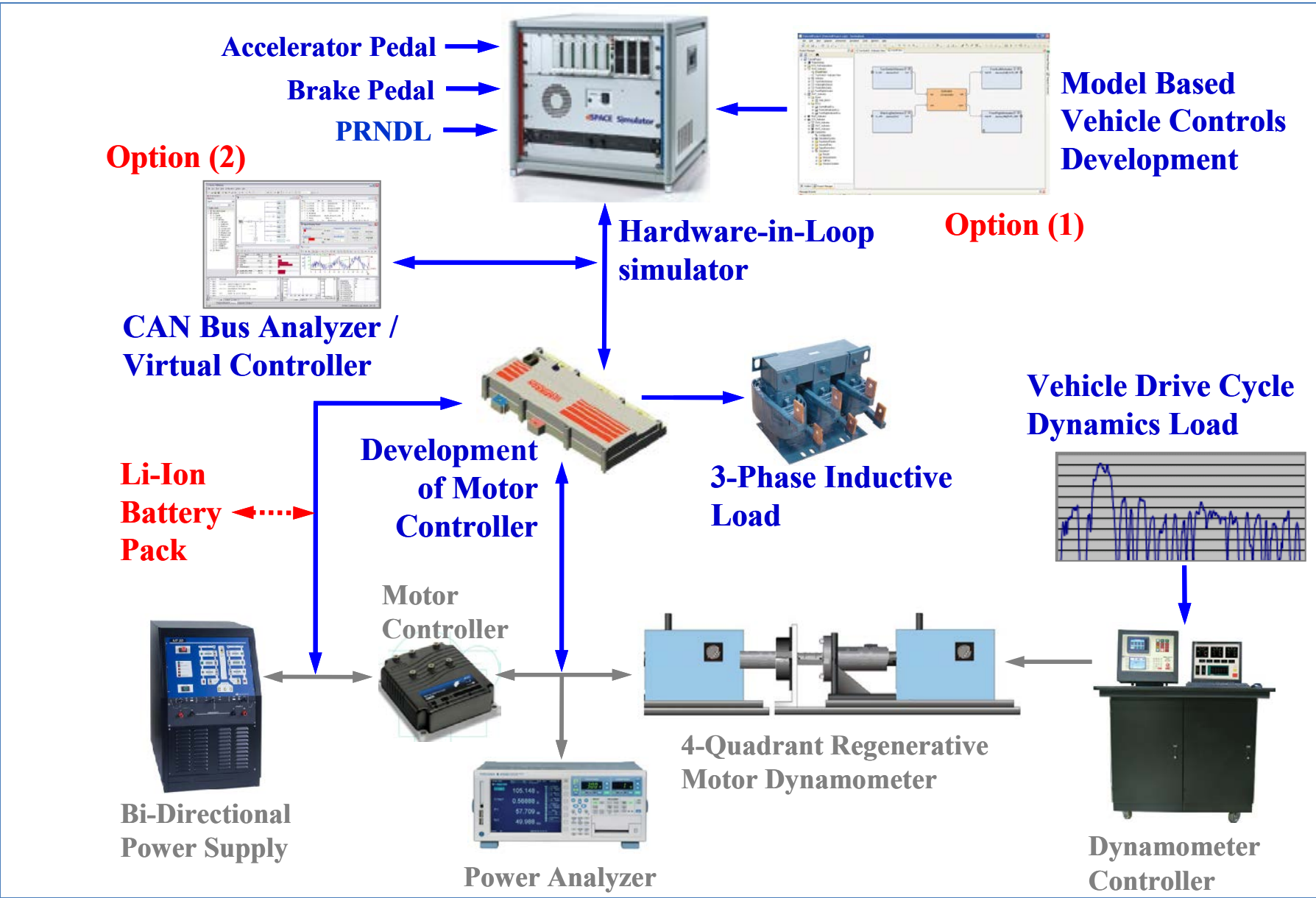
Technical Accomplishments: Energy Storage Laboratory



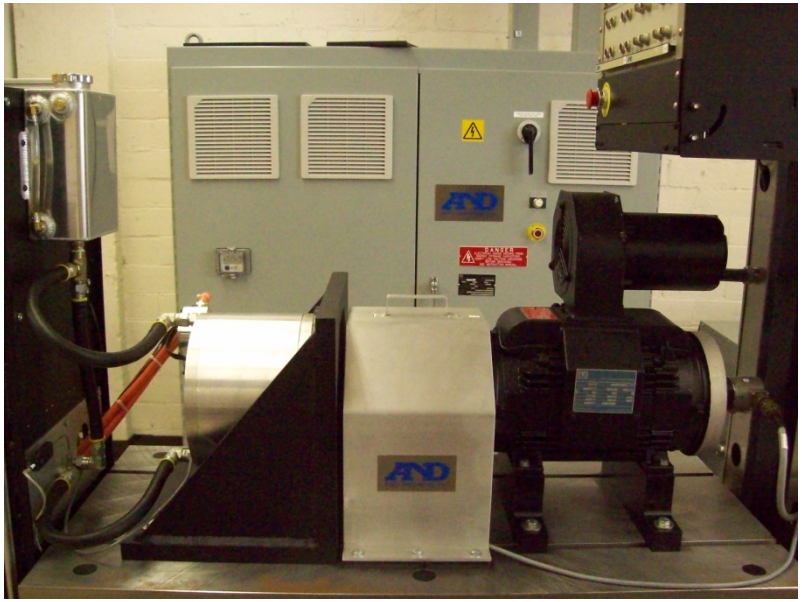


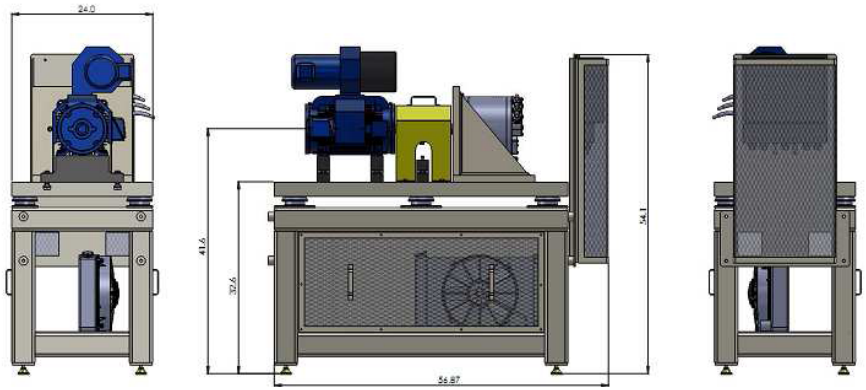


Technical Accomplishments: Electric Propulsion Laboratory



Technical Accomplishments: Electric Propulsion Laboratory





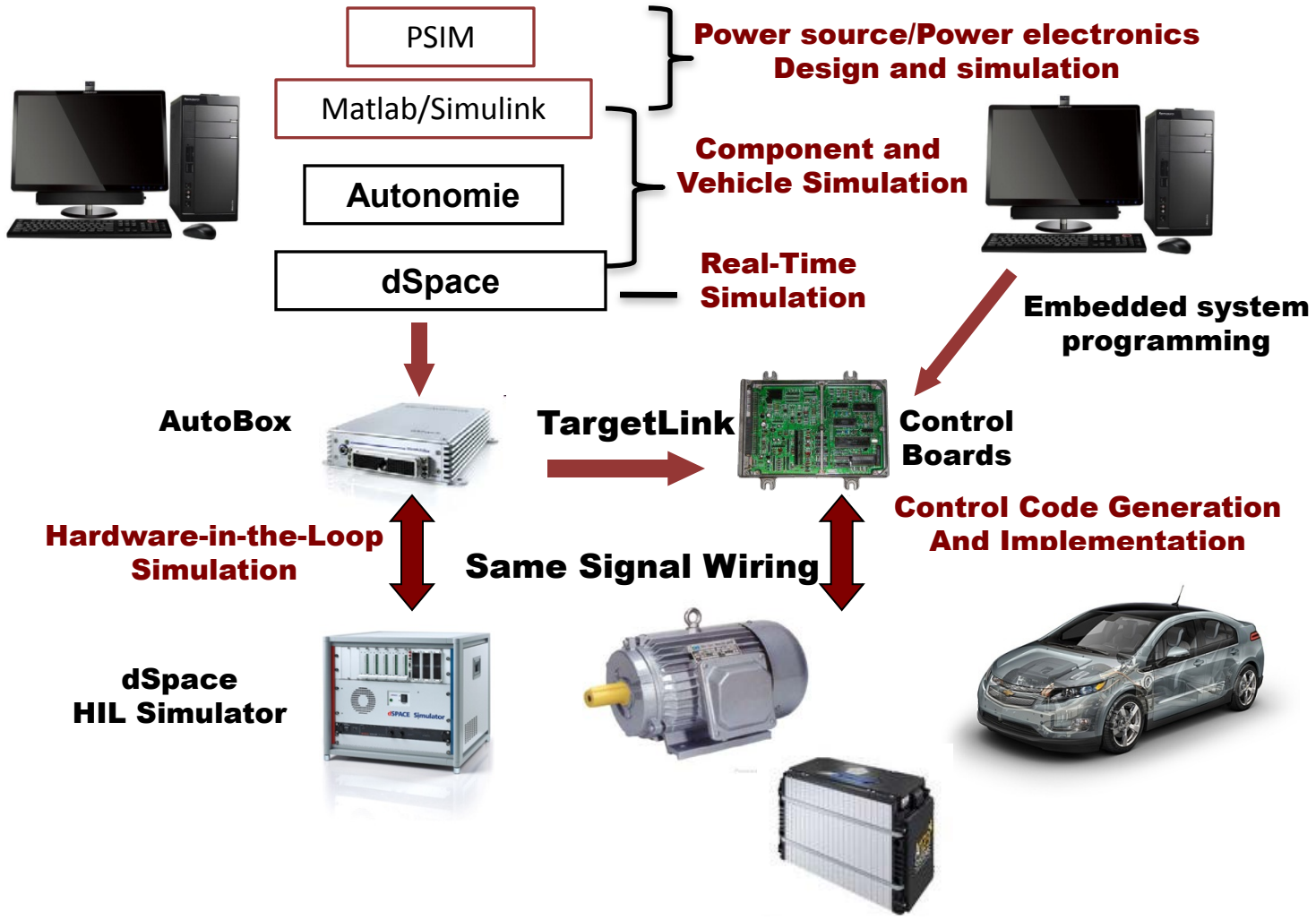
Technical Accomplishments:
Center of Electric Vehicle and Smart Grid Integration

dSpace and NI PXI-e DAQ

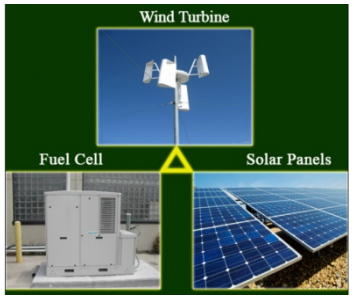
Battery Packs

Power Converters and Charge Controllers

Technical Accomplishments:
CEVSGI: Modeling, Design, and Simulation



Technical Accomplishments:
CEVSGI: Powertrain Control and Integration



Alternative Energy

SLA

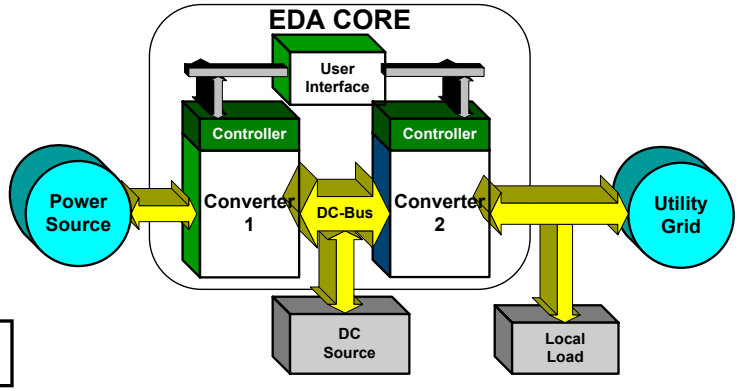
NiMH

Li-ion

Ultracapacitors

Battery Charger Controller

Grid-tie/Load Power Converters



30 kW Inverter: Special Design

Load Dyno: Motor/Generator Combo

Tunable DC Power:
Power Source Emulation

Bi-Directional Inverter (own design)

Battery Management

Power Conditioning and Coordination

Control of Electric Machines

Circuit Construction and Development Stations

Sensors and Meters, Power Quality Analyzers, Multichannel Data Acquisition System, Signal Generator, Oscilloscopes Embedded Control Systems

Collaboration

- Macomb Community College
  - AAS program
  - Articulation Agreement
  - Shared Laboratory Resources
  - Outreach Programs
  - Summer Workshops
- NextEnergy
  - E3 Conference: *Meeting the Educational Needs of the Electric Vehicle Industry*
  - E3 Conference: *Taking Charge of Electric Vehicle Industry's Educational Needs*
  - Workshops
- Industrial Advisory Board
  - Internship
  - Guest Lecturers
  - Plant visits (Volt, A123)

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Future Work (Q10 –Q13)

- Conduct student and employer survey
- Evaluation of courses and programs
- Refine courses and programs as needed
- Implement course and laboratory modules
- E^3 Seminar Series and Workshop
- Summer Workshop (June – August) for K-12 Instructors from the region
- Summer Academy (June – August) for EV/HEV technology
- Short course for K-12 teachers and community college instructors

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Summary

Accomplished all objectives for the Year 1-2 (Q1-Q9)

- Project Management Structure
- Advisory Board
- Approval of EVE and ETT Degree Programs
- Development of EVE and ETT Courses
- Scheduling for Program Implementation
- Established Three Integrated Laboratories
- Launched EVE Website
- Conducted E^3 Conferences
- Developed Summer Academy and Workshop

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Summary: Advisory Board

- **Ray Boeman**, Director, Advanced Transportation Systems Program and NTRC User Facility, Oakridge National Laboratory
- **Ronald Gardhouse**, CEO of NextEnergy
- **Sen. Hansen Clarke**, State Senator from the First District (Detroit)
- **Michael Fetcenko**, VP of BASF
- **Ricardo Espinosa**, Vice President of Engineering, Azure Dynamics, Inc.
- **Nancy Gioia**, Vice President of Global Electrification, Ford Motor Company
- **David Gorsich**, Chief Scientist, U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC)
- **William Wallace**, Director, General Motors
- **James Jacobs**, President, Macomb Community College
- **Steven Kurmas,** President and COO, DTE Energy
- **Michael Finney**, President, Michigan Economic Development Corp (MEDC)
- **Prabhakar Patil,** President and CEO, Compact Power, Inc.
- **Bob Purcell**, Purcell & Associates, LLC
- **Hilary Ratner,** WSU Vice President for Research and Chair of the Advisory Board

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